



TECHNICAL MEMORANDUM

Date: October 4, 2024
To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division
From: Olivia Wright, Herrera Environmental Consultants, Inc.
John Lenth, Herrera Environmental Consultants, Inc.
Subject: WQBE – Phase 3 Action and Program Fact Sheet Development (439-TM1)

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Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages," for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020):** Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021-2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- **Phase 3 (2023-2024):** An additional four Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the process used to develop the Phase 3 Action and Program Fact Sheets for the WQBE toolkit. It begins with a general overview of the Fact Sheet development process and guidance for their interpretation. Detailed supporting documentation on the technical basis for the Fact Sheet content is then provided in a series of appendices.

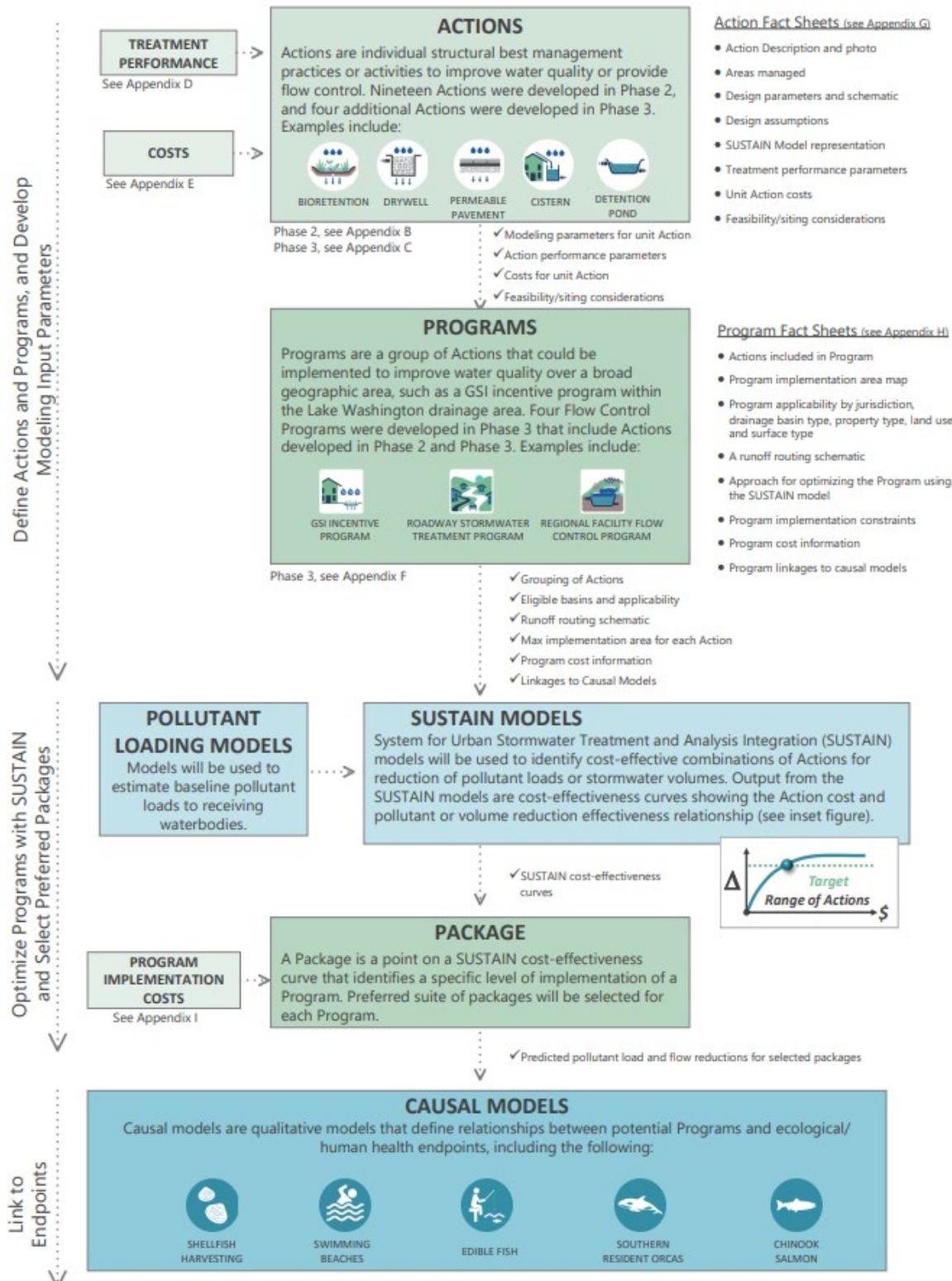
Action and Program Development Process

An overview of the process used to develop the Actions and Programs is provided in Figure 1. The graphic depicts the interrelationship between the WQBE elements (Actions, Programs, and computational models).

Supporting technical documentation for the development of the Phase 3 Action and Program Fact Sheets is provided in a series of appendices to this memorandum:

- WQBE terminology (Appendix A) – Provides key terminology that is used in the WQBE Toolkit.
- Phase 2 Action design assumptions (Appendix B) – Documents the design assumptions for the original nineteen Actions that were developed in Phase 2. A subset of these Actions are included in Flow Control Programs developed in Phase 3. Note the cost information in the Fact Sheets from this memorandum were update in Phase 3 as described below.
- Phase 3 Action design assumptions (Appendix C) – Documents the design assumptions for the four new Actions that were developed in Phase 3.
- Phase 3 Action performance assumptions (Appendix D) – Documents the water quality treatment assumptions for the original nineteen Actions developed in Phase 2 and the four new Actions developed in Phase 3.
- Phase 3 Action costs (Appendix E) – Documents the simplified costing approach that was developed in Phase 3. Included is a summary of the revised costs for the nineteen original Actions developed in Phase 2 and the four new Actions developed in Phase 3.
- Phase 3 Flow Control Program development (Appendix F) – Documents the assumptions for four Programs focused on flow control developed in Phase 3.
- Phase 3 Action Fact Sheets (Appendix G) – Fact Sheets for the original nineteen Actions that have updated costs from the simplified costing approach that was developed in Phase 3 and summarized in Appendix E. Also included are Fact Sheets for the four new Actions that were developed in Phase 3. These fact sheets supersede those developed during Phase 2 and included in Appendix B.
- Phase 3 Water Quality and Flow Control Program Fact Sheets (Appendix H) – Fact Sheets for four new Programs focused on flow control that were developed in Phase 3.
- Program Implementation delivery models and costing approach (Appendix I) – Provides example costs for Program implementation models that could be applied outside of SUSTAIN.

Figure 1. WQBE Elements.



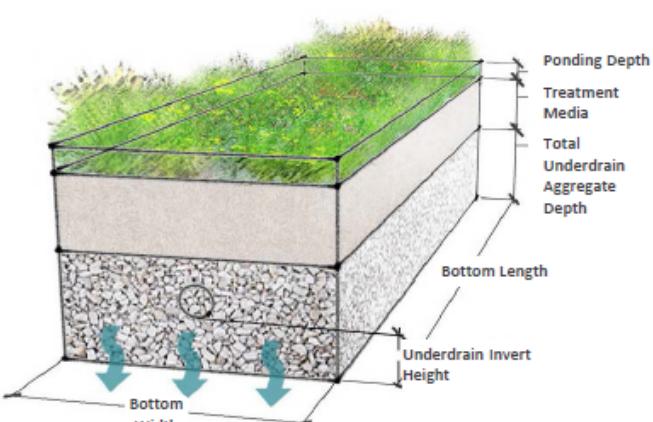
Action Fact Sheet Content and Interpretation Guidance

Nineteen Actions were developed in Phase 2 and an additional four Actions were developed in Phase 3. Action fact sheets were developed to compile Action descriptions and design details to support Program development and SUSTAIN modeling. The key design assumptions and technical basis for information included in the Action Fact Sheets for the Actions developed in Phase 2 and Phase 3 can be found in the Appendices B and C, respectively. The associated Action Fact Sheets can be found in Appendix G and include the following:

- Description and a representative photo of the Action
- Potential areas managed, including land uses, land cover types, and property types
- SUSTAIN model parameters for unit Action, including footprint area, drainage area, and design section
- Schematic for unit Action, illustrating section and dimensions
- Design assumptions, including basis for sizing
- Representation of hydrologic and treatment performance in the SUSTAIN model
- Action treatment performance parameters, including median percent removal and median effluent concentration
- Planning-level cost estimates for unit Action
- Programmatic feasibility and siting considerations

Figures 2 and 3 provide an annotated Action Fact Sheet to guide the user in interpreting the content.

Figure 2. Annotated Action Fact Sheet – Bioretention HPBSM Example (page 1 of 2).

BIORETENTION HPBSM		Phase 3																																																	
Water Quality Benefits Evaluation Action Fact Sheet																																																			
Action name																																																			
General description of the Action including major assumptions and benefits provided	ACTION DESCRIPTION  <p>Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.</p>	10/1/2024	Summary of where the Action can be applied, informing cost estimates and SUSTAIN model assumptions on implementation																																																
Photo depicting real-world application																																																			
Parameters used to inform the Action representation in SUSTAIN	UNIT ACTION SCHEMATIC 	DESIGN PARAMETERS <table border="1"> <thead> <tr> <th rowspan="2">Parameter</th> <th colspan="2">Soil Type</th> </tr> <tr> <th>Till</th> <th>Outwash</th> </tr> </thead> <tbody> <tr> <td>Unit Footprint Area</td> <td>85 SF</td> <td>85 SF</td> </tr> <tr> <td>Unit Drainage Area</td> <td>12,148 SF</td> <td>9,570 SF</td> </tr> <tr> <td>Ponding Depth</td> <td>6 in</td> <td>6 in</td> </tr> <tr> <td>Bottom Length</td> <td>16 ft</td> <td>16 ft</td> </tr> <tr> <td>Bottom Width</td> <td>5.33 ft</td> <td>5.33 ft</td> </tr> <tr> <td>Side Slope</td> <td>3H : 1V</td> <td>3H : 1V</td> </tr> <tr> <td>Treatment Media Depth</td> <td>18 in</td> <td>18 in</td> </tr> <tr> <td>Treatment Media Porosity</td> <td>30%</td> <td>30%</td> </tr> <tr> <td>Treatment Media Infiltration Rate</td> <td>6 in/hr</td> <td>6 in/hr</td> </tr> <tr> <td>Total Underdrain Aggregate Depth</td> <td>26 in</td> <td>N/A</td> </tr> <tr> <td>Underdrain Invert Height</td> <td>12 in</td> <td>N/A</td> </tr> <tr> <td>Underdrain Diameter</td> <td>8 in</td> <td>N/A</td> </tr> <tr> <td>Underdrain Aggregate Porosity</td> <td>40%</td> <td>N/A</td> </tr> <tr> <td>Native Soil Design Infiltration Rate</td> <td>0.3 in/hr</td> <td>2.5 in/hr</td> </tr> </tbody> </table> <p>N/A: Not Applicable</p> <p>Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.</p> <p>Visit kingcounty.gov/WQBE for more information.</p>	Parameter	Soil Type		Till	Outwash	Unit Footprint Area	85 SF	85 SF	Unit Drainage Area	12,148 SF	9,570 SF	Ponding Depth	6 in	6 in	Bottom Length	16 ft	16 ft	Bottom Width	5.33 ft	5.33 ft	Side Slope	3H : 1V	3H : 1V	Treatment Media Depth	18 in	18 in	Treatment Media Porosity	30%	30%	Treatment Media Infiltration Rate	6 in/hr	6 in/hr	Total Underdrain Aggregate Depth	26 in	N/A	Underdrain Invert Height	12 in	N/A	Underdrain Diameter	8 in	N/A	Underdrain Aggregate Porosity	40%	N/A	Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr	DESIGN ASSUMPTIONS <ul style="list-style-type: none"> Design is based on <i>2016 King County Surface Water Design Manual (KCSWDM)</i> Section C.2.6.1. Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment. The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included. For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6" cover, 8" underdrain pipe, and 12" bedding. For bioretention installed on outwash soils, no underdrain is included. 	Basis of design summary
Parameter	Soil Type																																																		
	Till	Outwash																																																	
Unit Footprint Area	85 SF	85 SF																																																	
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Schematic illustration to inform the Action representation in SUSTAIN																																																			

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Figure 3. Annotated Action Fact Sheet – Bioretention HPBSM Example (page 2 of 2).

BIORETENTION HPBSM
Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	25 th Percentile Effluent Concentration ^a
Total Copper	62.3%	7.1 µg/L
Dissolved Copper	57.6%	4.6 µg/L
Total Zinc	91.0%	5.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L ^b
Total Phosphorus	54.9%	0.024 mg/L
Total Nitrogen	51.3%	1.2 mg/L
Total Suspended Solids	78.0%	13.5 mg/L
Total PCBs	78.0% ^c	358 pg/L ^c
Total PBDEs	67.1% ^c	0.034 ng/L ^c
Total PAHs	95.1%	<0.01 µg/L ^b
Bis(2-ethylhexyl)phthalate	63.2% ^c	0.044 µg/L ^c
Fecal Coliform	61.5 %	31.5 CFU/100 mL

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash
b. Method detection limit
c. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

UNIT ACTION COSTS

Costs/Unit Action ^{a,b}	With Underdrain		No Underdrain	
	On Property without Acquisition	In Right of Way/ Highway	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$50,100	\$90,300	\$46,500	\$90,000
Total Direct Construction	\$35,400	\$63,900	\$32,800	\$63,700
Total Indirect Non-Construction	\$14,700	\$26,400	\$13,700	\$26,300
Operation and Maintenance	\$3,100/year	\$3,100/year	\$3,100/year	\$3,100/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the 2016 King County Surface Water Design Manual

Summary of SUSTAIN modeling processes

Median percent removal and median effluent concentrations for target pollutants analyzed in SUSTAIN

Total project, operation and maintenance, and property acquisition cost estimates for various model configurations

Considerations for program implementation and siting of individual Actions in SUSTAIN

Visit kingcounty.gov/WQBE for more information.

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Program Fact Sheet Content and Interpretation Guidance

Three Programs were developed under Phase 1 and subsequently refined in Phase 2 that focused on providing water quality improvements. Herrera (2022) provides the key assumptions and technical basis for these Programs.

- Green Stormwater Infrastructure (GSI) Incentive Program,
- Roadway Stormwater Treatment Program
- Regional Stormwater Treatment Program.

In Phase 3, four additional Programs were developed that focused on providing flow control:

- GSI Incentive Flow Control Program
- Roadway Retrofit Flow Control Program
- Regional Facility Flow Control Program
- Greening Flow Control Program

This technical memorandum focuses on the Programs developed in Phase 3. The key assumptions and technical basis for these Programs can be found in Appendix F. The associated Program Fact Sheets are provided in Appendix H. These Fact Sheets were developed to compile Program descriptions and implementation rules to support Program optimization using the SUSTAIN model. They include the following:

- Detailed description of the Program
- Actions developed in Phase 2 and Phase 3 that could be included in the Program
- Program implementation area, including a map showing eligible basins
- Program applicability by jurisdiction, drainage basin type, property type, land use and surface type
- A runoff routing schematic showing how flow is routed through Actions in the SUSTAIN model
- Program implementation constraints that are used to quantify the maximum area that could be treated by each Action
- Program cost information
- Approach for optimizing the Program using the SUSTAIN model
- Program linkages to causal models

Figures 4 through 7 provide an annotated Program Fact Sheet to guide the user in interpreting the content.

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Figure 4. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 1 of 4).

GSI INCENTIVE FLOW CONTROL PROGRAM
Water Quality Benefits Evaluation Program Fact Sheet

Phase 3
10/1/2024

Program name

Provides high-level description of Program

Program icon

Map shows King County basins eligible for Program. Map also shows excluded areas, if applicable (e.g., basin areas outside of County)

PROGRAM OVERVIEW

The GSI Incentive Flow Control Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide grants, rebates, or other financial incentives to eligible property owners for installing and maintaining GSI on their properties.

The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

The Program could include the GSI practices ("Actions") listed below. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

The following pages include key assumptions and an overview the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

ACTIONS INCLUDED IN PROGRAM

Shows Actions that could be included in Program. The most cost-effective combination of Actions would be identified using the SUSTAIN model. Also indicates if pretreatment is required. Refer to companion Action Fact Sheets and Appendix B and C for detailed descriptions of Actions. Icons shown here are included in upper right corner of Action Fact Sheets.

RAIN GARDEN BIORETENTION * CISTERN DEPAVING COMPOST AMENDMENT

DRYWELL ** DEEP UIC WELL *** PERMEABLE PAVEMENT BLUE ROOF

* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits
** Paired with upstream bioretention planter for pre-treatment
*** Paired with upstream high-rate filter for pre-treatment

PROGRAM IMPLEMENTATION AREA

PROGRAM APPLICABILITY

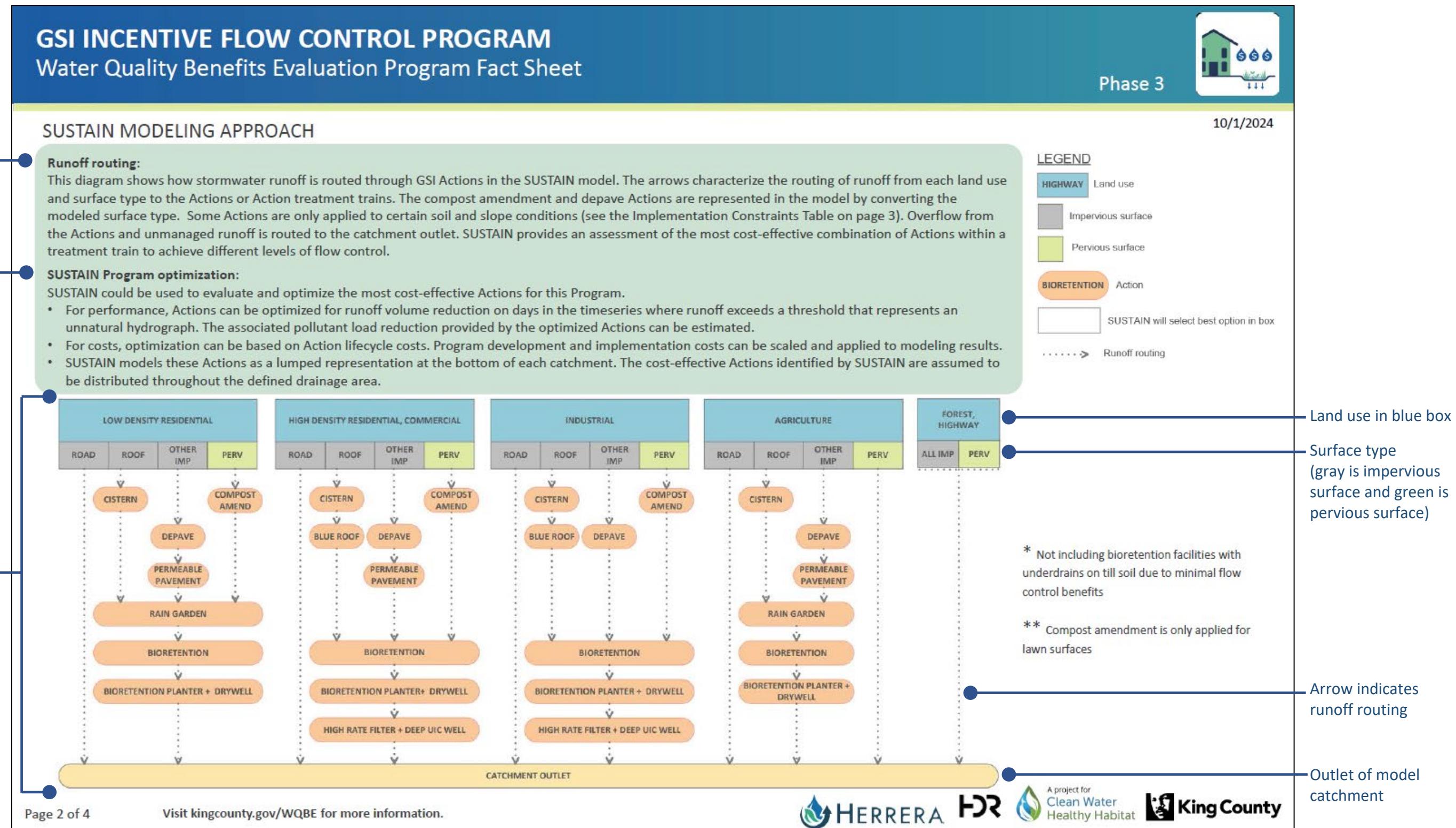
- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial land uses
- Private and public parcels

Page 1 of 4 Visit kingcounty.gov/WQBE for more information.

HERRERA **HDR** **A project for Clean Water Healthy Habitat** **King County**

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Figure 5. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 2 of 4).



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Figure 6. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 3 of 4).

GSI INCENTIVE FLOW CONTROL PROGRAM
Water Quality Benefits Evaluation Program Fact Sheet

Phase 3

10/1/2024

PROGRAM DESCRIPTION/ASSUMPTIONS

Program description:

- The GSI Flow Control Incentive Program would provide financial incentives in the form of rebates, grants, or other forms of funding to property owners to install GSI practices (Actions) to provide flow control for currently unmanaged stormwater runoff from roofs and other impervious surfaces, such as parking lots and driveways.
- The Program would be applicable to private parcels in residential, commercial, and industrial, agricultural areas with separated drainage systems. Eligible areas would include unincorporated King County and cities in the implementation area. GSI Actions would be implemented across the eligible areas based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies.
- Program elements would include:
 - Public outreach
 - Website with eligibility maps, design tools, and incentive calculator
 - Application processing and site/construction inspection
 - Contractor recruitment/trainings
 - Annual inspections and maintenance
- Modeling will determine full costs of design, construction, maintenance and replacement. A separate evaluation will determine rebates/grants for incentivizing participation. Costs of Program development and administration, would be borne by the County, or potentially shared with other partners.

Key assumptions:

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained).

Key risks and challenges:

- Relies, in part, on cooperation between King County and partners
- Relies on interested property owners
- Requires alignment with varied local codes
- Requires development of qualified contractor base
- Requires ongoing maintenance efforts and costs

Provides a detailed description of the Program including Program elements, key assumptions, and risks.

PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
= Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

GSI Action	Infeasible Areas ¹	Technical Factor ²								Participation Factor ³	Composite Factor (Technical x Participation) ⁴
		Low Density Residential			High Density Residential, Commercial, and Industrial		Agricultural				
		Roof	Other Imp	Perv	Roof	Other Imp	Perv	Roof	Other Imp		
Rain garden on till	Outwash soil, slopes > 10%	30%	30%	30%				30%	30%	20%	6.0%
Rain garden on outwash	Till soil, slopes > 10%	50%	50%	50%				50%	50%	20%	10.0%
Bioretention on outwash	Till soil, slopes > 10%	50%	50%	50%	40%	40%	40%	50%	50%	20%	8.0% - 10.0%
Cisterns	--	50%			50%			50%		25%	12.5%
Bioretention planter to drywell	Till soil	30%	30%	30%	30%	30%	30%	30%	30%	15%	4.5%
High rate filter to deep UIC well	Outwash soil, gw protection areas				20%	20%	20%			5%	1.0%
Depaving	--		20%			10%			20%	5%	0.5% - 1.0%
Permeable pavement	Slopes > 3%		30%			30% ⁵			10%	2%	0.2% - 0.6%
Blue roof					20%					2%	0.4%
Compost amendment				80%			80%			30%	24%

LEGEND

- Action not applied
- High Implementation ≥30%
- Medium Implementation 15 to <30%
- Low Implementation ≤15%

Page 3 of 4 Visit kingcounty.gov/WQBE for more information.

Only a portion of the drainage area routed to Actions in the schematic on page 2 can be feasibly treated due to technical and social constraints. To address this, the total drainage area was reduced to eliminate "infeasible areas" and apply "technical factor" and "participation factor" from this table. Technical and participation factors are based on professional judgement.

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Figure 7. Program Fact Sheet – GSI Incentive Flow Control Program Example (page 4 of 4).

GSI INCENTIVE FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

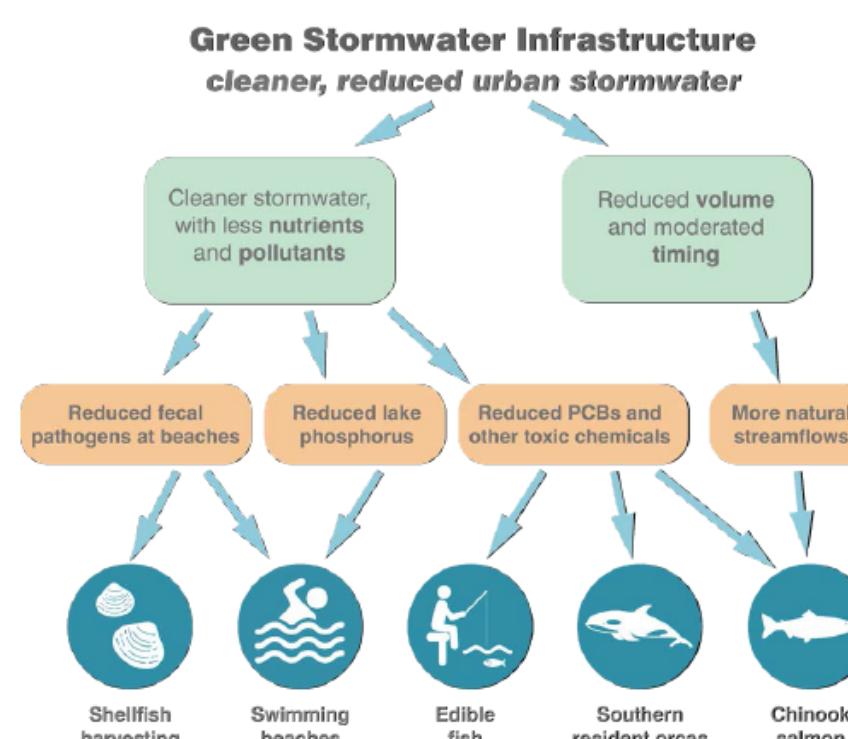
Phase 3



10/1/2024

LINKAGES TO CAUSAL MODELS

The GSI Incentive Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



Provides description of Program cost elements and how they will be used in SUSTAIN optimizations.

Provides lifecycle costs for Actions included in the Program. See Appendix E for basis of cost estimates.

Provides a description and graphic showing how the Program will link to the causal models. These models will be used to evaluate the benefit of the Program for human health and ecological endpoints.

PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on private property (see table below).
- Upfront Program development costs (develop website, standards, requirements)
- Average annual Program administration costs (outreach, application processing, construction inspections, maintenance education, annual inspections)

Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

Unit Action	Lifecycle Cost/Unit Action ^{1,2,3}
Rain garden	\$56,700
Bioretention without underdrain	\$117,900
Cisterns	\$46,100
Bioretention planter to drywell	\$76,000
High-rate filter to deep UIC well	\$250,000
Depaving ⁴	\$16,800
Permeable pavement ⁵	\$68,400
Blue roof	\$170,900
Compost amendment	\$13,400

1. All costs are per unit of Action installed on private property without property acquisition.
 2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
 3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.
 4. Costs based on driveway depaving with wheel strips
 5. Costs based on permeable paver driveway with sand layer.

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Next Steps

The information in the Program and Action Fact sheets can be used to develop SUSTAIN model inputs to accomplish the following:

- Optimize the Programs using the SUSTAIN model to identify cost-effective combinations of Actions for improving flow control and water quality.
- Identify a set of optimum Packages from the resultant SUSTAIN cost effectiveness curves.

References

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May.

Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December.

Appendix A

Terminology

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TECHNICAL MEMORANDUM

Date: October 4, 2024

To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

From: Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc.

Subject: WQBE Terminology (Appendix A to 439-TM1)

Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes regarding selection of cost-effective water quality improvement investments, reducing pollutant load, and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies, taking into account major pollutant pathways and sources
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality for reduction of pollutant loads or stormwater volumes
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches)

The WQBE Toolkit provides an important set of information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

The WQBE toolkit is being developed in several phases over a period extending from 2020 through 2024. Part of this effort has been developing "Actions" composed of structural practices that improve water quality. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. During Phase 1 (2020), a preliminary set

of Actions and Programs focused on improving water quality were developed to be modeled with the WQBE toolkit. In Phase 2 (2021–2022), the water quality Actions and Programs were further refined to improve their representation in SUSTAIN. In Phase 3 (2023–2024), the project team developed additional Actions and Program that could provide flow control in the basins discharging to the Puget Sound.

This technical memorandum is provided as Appendix A to 439-TM1. It specifically documents key terminology that is used in the WQBE Toolkit.

Program Terminology

Action: Individual structural and non-structural best management practices (BMPs) or activities to improve water quality (e.g., rain gardens, wetponds, street sweeping).

Assessment point: Location where a management objective is evaluated during optimization.

Basin: Grouping of catchments and subbasins that represent the primary discharge points and spatial scale for the Tier 2 System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) model optimization.

Basis of estimate (BOE): A document that details the premise, or basis, from which critical aspects of a project cost estimate were developed, including cost and labor estimates, material availability, any assumptions or deviations, any studies or analysis used as a reference, and any other details that impacted the cost estimates.

Catchment: Delineation of drainage areas for the LSPC baseline pollutant loading model.

Jurished: The result of intersecting the catchments and jurisdictional boundaries; serves as the scale of the individual Tier 1 SUSTAIN model cost-optimization.

Package: A point on a SUSTAIN cost-effectiveness curve that identifies a specific level of implementation of a Program (e.g., 200 unit rain gardens and 50 unit permeable pavement installations, in specified subbasins, representing a cost-effective implementation of a Green Stormwater Infrastructure [GSI] incentive program in the Lake Washington basin).

Programs will be evaluated with the SUSTAIN models by generating a Package of representative Actions optimized for stormwater volume or pollutant load reductions at an assessment point. Previously defined Projects could also be incorporated into the SUSTAIN models and included in optimization evaluations as desired.

Program: A group of unit Actions that could be implemented to improve water quality over a broad geographic area, such as a GSI incentive program within the Lake Washington basin or a roadway stormwater treatment program on County-owned roads within the Green/Duwamish basin.

Project: An individual Action or related group of Actions at a specific geographic location for which detailed, spatially-explicit characteristics are defined (e.g., a rain garden installation on a specified property or within a small defined area).

Subbasin: Grouping of catchments for which the SUSTAIN model output will be reported to inform Causal model inputs.

Unit Action: A representative vertical profile, areal footprint, and associated design-drainage area for an Action being modeled in SUSTAIN. Cost-benefit optimization is used to determine the collective sizes and/or number of unit Actions required to achieve a certain pollutant load reduction target. Each unit Action has an associated cost that is scalable during optimization to estimate total implementation costs.

Unit: Representative footprint of an Action defined so as to be compatible with the SUSTAIN model.

Appendix B

Phase 2 Action Design Assumptions and Modeling Parameters

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PHASE 2

WATER QUALITY ACTION DEVELOPMENT (APPENDIX B TO 431-TM1)

WATER QUALITY BENEFITS EVALUATION

Prepared For:

Herrera Environmental Consultants

and

King County Wastewater Treatment Division

January 14, 2022

Prepared By:

ROBIN KIRSCHBAUM, INC. water { planning
engineering

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KING COUNTY WASTEWATER TREATMENT DIVISION

WATER QUALITY BENEFITS EVALUATION

Date: January 14, 2022
To: John Lenth / Herrera
Cc: Carly Greyell / King County Water and Land Resources Division
From: Robin Kirschbaum, PE, and Steven Demmer / Robin Kirschbaum, Inc.
Subject: Phase 2 Water Quality Action Development (TM #431-TM1)

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- Attachment B. Decision Log
- Attachment C. Contech Filterra ® Bioscape External Bypass System Specifications
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- Attachment F. MGSFlood Modeling Output Reports
- Attachment G. Summary of Transformed Configurations and Design Flow Rates for SUSTAIN Input
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GLOSSARY

Action: Individual structural and non-structural best management practices (BMPs) or activities to improve water quality (e.g. rain gardens, wetponds, street sweeping).

Basic Water Quality Treatment: Water quality treatment standard that provides removal of 80% of the total suspended solids for flows or volumes up to and including the Water Quality design flow or volume. Also referred to as Basic Treatment (when referencing the *2019 Stormwater Management Manual for Western Washington*).

Best Management Practice: The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to receiving waters.

Deep Underground Injection Control (UIC) Well: A UIC well constructed by drilling and casing a 12-inch-diameter, up to 100-foot-deep borehole intended to infiltrate pre-treated stormwater runoff into deep soil horizons.

Design Standard: The design standard establishes the Basis of Design and associated design parameters for a given Action. For example, Bioretention is designed based on the Enhanced Water Quality Treatment Standard (2016 King County Surface Water Design Manual, Appendix C, Section C.2.6), with design parameters such as maximum side slope, maximum ponding depth, and minimum bioretention soil mix depth defined accordingly.

Enhanced Basic Water Quality Treatment: Water quality treatment standard that provides greater than 30% dissolved copper removal and greater than 60% dissolved zinc removal, in addition to Basic Water Quality Treatment for flows up to and including the Water Quality design flow or volume. Also referred to as Enhanced Treatment (when referencing the *2019 Stormwater Management Manual for Western Washington*).

Enhanced Maintenance: Actions intended to minimize pollutant loading to the stormwater conveyance system and receiving waters while extending the useful life of stormwater management assets.

Flow Control: Mitigation for the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control Actions are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.

Hard Surface: An impervious surface, a permeable pavement, or a vegetated roof.

Level 2 Flow Control Standard: Flow control standard that provides matching developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. Also provides matching developed peak discharge rates to predeveloped peak discharge rates for the 2- and 10-year return periods.

Long-term Continuous Modeling: Hydrologic modeling that includes algorithms that maintain a continuous water balance for a catchment to account for soil moisture and hydraulic conditions antecedent to each storm event.

Modified Level 1 Flow Control Standard: A modified version of King County's Level 1 Flow Control standard that provides matching developed peak discharge rates to the pre-developed (forested) peak discharge rates for the 2- and the 10-year recurrence intervals. By contrast to the pre-developed forest condition, the unmodified Level 1 Flow Control standard is designed to control flood flows at their current levels and to maintain peak flows within the capacity of the conveyance system for most storm events.

Off-line Actions: Water quality Actions to which stormwater runoff is restricted to some maximum flow rate or volume by a flow-splitter.

Peak Control Standard: Flow control standard from the *2017 Seattle Stormwater Manual* (Section 5.3.4) that provides:

- The post-development peak flow with 4% annual probability (25-year recurrence flow) shall not exceed 0.4 cubic feet per second per acre
- The peak flow with a 50% annual probability (2-year recurrence flow) shall not exceed 0.15 cubic feet per second per acre).

Performance Standard: The performance standard establishes the numerical target for water quality treatment or flow control that the Action is sized to achieve. For example, Bioretention is sized for a performance standard of filtering at least 91% of the average annual runoff based on long-term continuous hydrologic modeling.

Pollution-generating Hard Surface: Those hard surfaces considered to be a significant source of pollutants in stormwater runoff.

Pre-treatment: An Action that removes at least 50% solids, typically installed upstream of an Underground Injection Control (UIC) well or other Actions that do not provide basic water quality treatment.

Presettling: Catch basins or vaults located upstream of an Action intended to collect sediment, reduce the frequency of maintenance activities, and extend the useful life of the downstream Action. The *2016 King County Surface Water Design Manual* (Section 5.2.1 and Section 6.5.1) requires presettling upstream of all filtration and infiltration Actions.

Program: A group of Actions that could be implemented to improve water quality over a broad geographic area, such as a Green Stormwater Infrastructure incentive program within the Lake Washington drainage area or a roadway stormwater treatment program on County-owned roads within the Ship Canal drainage area.

Restoration: An Action that is intended to restore an area's land surface condition to its predeveloped condition.

Sizing Factor: Factors provided in the 2017 Seattle Stormwater Manual that represent the ratio of contributing hard surface area to the Action bottom footprint area, used in this project for rapid sizing of Actions.

Source Control: An Action or operation intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants.

System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN): A decision support system that assists stormwater management professions with developing and implementing plans for flow and pollution control measures to protect source waters and meet water quality goals.

Underground Injection Control (UIC) Well: A structure built to discharge fluids from the ground surface into the subsurface; a bored, drilled, or driven shaft whose depth is greater than the largest surface dimension; or a dug hole whose depth is greater than the largest surface dimension; or an improved sinkhole, which is a natural crevice that has been modified; or a subsurface fluid distribution system that includes an assemblage of perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground.

Unit Action: A single Action designed for the smallest unit contributing drainage areas included in the Program evaluation. Unit Actions are aggregated up (e.g., multiplied) by the ratio of actual contributing drainage area to unit drainage area based on Program definitions and SUSTAIN modeling assumptions. Different unit Actions can be combined to form water quality treatment trains that provide multiple benefits.

Water Quality: A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water Quality Design Flow: The flow rate at or below which 91% of the total runoff volume, as estimated by an approved continuous runoff model, will be treated.

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1 INTRODUCTION

1.1 Background

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes regarding selection of cost-effective water quality improvement investments, reducing pollutant load and improving ecological and human health outcomes. This toolkit will be applied to a suite of potential projects and programs that could improve water quality and could be implemented in the areas draining to the WTD service area receiving waters.

The results of the evaluation of the projects and programs will provide information about the multiple water quality benefits of potential WTD investments within the context of potential regional programs that could be implemented at a County-wide scale. This information will provide technical support for King County discussions with stakeholders, regulators and decision makers related to water quality investments and policies. The toolkit will also be adaptable and designed to respond to the values supported by the region and WTD ratepayers (including those identified by the Regional Engagement effort of the Clean Water Plan) and future strategic planning needs at the Division and Department level (including Clean Water Healthy Habitat).

1.2 Project Phasing

The WQBE toolkit is being developed in two phases over a period extending from 2020 through 2022. During Phase 1 (2020), a preliminary set of models was developed. In Phase 2 (2021-2022), these models are being further calibrated and refined to support County planning efforts (e.g., Clean Water Plan and CSO Long-Term Control Plan [LTCP]). Implementation of preliminary analyses using the WQBE toolkit will be performed during its development phases; once finalized, the WQBE toolkit will be used to support a wide range of future planning efforts by the County and potentially other municipalities within the County's jurisdictional borders.

To support preliminary model development in Phase 1, the Project team developed a suite of "Actions" comprised of structural practices that improve water quality. These Actions provide the unit building blocks (or "unit Actions") that were aggregated and combined to develop water quality "Programs", or groups of Actions that can be implemented to improve water quality over a broad geographic area. Fact Sheets were developed to document the defining characteristics of each Action and Program, including costs, performance, and modeling inputs. Subsequent work in Phase 1 included preliminary modeling of these Programs to identify the most cost-effective combinations of Actions or "Packages" for reducing pollutant loads or stormwater volumes as a proof of concept.

The Project team documented the process used to develop Phase 1 Actions and Programs for the WQBE toolkit in a technical memorandum (RKI 2020). The Phase 1 memorandum documented the preliminary assumptions and methods used to develop the water quality Actions, including design configuration, Action sizing, cost estimating, and water quality treatment performance.

A half-day workshop (Workshop 430-W1 Phase 2 Action Unit Cost Development) was conducted on January 29, 2021 with County staff to review the methods, assumptions, and results of Phase 1 evaluations. Potential refinements were identified and discussed regarding the cost estimating approach, Action design, and cost-benefit analysis in (System for Urban Stormwater Treatment and Analysis Integration) SUSTAIN. Shortly following the workshop, the project team agreed to the following key refinements to Action design to be implemented in Phase 2:

- Whereas Action sizing was based primarily on simplified sizing factors in Phase 1, Phase 2 would refine the sizing by use of explicit modeling in a King County-approved long-term continuous hydrologic model, such as MGSFlood. MGSFlood is a proprietary interface of Hydrological Simulation Program – FORTRAN (HSPF) used in the western Washington area for designing and sizing stormwater Best Management Practices (BMPs). This explicit modeling refinement was based on results of preliminary pre-Phase 2 modeling for bioretention, which found that the simplified sizing factors were overly conservative for purposes of this evaluation.
- Action design parameters (e.g., side slopes, ponding depths, freeboard depths, native soil infiltration rates, etc.) would generally remain unchanged from Phase 1, since the design parameters had been thoroughly vetted and agreed upon in Phase 1.
- In order to minimize re-work needed for Action cost estimating, Action bottom footprint areas would remain unchanged from Phase 1 wherever possible. Thus, while holding the bottom footprint areas constant (as well as design parameters and cost estimates), the contributing drainage areas were adjusted in MGSFlood until the Action was demonstrated to meet the applicable performance standard (e.g., water quality treatment, level 1 flow control, level 2 flow control) in the model.

In addition to the above refinements, Phase 2 also entailed development of regression equations to relate Mean Annual Precipitation (MAP) to contributing drainage area for each Action. These relationships, developed through modeling in MGSFlood, were needed to enable SUSTAIN modeling to account for variable Action performance as a result of the highly variable MAP across King County.

1.3 Purpose of this Memorandum

This memorandum documents the revised assumptions for Action cost-benefit evaluation that were developed for Phase 2 based on discussions during and after the January 29, 2021 workshop. Specifically, this memorandum documents the following:

- Basis of Design in accordance with the 2016 King County Surface Water Design Manual (KCSWDM) where applicable;
- Action sizing methodology and results;
- Scaling of contributing drainage area based on Mean Annual Precipitation (MAP); and
- Refined integration of unit Action sizing modeling with County-wide modeling in System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN).

2 ACTION DEFINITIONS

Table 1 includes a total of 24 Actions, of which 19 of the 24 Actions were defined and evaluated in Phase 1. Of these, 15 Actions were refined in Phase 2, where explicit modeling in MGSFlood was used to revise the drainage area that could be managed to the applicable design standard (Section 1.2). The remaining four Phase 1 Actions, including Media Filter Drain, Permeable Pavement, Depaving, and Cistern, were deemed satisfactory and not refined in this phase.

In addition to the 19 Actions developed and refined in Phases 1 and 2, another five Actions, including Sand Filter, Blue Roof, Creosote Wood Piling Removal, Enhanced Street Sweeping, and Urban Tree Planting, were identified for potential development in future project phases. These Actions have not yet been designed or evaluated.

Table 1 – Summary of Action Development and Refinement by Phase.

Action	Phase 1	Phase 2 Refinement	Notes
Rain Garden	X	X	
Bioretention	X	X	
Bioretention Planter	X	X	This Action was sized as both a stand-alone Action and as pretreatment (See Section 4.5 for Pre-treatment Sizing)
Bioswale	X	X	
Media Filter Drain (MFD)	X		No change from Phase 1
Drywell	X	X	Phase 2 includes bioretention planter as pretreatment
Deep Underground Injection Control (UIC) Well	X	X	Phase 2 includes bioretention planter and high rate underground filter system as pretreatment
Permeable Pavement	X		No change from Phase 1
Depaving (Removal of Impervious Surfaces)	X		No change from Phase 1
Stormwater Treatment Wetland	X	X	
Detention Vault	X	X	
Detention Pond	X	X	
Infiltration Pond	X	X	Phase 2 includes high rate underground filter system as pretreatment
Infiltration Vault	X	X	Phase 2 includes high rate underground filter system as pretreatment
Cistern	X		No change from Phase 1
Wetpond	X	X	
Wetvault	X	X	
High Rate Underground Filter System	X	X	This Action was sized as both a stand-alone Action and as pretreatment (See Section 4.5 for Pre-treatment Sizing)
Regional Vegetated Media Filtration Facility	X	X	
Sand Filter	N/A		These Actions were identified early in Phase 1 for possible future analysis, but have not yet been advanced to design.
Blue Roof			
Creosote Wood Piling Removal			
Enhanced Street Sweeping			
Urban Tree Planting			

Abbreviations:

N/A Not Applicable

2.1 Major Categories

The Actions were organized into the following six (6) major categories:

- Green Stormwater Infrastructure (GSI)
- Stormwater Retention/Detention/Infiltration
- Gray Stormwater Infrastructure
- Source Control
- Enhanced Maintenance
- Restoration

The feasibility and cost effectiveness of different categories of Actions are often dependent on land use type. For example, low-density residential areas are generally more conducive to GSI than high-density urban areas, while source control and gray stormwater infrastructure are often a good fit for industrial areas. Large-scale retention/detention/infiltration facilities are most often implemented in large open public spaces or in conjunction with large public redevelopment projects. Program development (see Appendix E to 431-TM1 [Herrera 2021a]) will consider the distinct characteristics of each Action in regard to targeting specific land use, land cover and property type for implementation, sequencing and funding, and creating partnerships with landowners and jurisdictional agencies.

Blue roofs, sand filters, source control (Creosote Wood Piling Removal), enhanced maintenance (Enhanced Street Sweeping), and restoration (Urban Tree Planting) Actions were identified in Phase 1 for possible future analysis, but have not yet been advanced to design (Table 1). The remainder of this memorandum focuses on GSI, stormwater retention/detention/infiltration, and gray stormwater infrastructure Actions, as summarized in Table 2.

2.2 Major Design Assumptions

Major assumptions related to design, siting, and cost estimating were developed based on local design manuals, design standards, manufacturer information, and recently constructed local project examples. In Phase 1, the major assumptions were collaboratively refined and agreed upon during two workshops with King County staff from relevant Department of Natural Resources and Parks (DNRP) programs conducted on May 6, 2020 and May 13, 2020. Design decisions were refined throughout Phase 2 as documented in the Decision Log in Attachment B.

In order to minimize re-work needed for Action cost estimating (Appendix D to 431-TM1 [HDR 2021]), the design assumptions were generally not modified in Phase 2. Instead, the contributing drainage areas were adjusted using explicit modeling in MGSFlood to meet the applicable design standard given the Phase 1 Action bottom footprint areas. This enabled the cost-performance relationship to be refined while using the Phase 1 cost estimates with minimal updates. See Section 4 for further detail on Phase 2 sizing methods and assumptions.

The design assumptions vary significantly among the many Actions; but the following major design assumptions were applied uniformly where applicable:

- All Actions were generally defined as off-line facilities, assuming a flow splitter or detention device will be installed upstream and that only flows up to the off-line water quality design flow rate will be routed to the Action.
- Long-term design native soil infiltration rates were assumed to be (COS 2017):
 - 0.3 inches per hour for till soils
 - 2.5 inches per hour for outwash soils
- Underdrains are included for some infiltration-based Actions (Bioretention and MFD) installed in till soils and some non-infiltration-based Actions (Bioretention Planter, High Rate Underground Filter System and Regional Vegetated Media Filtration Facility), sized as follows:
 - 8-inch-diameter, with the exception of High Rate Underground Filter System (4-inch-diameter) and Regional Vegetated Media Filtration Facility (12-inch-diameter)
 - Elevated underdrain (8-inch-diameter) for Bioretention on till soils provided to promote infiltration into underlying soils (see the Bioretention Fact Sheet in Attachment A)
- Underdrains are not included for Rain Gardens, Drywells, UIC Wells, Permeable Pavement, Infiltration Pond, or Infiltration Vault.
- Infiltration-based Actions installed in outwash soils do not include underdrains.

See Table 2 below for a more comprehensive list of Action definitions and major assumptions. Table 2 also provides additional information used for SUSTAIN modeling, including land uses managed, surface types managed, and property type. Note that the table is not all inclusive and there may be additional applications of the BMP types beyond what is listed in this table. This information is also summarized in the Fact Sheets (Attachment A).

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Table 2 – Action Definitions, Benefits, and Major Assumptions.

Action	Definition	Benefits Provided	Land Uses Managed	Surface Types Managed	Property Type	Treatment Media
Green Stormwater Infrastructure (GSI)						
Rain Garden	A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile.	Volume and Peak Flow Reduction, Water Quality Treatment	• Residential • Commercial	• Roofs • Lawns • Driveways • Sidewalks • Parking Lots	• Private Parcel • Public Parcel	• 3" compost tilled in to 8" depth
Bioretention Planter	Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.	Peak Flow Reduction, Water Quality Treatment	• Residential • Commercial • Industrial	• Roofs • Driveways • Parking Lots • Sidewalks • Plazas • Local Roads • Arterial Roads	• Private Parcel • Public Parcel • Public Right-of-Way	• 70% sand • 20% coir • 10% high carbon wood ash (biochar) • No polishing layer required
Bioretention	Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.	Volume and Peak Flow Reduction, Water Quality Treatment	• Residential • Commercial • Industrial • Highway • Agricultural	• Roofs • Lawn • Driveways • Parking Lots • Sidewalks • Plazas • Local Roads • Arterial Roads • Highways	• Private Parcel • Public Parcel • Public Right-of-Way	• 70% sand • 20% coir • 10% high carbon wood ash (biochar) • No polishing layer required
Bioswale	An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. These are designed to “filter” water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism.	Peak Flow Reduction, Water Quality Treatment	• Residential • Commercial • Industrial • Highway • Agricultural	• Parking Lots • Arterial Roads • Local Roads • Highways	• Private Parcel • Public Parcel • Public Right-of-Way	N/A

Action	Definition	Benefits Provided	Land Uses Managed	Surface Types Managed	Property Type	Treatment Media
Media Filter Drain (MFD)	A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system.	Volume and Peak Flow Reduction, Water Quality Treatment	• Highway • Agricultural	• Arterial Roads • Local Roads • Highways	• Public Right-of-Way	• Mix of crushed rock, dolomite, gypsum, and perlite (see Table V-6.4, Volume V, Chapter 6 of the Ecology Manual)
Drywell	A gravel filled hole that conveys stormwater runoff into the soil matrix.	Volume and Peak Flow Reduction	• Residential • Commercial • Industrial • Agricultural	• Roofs • Sidewalks • Driveways • Parking Lots • Lawns	• Private Parcel • Public Parcel	N/A
Deep UIC Well	A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action.	Volume and Peak Flow Reduction	• Residential • Commercial	• Roofs • Sidewalks • Lawns • Local Roads • Arterial Roads	• Private Parcel • Public Parcel • Public Right-of-Way	N/A
Permeable Pavement	Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides water quality treatment when sand treatment layer is provided.	Volume and Peak Flow Reduction, Water Quality Treatment	• Residential • Commercial	• Low Volume Residential Driveways • Sidewalks • Plazas • Trails • Pedestrian and Bike Paths • Parking Lots	• Private Parcel • Public Parcel	• Sand (Driveways) • No Treatment (All other surface types)
Depaving (Removal of Impervious Surfaces)	Depaving, or removal of impervious surfaces down to bare soil. The area is amended with soil and planted with low lying ground cover. To allow continued site use, the area is retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit".	Volume and Peak Flow Reduction	• Residential • Commercial • Industrial	• Driveways • Sidewalks • Parking Lots	• Private Parcel • Public Parcel	• 4" of well-decomposed compost tilled into broken up soil as deeply as possible ($\leq 18"$)

Action	Definition	Benefits Provided	Land Uses Managed	Surface Types Managed	Property Type	Treatment Media
Stormwater Treatment Wetland	Similar to a wetpond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal.	Peak Flow Reduction, Water Quality Treatment	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	N/A
Stormwater Retention/Detention/Infiltration						
Detention Vault	A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate.	Peak Flow Reduction	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Plazas Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	N/A
Detention Pond	A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events.	Volume and Peak Flow Reduction	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	N/A

Action	Definition	Benefits Provided	Land Uses Managed	Surface Types Managed	Property Type	Treatment Media
Infiltration Pond	A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration.	Volume and Peak Flow Reduction	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	N/A
Infiltration Vault	An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom.	Peak Flow Reduction	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Plazas Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	N/A
Cistern	A tank designed to provide temporary storage and slow release of rooftop stormwater runoff.	Peak Flow Reduction	<ul style="list-style-type: none"> Residential Commercial Industrial 	<ul style="list-style-type: none"> Roofs 	<ul style="list-style-type: none"> Private Parcel Public Parcel 	N/A
Gray Stormwater Treatment						
Wetpond	A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants.	Peak Flow Reduction, Water Quality Treatment	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	N/A

Action	Definition	Benefits Provided	Land Uses Managed	Surface Types Managed	Property Type	Treatment Media
Wetvault	An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.	Peak Flow Reduction, Water Quality Treatment	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Plazas Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	N/A
High Rate Underground Filter System	An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary.	Water Quality Treatment	<ul style="list-style-type: none"> Commercial Industrial Highway 	<ul style="list-style-type: none"> Roofs Sidewalks Driveways Parking Lots Plazas Local Roads Arterial Roads 	<ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	Filterra ® (Proprietary) Media
Regional Vegetated Media Filtration Facility	A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.	Water Quality Treatment	<ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural Forest 	<ul style="list-style-type: none"> Roofs Lawns Sidewalks Driveways Parking Lots Plazas Local Roads Arterial Roads Highways 	<ul style="list-style-type: none"> Private Parcel Public Parcel 	Filterra ® (Proprietary) Media

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3 BASIS OF DESIGN

3.1 Design Manuals and References

3.1.1 Applicable Stormwater Design Manuals

For non-proprietary and standard Actions, designs were generally based on the 2016 *King County Surface Water Design Manual* (KCSWDM; DNR 2016) when that manual provided sufficient information to formulate the basis of design consistent with the assumptions for this project. The 2017 Seattle Stormwater Manual (SPU 2017) and the 2019 *Washington State Department of Ecology (Ecology) Stormwater Management Manual for Western Washington* (SWMMWW; Ecology 2019) were used for supplemental guidance when needed to support the basis of design, as summarized in Table 3.

3.1.2 Other Design Guidance and References

For proprietary or non-standard Action designs, the following additional references from manufacturers and recently constructed projects in the region were used to supplement the basis of design as follows:

- **High Rate Underground Filter System Installation:** Design was based on a standard 4'X4' Contech Filterra® Bioscape External Bypass system (see Attachment B). These Actions were designed to meet requirements provided in Ecology's General Use Level Designation (GULD) for Enhanced Treatment (see Attachment C). This system was used as the basis of design for this Action because of the relatively high approved infiltration rate for Enhanced Treatment (175 inches per hour), readily available design and cost information, and track record of successful installation on numerous local projects.
- **Regional Vegetated Media Filtration Facility Installation:** Design was based on the *Kitsap County Manchester Stormwater Retrofit Drainage Report* (Manchester; Parametrix 2014), which provides enhanced water quality treatment for approximately 73 acres of contributing drainage area. See Section 4.4 for discussion of how the basis of design for Manchester was applied to this project.
- **Deep Underground Injection Control (UIC) Wells:** Design was based on King County's *Barton Basin Combined Sewer Overflow Project with Green Stormwater Infrastructure* (Barton; AESI 2013). Barton provides enhanced water quality treatment for approximately 200 acres of contributing drainage area, with a conservatively rounded average design discharge flow rate from the UICs into native soils of approximately 50 gallons per minute (0.111 cubic feet per second).

See Table 3 for a summary of the Basis of Design for each Action.

3.2 Design Standards

Phase 2 Actions were designed to meet Basic Water Quality Treatment, Enhanced Basic Water Quality Treatment, Modified Level 1 Flow Control, Level 2 Flow Control, or Peak Control Standards, as discussed further in this section and summarized in Table 3. Infiltration-based Actions that do not provide Basic Water Quality Treatment are preceded by pre-treatment facilities designed to provide at least 50% removal of solids (KCSWDM Section 6.5.1). For further information on pairing of pre-treatment facilities with Actions, see Section 4.5.

3.2.1 Basic Water Quality Treatment

The goal of Basic Water Quality Treatment is 80% removal of Total Suspended Solids (TSS) for flows or volumes up to and including the off-line water quality design flow rate or volume. As shown in Table 3, the following WQBE Actions are designated in the KCSWDM as Basic Water Quality Treatment Facilities (Section 6.1.1) and were designed in accordance with the KCSWDM:

- Bioswale (KCSWDM Section 6.3.1, Basic Bioswales)
- Wetpond (KCSWDM Section 6.4.1, Wetponds)
- Wetvault (KCSWDM Section 6.4.2, Wetvaults)
- Stormwater Treatment Wetland (KCSWDM Section 6.4.3, Stormwater Wetland)

While Permeable Pavement is not included in the KCSWDM Basic Water Quality Treatment Menu, Ecology recognizes Permeable Pavement as a basic treatment BMP if the design includes a 6" layer of sand that meets the size gradation (by weight) given in [Table V-6.1: Sand Medium Specification](#) of the SWMMWW.

This project proposes to use standard Permeable Pavements for low volume residential driveways, sidewalks, plazas, trails, and pedestrian and bike paths. For applications in pollution-generating areas (i.e. low volume residential driveways), the proposed design for Permeable Pavement includes a 6" layer of sand as required for water quality treatment (see Table 2). Although the Fact Sheets in Appendix A provide information for configurations with and without the sand layer, only the version with the sand layer was incorporated in the programs developed and evaluated by the project team (Herrera 2021a). Permeable pavement without a sand layer may be evaluated for flow control benefits in future phases of study (see Section 8: Summary and Recommended Next Steps).

Rain Gardens are not included in the KCSWDM Basic Water Quality Treatment Menu; however, for the purposes of this project, Rain Gardens are sized per *2017 Seattle Stormwater Manual* to meet Basic Water Quality Treatment (Volume 3, Table 5.19). See Section 4 for more information on sizing methodology.

3.2.2 Enhanced Basic Water Quality Treatment

The Enhanced Basic Water Quality menu (KCSWDM Section 6.1.2) is designed to achieve greater than 30% dissolved copper removal and greater than 60% dissolved zinc removal, in addition to Basic treatment (80% TSS removal) for flows up to and including the water quality design flow or volume (defined in Section 6.2.1 of the KCSWDM). The goal assumes that dissolved copper concentrations for untreated runoff are between 5 and 20 micrograms per liter ($\mu\text{g/L}$), and that dissolved zinc concentrations for untreated runoff are between 20 and 300 micrograms per liter ($\mu\text{g/L}$).

The High Rate Underground Filter System and Regional Vegetated Media Filtration Facility were designed to provide enhanced basic water quality treatment in accordance with the KCSWDM Section 6.7 (Proprietary Facility Designs).

The KCSWDM does not include Bioretention, Bioretention Planters, nor MFDs in the basic or enhanced basic water quality treatment menus. However, the SWMMWW (Figure III-1.1: Runoff Treatment BMP Selection Flow Chart) lists these Actions as enhanced water quality treatment facilities, and they were regarded as such for the purposes of this project.

For Bioretention and Bioretention planters, a specialized low phosphorus high-performance bioretention soil media (HPBSM) with 70% sand, 20% coir and 10% high carbon wood ash (biochar) is included for improved water quality treatment performance (Herrera 2020). Modified Level 1 Flow Control

The Level 1 Flow Control Standard is as follows (KCSWDM, Section 1.2.3.1):

Match the developed peak discharge rates to existing site conditions peak discharge rates for 2- and 10-year return periods.

The standard was modified for this project to match developed peak discharge rates to the pre-developed forested site condition, rather than to the existing site condition. See the Decision Log in Attachment B for additional information.

This Modified Level 1 Flow Control Standard was evaluated for Cisterns and Drywells but was ultimately only used for Drywells in Phase 2. The standard was found to be impractical for Cisterns given their small size and orifice diameter limitations. Therefore, the Phase 1 Peak Control Standard was maintained for Cisterns in Phase 2 (Section 3.2.5).

3.2.3 Level 2 Flow Control

The Level 2 Flow Control Standard is as follows (DNR 2016, Section 1.2.3.1):

Match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. Also match developed peak discharge rates to predeveloped peak discharge rates for the 2- and 10-year return periods.

A forested historic site condition was assumed for this project.

The following actions were sized based on the Level 2 Flow Control standard:

- Detention Pond (KCSWDM Section 5.1.1, Detention Ponds)
- Detention Vault (KCSWDM Section 5.1.3, Detention Vaults)
- Infiltration Pond (KCSWDM Section 5.2.2, Infiltration Ponds)
- Infiltration Vault (KCSWDM Section 5.2.4, Infiltration Vaults)

See Section 4.1 for a detailed summary of modeling methods used to size these Actions.

3.2.4 Peak Control Standard

In Phase 1, both Drywells and Cisterns were sized based on sizing factors provided in the *2017 Seattle Stormwater Manual* (Seattle) for the Peak Control Standard (Section 5.3.4 in the 2017 Seattle Stormwater Manual). The Peak Control Standard provides the following:

- The post-development peak flow with 4% annual probability (25-year recurrence flow) shall not exceed 0.4 cubic feet per second per acre; and
- The peak flow with a 50% annual probability (2-year recurrence flow) shall not exceed 0.15 cubic feet per second per acre).

Although the intention in Phase 2 was to explicitly model both Drywells and Cisterns in MGSFlood based on the Modified Level 1 Flow Control Standard (Section 3.2.3), preliminary modeling showed that the standard could not be reasonably met for Cisterns due to their small size and orifice diameter limitations. Therefore, the Phase 1 Peak Control Standard remained unchanged for Cisterns in Phase 2. No other Phase 2 Actions use this standard. See the Decision Log (Attachment B) for additional information.

3.2.5 Other

Depaving was designed in accordance with the KCSWDM (Appendix C, Section C.2.9), with no associated numerical standard for water quality treatment or flow control. See the Fact Sheets in Attachment A for additional design information.

Table 3 – Basis of Design.

Action	Basis of Design	Listed in KCSWDM Basic Water Quality Treatment Menu? (Y/N)	Applicable Treatment or Flow Control Standard	Pre-treatment Required for PGIS? (Y/N)
Green Stormwater Infrastructure (GSI)				
Rain Garden ^a	2017 Seattle SW Manual, "Rain Garden" (Volume 3, Section 5.4.5)	N	Basic Water Quality Treatment	N
Bioretention Planter ^b	2017 Seattle SW Manual, "Non-Infiltrating Bioretention" (Volume 3, Section 5.8.2)	N	Enhanced Water Quality Treatment	N
Bioretention ^b	2016 KCSWDM, "Bioretention 'Cell' or 'Swale'" (Appendix C, Section C.2.6)	N	Enhanced Water Quality Treatment	N
Bioswale	KCSWDM, "Basic Bioswales" (Section 6.3.1)	Y	Basic Water Quality Treatment	N
Media Filter Drains ^b	2019 Ecology SMMWW, "Media Filter Drain" (Volume V, Chapter 6, BMP T8.40)	N	Enhanced Water Quality Treatment	N
Drywell ^c	2017 Seattle SW Manual, "Drywells" (Volume 3, Section 5.4.3)	N	Modified Level 1 Flow Control	Y
Deep UIC Well ^c	2019 Ecology SMMWW, "Deep UIC Wells" (Volume I, Chapter 4, Section I-4.15)	N	N/A	Y
Permeable Pavement ^d	2016 KCSWDM, "Permeable Pavement" (Appendix C, Section C.2.7)	N	Basic Water Quality Treatment	N
Depaving (Removal of Impervious Surfaces)	2016 KCSWDM, "Reduced Impervious Surface Credit" (Appendix C, Section C.2.9).	N	N/A	N
Stormwater Treatment Wetland	2016 KCSWDM, "Stormwater Wetlands" (Chapter 6, Section 6.4.3)	Y	Basic Water Quality Treatment	N

Action	Basis of Design	Listed in KCSWDM Basic Water Quality Treatment Menu? (Y/N)	Applicable Treatment or Flow Control Standard	Pre-treatment Required for PGIS? (Y/N)
Stormwater Retention/Detention/Infiltration				
Detention Vault	2016 KCSWDM, "Detention Vaults" (Chapter 5, Section 5.1.3)	N	Level 2 Flow Control	N
Detention Pond	2016 KCSWDM, "Detention Ponds" (Chapter 5, Section 5.1.1)	N	Level 2 Flow Control	N
Infiltration Pond ^c	2016 KCSWDM, "Infiltration Ponds" (Chapter 5, Section 5.2.2)	N	Level 2 Flow Control	Y
Infiltration Vault ^c	2016 KCSWDM, "Infiltration Vaults" (Chapter 5, Section 5.2.4)	N	Level 2 Flow Control	Y
Cistern	2017 Seattle SW Manual, "Single-family Residential (SFR) Cisterns" (Volume 3, Section 5.5.2.5)	N	Peak Control Standard	N
Gray Stormwater Treatment				
Wetpond	2016 KCSWDM, "Wetponds - Basic and Large" (Chapter 6, Section 6.4.1)	Y	Basic Water Quality Treatment	N
Wetvault	2016 KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2)	Y	Basic Water Quality Treatment	N
High Rate Underground Filter System	Filterra ® - Ecology GULD Approval for Enhanced Water Quality Treatment	Y	Enhanced Water Quality Treatment	N
Regional Vegetated Media Filtration Facility	Kitsap County Manchester Stormwater Retrofit Drainage Report (April 2014)	Y	Enhanced Water Quality Treatment	N

Abbreviations:

KCSWDM	2016 King County Surface Water Design Manual
GULD	General Use Level Designation
N/A	Not Applicable
PGIS	Pollution-generating Impervious Surface
SMMWW	2019 Stormwater Management Manual for Western Washington
SW	Stormwater
UIC	Underground Injection Control

Notes:

- a. Rain gardens are not included in the KCSWDM Basic Water Quality Treatment Menu; however, they were designed to provide basic water quality treatment in accordance with the 2017 Seattle Stormwater Manual (Volume 3, Table 5.19).
- b. Bioretention planter, bioretention and media filter drain are not included in the KCSWDM Basic Water Quality Treatment Menu; however they were designed to provide enhanced water quality treatment in accordance with SMMWW (Figure III 1.1: Runoff Treatment BMP Selection Flow Chart).
- c. Drywell, deep UIC well, infiltration pond, and infiltration vault are paired with upstream pre-treatment Actions (see Section 4.5).
- d. Permeable pavements are not included in the KCSWDM Basic Water Quality Treatment Menu; however, they were designed to include a 6" sand treatment layer to provide basic water quality treatment in accordance with the BMP T5.15 in the SMMWW when used in PGIS applications (low volume driveways).

4 ACTION SIZING METHODOLOGY

As discussed in Section 1.2, the following key refinements to Action sizing were implemented in Phase 2:

- Whereas Action sizing was based on simplified sizing factors in Phase 1, Phase 2 refined the sizing by use of explicit modeling in MGSFlood where applicable.
- Action design parameters (e.g., side slopes, ponding depths, freeboard depths, native soil infiltration rates, etc.) generally remained unchanged from Phase 1, since the design parameters had been thoroughly vetted and agreed upon in Phase 1.
- In order to minimize re-work needed for Action cost estimating, the Action bottom footprint areas remained unchanged from Phase 1 wherever possible. Thus, while holding the bottom footprint areas constant, the contributing drainage areas were adjusted in MGSFlood until the Action was demonstrated to meet the applicable performance standard.
- For some Actions, the Basis of Sizing was revised from Phase 1 to better align with King County standards (see Table 4).

In addition to MGSFlood modeling, a combination of resources, including KCSWDM sizing worksheets, sizing factors from the 2017 Seattle Stormwater Manual (City of Seattle 2017), manufacturer standard specifications, and available design information from recently constructed local projects, were used where available or appropriate, as shown in Table 4.

Columns 2 through 7 of Table 4 summarize how the Action bottom footprint areas and contributing drainage areas were developed in Phase 1. For additional documentation of Phase 1 evaluations, see the *Phase 1 Water Quality Action Development; Water Quality Benefits Evaluation* Technical Memorandum (RKI 2020). The last 3 columns in Table 4 (Columns 8 through 10) summarize how the drainage areas were refined in Phase 2 using explicit modeling in MGSFlood where applicable. These Phase 2 refinements are the result of the explicit modeling conducted and the updated methodology for sizing Actions with side slopes (Section 7).

The Phase 2 Refined Drainage Areas shown in Table 4 are based on modeling in MGSFlood using the Puget East 40-inch Mean Annual Precipitation (MAP) climate region unless otherwise noted in the table. See Section 5 for additional discussion of precipitation analysis conducted to determine the relationship between contributing drainage area and MAP. The analysis was needed to develop a more reliable understanding of how much contributing drainage area can be managed to the applicable performance standard as a function not only of Action type, but also climate, which varies considerably across the County. The drainage area versus MAP relationships (Section 5) will be used to support future phases of SUSTAIN modeling.

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Table 4 – Basis of Unit Action Bottom Footprint Area and Drainage Area Sizing.

Action	Phase 1 – Determine Action Bottom Footprint Area						Phase 2 – Refine Action Drainage Area		
	Basis of Sizing Action Bottom Footprint Area	Max Ponding Depth / Max Flow Depth ^a (in)	Native Soil Infiltration Rate (in/hr)	Bottom Footprint Area Sizing Factor ^b	Drainage Area (SF)	Action Bottom Area Footprint (SF)	Basis of Sizing Refined Drainage Area	Refined Drainage Area (SF) ^c	Percent Drainage Area Change from Phase 1 (%) ^d
Green Stormwater Infrastructure (GSI)									
Rain Garden Installation – Till Soils	Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard (COS 2017)	6	0.3	4.7%	532	25	2016 KCSWDM Basic Water Quality Treatment (MGSFlood)	806	52%
Rain Garden Installation – Outwash Soils	Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard (COS 2017)	6	2.5	1.0%	2,500	25	2016 KCSWDM Basic Water Quality Treatment (MGSFlood)	2,844	14%
Bioretention Planter Installation	Sizing Factors (Table 5.45, Vertical sides), Water Quality Treatment Standard (COS 2017)	6	N/A	1.3%	1,923	25	2016 KCSWDM Basic Water Quality Treatment (MGSFlood)	2,357	23%
Bioretention Installation -Till Soils	Sizing Factors (Table 5.20, Sloped sides), Water Quality Treatment Standard (COS 2017)	6	0.3	[0.0097 x Contributing Impervious Area] - 11.3	9,928	85	2016 KCSWDM Basic Water Quality Treatment (MGSFlood)	12,148	22%
Bioretention Installation -Outwash Soils	Sizing Factors (Table 5.19, Sloped sides for Outwash), Water Quality Treatment Standard (COS 2017)	6	2.5	1.0%	8,500	85	2016 KCSWDM Basic Water Quality Treatment (MGSFlood)	9,570	13%
Bioswale Installation	2016 KCSWDM, "Basic Bioswales" (Section 6.3.1)	4	N/A	N/A	43,560	200	2016 KCSWDM, "Basic Bioswales" (Section 6.3.1)	27,878	-36%
Media Filter Drains – Till Soils	2019 SMMWW, Table V-6.5	0	0.3	N/A	2,000	200	2019 SMMWW, Table V-6.5	2,000	0%
Media Filter Drains – Outwash Soils	2019 SMMWW, Table V-6.5	0	2.5	N/A	2,000	200	2019 SMMWW, Table V-6.5	2,000	0%

Action	Phase 1 – Determine Action Bottom Footprint Area						Phase 2 – Refine Action Drainage Area		
	Basis of Sizing Action Bottom Footprint Area	Max Ponding Depth / Max Flow Depth ^a (in)	Native Soil Infiltration Rate (in/hr)	Bottom Footprint Area Sizing Factor ^b	Drainage Area (SF)	Action Bottom Area Footprint (SF)	Basis of Sizing Refined Drainage Area	Refined Drainage Area (SF) ^c	Percent Drainage Area Change from Phase 1 (%) ^d
Drywell – Till Soils	Sizing Factors (Table 5.15, 6' Drywell Depth, 0.3 in/hr infiltration [extrapolated], Peak Control Standard) (COS 2017)	N/A	0.3	7.6%	171	13	Modified Level 1 Flow Control (MGSFlood)	261	53%
Drywell – Outwash Soils	Sizing Factors (Table 5.15, 6' Drywell Depth, 2.5 in/hr infiltration, Peak Control Standard) (COS 2017)	N/A	2.5	3.9%	333	13	Modified Level 1 Flow Control (MGSFlood)	780	134%
Deep UIC Well ^e	Barton (AESI 2013)	N/A	N/A	N/A	N/A	42	Barton (AESI 2013)	N/A	N/A
Permeable Pavement – Till Soils	2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7)	0	0.3	N/A	200	200	2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7)	200	0%
Permeable Pavement–Outwash Soils	2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7)	0	2.5	N/A	200	200	2016 KCSWDM, Permeable Pavement (Appendix C, Section C.2.7)	200	0%
Depaving (Removal of Impervious Surfaces)	N/A	0	N/A	N/A	N/A	100	N/A	100	0%

Action	Phase 1 – Determine Action Bottom Footprint Area						Phase 2 – Refine Action Drainage Area		
	Basis of Sizing Action Bottom Footprint Area	Max Ponding Depth / Max Flow Depth ^a (in)	Native Soil Infiltration Rate (in/hr)	Bottom Footprint Area Sizing Factor ^b	Drainage Area (SF)	Action Bottom Area Footprint (SF)	Basis of Sizing Refined Drainage Area	Refined Drainage Area (SF) ^c	Percent Drainage Area Change from Phase 1 (%) ^d
Stormwater Treatment Wetland	2016 KCSWDM, "Stormwater Wetlands - Basic and Large" (Chapter 6, Section 6.4.3), Sized as Basic facility	48	N/A	N/A	43,560	503	2016 KCSWDM, "Stormwater Wetlands - Basic and Large" (Chapter 6, Section 6.4.3), Sized as Basic facility	62,988	45%
Stormwater Retention/Detention/Infiltration									
Detention Vault	2016 KCSWDM, Level 2 Flow Control (WWHM)	72	N/A	N/A	43,560	2,592	2016 KCSWDM, Level 2 Flow Control (MGSFlood)	28,658	-34%
Detention Pond	2016 KCSWDM, Level 2 Flow Control (WWHM)	48	N/A	N/A	43,560	4,500	2016 KCSWDM, Level 2 Flow Control (MGSFlood)	36,569	-16%
Infiltration Pond – Till Soils	2016 KCSWDM, Level 2 Flow Control (WWHM)	48	0.3	N/A	43,560	2,785	2016 KCSWDM, Level 2 Flow Control (MGSFlood)	36,595	-16%
Infiltration Pond – Outwash Soils	2016 KCSWDM, Level 2 Flow Control (WWHM)	48	2.5	N/A	43,560	1,479	2016 KCSWDM, Level 2 Flow Control (MGSFlood)	46,396	7%
Infiltration Vault – Till Soils	2016 KCSWDM, Level 2 Flow Control (WWHM)	72	0.3	N/A	43,560	1,836	2016 KCSWDM, Level 2 Flow Control (MGSFlood)	28,719	-34%
Infiltration Vault – Outwash Soils	2016 KCSWDM, Level 2 Flow Control (WWHM)	72	2.5	N/A	43,560	1,156	2016 KCSWDM, Level 2 Flow Control (MGSFlood)	39,365	-10%

Action	Phase 1 – Determine Action Bottom Footprint Area						Phase 2 – Refine Action Drainage Area		
	Basis of Sizing Action Bottom Footprint Area	Max Ponding Depth / Max Flow Depth ^a (in)	Native Soil Infiltration Rate (in/hr)	Bottom Footprint Area Sizing Factor ^b	Drainage Area (SF)	Action Bottom Area Footprint (SF)	Basis of Sizing Refined Drainage Area	Refined Drainage Area (SF) ^c	Percent Drainage Area Change from Phase 1 (%) ^d
Cistern	2017 Seattle SW Manual Sizing Factors for SFR cisterns (Table 5.31, COS 2017)	60	N/A	1.4%	1,300	18	2017 Seattle SW Manual Sizing Factors for SFR cisterns (Table 5.31, COS 2017)	1,300	0%
Gray Stormwater Treatment									
Wetpond	2016 KCSWDM, "Wetponds - Basic and Large" (Chapter 6, Section 6.4.1), Sized as Basic facility	48	N/A	N/A	43,560	553	2016 KCSWDM, "Wetponds - Basic and Large" (Chapter 6, Section 6.4.1), Sized as Basic facility	63,075	45%
Wetvault	2016 KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2)	48	N/A	N/A	43,560	1,615	2016 KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2)	63,010	45%
High Rate Underground Filter System	Filterra ® - Ecology GULD Approval for Enhanced Water Quality Treatment	2	N/A	N/A	30,492	16	Filterra ® - Ecology GULD Approval for Enhanced Water Quality Treatment	34,956	15%
Regional Vegetated Media Filtration Facility	Kitsap County Manchester Stormwater Retrofit Drainage Report (April 2014)	8.4	N/A	N/A	17,249,760	5,940	Kitsap County Manchester Stormwater Retrofit Drainage Report (April 2014)	17,249,760	0%

Abbreviations:

H:V	Horizontal:Vertical
hr	hour
in	inches
KCSWDM	2016 King County Surface Water Design Manual
N/A	Not Applicable
SF	square feet
SFR	Single Family Residential
SMMWW	2019 Stormwater Management Manual of Western Washington
SW	Stormwater

Notes:

- a. Max Ponding Depth applies to all Actions other than Bioswale, for which Max Flow Depth applies. Bioswales are not designed for ponding.
- b. Sizing factors used in Phase 1 were from the 2017 City of Seattle Stormwater Manual (COS 2017).
- c. Refined Drainage Areas are based on modeling in MGSFlood using the Puget East 40 inch Mean Annual Precipitation climate region. See additional discussion of precipitation analysis in Section 5.
- d. Percent Drainage Area Change for bioswale reports a negative value due to iterations required to provide sizing for 40-inch Mean Annual Precipitation (see Attachment H). Negative values are reported for Actions sized to the Level 2 Flow Control Standard due to 100% impervious area assumption in Phase 2, versus 30% pervious and 70% impervious drainage area assumption in Phase 1 (Section 4.1).
- e. Deep UIC wells have a maximum contributing flow rate of 0.111 cubic feet per second.

4.1 Long-term Continuous Hydrologic Modeling

Action sizing was primarily conducted through long-term continuous hydrologic modeling in MGSFlood where applicable (Table 4). Although the Western Washington Hydrology Model Version 12 (WWHM) was used in Phase 1 (RKI 2020), MGSFlood was used in Phase 2 because MGSFlood runs much faster and hundreds of model runs were needed in a short time frame for this analysis.

As discussed in Section 4, the modeling methodology entailed adjusting the Action drainage area to maintain consistency with Phase 1 unit Action dimensions and cost estimates.

The following key assumptions and methods were used for long-term continuous hydrologic modeling in MGSFlood:

- **Level 2 Flow Control Actions (Infiltration Ponds, Infiltration Vaults, Detention Ponds and Detention Vaults):** Level 2 Flow Control Actions were sized in Phase 1 based on a 10-acre drainage area consisting of 30% pervious and 70% impervious land use based on King County Department of Natural Resources and Parks *Development of a Stormwater Retrofit Plan for Water Resources Inventory Area 9: SUSTAIN Modeling Report* [WRIA 9; WLRD]). The resulting modeled footprint was scaled down by a factor of 10 to obtain a Unit Action Footprint for a drainage area of one acre.

In Phase 2, a similar approach was used, but in order to maintain land use consistency between MGSFlood and SUSTAIN models, the 10-acre drainage area was modeled as 100% impervious. This resulted in Level 2 Flow Control facilities having a smaller contributing drainage area when compared with Phase 1 (see Column 10 in Table 4).

MGSFlood was used to solve for the refined contributing drainage area that can be managed to the applicable standard for the given Phase 1 Action bottom footprint area. Both the Phase 1 Action bottom footprint areas and the Phase 2 refined contributing drainage areas were then scaled down by a factor of 10. See additional discussion of the decision to update to 100% impervious drainage areas for Level 2 Flow Control sizing in the Decision Log (Attachment B).

- **Drywells:** Drywells were designed as cylindrical facilities with infiltration through the bottom and half of the sidewall depth. In order to model the Drywells in MGSFlood, which does not provide for a cylindrical facility geometry, they were represented as rectangular facilities with equivalent total storage volume and wetted infiltration area as the cylindrical design.
- **Actions with Side Slopes (Rain Garden, Bioretention, Infiltration Ponds, and Detention Ponds):** Actions with side slopes modeled in MGSFlood were assumed to have side slopes along the longitudinal sides of the facilities, but vertical sides for the shorter fronts and backs of the facilities. This was done to prevent overestimating excavation and material import costs when such facilities are aggregated, or daisy-chained along their length, when modeled at the subbasin scale in SUSTAIN.

See additional discussion in the Decision Log (Attachment B). See also Attachment E for the modeling assumptions, Attachment F for MGSFlood model output reports for applicable Actions, and Appendix G for additional model outputs needed to support SUSTAIN modeling.

4.2 Sizing Factors

Sizing factors from the 2017 Seattle Stormwater Manual (COS 2017) were used for Cisterns only (see Table 4).

4.3 King County Surface Water Design Manual Sizing Worksheets

The King County Surface Water Design Manual (KCSWDM) Water Quality Facility Sizing Worksheets provided in Reference 8-C of the KCSWDM were used to size the following four (4) Actions:

1. Bioswale
2. Stormwater Treatment Wetland
3. Wetpond
4. Wetvault

See Section 5 for discussion of the precipitation analysis performed to develop rainfall inputs to the Worksheets. MAP values of 32-inch, 40-inch, and 60-inch were used in the analysis to represent the range of low, medium and high rainfall regions across lowland King County.

In order to size Bioswales, an off-line water quality design flow rate was modeled in MGSFlood for an impervious surface drainage area of 0.64 acres, resulting in a modeled off-line water quality design flow rate of 0.052 cubic feet per second. This off-line water quality design flow rate was used as input in the Worksheet.

Water quality design flow rates were also developed in MGSFlood for Wetponds, Wetvaults, and Stormwater Treatment Wetlands because they are needed as input for future modeling in SUSTAIN. This flow rate is used to determine what surface runoff gets into the facility and what bypasses the facility. The percent removal and irreducible concentration is applied to the runoff that gets into the facility and discharges through the orifice. See Attachment G for additional information.

The off-line water quality design flow rates for Wetponds, Wetvaults, and Stormwater Treatment Wetlands were modeled for an impervious surface drainage area of 1.44 acres, resulting in a modeled off-line water quality design flow rate of 0.118 cubic feet per second. See Attachment H for detailed calculations for these Actions. Off-line water quality design flow rates for SUSTAIN modeling are reported in Attachment G.

4.4 Manufacturer Information and Recently Installed Projects

Sizing for Deep UIC Well, High Rate Underground Filter System, and Regional Vegetated Media Filtration Facility was based on manufacturer information and available design information from recently constructed, local projects, as summarized in Table 4 and described below:

- **High Rate Underground Filter System Installation:** Sizing is based on a 4'X4' Contech Filterra ® Bioscape External Bypass system (see Attachment C), designed to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements (see Attachment D) for a 0.7-acre contributing drainage area, with a maximum unit treatment capacity of 0.065 cfs (per the manufacturer, see Attachment H). The current GULD-approved infiltration rate of 175 inches/hour was used for design.
- **Regional Vegetated Media Filtration Facility Installation:** Sizing is based on Kitsap County's Manchester Stormwater Park, which was based on an earlier (2014) GULD-approved infiltration rate of 24.8 inches/hour for Contech Filterra ® media (Parametrix 2014). For Phase 1 and Phase 2 of this project, the facility footprint size was maintained the same as for the Manchester Stormwater Park design (5,940 square feet), but the 73-acre contributing drainage area for Manchester was scaled up by a factor of 7.06, calculated as the ratio of current to previous GULD-approved infiltration rates (175 in/hr /

24.8 in/hr). A conservative factor of safety of 1.3 was then applied for a unit drainage area of 396 acres ($73 \times 7.06 / 1.3 = 396$). The factor of safety is conservative, assuming relatively high contributions from transportation and commercial areas with heavy sediment loading.

- **Deep UIC Well Installation:** Sizing is based on King County's Barton CSO Control project. A maximum flow rate from the UIC well to the surrounding soil of 50 gallons per minute (0.111 cubic feet per second) was used for this project based on the average flow rate measured by infiltration testing for *Barton*. The design configuration is as follows (AESI 2013):
 - Drilling and casing of 12-inch diameter borehole
 - 20-foot long 8-inch diameter pipe-sized well screen with filter pack
 - 5-foot deep stainless-steel well sump containing energy-dissipation rock, allowing water to drain out of well
 - Sand filter pack around well screen and sump, extending 8 feet above the top of the well screen
 - Maintenance hole over wellhead to convey treated stormwater into the well
 - Maximum well depth of 100 feet to accommodate future removal of sediment by Vactor equipment
 - Underdrain manhole to provide for additional sediment removal

4.5 Pre-treatment Sizing

The following Actions are composed of a primary Action (Drywells, Deep UIC Well, Infiltration Pond, Infiltration Vault) and an upstream pre-treatment Action (Bioretention Planter or High Rate Underground Filter System):

1. Drywell with pre-treatment via bioretention planter
2. Deep UIC well with pre-treatment via bioretention planter
3. Deep UIC well with high rate underground filter system as pre-treatment
4. Infiltration pond with high rate underground filter system as pre-treatment
5. Infiltration vault with high rate underground filter system as pre-treatment

The primary Actions are sized according to Table 4, while the upstream pre-treatment Actions are sized according to Table 5. In Phase 1, the upstream pre-treatment Actions were sized based on simplified sizing factors. In Phase 2, the pre-treatment Actions, similar to the primary Actions, were re-sized based on explicit modeling in MGSFlood. Note that primary Action sizing is independent of pre-treatment Action sizing (e.g., the primary Action size is not reduced as a result of the upstream pre-treatment Action sizing).

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Table 5 – Basis of Sizing for Treatment Trains

Action	Pre-treatment Action	Pre-treatment Sizing								
		Phase 1					Phase 2			
		Pre-treatment Action Size (SF)	Drainage Area (SF)	Basis of Drainage Area	Basis of Pre-treatment Action Size	Notes	Refined Drainage Area (SF) ^a	Basis of Drainage Area	Basis of Pre-treatment Action Size	Percent Drainage Area Change (%)
Drywell – Outwash Soils	Bioretention Planter	4.3	333	Unit Drainage Area for "Drywell – Outwash Soils" from Table 4	1.3% Sizing Factor for Water Quality Treatment Standard (2017 Seattle Stormwater Manual, Table 5.45: Non-infiltrating Bioretention with Vertical Sides)		396	Enhanced Water Quality Treatment Standard	Phase 1 Action Size	19%
Deep UIC Well	Bioretention Planter	579	44,550	Effective impervious area for one residential block based on GSI Program Block Template BL-18	11.3% Sizing Factor for Water Quality Treatment Standard (2017 Seattle Stormwater Manual, Table 5.45: Non-infiltrating Bioretention with Vertical Sides)	For costing purposes rounded to 570 SF (i.e. six 5 ft x 19 ft planters). Assumes UIC well can infiltrate all treated flow (design flow rate of approximately 35 gpm).	54,546	Enhanced Water Quality Treatment Standard	Phase 1 Action Size	22%
Deep UIC Well	High Rate Underground Filter System	24	44,550	Effective impervious area for one residential block based on GSI Program Block Template BL-18	Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements.	Required size is 23 SF. Rounded up to next standard unit size. Assumes UIC well can infiltrate all treated flow (design flow rate of approximately 44 gpm).	52,164	Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements.	Phase 1 Action Size	17%
Infiltration Pond – Outwash Soils	High Rate Underground Filter System	24	43,560	Unit Drainage Area for the "Infiltration Pond – Outwash Soils" Action from Table 4	Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements.	Required size is 22.4 SF. Rounded up to next standard unit size.	52,164	Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements.	Phase 1 Action Size	20%
Infiltration Vault – Outwash Soils	High Rate Underground Filter System	24	43,560	Unit Drainage Area for the "Infiltration Vault – Outwash Soils" Action from Table 4	Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements.	Required size is 22.4 SF. Rounded up to next standard unit size.	52,164	Sized to provide enhanced water quality treatment per Ecology's February 2020 General Use Level Designation (GULD) requirements.	Phase 1 Action Size	20%

Abbreviations:

gpm gallons per minute
ft feet

MAP Mean Annual Precipitation
SF square feet

Notes:

- a. Refined drainage areas in Phase 2 are based on modeling in MGSFlood for the Puget East 40-inch MAP climate region (see Section 5).

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5 PRECIPITATION ANALYSIS

Phase 2 entailed development of regression equations to relate MAP to contributing drainage area for each Action. These relationships, developed primarily through modeling in MGSFlood, are needed to improve the SUSTAIN model's representation of Action performance across the highly variable climate conditions of the King County lowlands.

To develop these relationships, three (3) MGSFlood climate regions were selected to represent Low, Medium, and High MAP, as follows:

- **Low:** Puget East 32-inch MAP
- **Medium:** Puget East 40-inch MAP
- **High:** Puget East 60-inch MAP

These values were used to develop relationships for KCSWDM Worksheet calculations and MGSFlood modeling as described below.

5.1 Scaling in KCSWDM Worksheets

Stormwater Treatment Wetlands, Wetponds, and Wetvaults, sized using KCSWDM worksheets, use a precipitation design value based on the 6-month, 24-hour storm event, estimated as 72% of the 2-year, 24-hour storm event. Storm event input values were calculated by selecting 2-year, 24-hour precipitation values in locations corresponding to the Low, Medium, and High MAP regions, then multiplying those values by 0.72. Figure 1 and Table 6 show the resulting Precipitation Design Values used to scale these Actions.

Table 6 – Precipitation Design Values for Actions Sized with KCSWDM Worksheets

MAP Category	MGSFlood Climate Region	2-Year, 24-Hour Precipitation	Precipitation Design Value ^a
Low	Puget East 32 in MAP	1.6 inch	1.15 inch
Medium	Puget East 40 in MAP	2.0 inch	1.44 inch
High	Puget East 60 in MAP	3.0 inch	2.16 inch

Note:

a 72% of the 2-year, 24-hour storm event is used as a precipitation design value for scaling stormwater treatment wetlands, wetponds, and wetvaults (Attachment H).

5.2 Scaling in MGSFlood

For those Actions that were sized in MGSFlood (Section 4.1), the Actions were first sized for the Medium MAP as described in Section 4 and Attachments A, E, and F. The same process was then repeated to size the Actions for the Low and High MAP in MGSFlood. The resulting three (3) data points for Low, Medium, and High MAP were then used to define polynomial-type expressions (for non-infiltration-based Actions, including Detention Pond and Detention Vault) and power-type expressions (for all other Actions) to illustrate the modeled relationship between MAP and contributing drainage area. These relationships are summarized in Table 7 and shown graphically in Attachment I, with resulting R² values range between 0.9805 and 1.

As shown in Attachment I, the polynomial-type expressions for Detention Pond and Detention Vault represent concave curves, indicating that increased drainage area can be managed to the applicable standard for increasing MAP between roughly 32 inches per year and 50 inches per year and that decreasing drainage area can be managed to the applicable standard for MAP between roughly 50 inches per year and 60 inches per year. As discussed further in Section 9 (Summary and Recommended Next Steps), these polynomial relationships for Detention Pond and Detention Vault may warrant additional evaluation to verify the type and shape of the resulting expression.

MGSFlood was also used to compute the off-line water quality design flow rates for the Low, Medium, and High MAP as needed for sizing Bioswales, High Rate Underground Filter Systems, and Regional Vegetation Media Filtration Systems.

Table 7 – Power and Polynomial Expressions Relating Drainage Area to Mean Annual Precipitation.

Action	A	B	C	R ²
y = A*x^B (y = Drainage Area in Acres, x = Mean Annual Precipitation in Inches)				
Rain Garden Installation – Till Soils	0.5723	-0.932	N/A	0.9998
Rain Garden Installation – Outwash Soils	1.3219	-0.815	N/A	1
Bioretention Planter Installation	1.0464	-0.803	N/A	1
Bioretention Installation -Till Soils	5.6493	-0.816	N/A	1
Bioretention Installation – Outwash Soils	4.4451	-0.816	N/A	1
Bioswale Installation	15.086	-0.856	N/A	0.9998
Drywell – Till Soils	0.1222	-0.817	N/A	1
Drywell – Outwash Soils	0.1268	-0.529	N/A	0.9984
Stormwater Treatment Wetland	100.87	-1.149	N/A	0.9970
Infiltration Pond – Till Soils	26.351	-0.936	N/A	0.9994
Infiltration Pond – Outwash Soils	11.515	-0.653	N/A	0.9863
Infiltration Vault – Till Soils	21.961	-0.954	N/A	0.9988
Infiltration Vault – Outwash Soils	9.906	-0.658	N/A	0.9805
Wetpond	101.23	-1.149	N/A	0.9997
Wetvault	101.12	-1.149	N/A	0.9997
High Rate Underground Filter System	18.147	-0.845	N/A	1
Regional Vegetated Media Filtration Facility	11157	-0.906	N/A	0.9999
Drywell with Pre-treatment via Bioretention Planter	0.1727	-0.797	N/A	1
Deep UIC Well with Pre-treatment via Bioretention Planter	23.956	-0.800	N/A	1
Deep UIC Well with Pre-treatment via High Rate Underground Filter System	27.081	-0.845	N/A	1
Infiltration pond with Pre-treatment via High rate Underground Filter System	27.081	-0.845	N/A	1
Infiltration Vault with Pre-treatment via High Rate Underground Filter System	27.081	-0.845	N/A	1
y = A*x² + B*x + C (y = Drainage Area in Acres, x = Mean Annual Precipitation in Inches)				
Detention Vault	-0.0012	0.115	-2.0716	1
Detention Pond	-0.0147	1.451	-26.105	1

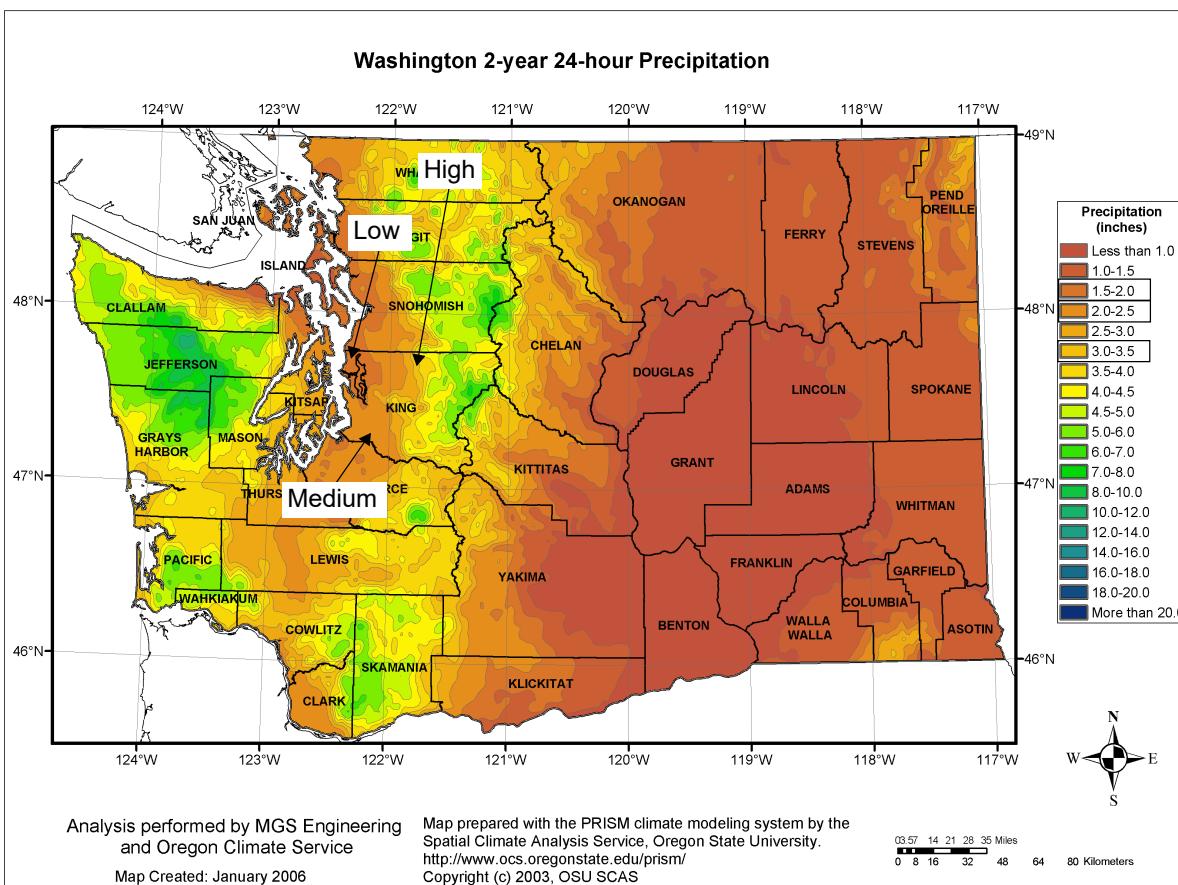
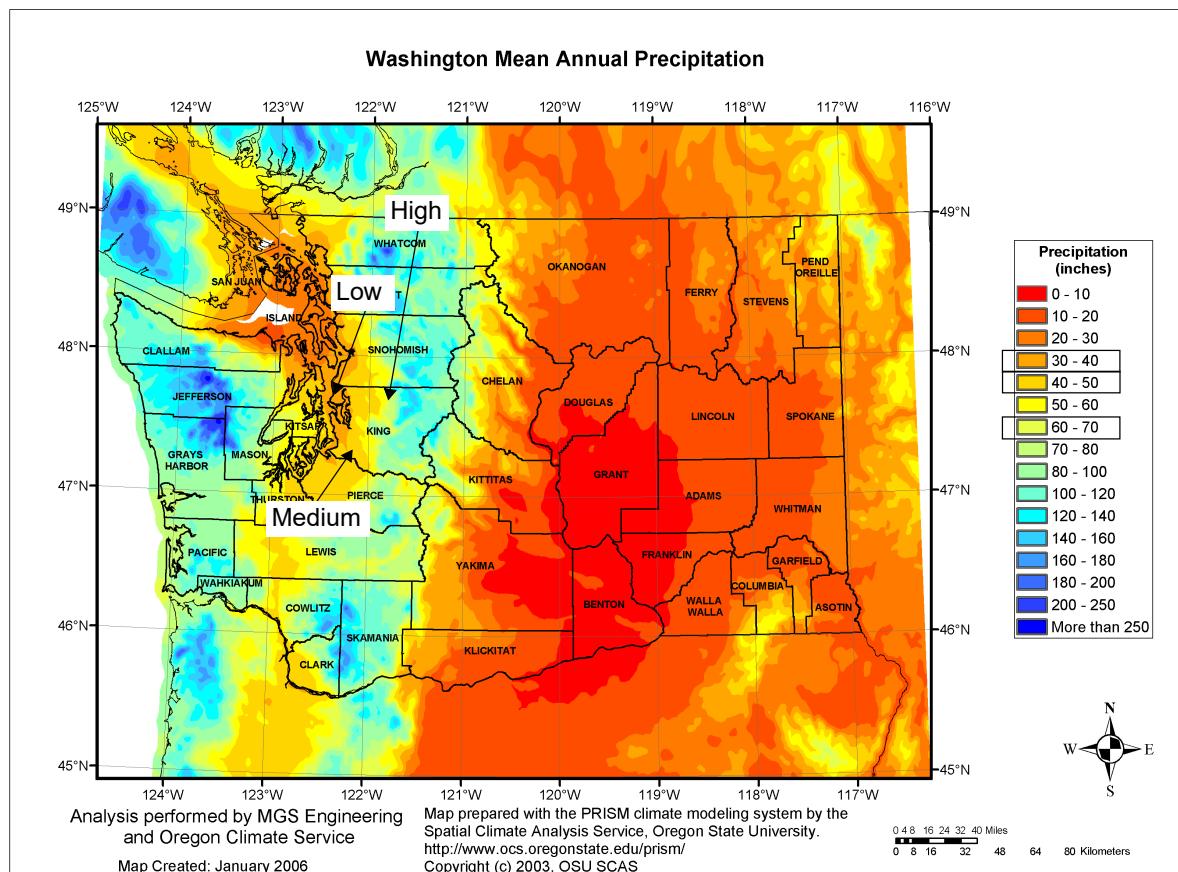


Figure 1 - Mean Annual Precipitation and 2-Year 24-Hour Precipitation, Washington State

6 ACTION FACT SHEET DEVELOPMENT

Action Fact Sheets were developed for 19 of the 24 water quality Actions identified in Phase 1 (see Table 1). These Fact Sheets were then refined in Phase 2 (see Attachment A) based on updated parameters and methodologies as discussed in this technical memo. The Fact Sheets provide a consistent template to document the design, SUSTAIN modeling methodology and inputs, performance parameters, unit cost assumptions, and programmatic feasibility and siting considerations.

Each Action Fact Sheet is 2-pages-long and organized as follows:

- Page 1:
 - Action Description
 - Drainage Areas
 - Unit Action Schematic
 - Design Parameters
 - Design Assumptions
- Page 2:
 - SUSTAIN Model Representation
 - Performance Parameters
 - Unit Action Costs
 - Programmatic Feasibility/Siting Considerations

See Attachment J for an annotated Fact Sheet summarizing key components of the Fact Sheets.

7 DESIGN CONFIGURATION, PERFORMANCE, AND COST PARAMETERS

See the Fact Sheets in Attachment A and Table 9 for the updated Phase 2 design parameters. Note that the values reported in both the table and attachment represent the Medium MAP (Section 5).

7.1 SUSTAIN Model Geometry

SUSTAIN does not account for side slope geometry nor infiltration through the sides of facilities. To overcome this in Phase 1, the SUSTAIN modeling used revised geometry that approximated Actions with side slopes (i.e., “Design Configuration”) as Actions with vertical side slopes (i.e., “Transformed Configuration for SUSTAIN Modeling”). The bottom width of the rectangular section was estimated in Phase 1 as the average of the bottom width and the ponded width. See *Phase I Water Quality Action Development: Water Quality Benefits Evaluation* (RKI 2020) for additional detail.

In Phase 2, the Transformed Configuration for SUSTAIN Modeling was refined to better emulate the performance in MGSFlood. The Basis of Sizing and the basis for the Transformed Configuration are detailed in Table 4. The Transformed Configurations for SUSTAIN Modeling were developed using the following five (5) steps (see a schematic diagram of this SUSTAIN Input Transformation method in Figure 2):

- **Step 1:** Adjust the drainage area for the Design Configuration to meet the applicable performance standard (see Table 4).

- **Step 2:** For infiltration-based Actions, calculate the Design Configuration infiltration wetted perimeter (i.e., in cross-sectional view, the perimeter of the Action where infiltration can occur).
- **Step 3:** Calculate the Design Configuration storage area (i.e., in cross-sectional view, the area below the maximum ponded water depth, including the void area within the bioretention or non-engineered soil layer where water can be stored).
- **Step 4:** Hold the Design Configuration bottom length (and ponding depth for non-infiltrating Actions) and the resulting drainage area constant, while adjusting the following:
 - Adjust the side slopes to vertical;
 - For infiltrating Actions with side slopes, adjust the bottom width to match the infiltration wetted perimeter from Step 2.
 - For non-infiltrating Actions with side slopes, adjust the bottom width to match the storage area from Step 3; and
 - Adjust the ponding depth to match total volume from Phase 1 (for infiltration Actions only).
- **Step 5:** Make final adjustments to the Action's bottom width to meet the applicable performance standard to develop the Transformed Configuration for SUSTAIN Modeling.

Prior to use on all applicable Actions, the method was first tested for Bioretention on till soils (with an elevated underdrain) and Bioretention on outwash soils (with no underdrain), as summarized in Table 8.

Table 8 – Preliminary Model Results, SUSTAIN Versus MGSFlood

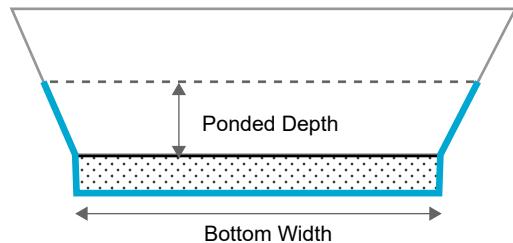
Parameter	MGSFlood Modeling of Transformed Configuration	SUSTAIN Modeling of Transformed Configuration
Simulation Period	1936 – 2097 (158 Years)	2009 – 2019 (20 Years)
Mean Annual Precipitation	40-inch	40-inch
Percent Captured/Percent Treated, Bioretention on Till Soils	91.05%	91.39%
Percent Captured/Percent Treated, Bioretention on Outwash Soils	91.01%	91.79%

Though SUSTAIN and MGSFlood use different precipitation data (including different periods of record), MGSFlood's 158-year time series is a composite of three different monitoring stations that have been proven to be statistically independent, but with comparable distribution; thus roughly each third of the 158 years are repeating similar climate conditions. Consequently, the longer MGSFlood simulation period is considered comparable to the shorter SUSTAIN model simulation period for purposes of this evaluation.

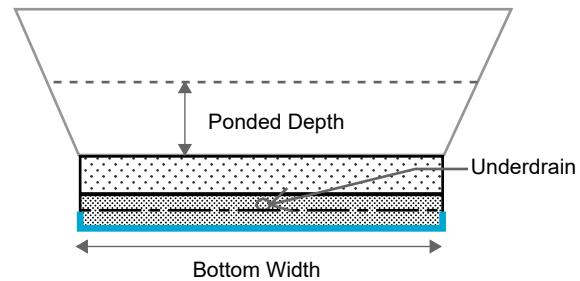
The preliminary model results in Table 8 show that the facility sized using MGSFlood modeling performed as expected when modeled in SUSTAIN (i.e., the Transformed Configuration modeled in SUSTAIN resulted in 91% treated). Based on these results, all Actions with side slopes were transformed using this same method. See the Decision Log in Attachment B. Dimensions for Transformed Configurations for SUSTAIN modeling are provided in Attachment G.

Design Configuration

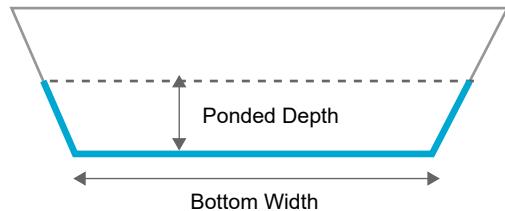
1. Bioretention/Rain Gardens (no underdrain)



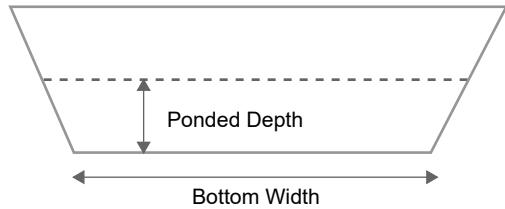
2. Bioretention (with underdrain)



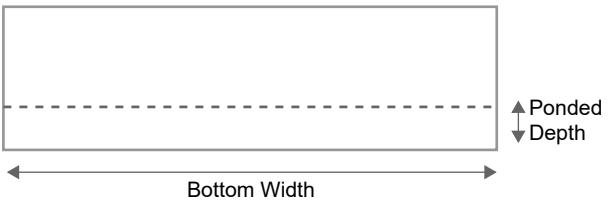
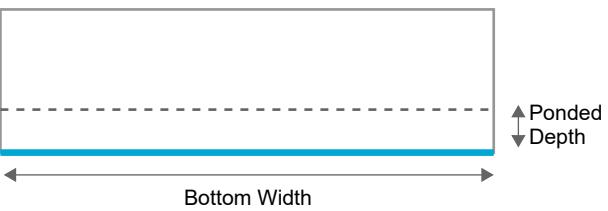
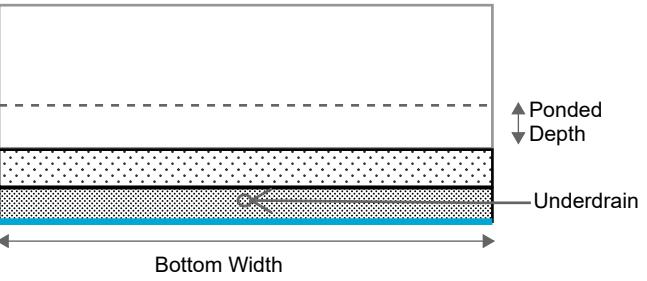
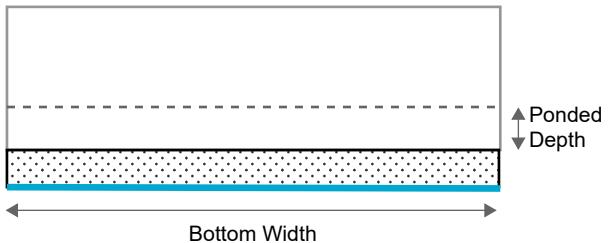
3. Infiltration Ponds



4. Non-Infiltrating Actions with Side Slopes



Transformed Configuration for SUSTAIN Modeling



Notes:

- For Actions with infiltration (1-3), bottom width and ponded depth values were adjusted to maintain equivalent infiltration wetted perimeter and storage area.
- For non-infiltrating Actions with side slopes (4), bottom width was adjusted to maintain equivalent storage area only.

Legend:

- Infiltration Wetted Perimeter
- - - Max Ponding Elevation
- — — Underdrain Invert Elevation
- Bioretention Soil Mix
- Underdrain Aggregate Layer

Figure 2 - SUSTAIN Input Transformation Schematic

7.2 Performance Parameters

The performance parameters on page 2 of each Action Fact Sheet (Attachment A) summarize the median percent removal and median effluent concentrations for several target pollutants that are analyzed in the SUSTAIN model. The target pollutants include:

- Total Copper
- Dissolved Copper
- Total Zinc
- Dissolved Zinc
- Total Phosphorus
- Total Nitrogen
- Total Suspended Solids
- Total PCBs
- Total PBDEs
- Total PAHs
- Bis(2-ethylhexyl)phthalate
- Fecal Coliform

The data sources that were used to identify the performance parameters for each Action and pollutant combination are documented in Appendix C to 431-TM1 (Herrera 2021b).

7.3 Cost Parameters

Unit Action Costs (provided on Page 2 of the Action Fact Sheets, Attachment A) are broken down by Total Project cost, including Total Direct Construction, Total Indirect Non-Construction, and Operation and Maintenance costs. Property Acquisition costs, which are a part of Total Indirect Non-Construction costs, are itemized separately in the Action Fact Sheets. These Unit Action Costs are based on the design information provided in Table 9 and in the Action Fact Sheets, as well as the long-term maintenance assumptions provided in Table 10.

The WQBE Phase 2 cost estimate updates refined the cost estimates prepared under Phase 1 to more closely align the costs with similar projects and programs. These refinements included evaluation of indirect cost multipliers such as complexity factors, contingency and cost multipliers. In general, the indirect costs were adjusted to reflect a programmatic delivery approach to implementing the actions. Additionally, property cost values were revised to reflect costs outside of Seattle and in King County in general. Several sources were used to evaluate Unit Action Costs, including internet sources, King County Technical Memoranda and Reports, and the Washington State Department of Transportation (WSDOT) Unit Bid Analysis database. See Appendix D to 431-TM1 (HDR 2021) for detailed documentation of unit Action cost development.

7.4 Design and Cost Limitations

The following text provides a summary of key design and cost limitations noted for this Phase of the project.

- **Infiltration for Actions with Side Slopes:** As described in Section 7.1, methodology was developed to transform Actions with side slopes into Actions with vertical slopes for purposes of SUSTAIN modeling, since SUSTAIN only models vertical side slopes. Preliminary modeling in Table 8 showed this method was effective for purposes of this evaluation; however, infiltration is head dependent, and ideally the infiltration rate for Actions with side slopes would vary as a function of Action volume and depth. Since the method described in Section 7.1 is based on a constant infiltration rate, the method developed for this Phase is noted as an approximation.
- **Action Cost and Sizing Optimization:** Action sizing was performed in MGSFlood by modeling the amount of drainage area that can be treated to a given standard under the given set of design and treatment assumptions (Tables 2 and 3). Thus, there was no optimization performed directly in MGSFlood. However, unit costs were optimized, where appropriate, with the goal of providing a representative unit cost for a typical application (HDR 2021) and the programmatic implementation of unit Actions was optimized in SUSTAIN (Herrera 2021a).
- **Climate Change:** Design assumptions are based on King County's current design requirements (2016 KCSWDM). Future climate change conditions have not been evaluated, but may be considered in future phases of study (see Section 8: Summary and Recommended Next Steps).

Table 9 – Design Parameters.

Action	Bottom Area Footprint (SF)	Drainage Area (SF)	Length to Width Ratio (L:W)	Side Slope (H:V) ^a	Max Ponding Depth (in)	Underdrain Diameter (in)	Underdrain Aggregate Porosity (%)	Underdrain Invert Height (in)	Total Underdrain Aggregate Depth (in)	Native Soil Design Infiltration Rate (in/hr)	Treatment Media Depth (in)	Treatment Media Porosity (%)	Treatment Media Design Infiltration Rate (in/hr)	Orifice diameter (in) / height (in)	Off-line Water Quality Design Flow Rate (cfs)
Green Stormwater Infrastructure (GSI)															
Rain Garden – Till Soils	25	806	2:1	3	6	N/A	N/A	N/A	0.3	8 ^b	25%	N/A	N/A	N/A	
Rain Garden – Outwash Soils	25	2,844	2:1	3	6	N/A	N/A	N/A	2.5	8 ^b	25%	N/A	N/A	N/A	
Bioretention Planter	25	2,357	3:1	0	6	8	40%	6	26	N/A	18	30%	6	N/A	
Bioretention – Till Soils	85	12,148	3:1	3	6	8 ^c	40%	12	26	0.3	18	30%	6	N/A	
Bioretention – Outwash Soils	85	9,570	3:1	3	6	N/A	N/A	N/A	2.5	18	30%	6	N/A	N/A	
Bioswale	200	27,878	50:1	3	1.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.052	
Media Filter Drains – Till Soils	200	2,000	50:1	3	0	8	40%	6	20	0.3	12	40%	10	N/A	
Media Filter Drains – Outwash Soils	200	2,000	50:1	3	0	N/A	N/A	N/A	2.5	12	40%	10	N/A	N/A	
Drywell – Till Soils	13	261	N/A	0	N/A	N/A	N/A	N/A	0.3	N/A ^d	N/A	N/A	N/A	N/A	
Drywell – Outwash Soils	13	780	N/A	0	N/A	N/A	N/A	N/A	2.5	N/A ^d	N/A	N/A	N/A	N/A	
Deep UIC Well	42	N/A ^e	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Permeable Pavement – Till Soils	200	200	2:1	N/A	0	N/A	N/A	N/A	0.3	6 ^f	35% ^f	N/A	N/A	N/A	
Permeable Pavement – Outwash Soils	200	200	2:1	N/A	0	N/A	N/A	N/A	2.5	6 ^f	35% ^f	N/A	N/A	N/A	
Depaving (Removal of Impervious Surfaces) ^g	100	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Stormwater Treatment Wetland	503	62,988	2:1	3	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.118	
Stormwater Retention/Detention/Infiltration															
Detention Vault	2,592	28,658	2:1 / 1.125:1 ^h	0	72	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.16 / 0 ⁱ	N/A	

Action	Bottom Area Footprint (SF)	Drainage Area (SF)	Length to Width Ratio (L:W)	Side Slope (H:V) ^a	Max Ponding Depth (in)	Underdrain Diameter (in)	Underdrain Aggregate Porosity (%)	Underdrain Invert Height (in)	Total Underdrain Aggregate Depth (in)	Native Soil Design Infiltration Rate (in/hr)	Treatment Media Depth (in)	Treatment Media Porosity (%)	Treatment Media Design Infiltration Rate (in/hr)	Orifice diameter (in) / height (in)	Off-line Water Quality Design Flow Rate (cfs)
Detention Pond	4,500	36,569	2:1	3	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.41 / 0 ⁱ	N/A
Infiltration Pond – Till Soils	2,785	36,595	2:1	3	48	N/A	N/A	N/A	N/A	0.3	N/A	N/A	N/A	N/A	N/A
Infiltration Pond – Outwash Soils	1,479	46,396	2:1	3	48	N/A	N/A	N/A	N/A	2.5	N/A	N/A	N/A	N/A	N/A
Infiltration Vault – Till Soils	1,836	28,719	N/A	0	72	N/A	N/A	N/A	N/A	0.3	N/A	N/A	N/A	N/A	N/A
Infiltration Vault – Outwash Soils	1,156	39,365	N/A	0	72	N/A	N/A	N/A	N/A	2.5	N/A	N/A	N/A	N/A	N/A
Cistern	18	1,300	2:1	0	60	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25 / 4	N/A

Gray Stormwater Treatment

Wetpond	553	63,075	2:1	3	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.118
Wetvault	1,615	63,010	3:1 / 4:1 ^h	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.118
High Rate Underground Filter System	16	34,956	1:1	N/A	2	4	40%	0	6	N/A	21	40%	175	N/A	0.081
Regional Vegetated Media Filtration Facility	5,940	17,249,760	1.2:1	N/A	8.4	12	40%	0	18	N/A	21.6	40%	175	N/A	N/A

Abbreviations:

cfs	cubic feet per second
ft	feet
hr	hour
in	inches
L:W	Length to Width ratio
N/A	Not Applicable
SF	square feet

Notes:

- a. Actions with side slopes are sloped only along the long sides, short sides are vertical.
- b. Rain gardens are not included in the KCSWDM Basic Water Quality Treatment Menu; however, they were designed to provide basic water quality treatment in accordance with the 2017 Seattle Stormwater Manual (Volume 3, Table 5.19).
- c. Bioretention on till soils includes an elevated underdrain with 6" cover, 8" underdrain pipe, and 12" bedding.
- d. Drywells do not provide water quality treatment; however, the Action assumes a 72-inch aggregate depth at 40% porosity.
- e. Unit Drainage Area based on drainage area of pre-treatment Action (determined during Program development) and assumed maximum flow rate.
- f. For permeable pavement, a 3" aggregate layer with 40% porosity is assumed (does not provide treatment). A 6-inch sand layer for treatment is included only for pollution-generating hard surfaces (e.g., low-volume driveways).
- g. Depaving will be represented in SUSTAIN as a change in the drainage area from impervious to pervious land use, instead of physically modeling treatment through the soil layers. The difference in runoff loading from the impervious and pervious land use is the assumed benefit from depaving actions.
- h. Detention Vaults and Wet vaults were designed with L:W ratio of 2:1 and 3:1, respectively, but costed with L:W ratios of 1.125:1 and 4:1, respectively.
- i. In addition to an orifice, detention vaults and ponds also have a notch. Notch and orifice dimensions vary with precipitation factors. The notch on the detention vault Action, using the medium precipitation factor, is 0.368 inches in length, 28.77 inches in height, and has an invert height of 3.6 feet. The notch on the detention pond Action, using the Medium MAP (Section 5), is 0.868 inches in length, 17.31 inches in height, and has an invert height of 2.56 feet.

Table 10 – Long-term Maintenance Assumptions.

Action	Maintenance Activity 1 (Frequency)	Maintenance Activity 2 (Frequency)	Maintenance Activity 3 (Frequency)	Source
Green Stormwater Infrastructure (GSI)				
Rain Garden	Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events)	Inspection and remediation of plant health, i.e. pest, disease, poor vegetation growth, excessive vegetation growth, weed growth (quarterly)	Remediation of erosion of mulch/media layer around inlets, outlets and along slopes (biannually and after major storm events)	2019 SMMWW, "Bioretention Facilities" (Appendix V-A.21)
Bioretention Planter	Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events)	Inspection and remediation of plant health, i.e. pest, disease, poor vegetation growth, excessive vegetation growth, weed growth (quarterly)	Remediation of erosion of mulch/media layer around inlets, outlets and along slopes (biannually and after major storm events)	2019 SMMWW, "Bioretention Facilities" (Appendix V-A.21)
Bioretention	Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events)	Inspection and remediation of plant health, i.e. pest, disease, poor vegetation growth, excessive vegetation growth, weed growth (quarterly)	Remediation of erosion of mulch/media layer around inlets, outlets and along slopes (biannually and after major storm events)	2019 SMMWW, "Bioretention Facilities" (Appendix V-A.21)
Bioswale	Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually and after major storm events)	Inspection and remediation of grass health, i.e. sparse growth or excessive growth (quarterly)	Inspection and remediation of eroded or scoured swale bottom due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12" (biannually)	2019 SMMWW, "Bioretention Facilities" (Appendix V-A.21)
Media Filter Drains	Removal of trash, sediment and debris, and releveling media filter drain areas damaged or destroyed by trash, sediment and debris removal. (biannually)	Inspection and remediation of grass health, i.e. sparse growth or excessive growth (quarterly)	Inspection and remediation of eroded or scoured swale bottom due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12" (biannually)	2019 SMMWW, "Media Filter Drain (MFD)" (Appendix V-A.19)
Drywell	Removal of trash, debris or obstructions limiting flow into drywell (annually and after major storm events)	Inspection of vegetation and removal of roots that reduce free movement of water through pipes (biannually)	Inspection and remediation of holes or breaks that allow water to leave the basin at locations other than per design (biannually)	KCSWDM, "Drywell BMP" (Appendix A, No.25)
Deep UIC Well	General inspection of UIC well and associated maintenance hole structures, including measuring water level and well depth, not including confined space entry (annually)	Sediment removal from well and associated maintenance hole structures, by use of vactor truck (annually)	UIC flow testing, performed under the direction of a licensed hydrogeologist or professional engineer experienced with aquifer testing methods. Testing procedures require total of 8 hours, and access to constant water source such as a fire hydrant (once every five years)	Barton CSO Control Project with GSI, O & M Manual (2015)
Permeable Pavement	Removal of soil, mulch or sediment on paving biannually with a crew of two using a regenerative air sweeper (quarterly)	Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes (annually)	Remediation of major cracks, trip hazards, or large areas of concrete spalling and raveling by cutting and replacing (annually)	2019 SMMWW, "Permeable Pavement" (Appendix V-A.22)
Depaving (Removal of Impervious Surfaces)	Tilling and overseeding (biannually)	N/A	N/A	Professional Judgement

Action	Maintenance Activity 1 (Frequency)	Maintenance Activity 2 (Frequency)	Maintenance Activity 3 (Frequency)	Source
Stormwater Treatment Wetland	Removal of sediment from forebay and inlet/outlet pipe (annually)	Removal of trash and debris from facility (annually or after each major storm event)	Remediation of eroded areas over 2" deep of side slopes, berms or embankments (biannually or after major storm event)	2016 KCSWDM, "Stormwater Wetland" (Appendix A: No. 18)
Stormwater Retention/Detention/Infiltration				
Detention Vault	Removal of all sediment and debris from storage area (annually)	Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually)	N/A	2019 SMMWW, "Closed Detention Systems (Tanks/Vaults)" (Appendix V-A.3)
Detention Pond	Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually)	Removal of dead, diseased or dying trees (annually)	Stabilization of eroded berms, slopes, embankments, and animal borrows (annually)	2019 SMMWW, "Detention Ponds" (Appendix V-A.1)
Infiltration Pond	Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal (annually)	Removal of dead, diseased or dying trees (annually)	Stabilization of eroded berms, slopes, embankments, and animal borrows (annually)	2019 SMMWW, "Detention Ponds" (Appendix V-A.1)
Infiltration Vault	Removal of all sediment and debris from storage area (annually)	Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually)	N/A	2019 SMMWW, "Closed Detention Systems (Tanks/Vaults)" (Appendix V-A.3)
Cistern	Removal of all sediment and debris from storage area (annually)	Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually)	N/A	2019 SMMWW, "Closed Detention Systems (Tanks/Vaults)" (Appendix V-A.3); 2016 KCSWDM "Rainwater Harvesting BMP" (Appendix A No. 32)
Gray Stormwater Treatment				
Wetpond	Removal of trash, debris and sediment (annually)	Removal of visible oil sheen by using oil-absorbent pads or vactor truck (annually)	Inspection and remediation of erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent (3 times per year)	2019 SMMWW, "Wetponds" (Appendix V-A.11)
Wetvault	Removal of all sediment and debris from storage area (annually)	Inspection and repair of joints, vault walls, cracks wider than 1/2 inch (annually)	N/A	2019 SMMWW, "Wetvaults" (Appendix V-A.12)
High Rate Underground Filter System	Removal of trash, debris and sediment from facility (biannually or after major storm event)	Removal and replacement of 3" mulch layer (biannually)	Evaluation of plant health and replacement and/or pruning (bi-annually)	Kitsap County Operations and Maintenance Manual: Manchester Stormwater Park (December 2015)
Regional Vegetated Media Filtration Facility	Removal of trash, debris and sediment from facility (biannually or after major storm event)	Removal and replacement of 3" mulch layer (biannually)	Evaluation of plant health and replacement and/or pruning (bi-annually)	Kitsap County Operations and Maintenance Manual: Manchester Stormwater Park (December 2015)

Abbreviations:

KCSWDM 2016 King County Surface Water Design Manual
SMMWW 2019 Stormwater Management Manual of Western Washington

8 SUMMARY AND RECOMMENDED NEXT STEPS

King County is developing the WQBE Toolkit to inform County decision-making processes regarding selection of cost-effective water quality improvement investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will provide transparent, standardized methods for evaluating benefits of water quality Actions and Programs in terms of estimated pollutant load reductions and improved outcomes for a suite of ecological/human health endpoints.

A SUSTAIN model will be used to identify cost-effective combinations of potential water quality Actions for reduction of pollutant loads or stormwater volumes. Qualitative causal models will be used to define relationships between potential water quality projects and programs and ecological/human health endpoints (such as southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE toolkit is being developed in two phases over a period extending from 2020 through 2022. During Phase 1 (2020), a preliminary set of models was developed. In Phase 2 (2021-2022), these models are being further calibrated and refined to support County planning efforts (e.g., Clean Water Plan and CSO Long-Term Control Plan [LTCP]). Significant refinements were also made with respect to scaling the contributing drainage area that can be managed to the applicable standard for each Action (Table 4) as a function of Mean Annual Precipitation, which varies widely across the lowlands of King County. Finally, this memorandum also documents significant refinements made to the way in which Actions with side slopes are represented in SUSTAIN. Collectively, these refinements are expected to significantly improve the accuracy and reliability of SUSTAIN modeling and the scaling of Action cost-benefits based on Action type, location, and climate.

Recommended next steps include the following:

- Further evaluate and refine, if needed, the polynomial expressions developed to illustrate the relationship between Mean Annual Precipitation and drainage area for the non-infiltration-based, flow control Actions (Detention Pond and Detention Vault). These relationships are more complex for non-infiltration-based, flow control Actions than those for infiltration-based Actions, and the relationships may warrant additional validation depending on how they will be used in future SUSTAIN modeling.
- Coordinate with the County to leverage ongoing climate change research to evaluate future changes to design storm intensities, durations, and frequencies.
- Evaluate advanced active treatment system Actions such as on polymer-enhanced filtration, electrocoagulation, activated carbon filtration, and ion exchange.
- Evaluate additional cost-effective Actions, such as vegetated filter strips, which can disperse runoff from surface types including roads.
- Consider incorporating permeable pavement without a sand layer for flow control (in addition to permeable pavement with a sand layer for water quality treatment) in future phases of study.
- Conduct further coordination between the Action Design and SUSTAIN Modeling Teams so that future SUSTAIN modeling methodologies incorporate the results documented in this memorandum, as well as any future revisions. For example, the SUSTAIN modeling method for flow control Actions, such as Detention Pond and Detention Vault, need to be developed and reviewed internally to ensure that the Performance Parameters (Attachment A) are paired with the correct flow rates to reliably predict pollutant load reductions that correspond with the sizing and cost estimates for those Actions.
- Update the Action Fact Sheets (Attachment A) as needed based on the above further coordination.

9 REFERENCES

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- Washington State Department of Transportation (WSDOT) 2019. *Highway Runoff Manual*. April.

ATTACHMENT A

Action Fact Sheets

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RAIN GARDEN

Water Quality Benefits Evaluation Action Fact Sheet



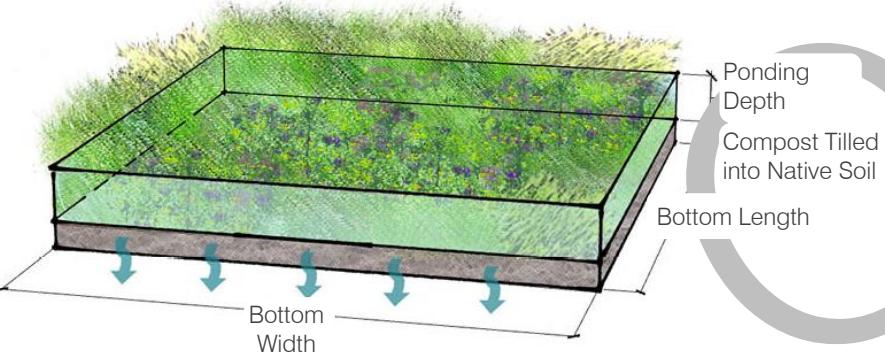
Phase 2

01/14/2022



City of Bellevue 145th Place SE Project
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile. Provides volume and peak flow reduction and water quality treatment.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	25 SF	25 SF
Unit Drainage Area	806 SF	2,844 SF
Ponding Depth	6 in	6 in
Bottom Length	7.08 ft	7.08 ft
Bottom Width	3.54 ft	3.54 ft
Side Slope	3H : 1V	3H : 1V
Treatment Media Depth ^a	8 in	8 in
Treatment Media Porosity ^a	25%	25%
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

N/A: Not Applicable

a. The Treatment Media is non-engineered and does not provide Basic Water Quality treatment. Infiltration through the Treatment Media is assumed to occur at the Native Soil Design Infiltration Rate

TREATMENT AREAS

Land Uses:

- Residential
- Commercial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Roofs
- Lawns
- Driveways
- Sidewalks
- Parking Lots

DESIGN ASSUMPTIONS

- Design is based on the Seattle Stormwater Manual, "Rain Garden" (Volume 3 Section 5.4.5).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the 2016 King County Surface Water Design Manual, this project assumes the Unit Action provides Basic Water Quality Treatment.
- Non-engineered treatment media consists of 3" compost tilled in to an 8-inch finished depth.
- No underdrain included.



RAIN GARDEN

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a,b}	On Property without Acquisition
Total Project	\$24,000
Total Direct Construction	\$17,000
Total Indirect Non-Construction	\$7,000
Operation and Maintenance	\$2,800/year
Property Acquisition ^c	\$0

- a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Maximum drainage areas of 10,000 square feet of impervious surface to an individual facility.
- Meet local jurisdiction utility separation requirements.
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation.
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas.
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the 2016 King County Surface Water Design Manual.

BIORETENTION PLANTER

Water Quality Benefits Evaluation Action Fact Sheet



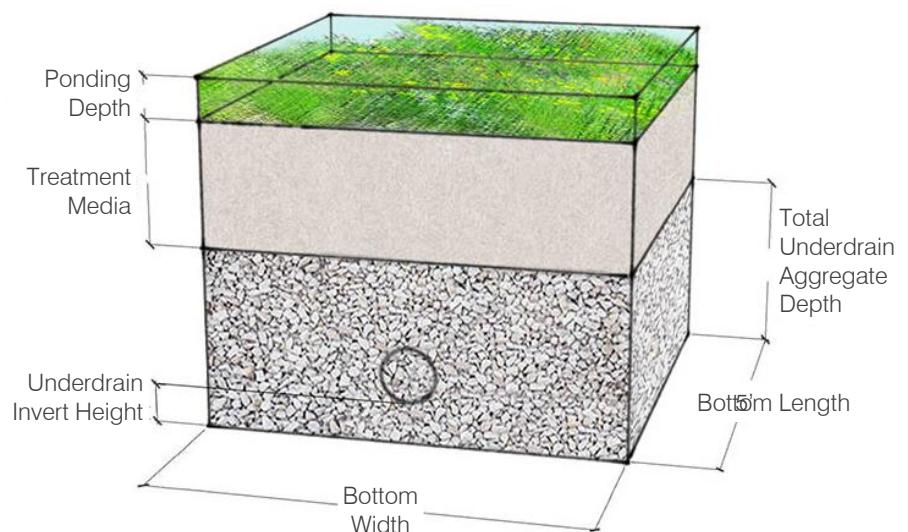
Phase 2

01/14/2022



Photo courtesy of Paradigm

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. Provides water quality treatment and peak flow reduction. For this analysis, the Action is assumed to have an underdrain and closed bottom.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	25 SF
Unit Drainage Area	2,357 SF
Ponding Depth	6 in
Bottom Length	8.7 ft
Bottom Width	2.9 ft
Side Slope	Vertical
Treatment Media Depth	18 in
Treatment Media Porosity	30%
Treatment Media Design Infiltration Rate	6 in/hr
Total Underdrain Aggregate Depth	26 in
Underdrain Invert Height	6 in
Underdrain Diameter	8 in
Underdrain Aggregate Porosity	40%
Native Soil Design Infiltration Rate ^a	N/A

N/A: Not Applicable

a. Any incidental infiltration to native soils ignored.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Driveways
- Parking Lots
- Sidewalks
- Plazas
- Local Roads
- Arterial Roads

DESIGN ASSUMPTIONS

- Design is based on the *Seattle Stormwater Manual*, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- Underdrain layer includes 12" cover, 8" underdrain pipe, and 6" bedding.
- Vertical sides.

BIORETENTION PLANTER

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	Median Effluent Concentration ^a
Total Copper	62.3%	10.5 µg/L
Dissolved Copper	57.6%	6.4 µg/L
Total Zinc	91.0%	10.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L ^b
Total Phosphorus	54.9%	0.113 mg-P/L
Total Nitrogen	51.3%	1.33 mg/L
Total Suspended Solids	78.0%	21.5 mg/L
Total PCBs	78.0% ^c	572 pg/L ^c
Total PBDEs	67.1% ^c	0.054 ng/L ^c
Total PAHs	95.0%	<0.01 µg/L ^b
Bis(2-ethylhexyl)phthalate	63.2% ^c	0.070 µg/L ^c
Fecal Coliform	61.5 %	240 CFU

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash

b. Method detection limit.

c. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition	In Right of Way
Total Project	\$44,000	\$42,000	\$56,000
Total Direct Construction	\$29,000	\$29,000	\$39,000
Total Indirect Non-Construction	\$15,000	\$13,000	\$17,000
Operation and Maintenance	\$2,800	\$2,800	\$2,800
Property Acquisition ^c	\$1,400	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

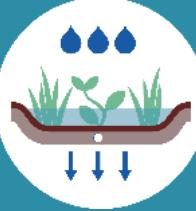
c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Because non-infiltrating bioretention facilities do not infiltrate water to surrounding soils (water discharges via an underdrain and surface overflow), these Actions are not subject to infiltration facility requirements.
- Non-infiltrating bioretention is not permitted if the under-drained water would be routed to a nutrient-critical receiving water.
- Public Right-of-Way installation for urban areas only.

BIORETENTION

Water Quality Benefits Evaluation Action Fact Sheet



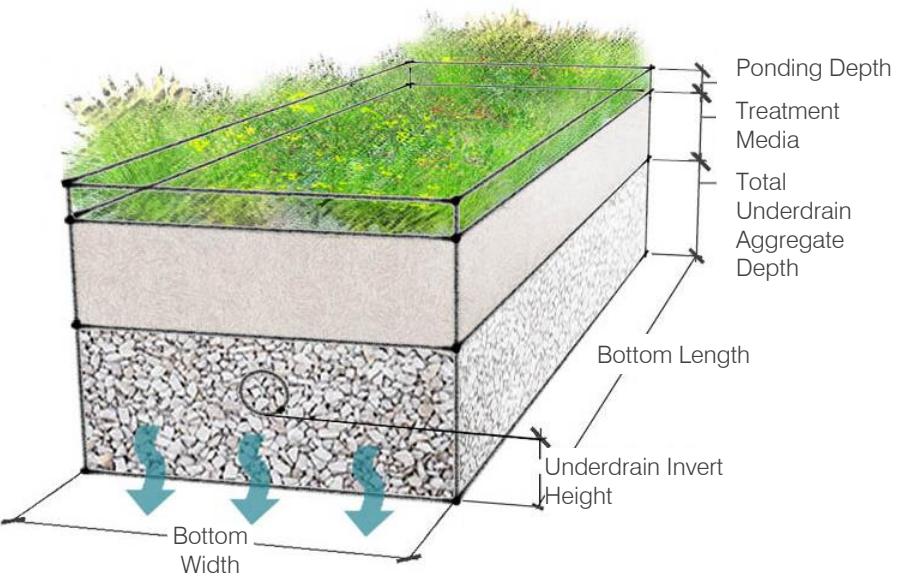
Phase 2

01/14/2022



City of Redmond Overlake Village LID Retrofit Project
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	85 SF	85 SF
Unit Drainage Area	12,148 SF	9,570 SF
Ponding Depth	6 in	6 in
Bottom Length	16 ft	16 ft
Bottom Width	5.33 ft	5.33 ft
Side Slope	3H : 1V	3H : 1V
Treatment Media Depth	18 in	18 in
Treatment Media Porosity	30%	30%
Treatment Media Infiltration Rate	6 in/hr	6 in/hr
Total Underdrain Aggregate Depth	26 in	N/A
Underdrain Invert Height	12 in	N/A
Underdrain Diameter	8 in	N/A
Underdrain Aggregate Porosity	40%	N/A
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

N/A: Not Applicable

Visit kingcounty.gov/WQBE for more information.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Driveways
- Parking Lots
- Sidewalk
- Plazas
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design is based on 2016 King County Surface Water Design Manual (KCSWDM) Section C.2.6.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6" cover, 8" underdrain pipe, and 12" bedding.
- For bioretention installed on outwash soils, no underdrain is included.

BIORETENTION

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	Median Effluent Concentration ^a
Total Copper	62.3%	10.5 µg/L
Dissolved Copper	57.6%	6.4 µg/L
Total Zinc	91.0%	10.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L ^b
Total Phosphorus	54.9%	0.113 mg-P/L
Total Nitrogen	51.3%	1.33 mg/L
Total Suspended Solids	78.0%	21.5 mg/L
Total PCBs	78.0% ^c	572 pg/L ^c
Total PBDEs	67.1% ^c	0.054 ng/L ^c
Total PAHs	95.0%	<0.01 µg/L ^b
Bis(2-ethylhexyl)phthalate	63.2% ^c	0.070 µg/L ^c
Fecal Coliform	61.5 %	240 CFU

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash

b. Method detection limit

c. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	With Underdrain			No Underdrain		
	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$100,000	\$85,000	\$139,000	\$98,000	\$83,000	\$135,000
Total Direct Construction	\$59,000	\$59,000	\$97,000	\$57,000	\$57,000	\$94,000
Total Indirect Non-Construction	\$42,000	\$26,000	\$42,000	\$41,000	\$25,000	\$41,000
Operation and Maintenance	\$2,800/year	\$2,800/year	\$2,800/year	\$2,800/year	\$2,800/year	\$2,800/year
Property Acquisition ^c	\$14,000	\$0	\$0	\$14,000	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

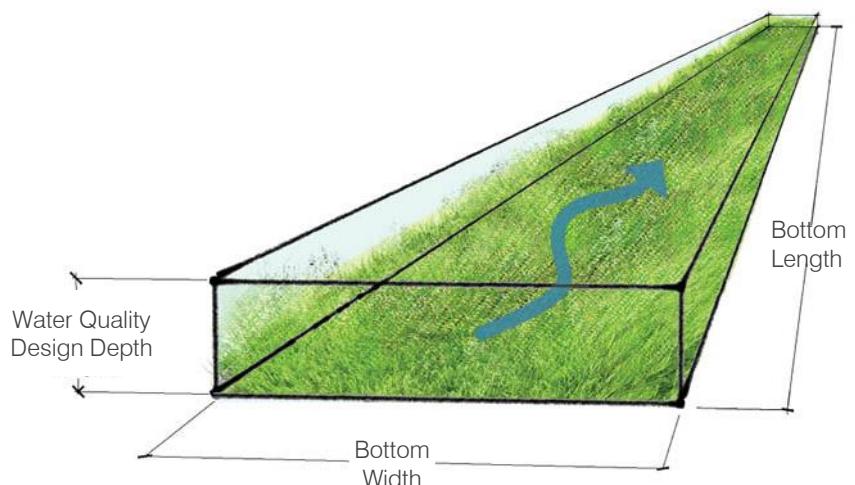
c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the 2016 King County Surface Water Design Manual



UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. Provides water quality treatment, peak flow reduction, and conveyance. These are designed to “filter” water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	200 SF
Unit Drainage Area	27,878 SF
Bottom Length	100 ft
Bottom Width	2 ft
Side Slope	3H : 1V
Water Quality Design Depth	1.4 in
Native Soil Design Infiltration Rate ^a	N/A
Water Quality Design Flow Rate (Off-line)	0.052 cfs

N/A: Not Applicable

a. Any incidental infiltration to native soils ignored.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Parking Lots
- Arterial Roads
- Local Roads
- Highways

DESIGN ASSUMPTIONS

- Design is based on the 2016 King County Surface Water Design Manual, "Basic Bioswales", Section 6.3.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
- Non-engineered soil media consists of 2" compost tilled into 6" native soil.
- Water flows relatively evenly across the entire width of a densely-vegetated area.
- No infiltration to underlying native soils assumed.



SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that flows through the bioswale (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	33.9%	9.20 µg/L
Dissolved Copper	8.99%	5.6 µg/L
Total Zinc	33.3%	35.0 µg/L
Dissolved Zinc	29.0%	20.9 µg/L
Total Phosphorus	-37.2%	0.188 mg-P/L
Total Nitrogen	-7.63%	0.860 mg/L
Total Suspended Solids	27.9%	22.3 mg/L
Total PCBs	27.9% ^a	592 pg/L ^a
Total PBDEs	24.0% ^a	0.056 ng/L ^a
Total PAHs	27.9% ^a	0.0028 µg/L ^a
Bis(2-ethylhexyl)phthalate	23.0% ^a	0.073 µg/L ^a
Fecal Coliform	6.25%	4900 CFU

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$66,000	\$20,000	\$41,000
Total Direct Construction	\$14,000	\$14,000	\$29,000
Total Indirect Non-Construction	\$52,000	\$6,000	\$12,000
Operation and Maintenance	\$2,600/year	\$2,600/year	\$2,600/year
Property Acquisition ^c	\$40,000	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

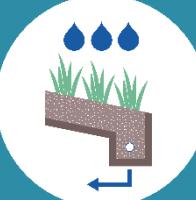
c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Generally appropriate when there is less than 5 acres of contributing impervious surface.
- Site in areas with a minimum of 6 hours of sunlight daily throughout the year.
- Do not site in high-use areas without oil control, as required in Section 6.6 in the *King County Surface Water Design Manual*.

MEDIA FILTER DRAIN (MFD)

Water Quality Benefits Evaluation Action Fact Sheet



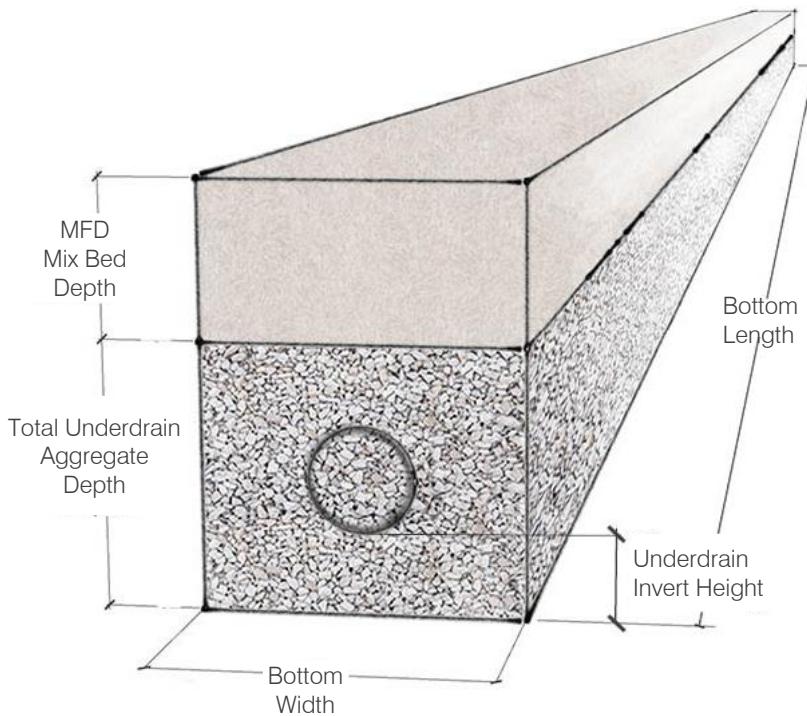
Phase 2

01/14/2022



Photo accessed on 7/2/2020 from
<https://www.wsdot.wa.gov/design/roadside/stormwater-management>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	200 SF	200 SF
Unit Drainage Area	2,000 SF	2,000 SF
Lateral Slope	3H : 1V	3H : 1V
Ponding Depth	0 in	0 in
Bottom Length	100 ft	100 ft
Bottom Width	2 ft	2 ft
MFD Mix Bed Depth	12 in	12 in
MFD Mix Porosity	40%	40%
MFD Mix Media Infiltration Rate	10 in/hr	10 in/hr
Total Underdrain Aggregate Depth	20 in	N/A
Underdrain Invert Height	6 in	N/A
Underdrain Diameter	8 in	N/A
Underdrain Aggregate Porosity	40%	N/A
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

N/A: Not Applicable

TREATMENT AREAS

Land Uses:

- Highway
- Agricultural

Property Types:

- Public Right-of-Way

Surface Types:

- Arterial Roads
- Local Roads
- Highway

DESIGN ASSUMPTIONS

- Design is based on the 2019 Washington State Department of Ecology Stormwater Management Manual for Western WA (SWMMWW), Best Management Practice (BMP) T8.40.
- Sizing is based on the SWMMWW Table V-6.5.
- The MFD mix consists crushed rock, dolomite, gypsum, and perlite.
- No underdrain included for MFDs installed on outwash soils.
- Treatment steps include:
 - Stormwater runoff enters the media filter drain and is conveyed via sheet flow over a vegetation-free gravel zone for sheet dispersion and to provide some pollutant trapping
 - A grass strip is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system
 - Runoff is then filtered through the treatment media bed and treated water is drained to an approved discharge location

MEDIA FILTER DRAIN (MFD)

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, filtration, underdrain flow, and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	68.7%	12.3 µg/L
Dissolved Copper	25.6%	9.0 µg/L
Total Zinc	68.5%	37.7 µg/L
Dissolved Zinc	51.0%	29.0 µg/L
Total Phosphorus	44.6%	0.067 mg-P/L
Total Nitrogen	NF	NF
Total Suspended Solids	86.1%	5.3 mg/L
Total PCBs	86.1% ^a	141 pg/L ^a
Total PBDEs	74.1% ^a	0.013 ng/L ^a
Total PAHs	86.1% ^a	0.00066 µg/L ^a
Bis(2-ethylhexyl)phthalate	70.0% ^a	0.017 µg/L ^a
Fecal Coliform	NF	NF

NF: No data found.

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	Rural Roadway/Highway	
	With Underdrain	No Underdrain
Total Project	\$34,000	\$30,000
Total Direct Construction	\$24,000	\$21,000
Total Indirect Non-Construction	\$10,000	\$9,000
Operation and Maintenance	\$2,300/year	\$2,300/year
Property Acquisition ^c	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Avoid construction on longitudinal slopes steeper than 5%.
- For narrow roadway shoulders, ensure sufficient space available for parking.
- Do not construct in wetlands and wetland buffers.
- Install above the site mean high water table levels to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow ground water.
- Do not site in areas of seasonal ground water inundation or basement flooding.
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields

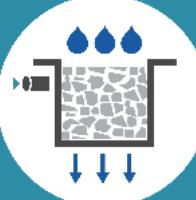
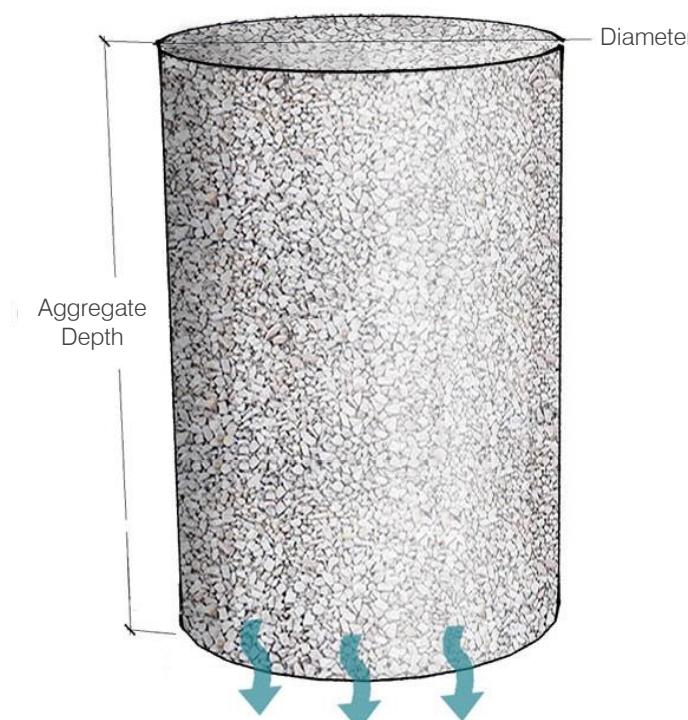


Photo accessed on 7/2/2020 from
<https://www.thisoldhouse.com/>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	13 SF	13 SF
Unit Drainage Area	261 SF	780 SF
Ponding Depth	N/A	N/A
Diameter	4 ft	4 ft
Aggregate Depth	6 ft	6 ft
Aggregate Porosity	40%	40%
Native Soil Design Infiltration Rate ^a	0.3 in/hr	2.5 in/hr

a. Lateral infiltration assumed to occur through half of the sidewall depth.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Agricultural

Property Types:

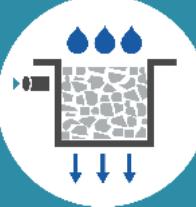
- Private Parcel
- Public Parcel

Surface Types:

- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Lawns

DESIGN ASSUMPTIONS

- Design is based on the 2017 Seattle Stormwater Manual, "Drywells" (Volume 3 Section 5.4.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet a Modified Level 1 Flow Control Standard, in which peak discharge rates were matched to the pre-developed (forested) peak discharge rates for the 2- and 10-year return intervals.
- Pre-treatment via upstream treatment Action will be provided.
- Infiltration to native soil assumes infiltration through the bottom surface and half of the sidewall surface area.
- The installed Action must be registered with Ecology as an Underground Injection Control (UIC).



SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents storage, infiltration and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition
Total Project	\$16,000
Total Direct Construction	\$11,000
Total Indirect Non-Construction	\$5,000
Operation and Maintenance	\$1,800/year
Property Acquisition ^c	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Minimum spacing between drywells is 10 feet.
- Setback is at least 15 feet from buildings with crawl space or basement elevations that are below the overflow point of the drywell.
- Can be placed under a pervious or impervious surface cover to conserve space.
- A minimum 5' setback shall be maintained between any part of the action and any structure or property line.
- Locate downgradient of the primary and secondary reserve drainfield areas.
- Locate away from sensitive area buffers.
- Do not direct overflows toward a slope steeper than 15%.
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields

DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL

Water Quality Benefits Evaluation Action Fact Sheet



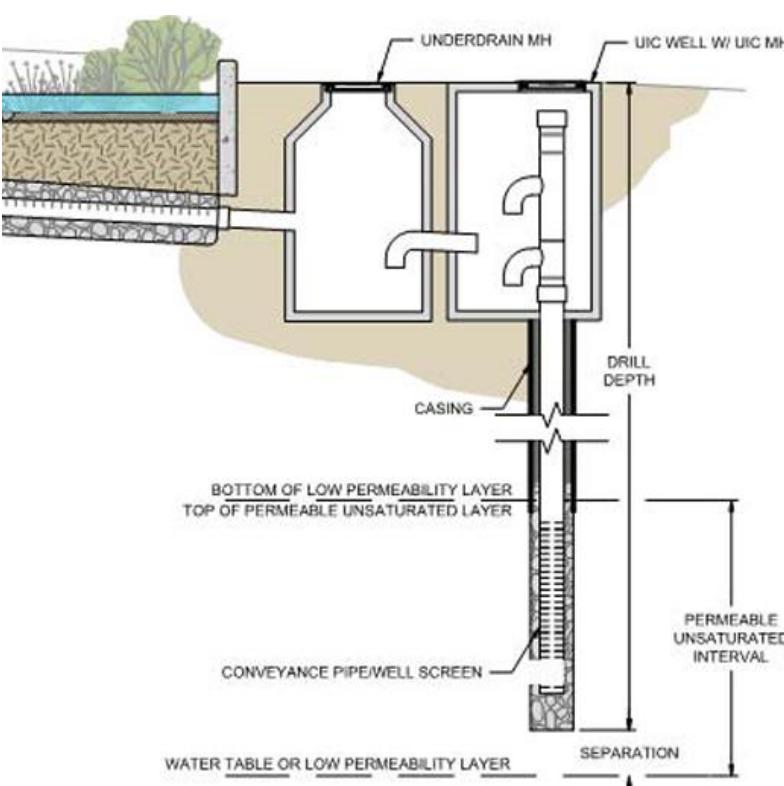
Phase 2

01/14/2022



Seattle Public Utilities Delridge Natural Drainage System
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action. Provides volume and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Assumed Maximum Flow Rate	0.111 cfs
Unit Footprint Area	42 SF
Unit Drainage Area ^a	N/A

N/A: Not Applicable

a. Unit Drainage Area based on drainage area of pre-treatment Action.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Sidewalks
- Lawns
- Local Roads
- Arterial Roads

DESIGN ASSUMPTIONS

- Design and sizing based on *King County Wastewater Treatment Division's Barton Basin Combined Sewer Overflow Control Project with Green Stormwater Infrastructure* (Barton).
- Maximum flow rate assumed to be 50 gallons per minute (0.111 cubic feet per second) based on average results presented in the Barton Drainage Report, Section 6.4.
- Well includes the following configuration:
 - Drilling and casing of 12-inch diameter borehole
 - 20-foot long 8-inch diameter pipe-sized well screen with filter pack
 - 5-foot deep stainless-steel well sump containing energy-dissipation rock, allowing water to drain out of well
 - Sand filter pack around well screen and sump, extending 8 feet above the top of the well screen
 - Maintenance hole over wellhead to convey treated stormwater into the well
 - Maximum well depth of 100 feet to accommodate future removal of sediment by vactor equipment
 - Underdrain manhole to provide for additional sediment removal
- Pre-treatment via upstream treatment Action will be provided.
- Includes a surface seal in the final completion of a deep UIC.

DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents infiltration and overflow

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition	In Right of Way
Total Project	\$48,000	\$46,000	\$66,000
Total Direct Construction	\$32,000	\$32,000	\$46,000
Total Indirect Non-Construction	\$16,000	\$14,000	\$20,000
Operation and Maintenance	\$2,000/year	\$2,000/year	\$2,000/year
Property Acquisition ^c	\$1,400	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

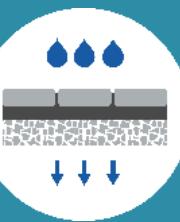
c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Locate away from wellhead protection area, Critical Aquifer Recharge Area, or a Sole Source Aquifer.
- Submittal of a State Waste Discharge Permit application required and will be determined on a site-by-site basis following the evaluation of the UIC permit application.

PERMEABLE PAVEMENT

Water Quality Benefits Evaluation Action Fact Sheet



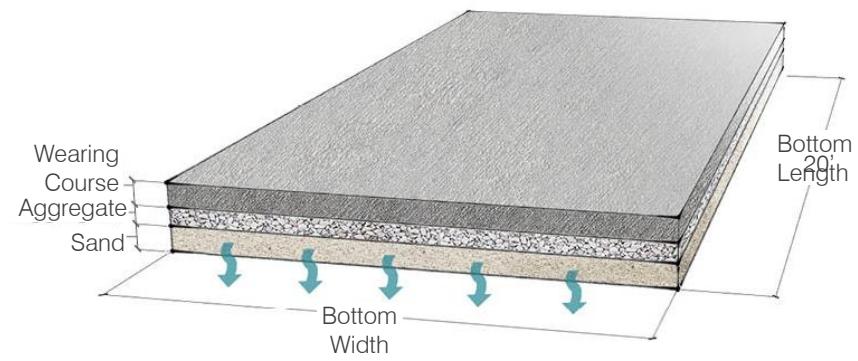
Phase 2

01/14/2022



City of Puyallup 9th St NW Porous Asphalt Roadway and Driveway Aprons
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides volume and peak flow reduction. Provides water quality treatment when sand treatment layer is provided.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	200 SF	200 SF
Unit Drainage Area	200 SF	200 SF
Ponding Depth	0 in	0 in
Bottom Length	20 ft	20 ft
Bottom Width	10 ft	10 ft
Treatment Media Depth ^a	6 in	6 in
Treatment Media Porosity	35%	35%
Aggregate Depth	3 in	3 in
Aggregate Porosity	40%	40%
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

a. Sand treatment layer provided for pollution-generating hard surfaces (i.e., low volume residential driveways) only.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial

Property Types:

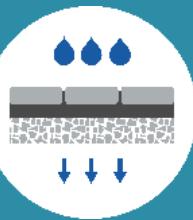
- Private Parcel
- Public Parcel

Surface Types:

- Low Volume Residential Driveways
- Sidewalks
- Plazas
- Trails
- Pedestrian and bike paths
- Parking Lots

DESIGN ASSUMPTIONS

- Design and sizing based on the 2016 King County Surface Water Design Manual, "Permeable Pavement", Appendix C, Section C.2.7.
- Section consists of 5" wearing course (pervious concrete or porous asphalt) over 3" aggregate. For low volume residential driveways, the section is underlain by 6" sand treatment layer
- Subsurface ponding assumed to include:
 - Ponding in aggregate layer: 3" x 40% porosity = 1.2"
 - Ponding in sand layer: 6" x 35% porosity = 2.1"
 - Storage in wearing course neglected
- The aggregate base contains less than 5% fines (material passing the #200 sieve) based on the fraction passing the #4 sieve.
- No run-on from other areas. The permeable pavement surface manages stormwater runoff from its own footprint only.
- Installation is on flat grades (e.g., <5% slope). No subsurface check dams required.



Phase 2

PERMEABLE PAVEMENT

Water Quality Benefits Evaluation Action Fact Sheet

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents subsurface ponding, infiltration, and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	Permeable Paver Plaza (no sand layer)	Pervious Concrete Sidewalk (no sand layer)	Permeable Paver Driveway (with sand layer)	Porous Asphalt Driveway (with sand layer)
Total Project	\$4,000	\$12,000	\$4,000	\$6,000
Total Direct Construction	\$3,000	\$8,000	\$3,000	\$4,000
Total Indirect Non-Construction	\$1,000	\$4,000	\$1,000	\$2,000
Operation and Maintenance	\$2,100/year	\$2,100/year	\$2,100/year	\$2,200/year
Property Acquisition ^c	\$0	\$0	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Limit to sites with 5% or less grade.
- Do not locate in high traffic or heavy load applications such as arterial roads, highways, and industrial/commercial loading areas.
- Do not locate in areas where King County's Permeable Pavement Infeasibility Criteria (see Section C.2.7 in the *2016 King County Surface Water Design Manual*) apply, such as (but not limited to) the following areas:
 - Where ground water drains into an erosion hazard or landslide hazard area
 - Where nearby basements that may be impacted
 - Where seasonal high groundwater or an underlying impermeable/low permeable layer lies within 1 foot of the bottom of the installation
 - Downslope of steep, erosion prone areas that are likely to deliver sediment
 - Within 50 feet from the top of slopes greater than 20%
 - Within 100 feet of a closed or active landfill
 - Within 100 feet of a drinking water well, or a spring used for drinking water supply, for pollution-generating surfaces (e.g., driveways)

DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022



Wheel strips replacing fully impervious driveway
Photo accessed on 7/2/2020 from
<https://www.cityofpacificgrove.org/>

ACTION DESCRIPTION

Depaving, or removal of impervious surfaces down to bare soil. The area is amended with soil and planted with low lying ground cover. To allow continued site use, the area is retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit". Provides volume and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	100 SF
Unit Drainage Area ^a	N/A
Ponding Depth	0 in

N/A: Not Applicable

- a. This Action will be modeled in SUSTAIN as a land swap (from an impervious to pervious surface) and not as a Best Management Practice. Therefore, no impervious surface will be directed to the Action area.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Driveways
- Sidewalks
- Parking Lots

DESIGN ASSUMPTIONS

- Designs based on the 2016 King County Surface Water Design Manual, "Reduced Impervious Surface Credit" (Appendix C, Section C.2.9).
- For wheel strip driveways, assume 10-foot-wide by 10-foot-long driveway converted to two (2) concrete pavement strips, each 2-feet-wide by 10-feet-long, for a total of 40 square feet impervious area (60% impervious area reduction).
- Restored pervious areas amended with 4 inches of well-rotted compost tilled into the upper 8 inches of the soil.



DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Change the land cover from existing pollution generating impervious land cover to a land cover representing amended native soil.

Treatment:

- Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.

PERFORMANCE PARAMETERS*

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	--	--
Dissolved Copper	--	--
Total Zinc	--	--
Dissolved Zinc	--	--
Total Phosphorus	--	--
Total Nitrogen	--	--
Total Suspended Solids	--	--
Total PCBs	--	--
Total PBDEs	--	--
Total PAHs	--	--
Bis(2-ethylhexyl)phthalate	--	--
Fecal Coliform	--	--

* Performance will be assessed based on conversion of pollutant generating surface to non-pollutant generating surface

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	Driveway Depaving with Wheel Strips	Driveway Depaving without Alternative Surface
Total Project	\$2,000	\$2,000
Total Direct Construction	\$1,000	\$1,000
Total Indirect Non-Construction	\$1,000	\$1,000
Operation and Maintenance	\$600/year	\$600/year
Property Acquisition ^c	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- The area credited as mitigated must be no more than 10,000 square feet on any one site/lot unless the surface is served by a flow control facility designed by a civil engineer in accordance with Section 1.2.3 of the *2016 King County Surface Water Design Manual*.
- Any runoff from the area credited as mitigated must be directed to vegetated pervious areas on the site/lot or discharged through a perforated pipe connection per Section C.2.11 of the *2016 King County Surface Water Design Manual*.
- Any portion of the area credited as mitigated that is pollution-generating impervious surface must be less than 5,000 square feet on any one site/lot unless the surface is served by a water quality treatment facility designed by a civil engineer in accordance with Section 1.2.8 of the *2016 King County Surface Water Design Manual*.

STORMWATER TREATMENT WETLAND

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

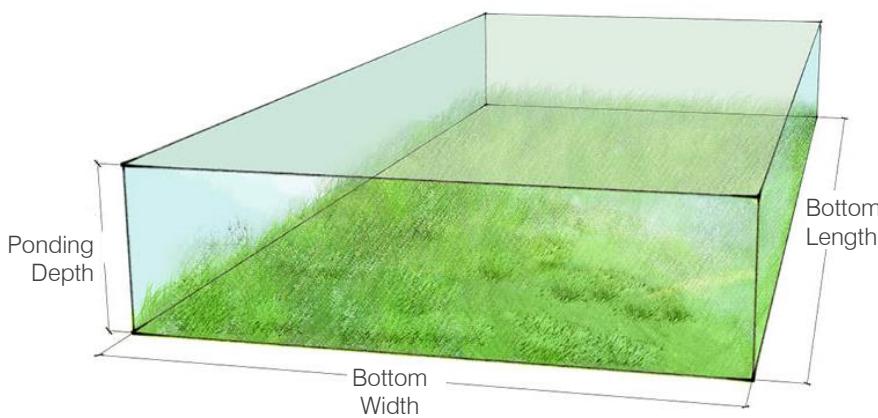
01/14/2022



Photo accessed on 7/2/2020 from

<https://www.portseattle.org/projects/wetlands-and-habitat-restoration>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Similar to a wet pond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal. Provides water quality treatment and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	503 SF
Unit Drainage Area	62,988 SF
Ponding Depth	48 in
Bottom Length	31.5 ft
Bottom Width	16 ft
Side Slope	3H : 1V
Water Quality Design Flow Rate (Off-line)	0.118 cfs
Native Soil Design Infiltration Rate ^a	N/A

a. Not Applicable, any incidental infiltration to native soils ignored.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- | | |
|----------------|------------------|
| • Roofs | • Local Roads |
| • Lawns | • Arterial Roads |
| • Sidewalks | • Highways |
| • Driveway | |
| • Parking Lots | |

DESIGN ASSUMPTIONS

- Design and sizing are based on 2016 King County Surface Water Design Manual Section 6.4.3 "Stormwater Wetlands".
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Sized and designed as a Basic facility.
- Two-cell facility includes:
 - Pre-settling cell with volume equal to one-third the volume of the entire facility and minimum sediment storage depth of 1 foot
 - 1-foot freeboard over entire surface area
 - Dividing berm submerged 1 foot below the WQ design water surface
- No infiltration to native soils.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.

STORMWATER TREATMENT WETLAND

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	25.0%	4.7 µg/L
Dissolved Copper	0.0%	7.8 µg/L
Total Zinc	45.9%	22.5 µg/L
Dissolved Zinc	0.0%	17.9 µg/L
Total Phosphorus	24.2%	0.139 mg-P/L
Total Nitrogen	5.81%	1.371 mg/L
Total Suspended Solids	52.4%	17.0 mg/L
Total PCBs	78.1%	406 pg/L
Total PBDEs	45.1% ^a	0.043 ng/L ^a
Total PAHs	85.6%	0.030 µg/L
Bis(2-ethylhexyl)phthalate	42.4% ^a	0.056 µg/L ^a
Fecal Coliform	19.1%	1450 CFU

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property/Highway without Acquisition
Total Project	\$1,489,000	\$642,000
Total Direct Construction	\$360,000	\$360,000
Total Indirect Non-Construction	\$1,130,000	\$282,000
Operation and Maintenance	\$2,300/year	\$2,300/year
Property Acquisition ^c	\$678,000	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Areas with high winter groundwater levels are ideal for wetland siting.
- Potential site evapotranspiration must be considered as sufficient water must be retained in facility to supply adequate water for aquatic vegetation.
- The pre-settling cell must retain a permanent pool of water throughout the wet season, and the second cell must retain water for at least 10 months of the year.
- Setback required from tract line is 5-feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetland inlet and outlet structures.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 6.2.3 and Section 6.4.2.

DETENTION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



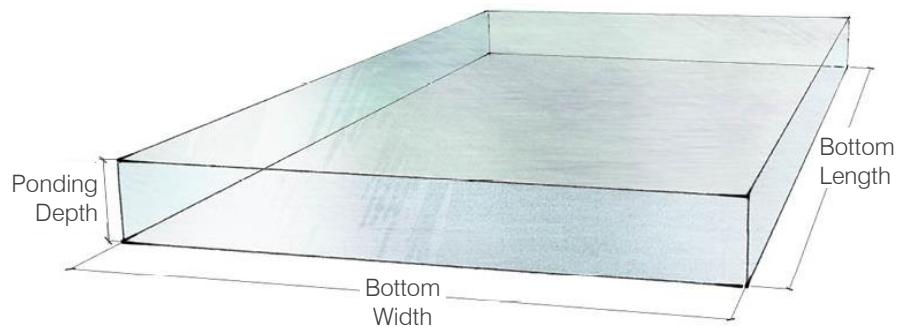
Phase 2

01/14/2022



Photo accessed on 7/2/2020 from
<https://csengineermag.com/>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate. Provides peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	2,592 SF
Unit Drainage Area	28,658 SF
Ponding Depth	72 in
Bottom Length	54 ft
Bottom Width	48 ft
Side Slope	Vertical
Orifice Diameter	1.16 in
Orifice Height	0 ft
Notch Width	0.37 in
Notch Height	2.40 ft

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual*, "Detention Vaults" (Chapter 5, Section 5.1.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet the Level 2 Flow Control standard with pre-developed forest condition.
- The invert elevation of the outlet is elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom.
- The outlet is also elevated a minimum of 2 feet above the orifice to retain oil within the vault.
- Access is provided by a 5-foot by 10-foot removable, locking panel.
- Internal height of 7 feet.



DETENTION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Orifice flow will be represented as a constant outflow rate equal to the water quality design flow rate.

Treatment:

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	26.2% ^b	9.5 µg/L ^b
Dissolved Copper	3.23% ^b	5.3 µg/L ^b
Total Zinc	44.0% ^b	45.2 µg/L ^b
Dissolved Zinc	13.6% ^b	9.5 µg/L ^b
Total Phosphorus	17.7% ^b	0.108 mg-P/L ^b
Total Nitrogen	7.80% ^b	1.04 mg-N/L ^b
Total Suspended Solids	57.6% ^b	25.8 mg/L ^b
Total PCBs	57.6% ^a	685 pg/L ^a
Total PBDEs	56.9%	93.5 ng/L
Total PAHs	52.1%	0.309 µg/L
Bis(2-ethylhexyl)phthalate	46.7% ^a	0.084 µg/L ^a
Fecal Coliform	31.4% ^b	2,600 CFU ^b

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

b. Performance based on detention pond performance which provide similar unit processes for pollutant removal.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$6,965,000	\$6,229,000	\$7,603,000
Total Direct Construction	\$3,519,000	\$3,519,000	\$4,473,000
Total Indirect Non-Construction	\$3,446,000	\$2,710,000	\$3,130,500
Operation and Maintenance	\$4,900/year	\$4,900/year	\$4,900/year
Property Acquisition ^c	\$589,000	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Setbacks to tract/easement lines for vaults shall be 5 feet; adjacent building setback lines shall be 10 feet.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.

DETENTION POND

Water Quality Benefits Evaluation Action Fact Sheet



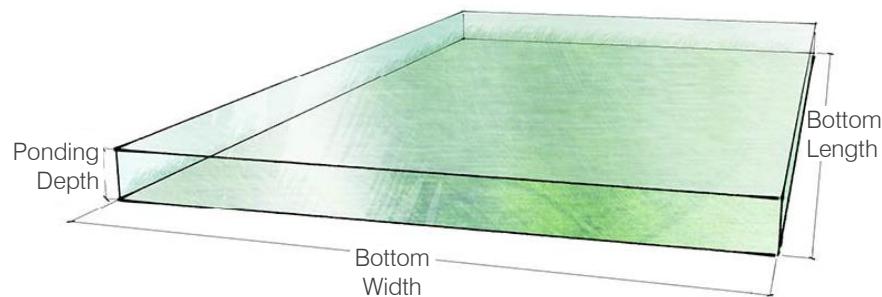
Phase 2

01/14/2022



Photo courtesy of Paradigm

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events. Provides peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	4,500 SF
Unit Drainage Area	36,569 SF
Ponding Depth	48 in
Bottom Length	95 ft
Bottom Width	47.4 ft
Side Slope	3H : 1V
Orifice Diameter	1.41 in
Orifice Elevation	0 ft
Notch Width	0.87 in
Notch Height	1.44 ft

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual*, Chapter 5, Section 5.1.1 "Detention Ponds".
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.



DETENTION POND

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Orifice flow will be represented as a constant outflow rate equal to the water quality design flow rate.
- Design Parameters were modified to accurately represent the Unit Action's performance in SUSTAIN.

Treatment:

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	26.2%	9.5 µg/L
Dissolved Copper	3.23%	5.3 µg/L
Total Zinc	44.0%	43.2 µg/L
Dissolved Zinc	13.6%	29.5 µg/L
Total Phosphorus	17.7%	0.198 mg-P/L
Total Nitrogen	7.80%	1.04 mg/L
Total Suspended Solids	57.6%	25.8 mg/L
Total PCBs	57.6% ^a	685 pg/L ^a
Total PBDEs	56.9% ^b	93.5 ng/L ^b
Total PAHs	52.1% ^b	0.309 µg/L ^b
Bis(2-ethylhexyl)phthalate	46.7% ^a	0.084 µg/L ^a
Fecal Coliform	31.4%	2600 CFU

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

b. Performance based on detention vault performance which provide similar unit processes for pollutant removal.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property/Highway without Acquisition
Total Project	\$2,443,000	\$1,102,000
Total Direct Construction	\$617,000	\$617,000
Total Indirect Non-Construction	\$1,826,000	\$484,000
Operation and Maintenance	\$9,400/year	\$9,400/year
Property Acquisition ^c	\$1,073,000	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Do not locate in dedicated public road right-of-way.
- Must meet the following setbacks:
 - Tract or property line must be setback 5 feet from the emergency overflow water surface
 - The water surface at the pond outlet invert elevation must be setback 100 feet from proposed or existing septic system drainfields
 - Design water surface must be a minimum of 200 feet from any steep slope hazard area or landslide hazard area
 - Design water surface must be setback a minimum distance from top of slope equal to the total vertical height of a slope area that is steeper than 15%
- Additional feasibility and siting considerations can be found in the 2016 King County Surface Water Design Manual Section 5.1.1.

INFILTRATION POND

Water Quality Benefits Evaluation Action Fact Sheet



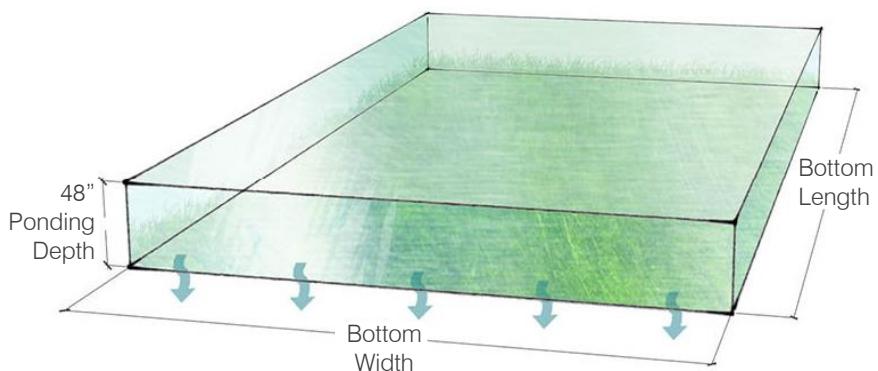
Phase 2

01/14/2022



Photo accessed on 7/2/2020 from
<https://www.stormwater.pca.state.mn.us>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration. Provides volume and peak flow reduction.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	2,785 SF	1,479 SF
Unit Drainage Area	36,595 SF	46,396 SF
Ponding Depth	48 in	48 in
Bottom Length	74.6 ft	54.4 ft
Bottom Width	37.3 ft	27.2 ft
Side Slope	3H : 1V	3H : 1V
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design based on 2016 King County Surface Water Design Manual Chapter 5, Section 5.2.2 "Infiltration Ponds"
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Length-to-width ratio assumed to be 2:1
- Pre-treatment via upstream treatment Action will be provided
- Maintenance access roads must be provided to the control structure and other drainage structures associated with the pond
- An overflow structure and emergency spillway shall be provided

INFILTRATION POND

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition		On Property/Highway without Acquisition	
	In Till Soil	In Outwash Soil	In Till Soil	In Outwash Soil
Total Project	\$1,834,000	\$1,758,000	\$705,000	\$629,000
Total Direct Construction	\$395,000	\$352,000	\$395,000	\$352,000
Total Indirect Non-Construction	\$1,439,000	\$1,405,000	\$310,000	\$276,000
Operation and Maintenance	\$5,500/year	\$3,500/year	\$5,500/year	\$3,500/year
Property Acquisition ^c	\$903,000	\$903,000	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

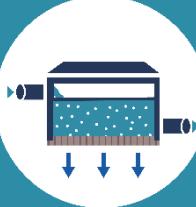
c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
 - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
 - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
 - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
 - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.2.2.

INFILTRATION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

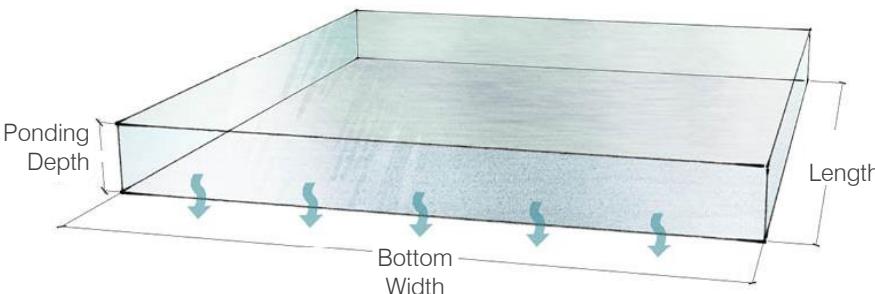
01/14/2022



City of Redmond Overlake Village Infiltration Vault
Photo accessed on 7/2/2020 from

<https://content.govdelivery.com/accounts/WAREDMOND/bulletins/1e5d116>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom. Provides volume reduction and peak flow reduction.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	1,836 SF	1,156 SF
Unit Drainage Area	28,719 SF	39,365 SF
Ponding Depth	72 in	72 in
Bottom Length	51 ft	34 ft
Bottom Width	36 ft	34 ft
Side Slope	Vertical	Vertical
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design based on 2016 King County Surface Water Design Manual Chapter 5, Section 5.2.4 "Infiltration Vaults".
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Pre-treatment via upstream treatment Action will be provided.
- Designs include a solid bottom riser (with clean-out gate) and outflow system for safely discharging overflows to the downstream conveyance system or acceptable discharge point.
- Energy dissipation at the inlet is required to prevent scour and will be accomplished by using the detail for the sand filter vault (see Figure 6.5.3.A in the 2016 King County Surface Water Design Manual).
- Access roads are required to the vault access panel.



INFILTRATION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition		On Property without Acquisition		In Right of Way/ Highway	
	In Till Soil	In Outwash Soil	In Till Soil	In Outwash Soil	In Till Soil	In Outwash Soil
Total Project	\$5,256,000	\$4,238,000	\$4,589,000	\$3,572,000	\$5,253,000	\$4,120,000
Total Direct Construction	\$2,577,000	\$2,009,000	\$2,577,000	\$2,009,000	\$3,008,000	\$2,351,000
Total Indirect Non-Construction	\$2,679,000	\$2,229,000	\$2,012,000	\$1,562,000	\$2,245,000	\$1,769,000
Operation and Maintenance	\$4,900/year	\$4,900/year	\$4,900/year	\$4,900/year	\$4,900/year	\$4,900/year
Property Acquisition ^c	\$533,000	\$533,000	\$0	\$0	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

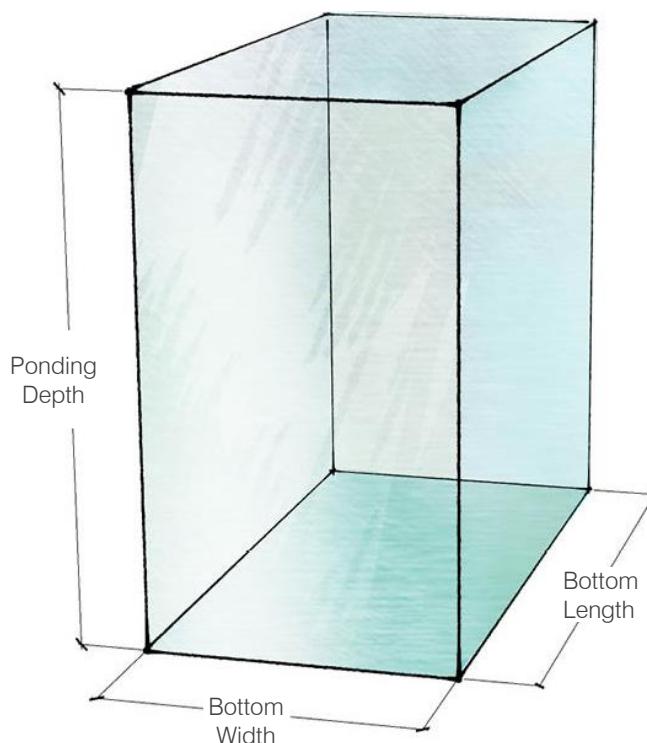
The proposed vault bottom shall be at least 3 feet above the seasonal high groundwater level and have at least 3 feet of permeable soil beneath the bottom.

- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
 - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
 - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
 - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
 - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the 2016 King County Surface Water Design Manual Section 5.2.4.



Freelard RainCatchers
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A tank designed to provide temporary storage and slow release of rooftop stormwater runoff. Provides peak flow reduction.

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Roofs

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	18 SF
Unit Drainage Area	1,300 SF
Ponding Depth	60 in
Bottom Length	6 ft
Bottom Width	3 ft
Orifice Diameter	0.25 in
Orifice Elevation	4 in

DESIGN ASSUMPTIONS

- Design is based on 2017 Seattle SW Manual, Volume 3 Section 5.5.2 “Single Family Residential (SFR) Cisterns”.
- Sizing is based on sizing factors for the On-site Performance Standard from the 2017 Seattle Stormwater Manual Section 5.5.2.6.
- Flow control orifice assumed to be 0.25-inch-diameter at 4-inch-elevation.
- Designs include a filter screen or other debris barrier to prevent insects, leaves, and other larger debris from entering the system.
- Overflow conveyance to an approved discharge or another Action (e.g., bioretention installation, etc.) provided by gravity flow pipe.



SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, orifice flow, and overflow.

Treatment:

- Model will assume no treatment provided unless Program includes manual operation of orifice valve by property owner.

PERFORMANCE PARAMETERS*

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	--	--
Dissolved Copper	--	--
Total Zinc	--	--
Dissolved Zinc	--	--
Total Phosphorus	--	--
Total Nitrogen	--	--
Total Suspended Solids	--	--
Total PCBs	--	--
Total PBDEs	--	--
Total PAHs	--	--
Bis(2-ethylhexyl)phthalate	--	--
Fecal Coliform	--	--

* Action provides negligible water quality benefit

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition
Total Project	\$26,000
Total Direct Construction	\$18,000
Total Indirect Non-Construction	\$8,000
Operation and Maintenance	\$2,100/year
Property Acquisition ^c	\$0

- a. All costs are per unit of Action. See Unit Action Design Parameters table.
b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Contributing drainage areas must not be pollution-generating.
- Cisterns are subject to local code requirements, such as Seattle Municipal Code Title 23 – Land Use Code due to height in excess of 4.5 feet.
- Rainwater shall be used for outdoor irrigation uses only.
- Additional feasibility and siting considerations can be found in the 2017 Seattle Stormwater Manual Volume 3 Section 5.5.2 and Appendix C.

WETPOND

Water Quality Benefits Evaluation Action Fact Sheet



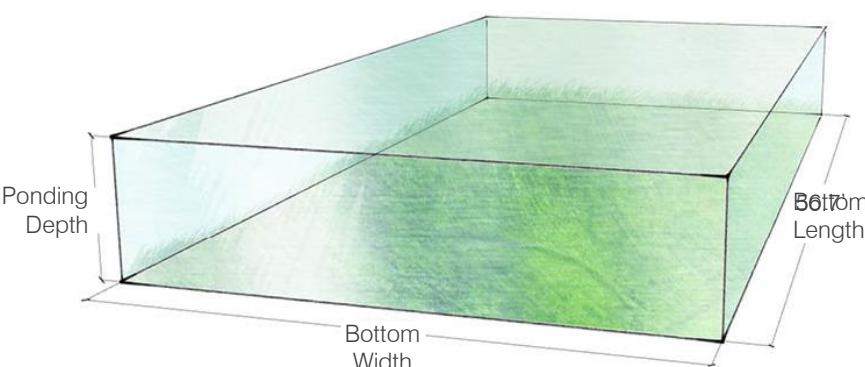
Phase 2

01/14/2022



Photo accessed on 7/2/2020 from
<https://www.redmond.gov/487/Stormwater-Ponds>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	553 SF
Unit Drainage Area	63,075 SF
Ponding Depth	48 in
Bottom Length	33.3 ft
Bottom Width	16.6 ft
Side Slope	3H : 1V
Water Quality Design Flow Rate (Off-line)	0.118 cfs

TREATMENT AREAS

Land Uses:

- Residential
 - Commercial
 - Industrial
 - Highway
 - Agricultural

Property Types:

- Private Parcel
 - Public Parcel
 - Public Right-of-Way

DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.1 “Wetponds”.
 - Sized as Basic facility.
 - Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
 - Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
 - Two-celled facility:
 - Pre-settling cell requires minimum sediment storage depth of 1-foot
 - Diving berm is submerged 1-foot below the Water Quality design water surface
 - No infiltration to surrounding soils.
 - 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.



SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	45.0%	6.0 µg/L
Dissolved Copper	22.7%	4.3 µg/L
Total Zinc	62.5%	24.2 µg/L
Dissolved Zinc	36.8%	19.6 µg/L
Total Phosphorus	49.5%	0.177 mg-P/L
Total Nitrogen	27.6%	1.260 mg/L
Total Suspended Solids	76.2%	16.7 mg/L
Total PCBs	76.2% ^a	443 pg/L ^a
Total PBDEs	65.5% ^a	0.042 ng/L ^a
Total PAHs	76.2% ^a	0.0021 µg/L ^a
Bis(2-ethylhexyl)phthalate	61.7% ^a	0.055 µg/L ^a
Fecal Coliform	60.0%	2381 CFU

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property/Highway without Acquisition
Total Project	\$1,581,000	\$683,000
Total Direct Construction	\$383,000	\$383,000
Total Indirect Non-Construction	\$1,198,000	\$300,000
Operation and Maintenance	\$2,000/year	\$2,000/year
Property Acquisition ^c	\$718,000	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

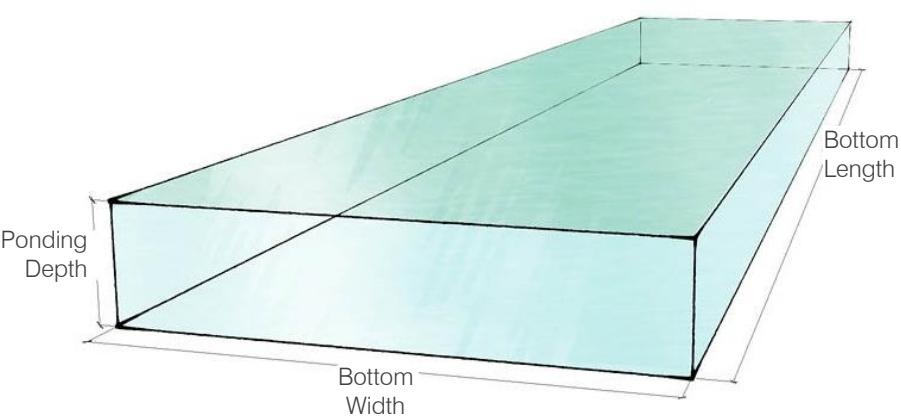
PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Both cells of the wetpond must retain a permanent pool of water throughout the wet season.
- Setback is required from tract line is 5 feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetpond inlet and outlet structures.
- See comprehensive list of infeasibility criteria in Section 6.2.3 and Section 6.4.1.2 of the 2016 King County Surface Water Design Manual.



Photo accessed on 7/2/2020 from:
<http://romtecutilities.com/wet-dry-panel-vault-installation>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	1,615 SF
Unit Drainage Area	63,010 SF
Ponding Depth	48 in
Bottom Length	80 ft
Bottom Width	20.2 ft
Side Slope	Vertical
Water Quality Design Flow Rate (Off-line)	0.118 cfs

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- | | |
|----------------|------------------|
| • Roofs | • Local Roads |
| • Lawns | • Arterial Roads |
| • Sidewalks | • Highways |
| • Driveways | |
| • Parking Lots | |
| • Plazas | |

DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.2 "Basic Wetvaults".
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality (WQ) Design Flow Rate to the Action
- Additional minimum sediment storage of 6 inches required.
- Two-celled facility with cells separated by baffle wall.
- Lockable grates instead of solid manhole covers included in design to increase air contact with the wetpool.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.
- 8-inch-diameter gravity drain controlled by a valve.





SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.

Treatment:

- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	Median Effluent Concentration
Total Copper	45.0% ^b	6.0 µg/L ^b
Dissolved Copper	22.7% ^b	4.3 µg/L ^b
Total Zinc	62.5% ^b	24.2 µg/L ^b
Dissolved Zinc	36.8% ^b	19.6 µg/L ^b
Total Phosphorus	49.5% ^b	0.177 mg-P/L ^b
Total Nitrogen	27.6% ^b	1.260 mg/L ^b
Total Suspended Solids	76.2% ^b	16.7 mg/L ^b
Total PCBs	76.2% ^a	443 pg/L ^a
Total PBDEs	65.5% ^a	0.042 ng/L ^a
Total PAHs	76.2% ^a	0.0021 µg/L ^a
Bis(2-ethylhexyl)phthalate	61.7% ^a	0.055 µg/L ^a
Fecal Coliform	60.0% ^b	2381 CFU ^b

a. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

b. Performance based on wet pond performance which provide similar unit processes for pollutant removal.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$5,728,000	\$5,055,000	\$5,806,000
Total Direct Construction	\$2,852,000	\$2,852,000	\$3,314,000
Total Indirect Non-Construction	\$2,876,000	\$2,203,000	\$2,493,000
Operation and Maintenance	\$2,900/year	\$2,900/year	\$2,900/year
Property Acquisition ^c	\$538,000	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Relatively small catchments (less than 10 acres of impervious surface) with high land values typically most practical because vaults are relatively expensive.
- Must have a flow length-to-width ratio greater than 3:1 minimum.
- 5-foot setback to tract/easement lines required.
- 10-foot setback for buildings adjacent to the vault required.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.
- Additional feasibility and siting considerations can be found in the 2016 King County Surface Water Design Manual Section 5.1.3 and Section 6.4.

HIGH RATE UNDERGROUND FILTER SYSTEM

Water Quality Benefits Evaluation Action Fact Sheet



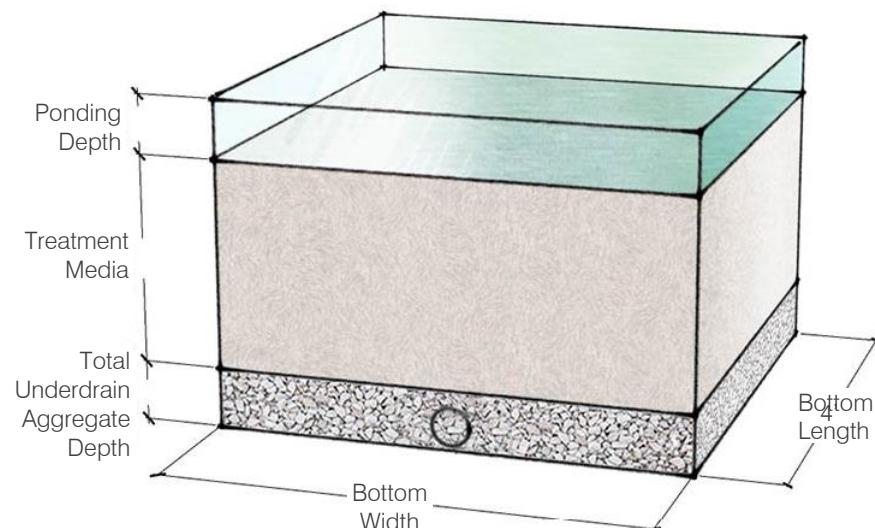
Phase 2

01/14/2022



Filterra® Bioretention System
Photo accessed on 7/2/2020 from
www.conteches.com

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary. Provides water quality treatment.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	16 SF
Unit Drainage Area	34,956 SF
Ponding Depth	2 in
Bottom Length	4 ft
Bottom Width	4 ft
Side Slope	Vertical
Treatment Media Depth	21 in
Treatment Media Porosity	40%
Treatment Media Design Infiltration Rate	175 in/hr
Total Underdrain Aggregate Depth	6 in
Underdrain Invert Height	0 in
Underdrain Diameter	4 in
Underdrain Aggregate Porosity	40%
Native Soil Design Infiltration Rate ^a	N/A
Water Quality Design Flow Rate (Off-line)	0.081 cfs

N/A: Not Applicable

a. Liner prevents infiltration to native soil

TREATMENT AREAS

Land Uses:

- Commercial
- Industrial
- Highway

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads

DESIGN ASSUMPTIONS

- Design is based on standards for Contech® Filterra® Bioscape External Bypass configuration.
- Sizing is based on Washington Department of Ecology (Ecology) General Use Level Designation (GULD) approved infiltration rate of 175 inches/hour for Enhanced Water Quality Treatment.
- Off-line Water Quality Design Flow Rate based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Proprietary Filterra® engineered media assumed. Other proprietary media and facilities may be used. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) for a full list of GULD approved media for Enhanced Water Quality Treatment.
- No infiltration to native soil.

HIGH RATE UNDERGROUND FILTER SYSTEM

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	Median Effluent Concentration ^a
Total Copper	47.9%	4.1 mg/L
Dissolved Copper	34.0%	3.5 mg/L
Total Zinc	55.6%	52.3 mg/L
Dissolved Zinc	54.0%	78.0 mg/L
Total Phosphorus	41.5%	0.046 mg-P/L
Total Nitrogen	34.4%	0.525 mg/L
Total Suspended Solids	86.6%	3.6 mg/L
Total PCBs	90.0%	3,199 pg/L
Total PBDEs	74.5% ^b	0.0090 ng/L ^b
Total PAHs	86.6% ^b	0.00045 µg/L ^b
Bis(2-ethylhexyl)phthalate	70.2% ^b	0.012 µg/L ^b
Fecal Coliform	NF	NF

NF: No data found

a. Performance based on proprietary Filterra® engineered media.

b. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property		Public Right of Way with Portland Cement Concrete Pavements		Public Right of Way with Hot Mix Asphalts	
	With Acquisition	Without Acquisition	Urban ROW	Highway ROW	Urban ROW	Highway ROW
Total Project	\$107,000	\$106,000	\$195,000	\$145,000	\$140,000	\$129,000
Total Direct Construction	\$64,000	\$64,000	\$120,000	\$89,000	\$86,000	\$79,000
Total Indirect Non-Construction	\$43,000	\$42,000	\$75,000	\$56,000	\$54,000	\$50,000
Operation and Maintenance	\$2,900/year	\$2,900/year	\$2,900/year	\$2,900/year	\$2,900/year	\$2,900/year
Property Acquisition ^c	\$900	\$0	\$0	\$0	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the 2016 King County Surface Water Design Manual Section 5.1.3 and Section 6.7.



REGIONAL VEGETATED MEDIA FILTRATION FACILITY

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

ACTION DESCRIPTION

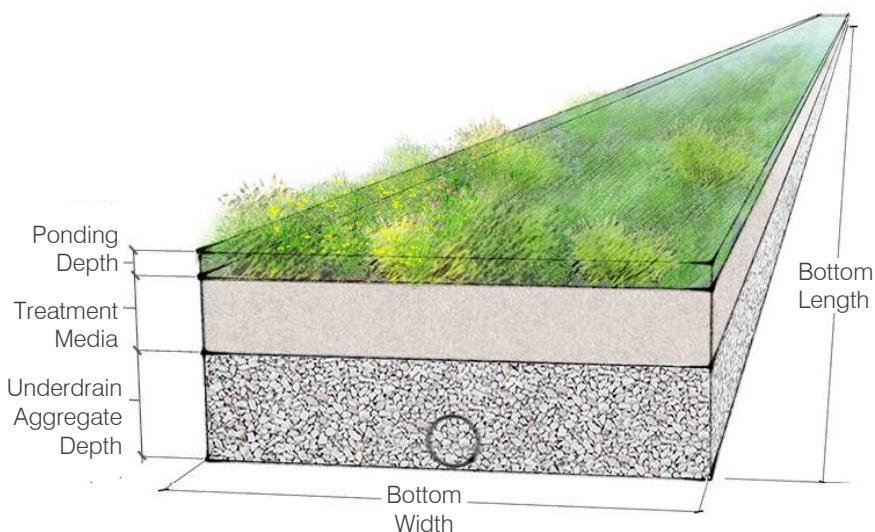
A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area. Provides water quality treatment.



Manchester Stormwater Park
Photo accessed on 7/2/2020 from

<http://nwcascade.com/projects/manchester-stormwater-park/>

UNIT ACTION SCHEMATIC



DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	5,940 SF
Unit Drainage Area	17,249,760 SF
Ponding Depth	8.4 in
Bottom Length	84.9 ft
Bottom Width	70 ft
Treatment Media Depth	21.6 in
Treatment Media Porosity	40%
Treatment Media Design Infiltration Rate	175 in/hr
Total Underdrain Aggregate Depth	18 in
Underdrain Invert Height	0 in
Underdrain Diameter	12 in
Underdrain Aggregate Porosity	40%
Native Soil Design Infiltration Rate ^a	N/A

N/A: Not Applicable

a. Liner prevents infiltration to native soil

TREATMENT AREAS

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural
- Forest

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- | | |
|----------------|------------------|
| • Roofs | • Local Roads |
| • Lawns | • Arterial Roads |
| • Sidewalks | • Highways |
| • Driveways | |
| • Parking Lots | |
| • Plazas | |

DESIGN ASSUMPTIONS

- Design based on *Kitsap County Manchester Stormwater Retrofit Drainage Report, April 2014* (Manchester).
- Manchester design used proprietary Filterra® treatment media. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) website for additional media types that are General Use Level Designation (GULD) approved for Enhanced Water Quality Treatment.
- Unit Footprint Area matches Manchester design bottom footprint area.
- Unit Drainage Area based on Manchester contributing drainage area, scaled as follows:
 - Scaled up by factor of approximately 7 based on the ratio of Ecology's currently approved GULD infiltration rate for Filterra® media for Enhanced Water Quality Treatment of 175 inches/hour to the infiltration rate of 24.8 inches/hour used for Manchester design
 - Scaled down by factor of safety of 1.3 to account for commercial and transportation areas within the Manchester contributing drainage area
- No infiltration to native soil (Manchester facility is concrete-lined).

REGIONAL VEGETATED MEDIA FILTRATION FACILITY

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

01/14/2022

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	Median Effluent Concentration ^a
Total Copper	47.9%	4.1 mg/L
Dissolved Copper	34.0%	3.5 mg/L
Total Zinc	55.6%	52.3 mg/L
Dissolved Zinc	54.0%	78.0 mg/L
Total Phosphorus	41.5%	0.046 mg-P/L
Total Nitrogen	34.4%	0.525 mg/L
Total Suspended Solids	86.6%	3.6 mg/L
Total PCBs	90.0%	3,199 pg/L
Total PBDEs	74.5% ^b	0.0090 ng/L ^b
Total PAHs	86.6% ^b	0.00045 µg/L ^b
Bis(2-ethylhexyl)phthalate	70.2% ^b	0.012 µg/L ^b
Fecal Coliform	NF	NF

NF: No data found

a. Performance based on proprietary Filterra® engineered media.

b. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

UNIT ACTION COSTS

Costs/Unit Action ^{a,b}	On Property with Acquisition	On Property without Acquisition
Total Project	\$7,224,000	\$6,038,000
Total Direct Construction	\$2,965,000	\$2,965,000
Total Indirect Non-Construction	\$4,259,000	\$3,073,000
Operation and Maintenance	\$12,000/year	\$12,000/year
Property Acquisition ^c	\$910,760	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the 2016 King County Surface Water Design Manual Section 6.7.



ATTACHMENT B

Decision Log

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King County Water Quality Benefits Evaluation, Phase 2

Decision Log

Decision					Approved by Design Team		
Decision No.	Date	Topic	Description	Lead	Yes/No	Comments	Date
1	3/25/2021	Model time step	Use 15-min time steps for all modeling in MGSFlood, per KCSWDM Ch 6.2.1.	RKI	Yes	Design Team Meeting	3/25/2021
2	3/25/2021	Level 2 Flow Control	For Actions sized to Level 2 Flow Control in Phase I, model post-developed drainage area as impervious only (vs KC WRRA 9 land use used in Phase I) and seek to hold the Action size equal to the Phase I sizing, while altering the contributing drainage area, in order to maintain Phase I costs if practicable.	RKI	Yes	Design Team Meeting	3/25/2021
3	3/25/2021	Pre-treatment standard	OUTSTANDING ITEM: Revisit pre-treatment standard for pre-treatment Actions at a later date	HEC	Yes	Design Team Meeting; no longer outstanding (see Decision #21)	3/25/2021
4	3/25/2021	Model version	To model rain garden, bioretention and bioretention planter, use original Bioretention model in MGSFlood instead of beta Ecology bioretention module. Discussed that this means the storage/infiltration benefits associated with elevated underdrains will be neglected.	RKI	Yes	Design Team Meeting	3/25/2021
5	3/25/2021	Action modeling	Model rain gardens with a 12-in soil layer with 25% porosity (Phase I) and 6 in/hr infiltration rate	RKI	Yes	Design Team Meeting; Phase I assumed 3" compost tilled into 8" native soil. Increasing tilling depth will not affect basis of estimate.	3/25/2021
6	3/25/2021	Action modeling	Do not include the rain garden area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified in MGSFlood.	RKI	Yes	Design Team Meeting, agreed upon decision based on the City of Seattle Stormwater Manual using the same assumption in developing sizing factors for designers to use.	3/25/2021
7	3/25/2021	Level 2 Flow Control	For Actions sized for Level 2 Flow Control, assume till soils for pre-developed drainage basin (even for infiltration-based Actions in outwash soils). This decision was made for consistency with Phase I and to acknowledge that soil conditions across a contributing drainage area may vary from the soil conditions at the Action site itself.	RKI	Yes	Agreed upon with Jeff Burkey via email	3/31/2021
8	3/25/2021	Action modeling	Model drywell as an infiltration pond, using equivalent depth to address gravel porosity in drywell (i.e., 40% porosity X 6-ft depth = 2.4-ft equivalent depth)	RKI	Yes	Design Team Meeting; Modeling as an infiltration trench produces computational errors in MGSFlood	3/25/2021
9	3/25/2021	Action modeling	Do not explicitly model permeable pavement; the Action will be designed to the King County standard and thus will treat to the required standard. Confirm standard section will meet the KC standard so that the costs are based on the correct section design.	RKI	Yes	Design Team Meeting	3/25/2021
10	3/25/2021	Action modeling	Update modeled Length:Width ratios to match HDR's cost spreadsheets from Phase I	RKI	Yes	Design Team Meeting	3/25/2021



King County Water Quality Benefits Evaluation, Phase 2

Decision Log

Decision					Approved by Design Team		
Decision No.	Date	Topic	Description	Lead	Yes/No	Comments	Date
11	3/25/2021	Action modeling	Model drywell and cistern to Modified Level 1 Flow Control Standard (i.e., match the 2- and 10-year peak discharge rates from pre-developed forested to post developed)	RKI	Yes	Agreed upon with Jeff Burkey via email. Determined, however, during preliminary modeling, that the standard is impracticable for cisterns. Therefore, maintained the Phase 1 sizing for cisterns. See Decision #18.	3/31/2021
12	3/25/2021	Action modeling	Assume 6-in freeboard for bioretention planter (minimum required for King County)	RKI	Yes	Design team meeting; Phase I HDR cost spreadsheet assumed 12-inch freeboard	3/25/2021
13	4/2/2021	Action modeling	RKI to use low (32in) and high values (60in) for Puget East climate region in MGSFlood. RKI to produce relationships between Mean Annual Precipitation and Contributing Drainage Area for the affected Actions (all Actions being explicitly modeled).	RKI	Yes	Modeling Team Meeting	4/2/2021
14	4/14/2021	Action modeling	Use 0.5-in minimum diameter orifice for flow control facilities.	HEC	Yes	Originally we assumed 0.25" minimum diameter orifice for flow control facilities based on KCSWDM Ch 5.1.4.1 Control Structures, Design Criteria, however after team discussion we noted that 0.5-in is more realistic regarding the Actions' drainage areas.	4/14/2021
15	4/22/2021	Action modeling	Revision to Decision #4 (3/25/2021): We ran a test to model the area underneath the underdrain as an infiltration trench upstream of the bioretention facility. The results indicated 7% additional contributing area could be treated when you account for the elevated underdrain by modeling in this way. To achieve the benefits of the elevated underdrain, a site would have to be relatively flat (i.e., <2%) or have subsurface weirs installed, which was not accounted for in the costs. Therefore, partial credit of 5% will be provided.	RKI	Yes	Design Team Meeting	4/28/2021
16	4/28/2021	Action Modeling	Revision to Decision #13 (4/2/2021): Based on Climate Region sensitivity analysis in MGSFlood, RKI to use Puget East 32, Puget East 40, and Puget East 60 MAP factors for low-, mid- and high- climate region factor values in MGSFlood.	RKI	Yes	Design Team Meeting	4/28/2021



King County Water Quality Benefits Evaluation, Phase 2

Decision Log

Decision					Approved by Design Team		
Decision No.	Date	Topic	Description	Lead	Yes/No	Comments	Date
17	4/29/2021	Action Modeling	For Infiltration Actions with sideslopes (bioretention, rain garden, infiltration ponds), these trapezoidal Actions will be modeled in MGSFlood to meet required standard, then transformed into a rectangular facility to represent a SUSTAIN model input. Transformation will occur by adjusting the ponding depth and bottom area in order to maintain the total volume (ponded + void volume) and the wetted perimeter consistent with the unaltered design cross-section. For non-infiltrating Actions with sideslopes, the transformation to a rectangular facility will occur by holding the total volume consistent during the transformation, and bottom footprint will be the average of the ponded and bottom area from the trapezoidal representation. For both types of Actions (infiltrating and non-infiltrating), after the transformation, bottom areas will be adjusted to meet the required standard (e.g., Basic Water Quality or Level 2 Flow Control)	RKI	Yes	Modeling Team Meeting	4/29/2021
18	4/29/2021	Action Modeling	Revision to Decision #11 (3/25/2021): Phase 1 sizing factors for cisterns (sized for Seattle Peak Control Standard) will be used for sizing in Phase 2 instead of explicitly modeling in MGSFlood using the Modified Level 1 Flow Control Standard (match 2- and 10-year peak discharge rates for pre-developed forested conditions and post-developed conditions). The Phase 1 design low-flow orifice size (0.25-in) produces an error in MGSFlood.	RKI	Yes	Design Team Meeting. While MGSFlood produces an error, the program still allows user to run the model. However, the proposed Modified Level 1 Flow Control Standard is unable to be met with the cistern configuration.	5/5/2021
19	5/5/2021	Action Modeling	Revision to Decision #2 (3/25/2021): Level 2 Flow Control facilities will be modeled using pre-unitized bottom areas from Phase 1, and maintaining the bottom footprint and adjusting the contributing area to meet the flow control standard. Unit Action footprint and respective Unit Action contributing area will be calculated by dividing both the bottom footprint and the new required drainage area by 10. The resulting Unit Action will be a footprint consistent with Phase 1, but a new contributing area.	HEC	Yes	Design Team Meeting	5/5/2021
20	5/5/2021	Action Modeling	For Actions with sideslopes (bioretention, rain garden, infiltration ponds and detention ponds), MGSFlood models that incorporate the precipitation/evaporation scaling factors will be based on facilities that have been transformed from trapezoidal ponds to rectangular ponds for SUSTAIN input. See Decision #17 for more information on Action transformation for SUSTAIN input.	RKI	Yes	Design Team Meeting	5/5/2021
21	5/5/2021	Action Modeling	Revision to Decision #3 (3/25/2021): For Actions paired with Bioretention Planter for pretreatment, model the planter using the bottom areas provided in Phase 1, and adjust the contributing area to match the water quality treatment standard (treat 91% of average annual runoff).	RKI	Yes	Design Team Meeting. The limiting factor in this modeling methodology is the bioretention planter; however team will confirm that downstream Action is able to handle the modeled flow through the bioretention planter.	5/5/2021

King County Water Quality Benefits Evaluation, Phase 2

Decision Log

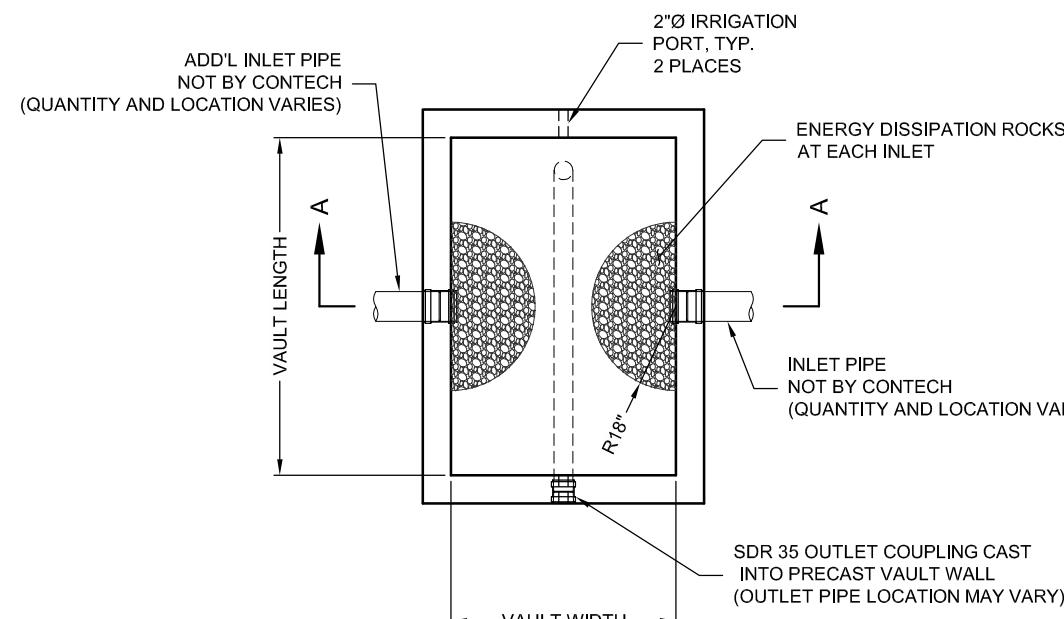


Decision					Approved by Design Team		
Decision No.	Date	Topic	Description	Lead	Yes/No	Comments	Date
22	5/11/2021	Action Fact Sheets	The target audience for the Action Fact Sheets is the design community. Therefore, the Design Parameters table on the first page of each Fact Sheet will contain design values that were used for Action costing (second page of each Fact Sheet). The Action Fact Sheets are not targeted to SUSTAIN modelers and will therefore not present details of SUSTAIN modeling or Unit Action transformations as may be necessary to represent the Unit Action in SUSTAIN. SUSTAIN modeling will be documented separately.	RKI	Yes	Check-in meeting with Olivia and John on 5/11/21, ahead of major deliverable due on 5/17/21.	5/11/2021

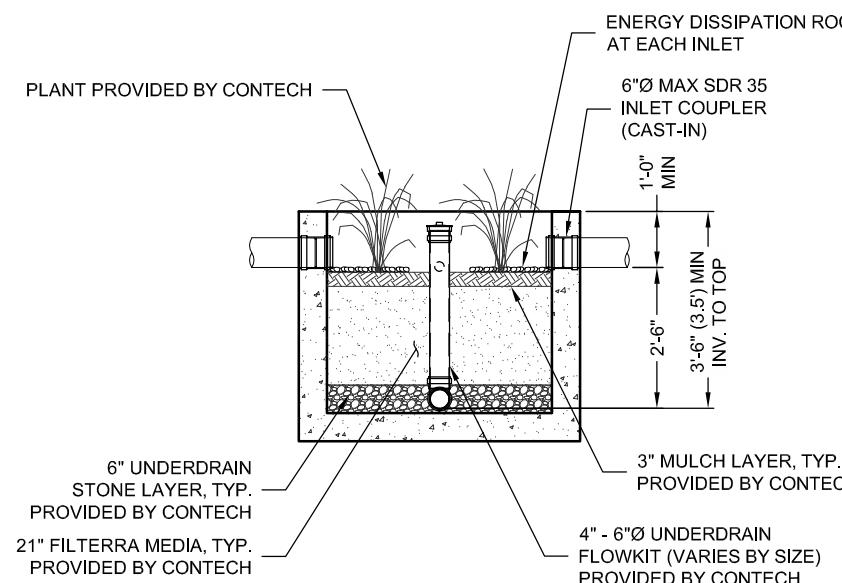
ATTACHMENT C

Contech Filterra ® Bioscape External Bypass System Specifications

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PLAN VIEW



SECTION A-A

INTERNAL PIPE CONFIGURATION MAY VARY
DEPENDING UPON OUTLET LOCATION.

FTBSV-P CONFIGURATION					
DESIGNATION	AVAILABILITY	MEDIA BAY SIZE	VAULT SIZE (L x W)	OUTLET PIPE	MIN NO. OF INLET PIPES
FTBSV0404-P	ALL	4 x 4	4 x 4	4" SDR 35	1
FTBSV0604-P	N/A CA	6 x 4	6 x 4	4" SDR 35	1
FTBSV0606-P	ALL	6 x 6	6 x 6	4" SDR 35	1
FTBSV06504-P	CA ONLY	6.5 x 4	6.5 x 4	4" SDR 35	1
FTBSV078045-P	MID-ATL ONLY	7.83 x 4.5	7.83 x 4.5	4" SDR 35	1
FTBSV0804-P	N/A MID-ATL	8 x 4	8 x 4	4" SDR 35	1
FTBSV0806-P	ALL	8 x 6	8 x 6	4" SDR 35	1
FTBSV1006-P	ALL	10 x 6	10 x 6	6" SDR 35	2
FTBSV1206-P	ALL	12 x 6	12 x 6	6" SDR 35	2
FTBSV1307-P	ALL	13 x 7	13 x 7	6" SDR 35	2
FTBSV1408-P	CALL CONTECH	14 x 8	14 x 8	6" SDR 35	3
FTBSV1608-P	CALL CONTECH	16 x 8	16 x 8	6" SDR 35	3
FTBSV1808-P	CALL CONTECH	18 x 8	18 x 8	6" SDR 35	3
FTBSV2008-P	CALL CONTECH	20 x 8	20 x 8	6" SDR 35	4
FTBSV2208-P	CALL CONTECH	22 x 8	22 x 8	6" SDR 35	4

N/A = NOT AVAILABLE

<small>The design and information shown on this drawing is provided as a service to the project owner, engineer and contractor by Contech Engineered Solutions LLC or one of its affiliated companies ("Contech"). Neither this drawing, nor any part thereof, may be used, reproduced or modified in any manner without the prior written consent of Contech. Failure to comply is done at the user's own risk and Contech expressly disclaims any liability or responsibility for such use. If discrepancies between the supplied information upon which the drawing is based and actual field conditions are encountered as site work progresses, these discrepancies must be reported to Contech immediately for re-evaluation of the design. Contech accepts no liability for designs based on missing, incomplete or inaccurate information supplied by others.</small>
 CONTECH ENGINEERED SOLUTIONS LLC www.ContechES.com 9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069 800-338-1122 513-645-7000 513-645-7993 FAX

**FILTERRA BIOSCAPE VAULT OFFLINE
WITH PIPE INLET (FTBSV-P)
CONFIGURATION DETAIL**

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ATTACHMENT D

Contech Filterra ® General Use Level Designation for Basic (TSS) Enhanced, Phosphorus & Oil Treatment

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February 2020

GENERAL USE LEVEL DESIGNATION FOR BASIC (TSS), ENHANCED, PHOSPHORUS & OIL TREATMENT

For

CONTECH Engineered Solutions Filterra®

Ecology's Decision:

Based on Contech's submissions, including the Final Technical Evaluation Reports, dated August 2019, March 2014, December 2009, and additional information provided to Ecology dated October 9, 2009, Ecology hereby issues the following use level designations:

1. A General Use Level Designation for Basic, Enhanced, Phosphorus, and Oil Treatment for the Filterra® system constructed with a minimum media thickness of 21 inches (1.75 feet), at the following water quality design hydraulic loading rates:

Treatment	Infiltration Rate (in/hr) for use in Sizing
Basic	175
Phosphorus	100
Oil	50
Enhanced	175

2. The Filterra is not appropriate for oil spill-control purposes.
3. Ecology approves Filterra systems for treatment at the hydraulic loading rates listed above, and sized based on the water quality design flow rate for an off-line system. Calculate the water quality design flow rates using the following procedures:

- Western Washington: for treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model.
- Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three flow rate based methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
- Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.

4. This General Use Level Designation has no expiration date, but Ecology may revoke or amend the designation, and is subject to the conditions specified below.

Ecology's Conditions of Use:

Filterra systems shall comply with these conditions shall comply with the following conditions:

1. Design, assemble, install, operate, and maintain the Filterra systems in accordance with applicable Contech Filterra manuals and this Ecology Decision.
2. The minimum size filter surface-area for use in Washington is determined by using the design water quality flow rate (as determined in this Ecology Decision, Item 3, above) and the Infiltration Rate from the table above (use the lowest applicable Infiltration Rate depending on the level of treatment required). Calculate the required area by dividing the water quality design flow rate (cu-ft/sec) by the Infiltration Rate (converted to ft/sec) to obtain required surface area (sq-ft) of the Filterra unit.
3. Each site plan must undergo Contech Filterra review before Ecology can approve the unit for site installation. This will ensure that design parameters including site grading and slope are appropriate for use of a Filterra unit.
4. Filterra media shall conform to the specifications submitted to and approved by Ecology and shall be sourced from Contech Engineered Solutions, LLC with no substitutions.
5. Maintenance includes removing trash, degraded mulch, and accumulated debris from the filter surface and replacing the mulch layer. Use inspections to determine the site-specific maintenance schedules and requirements. Follow maintenance procedures given in the most recent version of the Filterra Operation and Maintenance Manual.
6. Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a “one size fits all” maintenance cycle for a particular model/size of manufactured treatment device.
 - Contech designs Filterra systems for a target maintenance interval of 6 months in the Pacific Northwest. Maintenance includes removing and replacing the mulch layer above the media along with accumulated sediment, trash, and captured organic materials therein, evaluating plant health, and pruning the plant if deemed necessary.
 - Conduct maintenance following manufacturer’s guidelines.

7. Filterra systems come in standard sizes.

8. Install the Filterra in such a manner that flows exceeding the maximum Filterra operating rate are conveyed around the Filterra mulch and media and will not resuspend captured sediment.
9. Discharges from the Filterra units shall not cause or contribute to water quality standards violations in receiving waters.

Approved Alternate Configurations

Filterra Internal Bypass - Pipe (FTIB-P)

1. The Filterra® Internal Bypass – Pipe allows for piped-in flow from area drains, grated inlets, trench drains, and/or roof drains. Design capture flows and peak flows enter the structure through an internal slotted pipe. Filterra® inverted the slotted pipe to allow design flows to drop through to a series of splash plates that then disperse the design flows over the top surface of the Filterra® planter area. Higher flows continue to bypass the slotted pipe and convey out the structure.
2. To select a FTIB-P unit, the designer must determine the size of the standard unit using the sizing guidance described above.

Filterra Internal Bypass – Curb (FTIB-C)

1. The Filterra® Internal Bypass –Curb model (FTIB-C) incorporates a curb inlet, biofiltration treatment chamber, and internal high flow bypass in one single structure. Filterra® designed the FTIB-C model for use in a “Sag” or “Sump” condition and will accept flows from both directions along a gutter line. An internal flume tray weir component directs treatment flows entering the unit through the curb inlet to the biofiltration treatment chamber. Flows in excess of the water quality treatment flow rise above the flume tray weir and discharge through a standpipe orifice; providing bypass of untreated peak flows. Americast manufactures the FTIB-C model in a variety of sizes and configurations and you may use the unit on a continuous grade when a single structure providing both treatment and high flow bypass is preferred. The FTIB-C model can also incorporate a separate junction box chamber to allow larger diameter discharge pipe connections to the structure.
2. To select a FTIB-C unit, the designer must determine the size of the standard unit using the sizing guidance described above.

Filterra® Shallow

1. The Filterra Shallow provides additional flexibility for design engineers and designers in situations where various elevation constraints prevent application of a standard Filterra configuration. Engineers can design this system up to six inches shallower than any of the previous Filterra unit configurations noted above.
2. Ecology requires that the Filterra Shallow provide a media contact time equivalent to that of the standard unit. This means that with a smaller depth of media, the surface area must increase.
3. To select a Filterra Shallow System unit, the designer must first identify the size of the standard unit using the modeling guidance described above.
4. Once the size of the standard Filterra unit is established using the sizing technique described above, use information from the following table to select the appropriate size Filterra Shallow System unit.

Shallow Unit Basic, Enhanced, and Oil Treatment Sizing

Standard Depth	Equivalent Shallow Depth
4x4	4x6 or 6x4
4x6 or 6x4	6x6
4x8 or 8x4	6x8 or 8x6
6x6	6x10 or 10x6
6x8 or 8x6	6x12 or 12x6
6x10 or 10x6	13x7

Notes:

1. Shallow Depth Boxes are less than the standard depth of 3.5 feet but no less than 3.0 feet deep (TC to INV).

Applicant:

Contech Engineered Solutions, LLC.

Applicant's Address:

11815 NE Glenn Widing Drive
Portland, OR 97220

Application Documents:

- State of Washington Department of Ecology Application for Conditional Use Designation, Americast (September 2006)
- Quality Assurance Project Plan Filterra® Bioretention Filtration System Performance Monitoring, Americast (April 2008)
- Quality Assurance Project Plan Addendum Filterra® Bioretention Filtration System Performance Monitoring, Americast (June 2008)
- Draft Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (August 2009)
- Final Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (December 2009)
- Technical Evaluation Report Appendices Filterra® Bioretention Filtration System Performance Monitoring, Americast, (August 2009)
- Memorandum to Department of Ecology Dated October 9, 2009 from Americast, Inc. and Herrera Environmental Consultants
- Quality Assurance Project Plan Filterra® Bioretention System Phosphorus treatment and Supplemental Basic and Enhanced Treatment Performance Monitoring, Americast (November 2011)
- Filterra® letter August 24, 2012 regarding sizing for the Filterra® Shallow System.
- University of Virginia Engineering Department Memo by Joanna Crowe Curran, Ph. D dated March 16, 2013 concerning capacity analysis of Filterra® internal weir inlet tray.
- Terraphase Engineering letter to Jodi Mills, P.E. dated April 2, 2013 regarding Terraflume Hydraulic Test, Filterra® Bioretention System and attachments.
- Technical Evaluation Report, Filterra® System Phosphorus Treatment and Supplemental Basic Treatment Performance Monitoring. March 27th, 2014.
- State of Washington Department of Ecology Application for Conditional Use Level Designation, Contech Engineered Solutions (May 2015)

- Quality Assurance Project Plan Filterra® Bioretention System, Contech Engineered Solutions (May 2015)
- Filterra Bioretention System Armco Avenue General Use Level Designation Technical Evaluation Report, Contech Engineered Solutions (August 2019)

Applicant's Use Level Request:

General Level Use Designation for Basic (175 in/hr), Enhanced (175 in/hr), Phosphorus (100 in/hr), and Oil Treatment (50 in/hr).

Applicant's Performance Claims:

Field-testing and laboratory testing show that the Filterra® unit is promising as a stormwater treatment best management practice and can meet Ecology's performance goals for basic, enhanced, phosphorus, and oil treatment.

Findings of Fact:

Field Testing 2015-2019

1. Contech completed field testing of a 4 ft. x 4 ft. Filterra® unit at one site in Hillsboro, Oregon from September 2015 to July 2019. Throughout the monitoring period a total of 24 individual storm events were sampled, of which 23 qualified for TAPE sampling criteria.
2. Contech encountered several unanticipated events and challenges that prevented them from collecting continuous flow and rainfall data. An analysis of the flow data from the sampled events, including both the qualifying and non-qualifying events, demonstrated the system treated over 99 % of the influent flows. Peak flows during these events ranged from 25 % to 250 % of the design flow rate of 29 gallons per minute.
3. Of the 23 TAPE qualified sample events, 13 met requirements for TSS analysis. Influent concentrations ranged from 20.8 mg/L to 83 mg/L, with a mean concentration of 46.3 mg/L. The UCL95 mean effluent concentration was 15.9 mg/L, meeting the 20 mg/L performance goal for Basic Treatment.
4. All 23 TAPE qualified sample events met requirements for dissolved zinc analysis. Influent concentrations range from 0.0384 mg/L to 0.2680 mg/L, with a mean concentration of 0.0807 mg/L. The LCL 95 mean percent removal was 62.9 %, meeting the 60 % performance goal for Enhanced Treatment.
5. Thirteen of the 23 TAPE qualified sample events met requirements for dissolved copper analysis. Influent concentrations ranged from 0.00543 mg/L to 0.01660 mg/L, with a mean concentration of 0.0103 mg/L. The LCL 95 mean percent removal was 41.2 %, meeting the 30 % performance goal for Enhanced Treatment.
6. Total zinc concentrations were analyzed for all 24 sample events. Influent EMCs for total zinc ranged from 0.048 mg/L to 5.290 mg/L with a median of 0.162 mg/L. Corresponding effluent EMCs for total zinc ranged from 0.015 mg/L to 0.067 mg/L with a median of

0.029 mg/L. Total event loadings for the study for total zinc were 316.85 g at the influent and 12.92 g at the effluent sampling location, resulting in a summation of loads removal efficiency of 95.9 %.

7. Total copper concentrations were analyzed for all 24 sample events. Influent EMCs for total copper ranged from 0.003 mg/L to 35.600 mg/L with a median value of 0.043 mg/L. Corresponding effluent EMCs for total copper ranged from 0.002 mg/L to 0.015 mg/L with a median of 0.004 mg/L. Total event loadings for total copper for the study were 1,810.06 g at the influent and 1.90 g at the effluent sampling location, resulting in a summation of loads removal efficiency of 99.9 %.

Field Testing 2013

1. Filterra completed field-testing of a 6.5 ft x 4 ft. unit at one site in Bellingham, Washington. Continuous flow and rainfall data collected from January 1, 2013 through July 23, 2013 indicated that 59 storm events occurred. Water quality data was obtained from 22 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. The system treated 98.9 % of the total 8-month runoff volume during the testing period. Consequently, the system achieved the goal of treating 91 % of the volume from the site. Stormwater runoff bypassed Filterra treatment during four of the 59 storm events.
3. Of the 22 sampled events, 18 qualified for TSS analysis (influent TSS concentrations ranged from 25 to 138 mg/L). The data were segregated into sample pairs with influent concentration greater than and less than 100 mg/L. The UCL95 mean effluent concentration for the data with influent less than 100 mg/L was 5.2 mg/L, below the 20-mg/L threshold. Although the TAPE guidelines do not require an evaluation of TSS removal efficiency for influent concentrations below 100 mg/L, the mean TSS removal for these samples was 90.1 %. Average removal of influent TSS concentrations greater than 100 mg/L (three events) was 85 %. In addition, the system consistently exhibited TSS removal greater than 80 % at flow rates equivalent to a 100 in/hr infiltration rate and was observed at 150 in/hr.
4. Ten of the 22 sampled events qualified for TP analysis. Americast augmented the dataset using two sample pairs from previous monitoring at the site. Influent TP concentrations ranged from 0.11 to 0.52 mg/L. The mean TP removal for these twelve events was 72.6 %. The LCL95 mean percent removal was 66.0, well above the TAPE requirement of 50 %. Treatment above 50 % was evident at 100 in/hr infiltration rate and as high as 150 in/hr. Consequently, the Filterra test system met the TAPE Phosphorus Treatment goal at 100 in/hr. Influent ortho-P concentrations ranged from 0.005 to 0.012 mg/L; effluent ortho-P concentrations ranged from 0.005 to 0.013 mg/L. The reporting limit/resolution for the ortho-P test method is 0.01 mg/L, therefore the influent and effluent ortho-P concentrations were both at and near non-detect concentrations.

Field Testing 2008-2009

1. Filterra completed field-testing at two sites at the Port of Tacoma. Continuous flow and rainfall data collected during the 2008-2009 monitoring period indicated that 89 storm events occurred. The monitoring obtained water quality data from 27 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. During the testing at the Port of Tacoma, 98.96 to 99.89 % of the annual influent runoff volume passed through the POT1 and POT2 test systems respectively. Stormwater runoff bypassed the POT1 test system during nine storm events and bypassed the POT2 test system during one storm event. Bypass volumes ranged from 0.13 % to 15.3% of the influent storm volume. Both test systems achieved the 91 % water quality treatment-goal over the 1-year monitoring period.
3. Consultants observed infiltration rates as high as 133 in/hr during the various storms. Filterra did not provide any paired data that identified percent removal of TSS, metals, oil, or phosphorus at an instantaneous observed flow rate.
4. The maximum storm average hydraulic loading rate associated with water quality data is <40 in/hr, with the majority of flow rates < 25 in/hr. The average instantaneous hydraulic loading rate ranged from 8.6 to 53 in/hr.
5. The field data showed a removal rate greater than 80 % for TSS with an influent concentration greater than 20 mg/L at an average instantaneous hydraulic loading rate up to 53 in/hr (average influent concentration of 28.8 mg/L, average effluent concentration of 4.3 mg/L).
6. The field data showed a removal rate generally greater than 54 % for dissolved zinc at an average instantaneous hydraulic loading rate up to 60 in/hr and an average influent concentration of 0.266 mg/L (average effluent concentration of 0.115 mg/L).
7. The field data showed a removal rate generally greater than 40 % for dissolved copper at an average instantaneous hydraulic loading rate up to 35 in/hr and an average influent concentration of 0.0070 mg/L (average effluent concentration of 0.0036 mg/L).
8. The field data showed an average removal rate of 93 % for total petroleum hydrocarbon (TPH) at an average instantaneous hydraulic loading rate up to 53 in/hr and an average influent concentration of 52 mg/L (average effluent concentration of 2.3 mg/L). The data also shows achievement of less than 15 mg/L TPH for grab samples. Filterra provided limited visible sheen data due to access limitations at the outlet monitoring location.
9. The field data showed low percentage removals of total phosphorus at all storm flows at an average influent concentration of 0.189 mg/L (average effluent concentration of 0.171 mg/L). We may relate the relatively poor treatment performance of the Filterra system at this location to influent characteristics for total phosphorus that are unique to the Port of Tacoma site. It appears that the Filterra system will not meet the 50 % removal performance goal when the majority of phosphorus in the runoff is expected to be in the dissolved form.

Laboratory Testing

1. Filterra performed laboratory testing on a scaled down version of the Filterra unit. The lab data showed an average removal from 83-91 % for TSS with influents ranging from 21 to 320 mg/L, 82-84 % for total copper with influents ranging from 0.94 to 2.3 mg/L, and 50-61 % for orthophosphate with influents ranging from 2.46 to 14.37 mg/L.
2. Filterra conducted permeability tests on the soil media.
3. Lab scale testing using Sil-Co-Sil 106 showed removals ranging from 70.1 % to 95.5 % with a median removal of 90.7 %, for influent concentrations ranging from 8.3 to 260 mg/L. Filterra ran these laboratory tests at an infiltration rate of 50 in/hr.
4. Supplemental lab testing conducted in September 2009 using Sil-Co-Sil 106 showed an average removal of 90.6 %. These laboratory tests were run at infiltration rates ranging from 25 to 150 in/hr for influent concentrations ranging from 41.6 to 252.5 mg/L. Regression analysis results indicate that the Filterra system's TSS removal performance is independent of influent concentration in the concentration rage evaluated at hydraulic loading rates of up to 150 in/hr.

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Ecology web link: <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html>

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Water Quality Program
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Date	Revision
December 2009	GULD for Basic, Enhanced, and Oil granted, CULD for Phosphorus
September 2011	Extended CULD for Phosphorus Treatment
September 2012	Revised design storm discussion, added Shallow System.
January 2013	Revised format to match Ecology standards, changed Filterra contact information
February 2013	Added FTIB-P system
March 2013	Added FTIB-C system
April 2013	Modified requirements for identifying appropriate size of unit

June 2013	Modified description of FTIB-C alternate configuration
March 2014	GULD awarded for Phosphorus Treatment. GULD updated for a higher flow-rate for Basic Treatment.
June 2014	Revised sizing calculation methods
March 2015	Revised Contact Information
June 2015	CULD for Basic and Enhanced at 100 in/hr infiltration rate
September 2019	GULD for Basic and Enhanced at 175 in/hr infiltration rate
February 2020	Revised sizing language to note sizing based on off-line calculations.

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ATTACHMENT E

Phase 2 Modeling Assumptions Matrices for MGSFlood Modeling

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Inputs and Assumptions		Notes
Action Description		
Action Name	Rain Garden	
Soil Type	Till	
Phase 1 Assumptions		
Sizing Standard	Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard	
Drainage Area	532 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Basic Water Quality Treatment Standard	Rain Gardens are not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard.	
Drainage Area	Do not include the rain garden area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified.	Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the rain garden Action lies outside the drainage area, no need for drainage area adjustments.
Pre developed	Impervious	
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Bioretention	Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Module Schematic		
Ponding Depth	0.5 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	From Rain Garden Installation Cost Estimate spreadsheet (HDR)
Overflow Diameter	12 in	Note that HDR cost estimate assumes 6-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip
Bioretention Soil Porosity	25%	Phase 1 Action Fact Sheet
Bioretention Soil Thickness	1 ft	3" compost tilled into 12" depth, modeled as 12" layer (confirmed in 3/25/21 meeting with HEC, see Design Decision Log)
Bioretention Soil Infiltration Rate	6 in/hr	Confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Native Soil Infiltration Rate	0.3 in/hr	Phase 1 Action Fact Sheet
Infiltration Area	Bottom and Sides	Phase 1 Action Fact Sheet
Side Slopes	3H:1V (Long sides), Vertical (Short sides)	Phase 1 Action Fact Sheet
Bottom Area	25 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	7.08 ft	
Bottom Width	3.54 ft	
Underdrain	N/A	Phase 1 Action Fact Sheet



Inputs and Assumptions		Notes
Action Description		
Action Name	Rain Garden	
Soil Type	Outwash	
Phase 1 Assumptions		
Sizing Standard	Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.19, Sloped sides), Water Quality Treatment Standard	
Drainage Area	2500 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Basic Water Quality Treatment Standard	Rain Gardens are not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard.	
Drainage Area	Do not include the rain garden area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified.	Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the rain garden Action lies outside the drainage area, no need for drainage area adjustments.
Pre developed	Impervious	
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Bioretention	Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Model Schematic		
Ponding Depth	0.5 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	From Rain Garden Installation Cost Estimate spreadsheet (HDR)
Overflow Diameter	12 in	Note that HDR cost estimate assumes 6-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip
Bioretention Soil Porosity	25%	Phase 1 Action Fact Sheet
Bioretention Soil Thickness	1 ft	3" compost tilled into 12" depth, modeled as 12" layer (confirmed in 3/25/21 meeting with HEC, see Design Decision Log)
Bioretention Soil Infiltration Rate	6 in/hr	Confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Native Soil Infiltration Rate	2.5 in/hr	Phase 1 Action Fact Sheet
Infiltration Area	Bottom and Sides	Phase 1 Action Fact Sheet
Side Slopes	3H:1V (Long sides), Vertical (Short sides)	Phase 1 Action Fact Sheet
Bottom Area	25 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	7.08 ft	
Bottom Width	3.54 ft	
Underdrain	N/A	Phase 1 Action Fact Sheet



Inputs and Assumptions		Notes
Action Description		
Action Name	Bioretention Planter	
Soil Type	N/A	
Phase 1 Assumptions		
Sizing Standard	Seattle SW Manual Volume 3 Section 5.8.2.6 Sizing Factors (Table 5.45, Vertical sides), Water Quality Treatment Standard	
Drainage Area	1923 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Basic Water Quality Treatment Standard	Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard.	
Drainage Area	Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified.	Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments.
Pre developed	Impervious	
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Bioretention	Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Model Schematic		
Ponding Depth	0.5 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	KCSWDM Appendix A
Overflow Diameter	12 in	Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip
Bioretention Soil Porosity	30%	Phase 1 Action Fact Sheet
Bioretention Soil Thickness	1.5 ft	Phase 1 Action Fact Sheet
Bioretention Soil Infiltration Rate	6 in/hr	Phase 1 Action Fact Sheet
Native Soil Infiltration Rate	N/A	Phase 1 Action Fact Sheet
Infiltration Area	N/A	
Side Slopes	Vertical	Phase 1 Action Fact Sheet
Bottom Area	25 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	3:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	8.67 ft	
Bottom Width	2.89 ft	
Underdrain	Yes	Phase 1 Action Fact Sheet



Inputs and Assumptions		Notes
Action Description		
Action Name	Bioretention	
Soil Type	Till	
Phase 1 Assumptions		
Sizing Standard	Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.20, Sloped sides), Water Quality Treatment Standard	
Drainage Area	8500 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Basic Water Quality Treatment Standard	Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard. A post-modeling scaling factor of +5% will be applied to the contributing area to account for the elevated underdrain.	A test model run was conducted to estimate treatment below the underdrain. The results indicated 7% additional drainage area could be treated when accounting for the elevated underdrain. To achieve the benefits of the elevated underdrain, a site would have to be relatively flat (i.e., <2%) or have subsurface weirs installed, which was not accounted for in the costs. We will provide partial credit of 5% for elevated underdrains. (See Design Decision log)
Drainage Area	Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified.	Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments.
Pre developed	Impervious	
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Bioretention	Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Model Schematic		
Ponding Depth	0.5 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	From Bioretention Installation Cost Estimate spreadsheet (HDR)
Overflow Diameter	12 in	Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip
Bioretention Soil Porosity	30%	Phase 1 Action Fact Sheet
Bioretention Soil Thickness	1.5 ft	Phase 1 Action Fact Sheet
Bioretention Soil Infiltration Rate	6 in/hr	Phase 1 Action Fact Sheet
Native Soil Infiltration Rate	0.3 in/hr	Phase 1 Action Fact Sheet
Infiltration Area	Bottom and Sides	Phase 1 Action Fact Sheet
Side Slopes	3H:1V (Long sides), Vertical (Short sides)	Phase 1 Action Fact Sheet
Bottom Area	85 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	3:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	16 ft	
Bottom Width	5.33 ft	
Underdrain	Yes	MGS Flood does not allow for an elevated underdrain. The drainage area resulting from the MGS Flood modeling will be increased by 5% to account for the elevated underdrain. See modeling methodology assumptions.



Inputs and Assumptions		Notes
Action Description		
Action Name	Bioretention	
Soil Type	Outwash	
Phase 1 Assumptions		
Sizing Standard	Seattle SW Manual Volume 3 Section 5.4.4.6 Sizing Factors (Table 5.19, Sloped sides for Outwash), Water Quality Treatment Standard	
Drainage Area	9928 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Basic Water Quality Treatment Standard	Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard.	
Drainage Area	Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified.	Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments.
Pre developed	Impervious	
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Bioretention	Ecology Bioretention (beta version) will not be used, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Model Schematic		
Ponding Depth	0.5 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	From Bioretention Installation Cost spreadsheets (HDR)
Overflow Diameter	12 in	Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip
Bioretention Soil Porosity	30%	Phase 1 Action Fact Sheet
Bioretention Soil Thickness	1.5 ft	Phase 1 Action Fact Sheet
Bioretention Soil Infiltration Rate	6 in/hr	Phase 1 Action Fact Sheet
Native Soil Infiltration Rate	2.5 in/hr	Phase 1 Action Fact Sheet
Infiltration Area	Bottom and Sides	Phase 1 Action Fact Sheet
Side Slopes	3H:1V (Long sides), Vertical (Short sides)	Phase 1 Action Fact Sheet
Bottom Area	85 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	3:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	16 ft	
Bottom Width	5.33 ft	
Underdrain	N/A	



Inputs and Assumptions		Notes
Action Description		
Action Name	Drywell	
Soil Type	Till	
Phase 1 Assumptions		
Sizing Standard	Seattle SW Manual Sizing Factors (Table 5.15, 6' Drywell Depth, 0.3 in/hr infiltration [extrapolated], Peak Control Standard)	
Drainage Area	171 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Modified Level 1 Flow Control (match pre-developed [forested] and post-developed peak discharge rates for the 2- and 10- year return periods)	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Use effective depth to account for gravel (i.e. gravel porosity X drywell depth) and equivalent bottom area to account for lateral infiltration. Adjust contribution area to meet required standard.	Effective depth assumption confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Drainage Area	Assume the drywell is in the drainage area (i.e., postdeveloped simulations the same total drainage area than predeveloped simulations). This is the default setting, postdeveloped area will not need to be modified.	Precipitation and evaporation at the drywell area is considered negligible.
Pre developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic	<p>Figure 1</p>	<p>Figure 2</p> <p>IA = (pi * r^2) + 50% * (2*pi*r^2 * h) Storage = (pi * r^2) * h</p> <p>IA = sqrt(13sf / pi) = 2.034ft IA = (pi * 2.034^2) + 50% * (2*pi*2.034ft * 6ft) IA = 51.34 sf = s^2 s = 7.17 ft Storage = 31.2 cf = s^2 * h h = 0.608 ft</p>
Ponding Depth	0.608 ft	Height calculated as shown in Figure 2. Storage of the cylindrical (actual) drywell will be set equal to the rectangular (modeled) drywell, and equations will be solved for model depth. Effective depth used for calculating the storage of the cylindrical drywell is 2.4 ft to account for the 40% porosity (40% * 6ft = 2.4 ft), confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Freeboard Depth	0 ft	Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser and no freeboard.
Overflow Diameter	1,000 in	Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser. A 1,000-in riser was used in the simulation to represent a free flowing overflow condition.
Minimum Orifice Diameter	N/A	
Native Soil Infiltration Rate	0.3 in/hr	Phase 1 Action Fact Sheet
Side Slopes	Vertical	Phase 1 Action Fact Sheet
Bottom Area	51.34 sf	Infiltration area (highlighted in yellow on Figure 2) of the cylindrical drywell will be set equal to the bottom area of a rectangular drywell, and we will solve for model bottom area. Only 50% of the sidewall area will be used for infiltration area. This assumption was made since lateral infiltration rates will be significantly less than infiltration through the bottom footprint. Based on 13 sf cylindrical bottom area from Phase 1 Cost and Modeling Assumptions spreadsheet (RKI).
Bottom Length:Width	1:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	7.17 ft	
Bottom Width	7.17 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Drywell	
Soil Type	Outwash	
Phase 1 Assumptions		
Sizing Standard	Seattle SW Manual Sizing Factors (Table 5.15, 6' Drywell Depth, 2.5 in/hr infiltration, Peak Control Standard)	
Drainage Area	333 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Modified Level 1 Flow Control (match pre-developed [forested] and post-developed peak discharge rates for the 2- and 10- year return periods)	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Use effective depth to account for gravel (i.e. gravel porosity X drywell depth) and equivalent bottom area to account for lateral infiltration. Adjust contribution area to meet required standard.	Effective depth assumption confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Drainage Area	Assume the drywell is in the drainage area (i.e., postdeveloped simulations the same total drainage area than predeveloped simulations). This is the default setting, postdeveloped area will not need to be modified.	Precipitation and evaporation at the drywell area is considered negligible.
Pre developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic	<p>Figure 1</p>	<p>Figure 2</p> <p>Height calculated as shown in Figure 2. Storage of the cylindrical (actual) drywell will be set equal to the rectangular (modeled) drywell, and equations will be solved for model depth. Effective depth used for calculating the storage of the cylindrical drywell is 2.4 ft to account for the 40% porosity (40% * 6ft = 2.4 ft), confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)</p> <p>IA = $\pi r^2 h + 50\% (2\pi r^2 h)$ $IA = (\pi r^2) h$</p> <p>$r = \sqrt{13sf / \pi} = 2.034ft$ $IA = (\pi r^2) h = 50\% (2\pi r^2 h)$ $= 51.34 sf$ $Storage = (\pi r^2) h = 51.34 sf * 2.4ft = 123.2 cf$ $h = .608 ft$</p> <p>$IA = s^2 h$ $Storage = s^2 h$</p> <p>IA = 51.34 sf = s² $s = 7.17 ft$ $Storage = 31.2 cf = s^2 * h$ $h = .608 ft$</p>
Ponding Depth	0.608 ft	
Freeboard Depth	0 ft	Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser and no freeboard.
Overflow Diameter	1,000 in	Although drywells are modeled using an infiltration vault in MGS Flood, drywells have no actual riser. A 1,000-in riser was used in the simulation to represent a free flowing overflow condition.
Minimum Orifice Diameter	N/A	
Native Soil Infiltration Rate	2.5 in/hr	Phase 1 Action Fact Sheet
Side Slopes	Vertical	Phase 1 Action Fact Sheet
Bottom Area	51.34 sf	Infiltration area (highlighted in yellow on Figure 2) of the cylindrical drywell will be set equal to the bottom area of a rectangular drywell, and we will solve for model bottom area. Only 50% of the sidewall area will be used for infiltration area. This assumption was made since lateral infiltration rates will be significantly less than infiltration through the bottom footprint. See Design Decision log. Based on 13 sf cylindrical bottom area from Phase 1 Cost and Modeling Assumptions spreadsheet (RKI).
Bottom Length:Width	1:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	7.17 ft	
Bottom Width	7.17 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Detention Vault	
Soil Type	N/A	
Phase 1 Assumptions		
Sizing Standard	Level 2 Flow Control (Forest Duration Standard)	Modeled in WWHM in Phase 1
Drainage Area	43560 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods)	
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint.	
Drainage Area	Do not include the vault area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified.	Section 8 of the MGS Flood Manual. MGS Flood does not calculate for precipitation and evaporation in the vault area, no need for drainage area adjustments.
Pre-developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post-developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic		
Ponding Depth	6 ft	Phase 1 Action Fact Sheet
Freeboard Depth	1 ft	Phase 1 Action Fact Sheet, internal height of 7ft
Overflow Diameter	18 in	Based on KC Modeling for WRIA 9, HRU 11
Minimum Orifice Diameter	0.5 in	Confirmed by team 4/14/21 (see Design Decision log.)
Minimum Notch Width	0.25 in	Minimum allowed by MGS Flood
Native Soil Infiltration Rate	N/A	
Side Slopes	Vertical	Phase 1 Action Fact Sheet
Bottom Area	25,920 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	227.7 ft	
Bottom Width	113.8 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Detention Pond	
Soil Type	N/A	
Phase 1 Assumptions		
Sizing Standard	Level 2 Flow Control (Forest Duration Standard)	Modeled in WWHM in Phase 1
Drainage Area	43560 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods)	
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint.	
Drainage Area	Do not include the pond area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified.	
Pre-developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post-developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic		
Ponding Depth	4 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	From Detention Pond Installation cost estimate spreadsheet
Overflow Diameter	18 in	Based on KC Modeling for WRIA 9, HRU 11
Minimum Orifice Diameter	0.5 in	Confirmed by team 4/14/21 (see Design Decision log.)
Minimum Notch Width	0.25 in	Minimum allowed by MGS Flood
Native Soil Infiltration Rate	N/A	
Side Slopes	3H:1V (Long sides), Vertical (Short sides)	Phase 1 Action Fact Sheet
Bottom Area	45,000 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	300 ft	
Bottom Width	150 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Infiltration Pond	
Soil Type	Till	
Phase 1 Assumptions		
Sizing Standard	Level 2 Flow Control (Forest Duration Standard)	Modeled in WWHM in Phase 1
Drainage Area	43560 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods)	
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint.	
Drainage Area	Do not include the pond area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified.	
Pre-developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post-developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic		
Ponding Depth	4 ft	Phase 1 Action Fact Sheet
Freeboard Depth	1 ft	From Infiltration Pond Cost spreadsheets (HDR)
Overflow Diameter	18 in	Based on KC Modeling for WRIA 9, HRU 11
Minimum Orifice Diameter	0.5 in	Confirmed by team 4/14/21 (see Design Decision log.)
Minimum Notch Width	0.25 in	Minimum allowed by MGS Flood
Native Soil Infiltration Rate	0.3 in/hr	Phase 1 Action Fact Sheet
Side Slopes	3H:1V (Long sides), Vertical (Short sides)	Phase 1 Action Fact Sheet
Bottom Area	27,850 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	236 ft	
Bottom Width	118 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Infiltration Pond	
Soil Type	Outwash	
Phase 1 Assumptions		
Sizing Standard	Level 2 Flow Control (Forest Duration Standard)	Modeled in WWHM in Phase 1
Drainage Area	43560 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods)	
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint.	
Drainage Area	Do not include the pond area as part of the drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified.	
Pre-developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post-developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic		
Ponding Depth	4 ft	Phase 1 Action Fact Sheet
Freeboard Depth	1 ft	From Infiltration Pond Cost spreadsheets (HDR)
Overflow Diameter	18 in	Based on KC Modeling for WRIA 9, HRU 11
Minimum Orifice Diameter	0.5 in	Confirmed by team 4/14/21 (see Design Decision log.)
Minimum Notch Width	0.25 in	Minimum allowed by MGS Flood
Native Soil Infiltration Rate	2.5 in/hr	Phase 1 Action Fact Sheet
Side Slopes	3H:1V (Long sides), Vertical (Short sides)	Phase 1 Action Fact Sheet
Bottom Area	14,790 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	172 ft	
Bottom Width	86 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Infiltration Vault	
Soil Type	Till	
Phase 1 Assumptions		
Sizing Standard	Level 2 Flow Control (Forest Duration Standard)	Modeled in WWHM in Phase 1
Drainage Area	43560 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods)	
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint.	
Drainage Area	Do not include the vault area as part of the contributing drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified.	Section 8 of the MGS Flood Manual. MGS Flood does not calculate for precipitation and evaporation in the vault area, no need for drainage area adjustments.
Pre-developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post-developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic	<p>The diagram illustrates the geometry of an infiltration vault. The Plan View shows a rectangular vault with dimensions L (length) and W (width). Four corner points are labeled Z1 (top-left), Z2 (bottom-left), Z3 (top-right), and Z4 (bottom-right). The Elevation View shows a trapezoidal cross-section with a slope labeled 'i (in/hr)'. The top horizontal line is labeled 'Max Pond Elev.'. The bottom horizontal line is labeled 'Pond Floor or Top of Dead Storage'. A vertical line labeled 'Riser Structure' extends from the pond floor upwards.</p>	
Ponding Depth	6 ft	Phase 1 Action Fact Sheet
Freeboard Depth	1 ft	Phase 1 Action Fact Sheet
Overflow Diameter	18 in	Based on KC Modeling for WRIA 9, HRU 11
Minimum Orifice Diameter	0.5 in	Confirmed by team 4/14/21 (see Design Decision log.)
Minimum Notch Width	0.25 in	Minimum allowed by MGS Flood
Native Soil Infiltration Rate	0.3 in/hr	Phase 1 Action Fact Sheet
Side Slopes	Vertical	Phase 1 Action Fact Sheet
Bottom Area	18,360 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	191.6 ft	
Bottom Width	95.8 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Infiltration Vault	
Soil Type	Outwash	
Phase 1 Assumptions		
Sizing Standard	Level 2 Flow Control (Forest Duration Standard)	Modeled in WWHM in Phase 1
Drainage Area	43560 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Level 2 Flow Control (Forest Duration Standard: match 50% of the 2-year peak flow up to the 50-year peak flow; match pre- and post-developed peak discharge rates for the 2- and 10- year return periods)	
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions below (Action Configuration). Adjust orifice controls and drainage area to meet required standard. Divide by the Phase 2 modeled contributing area to obtain Unit Action Footprint.	
Drainage Area	Do not include the vault area as part of the contributing drainage area (i.e., postdeveloped simulations will have the same total drainage area as the predeveloped simulations). This is the default setting, post developed area will not be modified.	Section 8 of the MGS Flood Manual. MGS Flood does not calculate for precipitation and evaporation in the vault area, no need for drainage area adjustments.
Pre-developed	Till Forest	Confirmed by Jeff Burkey via 3/31/21 email (see Design Decision Log)
Post-developed	Impervious	
Action Configuration		
MGSFlood Module	Structure	
Model Schematic		
Ponding Depth	6 ft	Phase 1 Action Fact Sheet
Freeboard Depth	1 ft	Phase 1 Action Fact Sheet
Overflow Diameter	18 in	Based on KC Modeling for WRIA 9, HRU 11
Minimum Orifice Diameter	0.5 in	Confirmed by team 4/14/21 (see Design log.)
Minimum Notch Width	0.25 in	Minimum allowed by MGS Flood
Native Soil Infiltration Rate	2.5 in/hr	Phase 1 Action Fact Sheet
Side Slopes	Vertical	Phase 1 Action Fact Sheet
Bottom Area	11,560 sq ft	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length:Width	2:1	Phase 1 Cost and Modeling Assumptions spreadsheet (RKI)
Bottom Length	152.1 ft	
Bottom Width	76 ft	



Inputs and Assumptions		Notes
Action Description		
Action Name	Drywell with Bioretention Planter as Pretreatment	
Soil Type	Outwash	
Phase 1 Assumptions		
Sizing Standard	1.3% Sizing Factor for Water Quality Treatment Standard	
Drainage Area	333 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Basic Water Quality Treatment Standard	Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard.	
Drainage Area	Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified.	Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments.
Pre developed	Impervious	
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Bioretention	Ecology Bioretention (beta version) will not be used
Model Schematic		
Ponding Depth	0.5 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	KCSWDM Appendix A
Overflow Diameter	12 in	Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip
Bioretention Soil Porosity	30%	Phase 1 Action Fact Sheet - Bioretention Planter
Bioretention Soil Thickness	1.5 ft	Phase 1 Action Fact Sheet - Bioretention Planter
Bioretention Soil Infiltration Rate	6 in/hr	Phase 1 Action Fact Sheet - Bioretention Planter
Native Soil Infiltration Rate	N/A	Phase 1 Action Fact Sheet - Bioretention Planter
Infiltration Area	N/A	
Side Slopes	Vertical	Phase 1 Action Fact Sheet - Bioretention Planter
Bottom Area	4.3 sq ft	Phase 1 Cost and Modeling Assumptions Technical Memo (RKI)
Bottom Length:Width	3:1	Assumed, same as Bioretention Planter Action
Bottom Length	3.59 ft	
Bottom Width	1.19 ft	
Underdrain	Yes	Phase 1 Action Fact Sheet - Bioretention Planter



Inputs and Assumptions		Notes
Action Description		
Action Name	Deep UIC Well with Bioretention Planter as Pretreatment	
Soil Type	Outwash	
Phase 1 Assumptions		
Sizing Standard	1.3% Sizing Factor for Water Quality Treatment Standard	
Drainage Area	44550 SF	
Model Assumptions		
Model Software	MGSFlood v. 4.54	
Time Step	15 minute	KCSWDM Chapter 6.2.1, confirmed in 3/25/2021 meeting with HEC (see Design Decision Log)
Climate Region	Puget East 32, Puget East 40, Puget East 60 in MAP	Range of Climate Region Factors will be explicitly modeled to produce scaling relationship (see Design Decision Log)
Time Series	158 years	
Phase 2 Sizing Standard	Basic Water Quality Treatment Standard	Bioretention is not in the Basic or Enhanced Basic WQ Menu for King County, but will be sized to the standard to treat 91% of total annual runoff
Modeling Methodology	Use facility sizing from Phase 1 and design assumptions listed below (Action Configuration). Adjust contribution area to meet required standard.	
Drainage Area	Do not include the bioretention area as part of the contributing drainage area (i.e., postdeveloped simulations will have larger total drainage area than predeveloped simulations). This is the default setting, post developed area will not need to be modified.	Section 15 of the MGS Flood Manual. "Precipitation and evapotranspiration are applied to the facility so the area occupied by the bioretention facility should not be included in the Subbasin Area input." Assume that the bioretention Action lies outside the drainage area, no need for drainage area adjustments.
Pre developed	Impervious	
Post developed	Impervious	
Action Configuration		
MGSFlood Module	Bioretention	Ecology Bioretention (beta version) will not be used
Model Schematic		
Ponding Depth	0.5 ft	Phase 1 Action Fact Sheet
Freeboard Depth	0.5 ft	KCSWDM Appendix A
Overflow Diameter	12 in	Note that HDR cost estimate assumes 8-in-diameter. Cost difference between 6 in and 12 in should be negligible, but the 6 in diameter overflow could artificially impact model results, especially for high mean annual precip
Bioretention Soil Porosity	30%	Phase 1 Action Fact Sheet - Bioretention Planter
Bioretention Soil Thickness	1.5 ft	Phase 1 Action Fact Sheet - Bioretention Planter
Bioretention Soil Infiltration Rate	6 in/hr	Phase 1 Action Fact Sheet - Bioretention Planter
Native Soil Infiltration Rate	N/A	Phase 1 Action Fact Sheet - Bioretention Planter
Infiltration Area	N/A	Phase 1 Action Fact Sheet - Bioretention Planter
Side Slopes	Vertical	Phase 1 Action Fact Sheet - Bioretention Planter
Bottom Area	579 sq ft	Phase 1 Cost and Modeling Assumptions Technical Memo (RKI)
Bottom Length:Width	3:1	Assumed, same as Bioretention Planter Action
Bottom Length	41.68 ft	
Bottom Width	13.89 ft	
Underdrain	Yes	Phase 1 Action Fact Sheet - Bioretention Planter

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ATTACHMENT F

MGSFlood Modeling Output Reports

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MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 04/27/2021 11:36 AM

Report Generation Date: 04/27/2021 11:44 AM

Input File Name: Rain_Garden_Till_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Till Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.019	0.019
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.019	0.019

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.019

Subbasin Total 0.019

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.019

Subbasin Total 0.019

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Link Type: Bioretention
Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	7.1
Bottom Width (ft)	:	3.5
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft)	:	25.
Area at Riser Crest El (sq-ft)	:	46.
	(acres)	0.001
Volume at Riser Crest (cu-ft)	:	24.
	(ac-ft)	0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Soil Properties

Biosoil Thickness (ft)	:	1.00
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	25.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.30

Riser Geometry

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	6.895E-03
5-Year	8.955E-03
10-Year	1.007E-02
25-Year	1.268E-02
50-Year	1.614E-02
100-Year	1.866E-02
200-Year	1.934E-02
500-Year	2.025E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	6.895E-03
5-Year	8.955E-03
10-Year	1.007E-02
25-Year	1.268E-02
50-Year	1.614E-02
100-Year	1.866E-02
200-Year	1.934E-02
500-Year	2.025E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.502
1.11-Year	100.502
1.25-Year	100.503
2.00-Year	100.504
3.33-Year	100.505
5-Year	100.506
10-Year	100.507
25-Year	100.508
50-Year	100.509
100-Year	100.510

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Link: New Bio Lnk1	7.814
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Total:	7.814
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.049 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 8.29

Inflow Volume Including PPT-Evap (ac-ft): 8.59

Total Runoff Infiltrated (ac-ft): 7.81, 91.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.76

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	6.895E-03	2-Year	5.235E-03
5-Year	8.955E-03	5-Year	7.413E-03
10-Year	1.007E-02	10-Year	8.968E-03
25-Year	1.268E-02	25-Year	9.988E-03
50-Year	1.614E-02	50-Year	1.195E-02
100-Year	1.866E-02	100-Year	1.298E-02
200-Year	1.934E-02	200-Year	1.424E-02
500-Year	2.025E-02	500-Year	1.593E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -67.7%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -54.8%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): -53.3%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.5% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -67.7% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 5:08 PM

Report Generation Date: 05/10/2021 5:08 PM

Input File Name: Rain_Garden_Till_SUSTAIN_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Till Soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.023	0.023
Area of Links that Include Precip/Evap (acres)	0.000	0.002
Total (acres)	0.023	0.024

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.023

Subbasin Total 0.023

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.023

Subbasin Total 0.023

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.14
Storage Depth (ft) : 0.14
Bottom Length (ft) : 7.1
Bottom Width (ft) : 11.2
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 79.
Area at Riser Crest El (sq-ft) : 79.
 (acres) : 0.002
Volume at Riser Crest (cu-ft) : 31.
 (ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Riser Geometry

Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	7.286E-03
5-Year	9.854E-03
10-Year	1.149E-02
25-Year	1.430E-02
50-Year	1.816E-02
100-Year	2.280E-02
200-Year	2.358E-02
500-Year	2.458E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	7.286E-03
5-Year	9.854E-03
10-Year	1.149E-02
25-Year	1.430E-02
50-Year	1.816E-02
100-Year	2.280E-02
200-Year	2.358E-02
500-Year	2.458E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.142
1.11-Year	100.142
1.25-Year	100.143
2.00-Year	100.145
3.33-Year	100.146
5-Year	100.147
10-Year	100.148
25-Year	100.149
50-Year	100.151
100-Year	100.154

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Model Element	Total Post Developed Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Bio Lnk1	7.585
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Total:	7.585
--------	-------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.048 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 7.70

Inflow Volume Including PPT-Evap (ac-ft): 8.33

Total Runoff Infiltrated (ac-ft): 7.59, 91.07%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.74

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.07%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	7.286E-03	2-Year	6.077E-03
5-Year	9.854E-03	5-Year	8.478E-03
10-Year	1.149E-02	10-Year	1.036E-02
25-Year	1.430E-02	25-Year	1.175E-02
50-Year	1.816E-02	50-Year	1.373E-02
100-Year	2.280E-02	100-Year	1.761E-02
200-Year	2.358E-02	200-Year	2.054E-02
500-Year	2.458E-02	500-Year	2.440E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -61.8%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -44.2%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): -18.7%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.8% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -61.8% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 5:02 PM

Report Generation Date: 05/10/2021 5:02 PM

Input File Name: Rain_Garden_Till_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Till Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.019	0.019
Area of Links that Include Precip/Evap (acres)	0.000	0.002
Total (acres)	0.019	0.020

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.019

Subbasin Total 0.019

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.019

Subbasin Total 0.019

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.14
Storage Depth (ft)	:	0.14
Bottom Length (ft)	:	7.1
Bottom Width (ft)	:	11.2
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	79.
Area at Riser Crest El (sq-ft)	:	79. (acres) : 0.002
Volume at Riser Crest (cu-ft)	:	31. (ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.00
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	25.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	12.00
Common Length (ft)	:	0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	6.895E-03
5-Year	8.955E-03
10-Year	1.007E-02
25-Year	1.268E-02
50-Year	1.614E-02
100-Year	1.866E-02
200-Year	1.934E-02
500-Year	2.025E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	6.895E-03
5-Year	8.955E-03
10-Year	1.007E-02
25-Year	1.268E-02
50-Year	1.614E-02
100-Year	1.866E-02
200-Year	1.934E-02
500-Year	2.025E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.142
1.11-Year	100.142
1.25-Year	100.143
2.00-Year	100.145
3.33-Year	100.146
5-Year	100.146
10-Year	100.147
25-Year	100.148
50-Year	100.150
100-Year	100.152

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Total:	0.000
--------	-------

Model Element	Total Post Developed Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Bio Lnk1	8.294
--------------------	-------

Total:	8.294
--------	-------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.052 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 8.29

Inflow Volume Including PPT-Evap (ac-ft): 9.11

Total Runoff Infiltrated (ac-ft): 8.29, 91.02%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.81

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.02%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	6.895E-03	2-Year	5.899E-03
5-Year	8.955E-03	5-Year	7.793E-03
10-Year	1.007E-02	10-Year	9.407E-03
25-Year	1.268E-02	25-Year	1.039E-02
50-Year	1.614E-02	50-Year	1.351E-02
100-Year	1.866E-02	100-Year	1.544E-02
200-Year	1.934E-02	200-Year	1.708E-02
500-Year	2.025E-02	500-Year	1.923E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -62.7%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -43.5%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): -23.1%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -62.7% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 5:16 PM

Report Generation Date: 05/10/2021 5:16 PM

Input File Name: Rain_Garden_Till_SUSTAIN_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Till Soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.013	0.013
Area of Links that Include Precip/Evap (acres)	0.000	0.002
Total (acres)	0.013	0.014

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.013

Subbasin Total 0.013

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.013

Subbasin Total 0.013

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.14
Storage Depth (ft)	:	0.14
Bottom Length (ft)	:	7.1
Bottom Width (ft)	:	11.2
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	79.
Area at Riser Crest El (sq-ft)	:	79. (acres) : 0.002
Volume at Riser Crest (cu-ft)	:	31. (ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.00
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	25.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	12.00
Common Length (ft)	:	0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	5.524E-03
5-Year	7.060E-03
10-Year	8.301E-03
25-Year	1.049E-02
50-Year	1.255E-02
100-Year	1.472E-02
200-Year	1.495E-02
500-Year	1.525E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	5.524E-03
5-Year	7.060E-03
10-Year	8.301E-03
25-Year	1.049E-02
50-Year	1.255E-02
100-Year	1.472E-02
200-Year	1.495E-02
500-Year	1.525E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.142
1.11-Year	100.142
1.25-Year	100.143
2.00-Year	100.144
3.33-Year	100.144
5-Year	100.145
10-Year	100.146
25-Year	100.146
50-Year	100.147
100-Year	100.148

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Total:	0.000
--------	-------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	9.434

Total:	9.434
--------	-------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.060 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 9.06

Inflow Volume Including PPT-Evap (ac-ft): 10.36

Total Runoff Infiltrated (ac-ft): 9.43, 91.07%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.92

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.07%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	5.524E-03	2-Year	4.591E-03
5-Year	7.060E-03	5-Year	6.343E-03
10-Year	8.301E-03	10-Year	7.442E-03
25-Year	1.049E-02	25-Year	8.345E-03
50-Year	1.255E-02	50-Year	8.947E-03
100-Year	1.472E-02	100-Year	1.010E-02
200-Year	1.495E-02	200-Year	1.050E-02
500-Year	1.525E-02	500-Year	1.101E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -69.1%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -40.1%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): -35.7%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -69.1% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 3:45 PM

Report Generation Date: 05/10/2021 3:47 PM

Input File Name: Rain_Garden_Outwash_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Outwash Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.065	0.065
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.065	0.066

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.065

Subbasin Total 0.065

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.065

Subbasin Total 0.065

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	7.1
Bottom Width (ft)	:	3.5
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft)	:	25.
Area at Riser Crest El (sq-ft)	:	46.
	(acres)	0.001
Volume at Riser Crest (cu-ft)	:	24.
	(ac-ft)	0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.00
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	25.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	2.50

Riser Geometry

Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.434E-02
5-Year	3.161E-02
10-Year	3.556E-02
25-Year	4.476E-02
50-Year	5.698E-02
100-Year	6.588E-02
200-Year	6.828E-02
500-Year	7.146E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.434E-02
5-Year	3.161E-02
10-Year	3.556E-02
25-Year	4.476E-02
50-Year	5.698E-02
100-Year	6.588E-02
200-Year	6.828E-02
500-Year	7.146E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.509
1.11-Year	100.510
1.25-Year	100.511
2.00-Year	100.515
3.33-Year	100.517
5-Year	100.519
10-Year	100.520
25-Year	100.524
50-Year	100.529
100-Year	100.532

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Total:	0.000
--------	-------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	26.911

Total:	26.911
--------	--------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.170 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 29.28

Inflow Volume Including PPT-Evap (ac-ft): 29.57

Total Runoff Infiltrated (ac-ft): 26.91, 91.02%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 2.67

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.02%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.434E-02	2-Year	1.989E-02
5-Year	3.161E-02	5-Year	2.809E-02
10-Year	3.556E-02	10-Year	3.186E-02
25-Year	4.476E-02	25-Year	4.143E-02
50-Year	5.698E-02	50-Year	5.360E-02
100-Year	6.588E-02	100-Year	6.263E-02
200-Year	6.828E-02	200-Year	6.485E-02
500-Year	7.146E-02	500-Year	6.778E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -70.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -49.2%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 1.1%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.5% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -70.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 3:56 PM

Report Generation Date: 05/10/2021 3:56 PM

Input File Name: Rain_Garden_Outwash_SUSTAIN_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Outwash Soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.078	0.078
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.078	0.080

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.078

Subbasin Total 0.078

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.078

Subbasin Total 0.078

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.14
Storage Depth (ft) : 0.14
Bottom Length (ft) : 7.1
Bottom Width (ft) : 9.2
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 65.
Area at Riser Crest El (sq-ft) : 65.
 (acres) : 0.001
Volume at Riser Crest (cu-ft) : 25.
 (ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry

Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.524E-02
5-Year	3.414E-02
10-Year	3.982E-02
25-Year	4.953E-02
50-Year	6.291E-02
100-Year	7.899E-02
200-Year	8.168E-02
500-Year	8.517E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.524E-02
5-Year	3.414E-02
10-Year	3.982E-02
25-Year	4.953E-02
50-Year	6.291E-02
100-Year	7.899E-02
200-Year	8.168E-02
500-Year	8.517E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.148
1.11-Year	100.149
1.25-Year	100.151
2.00-Year	100.156
3.33-Year	100.158
5-Year	100.160
10-Year	100.162
25-Year	100.166
50-Year	100.172
100-Year	100.177

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Model Element	Total Post Developed Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Link: New Bio Lnk1	24.722
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Total:	24.722
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.156 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 26.68

Inflow Volume Including PPT-Evap (ac-ft): 27.17

Total Runoff Infiltrated (ac-ft): 24.72, 91.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 2.52

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.524E-02	2-Year	2.132E-02
5-Year	3.414E-02	5-Year	3.095E-02
10-Year	3.982E-02	10-Year	3.640E-02
25-Year	4.953E-02	25-Year	4.630E-02
50-Year	6.291E-02	50-Year	6.014E-02
100-Year	7.899E-02	100-Year	7.655E-02
200-Year	8.168E-02	200-Year	7.979E-02
500-Year	8.517E-02	500-Year	8.402E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -64.4%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -43.3%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.9% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -64.4% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 3:51 PM

Report Generation Date: 05/10/2021 3:51 PM

Input File Name: Rain_Garden_Outwash_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Outwash Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.065	0.065
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.065	0.067

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.065

Subbasin Total 0.065

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.065

Subbasin Total 0.065

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.14
Storage Depth (ft)	:	0.14
Bottom Length (ft)	:	7.1
Bottom Width (ft)	:	9.2
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	65.
Area at Riser Crest El (sq-ft) (acres)	:	65. 0.001
Volume at Riser Crest (cu-ft) (ac-ft)	:	25. 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.434E-02
5-Year	3.161E-02
10-Year	3.556E-02
25-Year	4.476E-02
50-Year	5.698E-02
100-Year	6.588E-02
200-Year	6.828E-02
500-Year	7.146E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.434E-02
5-Year	3.161E-02
10-Year	3.556E-02
25-Year	4.476E-02
50-Year	5.698E-02
100-Year	6.588E-02
200-Year	6.828E-02
500-Year	7.146E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.149
1.11-Year	100.150
1.25-Year	100.151
2.00-Year	100.155
3.33-Year	100.157
5-Year	100.159
10-Year	100.160
25-Year	100.165
50-Year	100.169
100-Year	100.173

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	27.242

Total:	27.242
--------	--------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.172 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 29.28

Inflow Volume Including PPT-Evap (ac-ft): 29.92

Total Runoff Infiltrated (ac-ft): 27.24, 91.05%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 2.78

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.05%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.434E-02	2-Year	2.019E-02
5-Year	3.161E-02	5-Year	2.843E-02
10-Year	3.556E-02	10-Year	3.225E-02
25-Year	4.476E-02	25-Year	4.203E-02
50-Year	5.698E-02	50-Year	5.427E-02
100-Year	6.588E-02	100-Year	6.399E-02
200-Year	6.828E-02	200-Year	6.672E-02
500-Year	7.146E-02	500-Year	7.032E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -68.4%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -47.5%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 1.1%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -90.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -68.4% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 4:51 PM

Report Generation Date: 05/10/2021 4:51 PM

Input File Name: Rain_Garden_Outwash_SUSTAIN_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Rain Garden on Outwash Soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.047	0.047
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.047	0.048

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.047

Subbasin Total 0.047

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.047

Subbasin Total 0.047

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Link type: Discretionary

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.00
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 25.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.14 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

***** Subbasin: Subbasin 1 *****

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.056E-02
5-Year	2.628E-02
10-Year	3.090E-02
25-Year	3.904E-02
50-Year	4.670E-02
100-Year	5.479E-02
200-Year	5.565E-02
500-Year	5.676E-02

***** Link: New Bio Lnk1

***** Link Inflow Frequency

Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) Flood Peak (cfs)

2-Year	2.056E-02
5-Year	2.628E-02
10-Year	3.090E-02
25-Year	3.904E-02
50-Year	4.670E-02
100-Year	5.479E-02
200-Year	5.565E-02
500-Year	5.676E-02

***** Link: New Bio Lnk1

***** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs) WSEL Peak (ft)

1.05-Year	100.147
1.11-Year	100.148
1.25-Year	100.150
2.00-Year	100.153
3.33-Year	100.155
5-Year	100.157
10-Year	100.159
25-Year	100.162
50-Year	100.165
100-Year	100.169

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Model Element	Total Post Developed Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Bio Lnk1	31.648
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Total:	31.648
--------	--------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.200 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 33.72

Inflow Volume Including PPT-Evap (ac-ft): 34.77

Total Runoff Infiltrated (ac-ft): 31.65, 91.03%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 3.27

Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.03%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.056E-02	2-Year	1.681E-02
5-Year	2.628E-02	5-Year	2.338E-02
10-Year	3.090E-02	10-Year	2.774E-02
25-Year	3.904E-02	25-Year	3.630E-02
50-Year	4.670E-02	50-Year	4.423E-02
100-Year	5.479E-02	100-Year	5.178E-02
200-Year	5.565E-02	200-Year	5.327E-02
500-Year	5.676E-02	500-Year	5.525E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -81.1%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -57.5%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.8% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -81.1% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/11/2021 8:53 AM

Report Generation Date: 05/11/2021 8:53 AM

Input File Name: Bioretention_Planter_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.065	0.065
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.065	0.065

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.065

Subbasin Total 0.065

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.065

Subbasin Total 0.065

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 8.7
Bottom Width (ft) : 2.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 25.
Area at Riser Crest El (sq-ft) : 25.
 (acres) : 0.001
Volume at Riser Crest (cu-ft) : 24.
 (ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
--------	-------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 22.01
 Inflow Volume Including PPT-Evap (ac-ft): 22.19
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 20.19, 91.00%
 Primary Outflow To Downstream System (ac-ft): 22.18
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

	Predevelopment Runoff		Postdevelopment Runoff
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.083E-02	2-Year	2.067E-02
5-Year	2.817E-02	5-Year	2.842E-02
10-Year	3.285E-02	10-Year	3.299E-02
25-Year	4.086E-02	25-Year	4.113E-02
50-Year	5.191E-02	50-Year	5.235E-02
100-Year	6.517E-02	100-Year	6.568E-02
200-Year	6.739E-02	200-Year	6.813E-02
500-Year	7.027E-02	500-Year	7.131E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): PASS	-10.8%
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): Maximum Excursion from Q2 to Q50 (Must be less than 10%): FAIL	1.4% FAIL 99999.0%
Percent Excursion from Q2 to Q50 (Must be less than 50%): PASS	43.5%

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	7.8%	FAIL
	41.2%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 04/27/2021 12:19 PM

Report Generation Date: 04/27/2021 12:19 PM

Input File Name: Bioretention_Planter_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.054	0.054
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.054	0.055

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.054

Subbasin Total 0.054

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.054

Subbasin Total 0.054

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 8.7
Bottom Width (ft) : 2.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 25.
Area at Riser Crest El (sq-ft) : 25.
 (acres) : 0.001
Volume at Riser Crest (cu-ft) : 24.
 (ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000

Total:	0.000
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Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 24.26
 Inflow Volume Including PPT-Evap (ac-ft): 24.49
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 22.29, 91.01%
 Primary Outflow To Downstream System (ac-ft): 24.49
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.01%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

	Predevelopment Runoff		Postdevelopment Runoff
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.016E-02	2-Year	2.004E-02
5-Year	2.619E-02	5-Year	2.637E-02
10-Year	2.946E-02	10-Year	2.966E-02
25-Year	3.708E-02	25-Year	3.744E-02
50-Year	4.720E-02	50-Year	4.766E-02
100-Year	5.458E-02	100-Year	5.531E-02
200-Year	5.657E-02	200-Year	5.745E-02
500-Year	5.920E-02	500-Year	6.026E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-10.5%
PASS	
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	1.7% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%
FAIL	
Percent Excursion from Q2 to Q50 (Must be less than 50%):	56.8% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	8.3%	FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	46.4%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/11/2021 8:48 AM

Report Generation Date: 05/11/2021 8:48 AM

Input File Name: Bioretention_Planter_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.039	0.039
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.039	0.040

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.039

Subbasin Total 0.039

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.039

Subbasin Total 0.039

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 8.7
Bottom Width (ft) : 2.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 25.
Area at Riser Crest El (sq-ft) : 25.
 (acres) : 0.001
Volume at Riser Crest (cu-ft) : 24.
 (ac-ft) : 0.001

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Total:	0.000

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000
Total:	0.000

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 28.04
 Inflow Volume Including PPT-Evap (ac-ft): 28.44
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 25.89, 91.05%
 Primary Outflow To Downstream System (ac-ft): 28.44
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.05%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

	Predevelopment Runoff		Postdevelopment Runoff
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.710E-02	2-Year	1.717E-02
5-Year	2.185E-02	5-Year	2.218E-02
10-Year	2.569E-02	10-Year	2.592E-02
25-Year	3.247E-02	25-Year	3.290E-02
50-Year	3.883E-02	50-Year	3.952E-02
100-Year	4.556E-02	100-Year	4.668E-02
200-Year	4.627E-02	200-Year	4.713E-02
500-Year	4.720E-02	500-Year	4.769E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-15.2%
PASS	
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	1.3% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%
FAIL	
Percent Excursion from Q2 to Q50 (Must be less than 50%):	65.3% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	7.4%	FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	43.2%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 10:53 AM

Report Generation Date: 05/10/2021 10:53 AM

Input File Name: Bioretention_Till_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Till soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.266	0.266
Area of Links that Include Precip/Evap (acres)	0.000	0.002
Total (acres)	0.266	0.268

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.266

Subbasin Total 0.266

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.266

Subbasin Total 0.266

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 16.0
Bottom Width (ft) : 5.3
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 85.
Area at Riser Crest El (sq-ft) : 133.
 (acres) : 0.003
Volume at Riser Crest (cu-ft) : 93.
 (ac-ft) : 0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Total:	0.000

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000
Total:	0.000

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 119.08
 Inflow Volume Including PPT-Evap (ac-ft): 120.02
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 109.22, 91.00%
 Primary Outflow To Downstream System (ac-ft): 120.02
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff		Postdevelopment Runoff	
	Discharge (cfs)		Tr (Years)	Discharge (cfs)
2-Year	9.898E-02		2-Year	9.757E-02
5-Year	0.129		5-Year	0.128
10-Year	0.145		10-Year	0.145
25-Year	0.182		25-Year	0.182
50-Year	0.232		50-Year	0.231
100-Year	0.268		100-Year	0.266
200-Year	0.278		200-Year	0.277
500-Year	0.291		500-Year	0.292

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-7.2%
PASS	
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	0.7% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	23.1% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	43.2%
PASS	

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	11.2%	FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	22.4%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 11:07 AM

Report Generation Date: 05/10/2021 11:07 AM

Input File Name: Bioretention_Till_SUSTAIN_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Till soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.334	0.334
Area of Links that Include Precip/Evap (acres)	0.000	0.003
Total (acres)	0.334	0.337

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.334

Subbasin Total 0.334

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.334

Subbasin Total 0.334

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Link type: Discretionary

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.35
Storage Depth (ft)	:	0.35
Bottom Length (ft)	:	16.0
Bottom Width (ft)	:	8.6
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	137.
Area at Riser Crest El (sq-ft) (acres)	:	137. 0.003
Volume at Riser Crest (cu-ft) (ac-ft)	:	109. 0.003

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.30

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.35 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Total:	0.000
--------	-------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 113.78

Inflow Volume Including PPT-Evap (ac-ft): 114.76

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 104.42, 91.00%

Primary Outflow To Downstream System (ac-ft): 114.71

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

	Predevelopment Runoff Tr (Years)	Postdevelopment Runoff Tr (Years)	
	Discharge (cfs)	Discharge (cfs)	
2-Year	0.108	2-Year	0.107
5-Year	0.146	5-Year	0.146
10-Year	0.170	10-Year	0.170
25-Year	0.211	25-Year	0.210
50-Year	0.268	50-Year	0.267
100-Year	0.337	100-Year	0.337
200-Year	0.348	200-Year	0.347
500-Year	0.363	500-Year	0.360

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -7.2%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.6% FAIL

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 37.5% FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 38.0%

PASS

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 5.1% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 29.0% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 11:01 AM

Report Generation Date: 05/10/2021 11:01 AM

Input File Name: Bioretention_Till_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Till soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.279	0.279
Area of Links that Include Precip/Evap (acres)	0.000	0.003
Total (acres)	0.279	0.282

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.279

Subbasin Total 0.279

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.279

Subbasin Total 0.279

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Link type: Discretionary

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.35
Storage Depth (ft)	:	0.35
Bottom Length (ft)	:	16.0
Bottom Width (ft)	:	8.6
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	137.
Area at Riser Crest El (sq-ft)	:	137.
	(acres)	: 0.003
Volume at Riser Crest (cu-ft)	:	109.
	(ac-ft)	: 0.003

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.35 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Total:	0.000

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000
Total:	0.000

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 125.04
 Inflow Volume Including PPT-Evap (ac-ft): 126.35
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 115.04, 91.05%
 Primary Outflow To Downstream System (ac-ft): 126.35
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.05%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

	Predevelopment Runoff		Postdevelopment Runoff
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.104	2-Year	0.102
5-Year	0.135	5-Year	0.135
10-Year	0.152	10-Year	0.152
25-Year	0.191	25-Year	0.192
50-Year	0.243	50-Year	0.243
100-Year	0.281	100-Year	0.281
200-Year	0.292	200-Year	0.291
500-Year	0.305	500-Year	0.305

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-7.6%
PASS	
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	1.2% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	23.1% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	45.3%
PASS	

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	5.6%	FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	32.9%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 11:50 AM

Report Generation Date: 05/12/2021 11:51 AM

Input File Name: Bioretention_Till_SUSTAIN_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Till soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.200	0.200
Area of Links that Include Precip/Evap (acres)	0.000	0.003
Total (acres)	0.200	0.203

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.200

Subbasin Total 0.200

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.200

Subbasin Total 0.200

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.35
Storage Depth (ft) : 0.35
Bottom Length (ft) : 16.0
Bottom Width (ft) : 8.6
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 137.
Area at Riser Crest El (sq-ft) : 137.
 (acres) : 0.003
Volume at Riser Crest (cu-ft) : 109.
 (ac-ft) : 0.003

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.30

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.35 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000

Total:	0.000
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Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 143.82

Inflow Volume Including PPT-Evap (ac-ft): 145.96

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 132.95, 91.09%

Primary Outflow To Downstream System (ac-ft): 145.95

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.09%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff	Tr (Years)	Postdevelopment Runoff
	Discharge (cfs)		Discharge (cfs)
2-Year	8.768E-02	2-Year	8.784E-02
5-Year	0.112	5-Year	0.113
10-Year	0.132	10-Year	0.132
25-Year	0.166	25-Year	0.167
50-Year	0.199	50-Year	0.200
100-Year	0.234	100-Year	0.234
200-Year	0.237	200-Year	0.239
500-Year	0.242	500-Year	0.245

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -10.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 1.2% FAIL

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 53.7% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 4.9% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 37.6% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/13/2021 10:48 AM

Report Generation Date: 05/13/2021 10:49 AM

Input File Name: Bioretention_Outwash_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Outwash soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.220	0.220
Area of Links that Include Precip/Evap (acres)	0.000	0.002
Total (acres)	0.220	0.222

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.220

Subbasin Total 0.220

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.220

Subbasin Total 0.220

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	16.0
Bottom Width (ft)	:	5.3
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft)	:	85.
Area at Riser Crest El (sq-ft) (acres)	:	133. 0.003
Volume at Riser Crest (cu-ft) (ac-ft)	:	93. 0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	12.00
Common Length (ft)	:	0.000

Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
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Total:	0.000
--------	-------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Bio Lnk1	90.455
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Total:	90.455
--------	--------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.573 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 98.50
 Inflow Volume Including PPT-Evap (ac-ft): 99.40
 Total Runoff Infiltrated (ac-ft): 90.46, 91.00%
 Total Runoff Filtered (ac-ft): 0.00, 0.00%
 Primary Outflow To Downstream System (ac-ft): 9.51
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff	Postdevelopment Runoff	
	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	8.188E-02	2-Year	6.460E-02
5-Year	0.106	5-Year	9.229E-02
10-Year	0.120	10-Year	0.106
25-Year	0.151	25-Year	0.137
50-Year	0.192	50-Year	0.174
100-Year	0.222	100-Year	0.205
200-Year	0.230	200-Year	0.217
500-Year	0.240	500-Year	0.233

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -69.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -51.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): -13.6%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.7% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -69.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 11:53 AM

Report Generation Date: 05/12/2021 11:54 AM

Input File Name: Bioretention_Outwash_SUSTAIN_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Outwash soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.263	0.263
Area of Links that Include Precip/Evap (acres)	0.000	0.005
Total (acres)	0.263	0.267

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.263

Subbasin Total 0.263

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.263

Subbasin Total 0.263

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00	
Riser Crest Elevation (ft)	:	100.06	
Storage Depth (ft)	:	0.06	
Bottom Length (ft)	:	16.0	
Bottom Width (ft)	:	12.9	
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00	
Bottom Area (sq-ft)	:	206.	
Area at Riser Crest El (sq-ft)	:	206. (acres) :	0.005
Volume at Riser Crest (cu-ft)	:	105. (ac-ft) :	0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	12.00
Common Length (ft)	:	0.000

Riser Crest Elevation : 100.06 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Total:	0.000
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Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Bio Lnk1	82.856
--------------------	--------

Total:	82.856
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.524 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 89.51
 Inflow Volume Including PPT-Evap (ac-ft): 91.05
 Total Runoff Infiltrated (ac-ft): 82.86, 91.00%
 Total Runoff Filtered (ac-ft): 0.00, 0.00%
 Primary Outflow To Downstream System (ac-ft): 8.50
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff	Postdevelopment Runoff	
	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	8.470E-02	2-Year	6.964E-02
5-Year	0.115	5-Year	0.102
10-Year	0.134	10-Year	0.120
25-Year	0.166	25-Year	0.146
50-Year	0.211	50-Year	0.199
100-Year	0.265	100-Year	0.250
200-Year	0.274	200-Year	0.253
500-Year	0.286	500-Year	0.258

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -64.7%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -45.4%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.8% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -64.7% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/13/2021 10:50 AM

Report Generation Date: 05/13/2021 10:50 AM

Input File Name: Bioretention_Outwash_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Outwash soils - Vertical sides
Comments: Puget East 40 in MAP
Tested with vertical sides for SUSTAIN input analysis.

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.220	0.220
Area of Links that Include Precip/Evap (acres)	0.000	0.005
Total (acres)	0.220	0.224

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.220

Subbasin Total 0.220

-----**SCENARIO: POSTDEVELOPED**

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.220

Subbasin Total 0.220

***** **LINK DATA** *****

-----**SCENARIO: PREDEVELOPED**

Number of Links: 0

***** **LINK DATA** *****

-----**SCENARIO: POSTDEVELOPED**

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00	
Riser Crest Elevation (ft)	:	100.06	
Storage Depth (ft)	:	0.06	
Bottom Length (ft)	:	16.0	
Bottom Width (ft)	:	12.9	
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00	
Bottom Area (sq-ft)	:	206.	
Area at Riser Crest El (sq-ft)	:	206. (acres) :	0.005
Volume at Riser Crest (cu-ft)	:	105. (ac-ft) :	0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	12.00

Common Length (ft) : 0.000
Riser Crest Elevation : 100.06 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1 0.000

Total: 0.000

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1 0.000

Link: New Bio Lnk1 91.494

Total: 91.494

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.579 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 98.50
 Inflow Volume Including PPT-Evap (ac-ft): 100.53
 Total Runoff Infiltrated (ac-ft): 91.49, 91.01%
 Total Runoff Filtered (ac-ft): 0.00, 0.00%
 Primary Outflow To Downstream System (ac-ft): 9.44
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.01%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff	Postdevelopment Runoff	
	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	8.188E-02	2-Year	6.659E-02
5-Year	0.106	5-Year	9.127E-02
10-Year	0.120	10-Year	0.107
25-Year	0.151	25-Year	0.135
50-Year	0.192	50-Year	0.181
100-Year	0.222	100-Year	0.210
200-Year	0.230	200-Year	0.219
500-Year	0.240	500-Year	0.231

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ***

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): PASS	-68.8%
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): PASS	-49.1%
Maximum Excursion from Q2 to Q50 (Must be less than 10%): PASS	-13.6%
Percent Excursion from Q2 to Q50 (Must be less than 50%): PASS	0.0%

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ***

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	-89.9%	PASS
	-68.7%	PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/07/2021 9:50 AM

Report Generation Date: 05/07/2021 9:50 AM

Input File Name: Bioretention_Outwash_SUSTAIN_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention on Outwash soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.157	0.157
Area of Links that Include Precip/Evap (acres)	0.000	0.005
Total (acres)	0.157	0.162

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.157

Subbasin Total 0.157

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.157

Subbasin Total 0.157

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.06
Storage Depth (ft) : 0.06
Bottom Length (ft) : 16.0
Bottom Width (ft) : 12.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 206.
Area at Riser Crest El (sq-ft) : 206.
 (acres) : 0.005
Volume at Riser Crest (cu-ft) : 105.
 (ac-ft) : 0.002

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 2.50

Riser Geometry

Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000

Riser Crest Elevation : 100.06 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
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Subbasin: Subbasin 1	0.000
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Total:	0.000
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Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
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Link: New Bio Lnk1	105.993
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Total:	105.993
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.671 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 113.18
 Inflow Volume Including PPT-Evap (ac-ft): 116.47
 Total Runoff Infiltrated (ac-ft): 105.99, 91.00%
 Total Runoff Filtered (ac-ft): 0.00, 0.00%
 Primary Outflow To Downstream System (ac-ft): 10.96
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff		Postdevelopment Runoff	
	Discharge (cfs)		Tr (Years)	Discharge (cfs)
2-Year	6.901E-02		2-Year	5.430E-02
5-Year	8.819E-02		5-Year	7.744E-02
10-Year	0.104		10-Year	8.516E-02
25-Year	0.131		25-Year	0.110
50-Year	0.157		50-Year	0.138
100-Year	0.184		100-Year	0.165
200-Year	0.187		200-Year	0.175
500-Year	0.190		500-Year	0.189

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -81.1%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -58.3%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): -18.7%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -89.8% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -81.1% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/11/2021 9:01 AM

Report Generation Date: 05/11/2021 9:01 AM

Input File Name: Drywell_Till_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Drywell in Till soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.007	0.007
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.007	0.007

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 0.007

Subbasin Total 0.007

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.007

Subbasin Total 0.007

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: New Structure

Downstream Link: None

Prismatic Pond Option Used

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 1000.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.61 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.931
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Total:	0.931
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Model Element	Total Post Developed Recharge During Simulation
	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Link: New Structure Lnk1	2.453
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Total:	2.453
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.006 ac-ft/year, Post Developed: 0.016 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 27. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 40. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 21.62

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 2.45

Inflow Volume Including PPT-Evap (ac-ft): 2.45

Total Runoff Infiltrated (ac-ft): 2.45, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.01

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.000	2-Year	0.000
5-Year	1.438E-04	5-Year	0.000
10-Year	2.234E-04	10-Year	1.344E-04
25-Year	2.683E-04	25-Year	1.683E-03
50-Year	3.357E-04	50-Year	2.260E-03
100-Year	3.811E-04	100-Year	2.812E-03
200-Year	4.686E-04	200-Year	3.099E-03
500-Year	5.864E-04	500-Year	3.472E-03

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.4%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99999.0%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 70.4% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -99.9% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 04/27/2021 12:33 PM

Report Generation Date: 05/12/2021 9:01 AM

Input File Name: Drywell_Till_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Drywell in Till soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.006	0.006
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.006	0.006

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 0.006

Subbasin Total 0.006

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.006

Subbasin Total 0.006

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Geometry	:	
Riser Structure Type	:	Circular
Riser Diameter (in)	:	1000.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	100.61 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
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Subbasin: Subbasin 1	1.035
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Total:	1.035
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Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
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Link: New Structure Lnk1	2.690
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Total:	2.690
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.007 ac-ft/year, Post Developed: 0.017 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 27. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 40. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 21.50

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 2.69

Inflow Volume Including PPT-Evap (ac-ft): 2.69

Total Runoff Infiltrated (ac-ft): 2.69, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.01

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Postdevelopment Runoff	
		Tr (Years)	Discharge (cfs)
2-Year	1.279E-04	2-Year	0.000
5-Year	2.084E-04	5-Year	0.000
10-Year	2.808E-04	10-Year	1.143E-04
25-Year	3.560E-04	25-Year	1.666E-03
50-Year	4.543E-04	50-Year	2.317E-03
100-Year	4.923E-04	100-Year	2.558E-03
200-Year	7.663E-04	200-Year	2.784E-03
500-Year	1.134E-03	500-Year	3.089E-03

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.4%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99999.0%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 64.3% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -99.9% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 12:03 PM

Report Generation Date: 05/12/2021 12:03 PM

Input File Name: Drywell_Till_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Drywell in Till soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.005	0.005
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.005	0.005

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 0.005

Subbasin Total 0.005

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
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Subbasin: Subbasin 1	1.232
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Total:	1.232
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Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
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Link: New Structure Lnk1	3.592
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Total:	3.592
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.008 ac-ft/year, Post Developed: 0.023 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 30. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 46. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 24.37

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3.60

Inflow Volume Including PPT-Evap (ac-ft): 3.60

Total Runoff Infiltrated (ac-ft): 3.59, 99.92%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.02

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.92%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	2.123E-04	2-Year	0.000
5-Year	3.289E-04	5-Year	0.000
10-Year	4.361E-04	10-Year	1.019E-03
25-Year	6.390E-04	25-Year	1.902E-03
50-Year	8.787E-04	50-Year	2.415E-03
100-Year	9.590E-04	100-Year	2.484E-03
200-Year	1.414E-03	200-Year	2.588E-03
500-Year	2.027E-03	500-Year	2.725E-03

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -91.0%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 72.0% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -99.9% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 12:07 PM

Report Generation Date: 05/12/2021 12:07 PM

Input File Name: Drywell_Outwash_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Drywell in Outwash soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.020	0.020
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.020	0.020

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 0.020

Subbasin Total 0.020

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.020

Subbasin Total 0.020

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: New Str.

Downstream Link: None

Prismatic Pond Option Used

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Geometry	
Riser Structure Type	: Circular
Riser Diameter (in)	: 1000.00
Common Length (ft)	: 0.000
Riser Crest Elevation	: 100.61 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	2.637
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Total:	2.637
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Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	6.951
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Total:	6.951
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.017 ac-ft/year, Post Developed: 0.044 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 76. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 114. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 7.10

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 6.95

Inflow Volume Including PPT-Evap (ac-ft): 6.95

Total Runoff Infiltrated (ac-ft): 6.95, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.01

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Postdevelopment Runoff	
		Tr (Years)	Discharge (cfs)
2-Year	2.417E-04	2-Year	0.000
5-Year	4.075E-04	5-Year	0.000
10-Year	6.331E-04	10-Year	6.217E-04
25-Year	7.601E-04	25-Year	5.758E-03
50-Year	9.510E-04	50-Year	6.941E-03
100-Year	1.080E-03	100-Year	7.820E-03
200-Year	1.328E-03	200-Year	9.739E-03
500-Year	1.661E-03	500-Year	1.231E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.8%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.1%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 28.3%

PASS

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 04/27/2021 1:21 PM

Report Generation Date: 04/27/2021 1:21 PM

Input File Name: Drywell_Outwash_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Drywell in Outwash soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.018	0.018
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.018	0.018

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 0.018

Subbasin Total 0.018

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	3.086
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Total:	3.086
--------	-------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	8.025
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Total:	8.025
--------	-------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.020 ac-ft/year, Post Developed: 0.051 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 79. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 119. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 7.43

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 8.03

Inflow Volume Including PPT-Evap (ac-ft): 8.03

Total Runoff Infiltrated (ac-ft): 8.03, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.01

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff	Tr (Years)	Postdevelopment Runoff
	Discharge (cfs)		Discharge (cfs)
2-Year	3.814E-04	2-Year	0.000
5-Year	6.217E-04	5-Year	0.000
10-Year	8.376E-04	10-Year	2.976E-04
25-Year	1.062E-03	25-Year	4.121E-03
50-Year	1.355E-03	50-Year	5.572E-03
100-Year	1.469E-03	100-Year	8.728E-03
200-Year	2.286E-03	200-Year	1.038E-02
500-Year	3.384E-03	500-Year	1.251E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.8%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -98.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 41.1%

PASS

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99999.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/10/2021 1:28 PM

Report Generation Date: 05/10/2021 1:29 PM

Input File Name: Drywell_Outwash_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Drywell in Outwash soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.015	0.015
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.015	0.015

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 0.015

Subbasin Total 0.015

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.015

Subbasin Total 0.015

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 1000.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.61 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	3.597
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Total:	3.597
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Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	10.499
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Total:	10.499
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.023 ac-ft/year, Post Developed: 0.066 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 89. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 133. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 8.29

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 10.50

Inflow Volume Including PPT-Evap (ac-ft): 10.50

Total Runoff Infiltrated (ac-ft): 10.50, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.01

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	6.199E-04	2-Year	0.000
5-Year	9.603E-04	5-Year	0.000
10-Year	1.273E-03	10-Year	1.034E-03
25-Year	1.866E-03	25-Year	4.087E-03
50-Year	2.566E-03	50-Year	4.961E-03
100-Year	2.800E-03	100-Year	6.385E-03
200-Year	4.129E-03	200-Year	6.501E-03
500-Year	5.920E-03	500-Year	6.618E-03

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.8%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -98.2%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 62.2% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.8% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/11/2021 2:29 PM

Report Generation Date: 05/12/2021 11:01 AM

Input File Name: Detention_Vault_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Detention Vault
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	4.114	4.114
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	4.114	4.114

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 4.114

Subbasin Total 4.114

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 4.114

Subbasin Total 4.114

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	227.7
Pond Bottom Width (ft)	:	113.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	25920.
Area at Riser Crest El (sq-ft)	:	25,920.
(acres)	:	0.595
Volume at Riser Crest (cu-ft)	:	155,521.
	(ac-ft)	: 3.570
Area at Max Elevation (sq-ft)	:	25920.
	(acres)	: 0.595
Vol at Max Elevation (cu-ft)	:	181,442.
	(ac-ft)	: 4.165

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.00

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 0.64
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 104.49
Length (in) : 0.37
Height (in) : 18.15
Orientation : Vertical
Elbow : No

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerlnD Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	531.743
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Total:	531.743
--------	---------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge is Greater than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 3.365 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 15271. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 22906. cu-ft

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 1401.77

Inflow Volume Including PPT-Evap (ac-ft): 1401.77

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 1400.80

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	4.873E-02	2-Year	1.994E-02
5-Year	8.218E-02	5-Year	2.823E-02
10-Year	0.128	10-Year	5.189E-02
25-Year	0.153	25-Year	0.106
50-Year	0.192	50-Year	0.135
100-Year	0.218	100-Year	0.143
200-Year	0.268	200-Year	0.164
500-Year	0.335	500-Year	0.192

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -20.0%
PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -20.0%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 918.2% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 1521.3% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 11:02 AM

Report Generation Date: 05/12/2021 11:02 AM

Input File Name: Detention_Vault_PugetEast40.fld

Project Name: WQBE Phase 2

Analysis Title: Detention Vault

Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	6.579	6.579
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	6.579	6.579

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 6.579

Subbasin Total 6.579

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 6.579

Subbasin Total 6.579

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	227.7
Pond Bottom Width (ft)	:	113.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	25920.
Area at Riser Crest El (sq-ft)	:	25,920.
(acres)	:	0.595
Volume at Riser Crest (cu-ft)	:	155,521.
(ac-ft)	:	3.570
Area at Max Elevation (sq-ft)	:	25920.
(acres)	:	0.595
Vol at Max Elevation (cu-ft)	:	181,442.
(ac-ft)	:	4.165

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.00

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 1.16
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 103.60
Length (in) : 0.37
Height (in) : 28.77
Orientation : Vertical
Elbow : No

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerlnD Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1134.393
----------------------	----------

Total:	1134.393
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge is Greater than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 7.180 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 29141. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 43711. cu-ft

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 2949.64

Inflow Volume Including PPT-Evap (ac-ft): 2949.64

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 2948.85

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.140	2-Year	6.636E-02
5-Year	0.228	5-Year	0.146
10-Year	0.308	10-Year	0.222
25-Year	0.390	25-Year	0.289
50-Year	0.498	50-Year	0.328
100-Year	0.540	100-Year	0.354
200-Year	0.840	200-Year	0.362
500-Year	1.244	500-Year	0.372

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -14.4%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -10.0%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 457.4% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 728.0% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/11/2021 2:56 PM

Report Generation Date: 05/12/2021 11:03 AM

Input File Name: Detention_Vault_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Detention Vault
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	6.192	6.192
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	6.192	6.192

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 6.192

Subbasin Total 6.192

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 6.192

Subbasin Total 6.192

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	227.7
Pond Bottom Width (ft)	:	113.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	25920.
Area at Riser Crest El (sq-ft)	:	25,920.
(acres)	:	0.595
Volume at Riser Crest (cu-ft)	:	155,521.
(ac-ft)	:	3.570
Area at Max Elevation (sq-ft)	:	25920.
(acres)	:	0.595
Vol at Max Elevation (cu-ft)	:	181,442.
(ac-ft)	:	4.165

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.00

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 1.67
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 102.95
Length (in) : 0.35
Height (in) : 36.65
Orientation : Vertical
Elbow : No

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerlnD Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1525.350
----------------------	----------

Total:	1525.350
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge is Greater than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 9.654 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 37571. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 56356. cu-ft

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4452.16

Inflow Volume Including PPT-Evap (ac-ft): 4452.16

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 4451.41

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.263	2-Year	0.155
5-Year	0.407	5-Year	0.290
10-Year	0.540	10-Year	0.376
25-Year	0.791	25-Year	0.473
50-Year	1.088	50-Year	0.525
100-Year	1.188	100-Year	0.592
200-Year	1.751	200-Year	0.789
500-Year	2.511	500-Year	1.052

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -25.3%
PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -11.6%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 189.4% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 294.1% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 10:59 AM

Report Generation Date: 05/12/2021 11:00 AM

Input File Name: Detention_Pond_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Detention Pond
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	8.395	8.395
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	8.395	8.395

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 8.395

Subbasin Total 8.395

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 8.395

Subbasin Total 8.395

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	104.00
Max Pond Elevation (ft)	:	104.50
Storage Depth (ft)	:	4.00
Pond Bottom Length (ft)	:	300.0
Pond Bottom Width (ft)	:	150.0
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft)	:	45000.
Area at Riser Crest El (sq-ft)	:	52,200.
(acres)	:	1.198
Volume at Riser Crest (cu-ft)	:	194,400.
(ac-ft)	:	4.463
Area at Max Elevation (sq-ft)	:	53100.
(acres)	:	1.219
Vol at Max Elevation (cu-ft)	:	220,725.
(ac-ft)	:	5.067

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.00

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	104.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 1.41
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 102.56
Length (in) : 0.87
Height (in) : 17.31
Orientation : Vertical
Elbow : No

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerlnD Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1447.524
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Total:	1447.524
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge is Greater than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 9.162 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----**SCENARIO: PREDEVELOPED**

Number of Links: 0

-----**SCENARIO: POSTDEVELOPED**

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 37184. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 55777. cu-ft

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3763.84
Inflow Volume Including PPT-Evap (ac-ft): 3763.84
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 3762.82
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff		Postdevelopment Runoff	
	Discharge (cfs)		Discharge (cfs)	
2-Year	0.179		2-Year	8.259E-02
5-Year	0.292		5-Year	0.183
10-Year	0.393		10-Year	0.280
25-Year	0.498		25-Year	0.365
50-Year	0.636		50-Year	0.413
100-Year	0.689		100-Year	0.512
200-Year	1.072		200-Year	0.536
500-Year	1.587		500-Year	0.563

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -16.1%
PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -10.1%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 460.3% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 731.3% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 3:40 PM

Report Generation Date: 05/12/2021 3:41 PM

Input File Name: Detention_Pond_SUSTAIN_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Detention Pond
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	5.262	5.262
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	5.262	5.262

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 5.262

Subbasin Total 5.262

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 5.262

Subbasin Total 5.262

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	104.00
Max Pond Elevation (ft)	:	104.50
Storage Depth (ft)	:	4.00
Pond Bottom Length (ft)	:	300.0
Pond Bottom Width (ft)	:	165.7
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	49710.
Area at Riser Crest El (sq-ft)	:	49,710.
(acres)	:	1.141
Volume at Riser Crest (cu-ft)	:	198,840.
(ac-ft)	:	4.565
Area at Max Elevation (sq-ft)	:	49710.
(acres)	:	1.141
Vol at Max Elevation (cu-ft)	:	223,695.
(ac-ft)	:	5.135

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.00

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	104.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 0.80
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 102.95
Length (in) : 0.87
Height (in) : 12.55
Orientation : Vertical
Elbow : No

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1 680.158

Total: 680.158

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1 0.000
Link: New Structure Lnk1 0.000

Total: 0.000

Total Predevelopment Recharge is Greater than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 4.305 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 19533. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 29299. cu-ft

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 1793.02

Inflow Volume Including PPT-Evap (ac-ft): 1793.02

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 1791.83

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff		Postdevelopment Runoff	
	Discharge (cfs)		Discharge (cfs)	
2-Year	6.233E-02		2-Year	2.573E-02
5-Year	0.105		5-Year	3.652E-02
10-Year	0.163		10-Year	6.640E-02
25-Year	0.196		25-Year	0.136
50-Year	0.245		50-Year	0.173
100-Year	0.278		100-Year	0.183
200-Year	0.342		200-Year	0.210
500-Year	0.429		500-Year	0.246

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -17.8%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -17.8%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 913.3% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 1520.2% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 3:28 PM

Report Generation Date: 05/12/2021 3:28 PM

Input File Name: Detention_Pond_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Detention Pond
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	8.395	8.395
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	8.395	8.395

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 8.395

Subbasin Total 8.395

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 8.395

Subbasin Total 8.395

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	104.00
Max Pond Elevation (ft)	:	104.50
Storage Depth (ft)	:	4.00
Pond Bottom Length (ft)	:	300.0
Pond Bottom Width (ft)	:	165.7
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	49710.
Area at Riser Crest El (sq-ft)	:	49,710.
(acres)	:	1.141
Volume at Riser Crest (cu-ft)	:	198,840.
(ac-ft)	:	4.565
Area at Max Elevation (sq-ft)	:	49710.
(acres)	:	1.141
Vol at Max Elevation (cu-ft)	:	223,695.
(ac-ft)	:	5.135

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.00

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	104.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 1.41
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 102.56
Length (in) : 0.87
Height (in) : 17.31
Orientation : Vertical
Elbow : No

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerlnD Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1447.524
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Total:	1447.524
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge is Greater than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 9.162 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 37184. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 55777. cu-ft

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3763.84

Inflow Volume Including PPT-Evap (ac-ft): 3763.84

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 3762.79

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.179	2-Year	8.155E-02
5-Year	0.292	5-Year	0.176
10-Year	0.393	10-Year	0.281
25-Year	0.498	25-Year	0.370
50-Year	0.636	50-Year	0.416
100-Year	0.689	100-Year	0.435
200-Year	1.072	200-Year	0.561
500-Year	1.587	500-Year	0.729

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -20.1%
PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -15.1%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 466.0% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 727.7% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 3:56 PM

Report Generation Date: 05/12/2021 3:56 PM

Input File Name: Detention_Pond_SUSTAIN_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Detention Pond
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	7.987	7.987
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	7.987	7.987

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 7.987

Subbasin Total 7.987

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 7.987

Subbasin Total 7.987

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	104.00
Max Pond Elevation (ft)	:	104.50
Storage Depth (ft)	:	4.00
Pond Bottom Length (ft)	:	300.0
Pond Bottom Width (ft)	:	165.7
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	49710.
Area at Riser Crest El (sq-ft)	:	49,710.
	(acres)	1.141
Volume at Riser Crest (cu-ft)	:	198,840.
	(ac-ft)	4.565
Area at Max Elevation (sq-ft)	:	49710.
	(acres)	1.141
Vol at Max Elevation (cu-ft)	:	223,695.
	(ac-ft)	5.135

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.00

Riser Geometry

Riser Geometry	:	
Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	104.00 f

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 2.09
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 101.97
Length (in) : 0.82
Height (in) : 24.41
Orientation : Vertical
Elbow : No

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1967.562
----------------------	----------

Total:	1967.562
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge is Greater than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 12.453 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 48463. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 72695. cu-ft

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 5742.97

Inflow Volume Including PPT-Evap (ac-ft): 5742.97

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 5742.00

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.339	2-Year	0.201
5-Year	0.525	5-Year	0.376
10-Year	0.697	10-Year	0.487
25-Year	1.021	25-Year	0.612
50-Year	1.404	50-Year	0.680
100-Year	1.532	100-Year	0.797
200-Year	2.259	200-Year	1.007
500-Year	3.238	500-Year	1.286

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -24.7%
PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -10.6%
PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 189.8% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 293.6% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 1:29 PM

Report Generation Date: 05/12/2021 1:30 PM

Input File Name: Infiltration_Pond_Till_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Till Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	8.401	8.401
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	8.401	8.401

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 8.401

Subbasin Total 8.401

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 8.401

Subbasin Total 8.401

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	104.00
Max Pond Elevation (ft)	:	105.00
Storage Depth (ft)	:	4.00
Pond Bottom Length (ft)	:	236.0
Pond Bottom Width (ft)	:	118.0
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft)	:	27848.
Area at Riser Crest El (sq-ft)	:	33,512.
(acres)	:	0.769
Volume at Riser Crest (cu-ft)	:	122,720.
(ac-ft)	:	2.817
Area at Max Elevation (sq-ft)	:	34928.
(acres)	:	0.802
Vol at Max Elevation (cu-ft)	:	156,940.
(ac-ft)	:	3.603

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	104.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
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Subbasin: Subbasin 1	1448.490
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Total:	1448.490
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	3765.999

Total:	3765.999
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 9.168 ac-ft/year, Post Developed: 23.835 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 37209. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 55814. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 53.15

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3766.35

Inflow Volume Including PPT-Evap (ac-ft): 3766.35

Total Runoff Infiltrated (ac-ft): 3766.00, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.35

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.179	2-Year	0.000
5-Year	0.292	5-Year	0.000
10-Year	0.393	10-Year	0.000
25-Year	0.498	25-Year	0.000
50-Year	0.636	50-Year	0.000
100-Year	0.689	100-Year	0.000
200-Year	1.073	200-Year	0.445
500-Year	1.588	500-Year	1.045

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.6%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 4:52 PM

Report Generation Date: 05/12/2021 4:52 PM

Input File Name: Infiltration_Pond_Till_SUSTAIN_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Till Soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	10.213	10.213
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	10.213	10.213

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 10.213

Subbasin Total 10.213

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 10.213

Subbasin Total 10.213

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	103.63
Max Pond Elevation (ft)	:	105.00
Storage Depth (ft)	:	3.63
Pond Bottom Length (ft)	:	236.0
Pond Bottom Width (ft)	:	139.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	32986.
Area at Riser Crest El (sq-ft)	:	32,986.
(acres)	:	0.757
Volume at Riser Crest (cu-ft)	:	119,738.
	(ac-ft)	: 2.749
Area at Max Elevation (sq-ft)	:	32986.
	(acres)	: 0.757
Vol at Max Elevation (cu-ft)	:	164,929.
	(ac-ft)	: 3.786

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	103.63 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1320.051
----------------------	----------

Total:	1320.051
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	3479.621
--------------------------	----------

Total:	3479.621
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 8.355 ac-ft/year, Post Developed: 22.023 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 37910. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 56864. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 47.52

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3479.89

Inflow Volume Including PPT-Evap (ac-ft): 3479.89

Total Runoff Infiltrated (ac-ft): 3479.62, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.27

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.121	2-Year	0.000
5-Year	0.204	5-Year	0.000
10-Year	0.317	10-Year	0.000
25-Year	0.381	25-Year	0.000
50-Year	0.476	50-Year	0.000
100-Year	0.540	100-Year	0.000
200-Year	0.665	200-Year	0.325
500-Year	0.832	500-Year	0.763

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.7%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/13/2021 10:30 AM

Report Generation Date: 05/13/2021 10:31 AM

Input File Name: Infiltration_Pond_Till_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Till Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	8.401	8.401
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	8.401	8.401

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 8.401

Subbasin Total 8.401

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 8.401

Subbasin Total 8.401

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	103.63
Max Pond Elevation (ft)	:	105.00
Storage Depth (ft)	:	3.63
Pond Bottom Length (ft)	:	236.0
Pond Bottom Width (ft)	:	139.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	32986.
Area at Riser Crest El (sq-ft)	:	32,986.
(acres)	:	0.757
Volume at Riser Crest (cu-ft)	:	119,738.
	(ac-ft)	: 2.749
Area at Max Elevation (sq-ft)	:	32986.
	(acres)	: 0.757
Vol at Max Elevation (cu-ft)	:	164,929.
	(ac-ft)	: 3.786

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	103.63 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1448.490
----------------------	----------

Total:	1448.490
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	3766.017
--------------------------	----------

Total:	3766.017
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 9.168 ac-ft/year, Post Developed: 23.836 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 37209. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 55814. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 46.69

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3766.35

Inflow Volume Including PPT-Evap (ac-ft): 3766.35

Total Runoff Infiltrated (ac-ft): 3766.02, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.34

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.179	2-Year	0.000
5-Year	0.292	5-Year	0.000
10-Year	0.393	10-Year	0.000
25-Year	0.498	25-Year	0.000
50-Year	0.636	50-Year	0.000
100-Year	0.689	100-Year	0.000
200-Year	1.073	200-Year	0.443
500-Year	1.588	500-Year	1.039

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.6%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 4:57 PM

Report Generation Date: 05/12/2021 4:57 PM

Input File Name: Infiltration_Pond_Till_SUSTAIN_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Till Soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	5.683	5.683
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	5.683	5.683

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 5.683

Subbasin Total 5.683

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 5.683

Subbasin Total 5.683

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	103.63
Max Pond Elevation (ft)	:	105.00
Storage Depth (ft)	:	3.63
Pond Bottom Length (ft)	:	236.0
Pond Bottom Width (ft)	:	139.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	32986.
Area at Riser Crest El (sq-ft)	:	32,986.
(acres)	:	0.757
Volume at Riser Crest (cu-ft)	:	119,738.
(ac-ft)	:	2.749
Area at Max Elevation (sq-ft)	:	32986.
(acres)	:	0.757
Vol at Max Elevation (cu-ft)	:	164,929.
(ac-ft)	:	3.786

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	103.63 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1400.077
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Total:	1400.077
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	4086.118
--------------------------	----------

Total:	4086.118
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 8.861 ac-ft/year, Post Developed: 25.862 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 34486. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 51728. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 43.46

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4086.58

Inflow Volume Including PPT-Evap (ac-ft): 4086.58

Total Runoff Infiltrated (ac-ft): 4086.12, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.46

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.241	2-Year	0.000
5-Year	0.374	5-Year	0.000
10-Year	0.496	10-Year	0.000
25-Year	0.726	25-Year	0.000
50-Year	0.999	50-Year	0.000
100-Year	1.090	100-Year	4.341E-02
200-Year	1.607	200-Year	0.655
500-Year	2.304	500-Year	1.477

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.5%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 5:02 PM

Report Generation Date: 05/12/2021 5:02 PM

Input File Name: Infiltration_Pond_Outwash_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Outwash Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	10.651	10.651
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	10.651	10.651

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 10.651

Subbasin Total 10.651

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1836.472
----------------------	----------

Total:	1836.472
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	4774.922
--------------------------	----------

Total:	4774.922
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 11.623 ac-ft/year, Post Developed: 30.221 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 47176. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 70764. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 13.96

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4775.18

Inflow Volume Including PPT-Evap (ac-ft): 4775.18

Total Runoff Infiltrated (ac-ft): 4774.92, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.26

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.227	2-Year	0.000
5-Year	0.370	5-Year	0.000
10-Year	0.498	10-Year	0.000
25-Year	0.632	25-Year	0.000
50-Year	0.806	50-Year	0.000
100-Year	0.874	100-Year	0.000
200-Year	1.360	200-Year	1.559
500-Year	2.014	500-Year	3.660

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 5:27 PM

Report Generation Date: 05/12/2021 5:28 PM

Input File Name: I_Pond_Outwash_SUSTAIN_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Outwash Soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	11.768	11.768
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	11.768	11.768

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 11.768

Subbasin Total 11.768

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 11.768

Subbasin Total 11.768

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	103.52
Max Pond Elevation (ft)	:	105.00
Storage Depth (ft)	:	3.52
Pond Bottom Length (ft)	:	172.0
Pond Bottom Width (ft)	:	104.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	18031.
Area at Riser Crest El (sq-ft)	:	18,031.
(acres)	:	0.414
Volume at Riser Crest (cu-ft)	:	63,468.
(ac-ft)	:	1.457
Area at Max Elevation (sq-ft)	:	18031.
(acres)	:	0.414
Vol at Max Elevation (cu-ft)	:	90,154.
(ac-ft)	:	2.070

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	103.52 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1521.112
----------------------	----------

Total:	1521.112
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	4009.833
--------------------------	----------

Total:	4009.833
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 9.627 ac-ft/year, Post Developed: 25.379 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 43684. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 65526. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 11.72

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4009.92

Inflow Volume Including PPT-Evap (ac-ft): 4009.92

Total Runoff Infiltrated (ac-ft): 4009.83, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.09

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.139	2-Year	0.000
5-Year	0.235	5-Year	0.000
10-Year	0.365	10-Year	0.000
25-Year	0.438	25-Year	0.000
50-Year	0.549	50-Year	0.000
100-Year	0.623	100-Year	0.000
200-Year	0.766	200-Year	0.640
500-Year	0.958	500-Year	1.503

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 5:19 PM

Report Generation Date: 05/12/2021 5:19 PM

Input File Name: I_Pond_Outwash_SUSTAIN_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Outwash Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	10.651	10.651
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	10.651	10.651

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 10.651

Subbasin Total 10.651

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 10.651

Subbasin Total 10.651

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	103.1
Max Pond Elevation (ft)	:	105.00
Storage Depth (ft)	:	3.52
Pond Bottom Length (ft)	:	172.0
Pond Bottom Width (ft)	:	104.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2=
Bottom Area (sq-ft)	:	18031.
Area at Riser Crest El (sq-ft)	:	18,031.
	(acres)	: 0.414
Volume at Riser Crest (cu-ft)	:	63,468.
	(ac-ft)	: 1.457
Area at Max Elevation (sq-ft)	:	18031.
	(acres)	: 0.414
Vol at Max Elevation (cu-ft)	:	90,154.
	(ac-ft)	: 2.070

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Geometry	:	
Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	103.52 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1836.472
----------------------	----------

Total:	1836.472
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	4774.918
--------------------------	----------

Total:	4774.918
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 11.623 ac-ft/year, Post Developed: 30.221 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 47176. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 70764. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 12.64

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4775.18

Inflow Volume Including PPT-Evap (ac-ft): 4775.18

Total Runoff Infiltrated (ac-ft): 4774.92, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.26

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.227	2-Year	0.000
5-Year	0.370	5-Year	0.000
10-Year	0.498	10-Year	0.000
25-Year	0.632	25-Year	0.000
50-Year	0.806	50-Year	0.000
100-Year	0.874	100-Year	0.000
200-Year	1.360	200-Year	1.623
500-Year	2.014	500-Year	3.811

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 5:35 PM

Report Generation Date: 05/12/2021 5:35 PM

Input File Name: I_Pond_Outwash_SUSTAIN_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Pond in Outwash Soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	7.870	7.870
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	7.870	7.870

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 7.870

Subbasin Total 7.870

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 7.870

Subbasin Total 7.870

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	103.52
Max Pond Elevation (ft)	:	105.00
Storage Depth (ft)	:	3.52
Pond Bottom Length (ft)	:	172.0
Pond Bottom Width (ft)	:	104.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	18031.
Area at Riser Crest El (sq-ft)	:	18,031.
(acres)	:	0.414
Volume at Riser Crest (cu-ft)	:	63,468.
(ac-ft)	:	1.457
Area at Max Elevation (sq-ft)	:	18031.
(acres)	:	0.414
Vol at Max Elevation (cu-ft)	:	90,154.
(ac-ft)	:	2.070

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	103.52 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1938.837
----------------------	----------

Total:	1938.837
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	5658.921

Total:	5658.921
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 12.271 ac-ft/year, Post Developed: 35.816 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 47756. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 71634. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 12.79

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 5659.12

Inflow Volume Including PPT-Evap (ac-ft): 5659.12

Total Runoff Infiltrated (ac-ft): 5658.92, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.20

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.334	2-Year	0.000
5-Year	0.518	5-Year	0.000
10-Year	0.686	10-Year	0.000
25-Year	1.006	25-Year	0.000
50-Year	1.383	50-Year	0.000
100-Year	1.510	100-Year	0.000
200-Year	2.226	200-Year	1.316
500-Year	3.191	500-Year	3.089

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 11:37 AM

Report Generation Date: 05/12/2021 11:37 AM

Input File Name: Infiltration_Vault_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Vault in Till Soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	7.994	7.994
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	7.994	7.994

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 7.994

Subbasin Total 7.994

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 7.994

Subbasin Total 7.994

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	191.6
Pond Bottom Width (ft)	:	95.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	18359.
Area at Riser Crest El (sq-ft)	:	18,359.
(acres)	:	0.421
Volume at Riser Crest (cu-ft)	:	110,155.
	(ac-ft)	: 2.529
Area at Max Elevation (sq-ft)	:	18359.
	(acres)	: 0.421
Vol at Max Elevation (cu-ft)	:	128,514.
	(ac-ft)	: 2.950

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1033.227
----------------------	----------

Total:	1033.227
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	2719.112

Total:	2719.112
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 6.539 ac-ft/year, Post Developed: 17.210 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 29673. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 44509. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 66.43

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 2723.77

Inflow Volume Including PPT-Evap (ac-ft): 2723.77

Total Runoff Infiltrated (ac-ft): 2719.11, 99.83%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.28

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.83%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	9.469E-02	2-Year	0.000
5-Year	0.160	5-Year	0.000
10-Year	0.248	10-Year	0.000
25-Year	0.298	25-Year	0.000
50-Year	0.373	50-Year	0.000
100-Year	0.423	100-Year	0.000
200-Year	0.520	200-Year	0.273
500-Year	0.651	500-Year	0.640

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.7%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 11:24 AM

Report Generation Date: 05/12/2021 11:27 AM

Input File Name: Infiltration_Vault_PugetEast40.fld

Project Name: WQBE Phase 2

Analysis Title: Infiltration Vault in Till Soils

Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	6.593	6.593
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	6.593	6.593

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 6.593

Subbasin Total 6.593

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 6.593

Subbasin Total 6.593

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	191.6
Pond Bottom Width (ft)	:	95.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	18359.
Area at Riser Crest El (sq-ft)	:	18,359.
(acres)	:	0.421
Volume at Riser Crest (cu-ft)	:	110,155.
	(ac-ft)	: 2.529
Area at Max Elevation (sq-ft)	:	18359.
	(acres)	: 0.421
Vol at Max Elevation (cu-ft)	:	128,514.
	(ac-ft)	: 2.950

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1136.841
----------------------	----------

Total:	1136.841
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
Link: New Structure Lnk1	2951.695

Total:	2951.695
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 7.195 ac-ft/year, Post Developed: 18.682 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 29204. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 43805. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 65.43

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 2956.01

Inflow Volume Including PPT-Evap (ac-ft): 2956.01

Total Runoff Infiltrated (ac-ft): 2951.70, 99.85%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.39

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.85%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.140	2-Year	0.000
5-Year	0.229	5-Year	0.000
10-Year	0.309	10-Year	0.000
25-Year	0.391	25-Year	0.000
50-Year	0.499	50-Year	0.000
100-Year	0.541	100-Year	0.173
200-Year	0.842	200-Year	0.442
500-Year	1.246	500-Year	0.797

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.6%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 11:46 AM

Report Generation Date: 05/12/2021 11:46 AM

Input File Name: Infiltration_Vault_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Vault in Till Soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	4.405	4.405
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	4.405	4.405

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 4.405

Subbasin Total 4.405

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 4.405

Subbasin Total 4.405

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	191.6
Pond Bottom Width (ft)	:	95.8
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	18359.
Area at Riser Crest El (sq-ft)	:	18,359.
(acres)	:	0.421
Volume at Riser Crest (cu-ft)	:	110,155.
	(ac-ft)	: 2.529
Area at Max Elevation (sq-ft)	:	18359.
	(acres)	: 0.421
Vol at Max Elevation (cu-ft)	:	128,514.
	(ac-ft)	: 2.950

Constant Infiltration Option Used

Infiltration Rate (in/hr): 0.30

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1085.083
----------------------	----------

Total:	1085.083
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Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	3164.794
--------------------------	----------

Total:	3164.794
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Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 6.868 ac-ft/year, Post Developed: 20.030 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 26727. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 40090. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 60.15

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3167.17

Inflow Volume Including PPT-Evap (ac-ft): 3167.17

Total Runoff Infiltrated (ac-ft): 3164.79, 99.93%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.75

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.93%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.187	2-Year	0.000
5-Year	0.290	5-Year	0.000
10-Year	0.384	10-Year	0.000
25-Year	0.563	25-Year	0.000
50-Year	0.774	50-Year	0.000
100-Year	0.845	100-Year	0.634
200-Year	1.246	200-Year	0.653
500-Year	1.786	500-Year	0.654

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.0%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -99.9% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 12:02 PM

Report Generation Date: 05/12/2021 12:02 PM

Input File Name: Infiltration_Vault_PugetEast32_Outwash.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Vault in Outwash Soils
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	9.902	9.902
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	9.902	9.902

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 9.902

Subbasin Total 9.902

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 9.902

Subbasin Total 9.902

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	152.0
Pond Bottom Width (ft)	:	76.0
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	11556.
Area at Riser Crest El (sq-ft)	:	11,556.
(acres)	:	0.265
Volume at Riser Crest (cu-ft)	:	69,335.
(ac-ft)	:	1.592
Area at Max Elevation (sq-ft)	:	11556.
(acres)	:	0.265
Vol at Max Elevation (cu-ft)	:	80,891.
(ac-ft)	:	1.857

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1279.929
----------------------	----------

Total:	1279.929
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	3374.043
--------------------------	----------

Total:	3374.043
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 8.101 ac-ft/year, Post Developed: 21.355 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 36757. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 55136. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 15.37

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 3374.12

Inflow Volume Including PPT-Evap (ac-ft): 3374.12

Total Runoff Infiltrated (ac-ft): 3374.04, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.07

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.117	2-Year	0.000
5-Year	0.198	5-Year	0.000
10-Year	0.307	10-Year	0.000
25-Year	0.369	25-Year	0.000
50-Year	0.462	50-Year	0.000
100-Year	0.524	100-Year	0.000
200-Year	0.645	200-Year	0.534
500-Year	0.806	500-Year	1.254

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 11:52 AM

Report Generation Date: 05/12/2021 11:52 AM

Input File Name: Infiltration_Vault_PugetEast40_Outwash.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Vault in Outwash Soils
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	9.037	9.037
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	9.037	9.037

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 9.037

Subbasin Total 9.037

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 9.037

Subbasin Total 9.037

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	152.0
Pond Bottom Width (ft)	:	76.0
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	11556.
Area at Riser Crest El (sq-ft)	:	11,556.
(acres)	:	0.265
Volume at Riser Crest (cu-ft)	:	69,335.
(ac-ft)	:	1.592
Area at Max Elevation (sq-ft)	:	11556.
(acres)	:	0.265
Vol at Max Elevation (cu-ft)	:	80,891.
(ac-ft)	:	1.857

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	1558.189
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Total:	1558.189
--------	----------

Model Element	Total Post Developed Recharge During Simulation Recharge Amount (ac-ft)
---------------	--

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	4051.330
--------------------------	----------

Total:	4051.330
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 9.862 ac-ft/year, Post Developed: 25.641 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 40027. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 60041. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 16.72

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4051.59

Inflow Volume Including PPT-Evap (ac-ft): 4051.59

Total Runoff Infiltrated (ac-ft): 4051.33, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.26

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 99.99%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.193	2-Year	0.000
5-Year	0.314	5-Year	0.000
10-Year	0.423	10-Year	0.000
25-Year	0.536	25-Year	0.000
50-Year	0.684	50-Year	0.000
100-Year	0.741	100-Year	0.000
200-Year	1.154	200-Year	1.749
500-Year	1.708	500-Year	4.106

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 12:09 PM

Report Generation Date: 05/12/2021 12:09 PM

Input File Name: Infiltration_Vault_PugetEast60_Outwash.fld
Project Name: WQBE Phase 2
Analysis Title: Infiltration Vault in Outwash Soils
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	6.611	6.611
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	6.611	6.611

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Till Forest 6.611

Subbasin Total 6.611

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 6.611

Subbasin Total 6.611

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Structure Lnk1

Link Type: Structure

Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	106.00
Max Pond Elevation (ft)	:	107.00
Storage Depth (ft)	:	6.00
Pond Bottom Length (ft)	:	152.0
Pond Bottom Width (ft)	:	76.0
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	11556.
Area at Riser Crest El (sq-ft)	:	11,556.
(acres)	:	0.265
Volume at Riser Crest (cu-ft)	:	69,335.
(ac-ft)	:	1.592
Area at Max Elevation (sq-ft)	:	11556.
(acres)	:	0.265
Vol at Max Elevation (cu-ft)	:	80,891.
(ac-ft)	:	1.857

Constant Infiltration Option Used

Infiltration Rate (in/hr): 2.50

Riser Geometry

Riser Structure Type	:	Circular
Riser Diameter (in)	:	18.00
Common Length (ft)	:	0.000
Riser Crest Elevation	:	106.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	1628.549
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Total:	1628.549
--------	----------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Link: New Structure Lnk1	4753.263
--------------------------	----------

Total:	4753.263
--------	----------

Total Predevelopment Recharge is Less than Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 10.307 ac-ft/year, Post Developed: 30.084 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Structure Lnk1 *****

Basic Wet Pond Volume (91% Exceedance): 40113. cu-ft

Computed Large Wet Pond Volume, 1.5*Basic Volume: 60170. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 16.75

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4753.45

Inflow Volume Including PPT-Evap (ac-ft): 4753.45

Total Runoff Infiltrated (ac-ft): 4753.26, 100.00%

Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.19

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

*******Compliance Point Results *******

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff Discharge (cfs)	Tr (Years)	Postdevelopment Runoff Discharge (cfs)
2-Year	0.281	2-Year	0.000
5-Year	0.435	5-Year	0.000
10-Year	0.577	10-Year	0.000
25-Year	0.845	25-Year	0.000
50-Year	1.162	50-Year	0.000
100-Year	1.268	100-Year	0.000
200-Year	1.870	200-Year	1.323
500-Year	2.680	500-Year	3.106

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -100.0%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): -99.9%

PASS

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 0.0%

PASS

Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0%

PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): -100.0% PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 12:18 PM

Report Generation Date: 05/12/2021 12:18 PM

Input File Name: Planter_Drywell_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter pretreatment for drywell
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.011	0.011
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.011	0.011

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.011

Subbasin Total 0.011

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.011

Subbasin Total 0.011

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	3.6
Bottom Width (ft)	:	1.2
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	4.
Area at Riser Crest El (sq-ft)	:	4. (acres) : 0.000
Volume at Riser Crest (cu-ft)	:	4. (ac-ft) : 0.000

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Total:	0.000
--------	-------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 3.71
 Inflow Volume Including PPT-Evap (ac-ft): 3.74
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 3.41, 91.13%
 Primary Outflow To Downstream System (ac-ft): 3.74
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.13%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

	Predevelopment Runoff		Postdevelopment Runoff
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	3.514E-03	2-Year	3.504E-03
5-Year	4.753E-03	5-Year	4.811E-03
10-Year	5.543E-03	10-Year	5.571E-03
25-Year	6.895E-03	25-Year	6.964E-03
50-Year	8.758E-03	50-Year	8.872E-03
100-Year	1.100E-02	100-Year	1.112E-02
200-Year	1.137E-02	200-Year	1.156E-02
500-Year	1.186E-02	500-Year	1.214E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): PASS	-11.0%
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): Maximum Excursion from Q2 to Q50 (Must be less than 10%): FAIL	2.8% FAIL 99999.0%
Percent Excursion from Q2 to Q50 (Must be less than 50%): PASS	48.9%

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	7.6%	FAIL
	39.7%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 12:12 PM

Report Generation Date: 05/12/2021 12:13 PM

Input File Name: Planter_Drywell_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter pretreatment for drywell
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.009	0.009
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.009	0.009

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.009

Subbasin Total 0.009

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.009

Subbasin Total 0.009

***** LINK DATA *****

SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Name: New Bio Link

Link Type: Bioretention
Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	3.6
Bottom Width (ft)	:	1.2
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	4.
Area at Riser Crest El (sq-ft)	:	4.
	(acres)	: 0.000
Volume at Riser Crest (cu-ft)	:	4.
	(ac-ft)	: 0.000

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Total:	0.000

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000
Total:	0.000

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 4.08
 Inflow Volume Including PPT-Evap (ac-ft): 4.12
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 3.76, 91.19%
 Primary Outflow To Downstream System (ac-ft): 4.12
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.19%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

	Predevelopment Runoff		Postdevelopment Runoff
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	3.391E-03	2-Year	3.376E-03
5-Year	4.405E-03	5-Year	4.469E-03
10-Year	4.955E-03	10-Year	5.005E-03
25-Year	6.238E-03	25-Year	6.318E-03
50-Year	7.940E-03	50-Year	8.046E-03
100-Year	9.180E-03	100-Year	9.358E-03
200-Year	9.516E-03	200-Year	9.729E-03
500-Year	9.959E-03	500-Year	1.022E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-10.7%
PASS	
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	1.7% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%
FAIL	
Percent Excursion from Q2 to Q50 (Must be less than 50%):	62.1% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	7.9%	FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	44.0%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 12:22 PM

Report Generation Date: 05/12/2021 12:22 PM

Input File Name: Planter_Drywell_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter pretreatment for drywell
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.007	0.007
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.007	0.007

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.007

Subbasin Total 0.007

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.007

Subbasin Total 0.007

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	3.6
Bottom Width (ft)	:	1.2
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	4.
Area at Riser Crest El (sq-ft)	:	4.
	(acres)	: 0.000
Volume at Riser Crest (cu-ft)	:	4.
	(ac-ft)	: 0.000

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
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Total:	0.000
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Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000

Total:	0.000
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Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 4.75

Inflow Volume Including PPT-Evap (ac-ft): 4.81

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%

Total Runoff Filtered (ac-ft): 4.39, 91.14%

Primary Outflow To Downstream System (ac-ft): 4.81

Secondary Outflow To Downstream System (ac-ft): 0.00

Volume Lost to ET (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.14%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff	Tr (Years)	Postdevelopment Runoff
	Discharge (cfs)		Discharge (cfs)
2-Year	2.894E-03	2-Year	2.912E-03
5-Year	3.698E-03	5-Year	3.759E-03
10-Year	4.348E-03	10-Year	4.396E-03
25-Year	5.494E-03	25-Year	5.584E-03
50-Year	6.572E-03	50-Year	6.717E-03
100-Year	7.710E-03	100-Year	7.954E-03
200-Year	7.831E-03	200-Year	8.008E-03
500-Year	7.987E-03	500-Year	8.073E-03

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -15.5%

PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): 2.7% FAIL

Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0%

FAIL

Percent Excursion from Q2 to Q50 (Must be less than 50%): 73.7% FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): 7.2% FAIL

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 51.9% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 1:14 PM

Report Generation Date: 05/12/2021 1:15 PM

Input File Name: Planter_UIC_PugetEast32.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter pretreatment for drywell
Comments: Puget East 32 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 13

Full Period of Record Available used for Routing

Precipitation Station : 96003205 Puget East 32 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961032 Puget East 32 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	1.496	1.496
Area of Links that Include Precip/Evap (acres)	0.000	0.013
Total (acres)	1.496	1.509

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 1.496

Subbasin Total 1.496

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 1.496

Subbasin Total 1.496

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Link Type: Bioretention
Downstream Link: None

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	41.7
Bottom Width (ft)	:	13.9
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	579.
Area at Riser Crest El (sq-ft) (acres)	:	579. 0.013
Volume at Riser Crest (cu-ft) (ac-ft)	:	550. 0.013

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Total:	0.000

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000
Total:	0.000

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.18 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.10 cfs

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 509.66
Inflow Volume Including PPT-Evap (ac-ft): 513.79
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 467.53, 91.00%
Primary Outflow To Downstream System (ac-ft): 513.33
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff		Postdevelopment Runoff	
	Discharge (cfs)		Discharge (cfs)	
2-Year	0.482		2-Year	0.468
5-Year	0.652		5-Year	0.651
10-Year	0.761		10-Year	0.746
25-Year	0.946		25-Year	0.907
50-Year	1.202		50-Year	1.144
100-Year	1.509		100-Year	1.435
200-Year	1.560		200-Year	1.458
500-Year	1.627		500-Year	1.486

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-13.7%
PASS	
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-3.9%
PASS	
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	37.5% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	26.1%
PASS	

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	7.9%	FAIL
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Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 41.7% FAIL

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 1:07 PM

Report Generation Date: 05/12/2021 1:07 PM

Input File Name: Planter_UIC_PugetEast40.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter pretreatment for drywell
Comments: Puget East 40 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 15

Full Period of Record Available used for Routing

Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961040 Puget East 40 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	1.252	1.252
Area of Links that Include Precip/Evap (acres)	0.000	0.013
Total (acres)	1.252	1.265

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 1.252

Subbasin Total 1.252

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 1.252

Subbasin Total 1.252

***** LINK DATA *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Downstream Link: None

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 100.50
Storage Depth (ft) : 0.50
Bottom Length (ft) : 41.7
Bottom Width (ft) : 13.9
Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 579.
Area at Riser Crest El (sq-ft) : 579.
 (acres) : 0.013
Volume at Riser Crest (cu-ft) : 550.
 (ac-ft) : 0.013

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.00
Native Soil Hydraulic Conductivity (in/hr) : 0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Total:	0.000

Total Post Developed Recharge During Simulation
Model Element Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000
Total:	0.000

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1

Infiltration/Filtration Statistics-----
 Inflow Volume (ac-ft): 561.42
 Inflow Volume Including PPT-Evap (ac-ft): 566.94
 Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
 Total Runoff Filtered (ac-ft): 515.89, 91.00%
 Primary Outflow To Downstream System (ac-ft): 566.59
 Secondary Outflow To Downstream System (ac-ft): 0.00
 Volume Lost to ET (ac-ft): 0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff	Tr (Years)	Postdevelopment Runoff
	Discharge (cfs)		Discharge (cfs)
2-Year	0.467	2-Year	0.449
5-Year	0.606	5-Year	0.596
10-Year	0.682	10-Year	0.678
25-Year	0.858	25-Year	0.836
50-Year	1.093	50-Year	1.051
100-Year	1.263	100-Year	1.196
200-Year	1.309	200-Year	1.287
500-Year	1.370	500-Year	1.411

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): PASS	-14.4%
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%): PASS	-4.7%
Maximum Excursion from Q2 to Q50 (Must be less than 10%): Percent Excursion from Q2 to Q50 (Must be less than 50%): PASS	23.1% FAIL 18.9%

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%): Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	8.4% 46.7%	FAIL FAIL
--	---------------	--------------

LID DURATION DESIGN CRITERIA: FAIL

MGS FLOOD PROJECT REPORT

Program Version: MGSFlood 4.54

Program License Number: 201810010

Project Simulation Performed on: 05/12/2021 1:22 PM

Report Generation Date: 05/12/2021 1:24 PM

Input File Name: Planter_UIC_PugetEast60.fld
Project Name: WQBE Phase 2
Analysis Title: Bioretention Planter pretreatment for UIC
Comments: Puget East 60 in MAP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected

Climatic Region Number: 20

Full Period of Record Available used for Routing

Precipitation Station : 96006005 Puget East 60 in_5min 10/01/1939-10/01/2097

Evaporation Station : 961060 Puget East 60 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1

HSPF Parameter Region Name : USGS Default

***** Default HSPF Parameters Used (Not Modified by User) *****

***** WATERSHED DEFINITION *****

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.905	0.905
Area of Links that Include Precip/Evap (acres)	0.000	0.013
Total (acres)	0.905	0.918

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----

-----Area (Acres) -----

Impervious 0.905

Subbasin Total 0.905

SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

----- Subbasin : Subbasin 1 -----
-----Area (Acres) -----
Impervious 0.905

Subbasin Total 0.905

***** LINK DATA *****

----- SCENARIO: PREDEVELOPED

Number of Links: 0

***** LINK DATA *****

----- SCENARIO: POSTDEVELOPED

Number of Links: 1

Link Name: New Bio Lnk1

Link Type: Bioretention Facility

Link type: Discretionary

Base Elevation (ft)	:	100.00
Riser Crest Elevation (ft)	:	100.50
Storage Depth (ft)	:	0.50
Bottom Length (ft)	:	41.7
Bottom Width (ft)	:	13.9
Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	579.
Area at Riser Crest El (sq-ft)	:	579.
	(acres)	0.013
Volume at Riser Crest (cu-ft)	:	550.
	(ac-ft)	0.013

Infiltration on Bottom and Sideslopes Selected

Soil Properties

Biosoil Thickness (ft)	:	1.50
Biosoil Saturated Hydraulic Conductivity (in/hr)	:	6.00
Biosoil Porosity (Percent)	:	30.00
Maximum Elevation of Bioretention Soil	:	101.00
Native Soil Hydraulic Conductivity (in/hr)	:	0.00

Underdrain Present

Orifice NOT Present in Under Drain

Riser Geometry

Riser Structure Type : Circular

Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 100.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

*****FLOOD FREQUENCY AND DURATION STATISTICS*****

-----SCENARIO: PREDEVELOPED

Number of Subbasins: 1
Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Subbasins: 1
Number of Links: 1

*****Groundwater Recharge Summary *****

Recharge is computed as input to PerInd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
----------------------	-------

Total:	0.000
--------	-------

Total Post Developed Recharge During Simulation	
Model Element	Recharge Amount (ac-ft)

Subbasin: Subbasin 1	0.000
Link: New Bio Lnk1	0.000

Total:	0.000
--------	-------

Total Predevelopment Recharge Equals Post Developed

Average Recharge Per Year, (Number of Years= 158)

Predeveloped: 0.000 ac-ft/year, Post Developed: 0.000 ac-ft/year

*****Water Quality Facility Data *****

-----SCENARIO: PREDEVELOPED

Number of Links: 0

-----SCENARIO: POSTDEVELOPED

Number of Links: 1

***** Link: New Bio Lnk1 *****

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.18 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.10 cfs

Infiltration/Filtration Statistics-----

Inflow Volume (ac-ft): 650.48
Inflow Volume Including PPT-Evap (ac-ft): 659.52
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 600.14, 91.00%
Primary Outflow To Downstream System (ac-ft): 659.52
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.00%

*****Compliance Point Results *****

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Bio Lnk1

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (Years)	Predevelopment Runoff		Postdevelopment Runoff	
	Discharge (cfs)		Discharge (cfs)	
2-Year	0.397		2-Year	0.386
5-Year	0.507		5-Year	0.507
10-Year	0.596		10-Year	0.590
25-Year	0.753		25-Year	0.727
50-Year	0.901		50-Year	0.859
100-Year	1.057		100-Year	0.982
200-Year	1.073		200-Year	1.035
500-Year	1.095		500-Year	1.106

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-19.1%
PASS	
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-5.3%
PASS	
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	23.1% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	15.8%
PASS	

FLOW DURATION DESIGN CRITERIA: FAIL

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	7.5%	FAIL
--	------	------

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): 43.7% FAIL

LID DURATION DESIGN CRITERIA: FAIL

ATTACHMENT G

Summary of Transformed Configurations and Design Flow Rates for SUSTAIN Input

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Table G-1: Transformed Configuration for Actions Sized Using Explicit Modeling in MGSFlood

Action ^a	Design Configuration				Transformed Configuration for SUSTAIN Modeling ^d			
	Ponding Depth or Design Flow Depth (ft) ^{b,c}	Bottom Width (ft)	Bottom Length (ft)	Bottom Footprint (sf)	Ponding Depth or Design Flow Depth (ft)	Bottom Width (ft)	Bottom Length (ft)	Bottom Footprint (sf)
Rain Garden - Till Soils	0.50	3.54	7.08	25.00	0.14	11.15	7.08	78.94
Rain Garden - Outwash Soils	0.50	3.54	7.08	25.00	0.14	9.20	7.08	65.14
Bioretention - Till Soils	0.50	5.33	16.00	85.00	0.35	8.55	16.00	136.80
Bioretention - Outwash Soils	0.50	5.33	16.00	85.00	0.06	12.90	16.00	206.40
Bioswale	0.12	2.00	100.00	200.00	0.12	2.00	117.98	235.96
Stormwater Treatment Wetland	N/A	21.50	32.75	502.98	N/A	8.00	269.01	2152.08
Infiltration Pond - Till Soils	4.00	118.00	236.00	27850.00	3.63	139.77	236.00	32985.72
Infiltration Pond - Outwash Soils	4.00	86.00	172.00	14790.00	3.52	104.83	172.00	18030.76
Wetpond	N/A	10.16	54.47	553.09	N/A	23.21	69.64	1616.51

Notes:

a Values reported for infiltration ponds (sized per King County Level 2 Flow Control) are based on a Unit Action Footprint multiplied by 10. See Technical Memo for more information on Level 2 Flow Control Sizing.

b Value reported for bioswales is the Design Flow Depth. All other values reported are Ponding Depths.

c Ponding Depth or Design Flow Depth is not a design value for Stormwater Treatment Wetlands and Wetponds. Instead, these Actions are based on a Design Basic Volume (Vb) of 6,456 cubic feet and 6,465 cubic feet, respectively. These values are consistent through the transformation process.

d Values reported for the transformed configurations apply to all climate regions (32-inch, 40-inch, 60-inch).

Table G-2: Tranformed Configuration for Detention Pond, Varying Climate Regions ^a

Mean Annual Precipitation (inches)	Design Configuration								Transformed Configuration for SUSTAIN Modeling							
	Ponding Depth (ft)	Bottom Width (ft)	Bottom Length (ft)	Bottom Footprint (sf)	Orifice Height (ft)	Orifice Diameter (in)	Top Notch Width (in)	Top Notch Length (in)	Ponding Depth (ft)	Bottom Width (ft)	Bottom Length (ft)	Bottom Footprint (sf)	Orifice Height (ft)	Orifice Diameter (in)	Top Notch Width (in)	Top Notch Length (in)
32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.00	165.70	300.00	49710.00	0.00	0.80	0.87	12.55
40	4.00	150.00	300.00	45000.00	0.00	1.41	0.87	17.31	4.00	165.70	300.00	49710.00	0.00	4.41	0.87	17.31
60	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.00	165.70	300.00	49710.00	0.00	2.09	0.82	24.41

Notes:

a Detention Pond Transformed Configurations are reported separate from Table J-1 since orifice and notch configurations vary between each modeled climate region (32-inch, 40-inch, and 60-inch Mean Annual Precipitation)

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ATTACHMENT H

Phase 2 Calculations

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Bioswale Sizing

KC SWDM Section 6.3.1



Goal: Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area from Phase 1, then transform facility for SUSTAIN input (vertical side slopes) and adjust drainage area for three precipitation factors.

Dimensions from Phase 1		
2	ft	bottom width
100	ft	bottom length

Legend	
Blue text	indicates inputs that were changed during Phase 2
Green text	indicates values to maintain from Phase 1
Orange text	indicates inputs that were changed for the SUSTAIN input transformation

Original Design	Parameter			Unit	Notes
	Transformed for SUSTAIN				
40	40	32	60		Precipitation Factor
0.64	0.64	0.78	0.455	ac	Drainage area, 100% impervious
0.052	0.052	0.052	0.052	cfs	Off-line WQ design flow rate
0.2	0.2	0.2	0.2		Mannings
0.119	0.119	0.119	0.119	ft	Design flow depth (initial 0.33)
0.015	0.015	0.015	0.015	ft/ft	Longitudinal slope
2.00	2.00	2.00	2.00	ft	Bottom width of swale
3	0	0	0	H:V	Side slope
0.28	0.24	0.24	0.24	sf	Cross-sectional area at design depth
0.19	0.22	0.22	0.22	fps	Design flow velocity
540	540	540	540	s	Hydraulic residence time
100.11	117.98	117.98	117.98	ft	Swale length
28.08	28.08	28.08	28.08	cf	Volume

Note: Calculations were performed in order from left to right.

Basic Stormwater Wetland Sizing,

KC SWDM Worksheet 8-C



Goal: Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area from Phase 1, then transform facility for SUSTAIN input (vertical side slopes) and adjust drainage area for three precipitation factors.

Dimensions from Phase 1	
503 sf	bottom area

Legend					
Blue text	indicates inputs that were changed during Phase 2				
Green text	indicates values to maintain from Phase 1				
Orange text	indicates inputs that were changed for the SUSTAIN input transformation				
Design Assumptions					
	Toggle value to meet specified condition for blue cells				
	Cells to match by toggling values				

Parameter				Units	Step in KC Worksheet	Notes
Original Design	Transformed for SUSTAIN					
40	40	32	60	in		Mean Annual Precipitation
1	1	1	1	unitless	Step 1	f=1 for Basic Size
98	98	98	98	unitless	Step 2	CN from Table 6.4.1.1.A, assuming 100% impervious
1.44	1.44	1.15	2.16	in	Step 3	Precipitation P, 72% of 2-year, 24-hour
0.2	0.2	0.2	0.2	in		Potential detention of area S, calculated
1.23	1.23	0.94	1.94	in		Runoff depth Qd, calculated
1.446	1.446	1.892	0.917	acre	Step 4	Drainage area A, Assumed (adjusted to get the same bottom area as Phase 1)
6456.2454	6456.245	6455.882	6457.697	cf		Basic volume Vb, calculated
6456.2454	6456.245	6455.882	6457.697	cf		Required volume, calculated
2152.0818	2152.082	2151.961	2152.566	sf	Step 5	Atop, Total ponding area
3	0	0	0	H:V		Sideslope
3	3	3	3	L:W		check length-to-width ratio at mid-depth
2152.0818	2152.082	2151.961	2152.566	cf	Step 6a	first cell volume (1/3 total volume)
4	4	4	4	ft		first cell depth
538.02045	538.0205	537.9902	538.1415	sf		first cell mid-depth surface area
8	8	8	8	ft		assumed bottom width
20	8	8	8	ft		first cell mid-depth width
26.9010225	67.25256	67.24878	67.26768	ft		first cell mid-depth length
1	8	8	8	L:W		check mid-depth length:width ratio
32	8	8	8	ft		first cell ponding area width
38.9010225	67.25256	67.24878	67.26768	ft		first cell ponding area length
8	8	8	8	ft		first cell bottom width check
14.9010225	67.25256	67.24878	67.26768	ft		first cell bottom length
2	8	8	8	L:W		check bottom length:width ratio
119.20818	538.0205	537.9902	538.1415	sf		first cell bottom area
1244.83272	538.0205	537.9902	538.1415	sf		first cell ponding area
907.24908	1614.061	1613.971	1614.424	sf	Step 6b	second cell ponding area
28.35	201.7577	201.7577	201.7577	ft		second cell ponding area length
2152.03272	2152.082	2152.052	2152.203	sf		total ponding area check
32	8	8	8	ft		second cell ponding area width
1.75	1.75	1.75	1.75	ft		second cell average depth
17.85	201.7577	201.7577	201.7577	ft		second cell bottom length
21.5	8	8	8	ft		second cell bottom width
383.775	1614.062	1614.062	1614.062	sf		second cell bottom area
67.2510225	269.0103	269.0065	269.0254	ft		total ponding area length
32	8	8	8	ft		total ponding area width
2152.03272	2152.082	2152.052	2152.203			ponding area
1	1	1	1	ft		freeboard
73.2510225	269.0103	269.0065	269.0254	ft		total top length
38	8	8	8	ft		total top width
32.7510225	269.0103	269.0065	269.0254	ft		total bottom length
21.5	8	8	8	ft		total bottom width
2783.538855	2152.082	2152.052	2152.203	sf		total top area
502.98318	2152.082	2152.052	2152.203			total bottom area
1.927658487	33.62628	33.62581	33.62817	L:W		top length:width
0.118	0.118	0.127	0.105	cfs		Off-line WQ design flow rate (modeled 100% impervious in MGSflood)

Note: Calculations were performed in order from left to right.



Basic Wetpond Sizing

KC SWDM Worksheet 8-C

Goal: Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area from Phase 1, then transform facility for SUSTAIN input (vertical side slopes) and adjust drainage area for three precipitation factors.

Dimensions from Phase 1	
553 sf	bottom area

Legend

Blue text	indicates inputs that were changed during Phase 2
Green text	indicates values to maintain from Phase 1
Orange text	indicates inputs that were changed for the SUSTAIN input transformation
Light orange	Design Assumptions
Yellow	Toggle value to meet specified condition for blue cells
Light blue	Cells to match by toggling values

Original Design	Parameter			Units	Step in KC Worksheet	Notes
	Transformed for SUSTAIN					
40	40	32	60			Mean Annual Precipitation
1	1	1	1	unitless	Step 1	f=1 for Basic Size
98	98	98	98	unitless	Step 2	CN from Table 6.4.1.1.A, assuming 100% impervious
1.44	1.44	1.15	2.16 in	Step 2		Precipitation P, 72% of 2-year, 24-hour
0.2	0.2	0.2	0.2 in			Potential detention of area S, calculated
1.23	1.23	0.94	1.94 in			Runoff depth Qd, calculated
1.448	1.448	1.895	0.9181 acre	Step 4		Drainage area A, Assumed
6465.175	6465.175	6466.119	6465.444 cf			Basic volume Vb, calculated
6465.175	6465.175	6466.119	6465.444 cf			Required volume, calculated
4	4	4	4 ft			Max ponding depth
2	2	2	2 ft			Mid depth
3	0	0	0 H:V			Sideslope
3	3	3	3 L:W			Length-to-width ratio at mid-depth
22.155	23.21278	23.21278	23.21278			W0, mid-depth
66.465	69.63835	69.63835	69.63835			L0, mid-depth
10.155	23.21278	23.21278	23.21278 ft			W2, assumed at minimum wetpond depth, assuming one geometry for entire facility, not varying by cell
54.465	69.63835	69.63835	69.63835 ft			L2, bottom length (calculated assuming sideslopes on all 4 sides)
34.155	23.21278	23.21278	23.21278 ft			W1, ponding area width
78.465	69.63835	69.63835	69.63835 ft			L1, ponding area length
3233	3233	3233	3233 sf			[A1 (ponding area) + A2 (bottom area)]
3233.064	3233	3233	3233 sf			A1 + A2 Backcheck
553.0921	1616.5	1616.5	1616.5 sf			A2, Bottom area
2679.972	1616.5	1616.5	1616.5 sf			A1, Ponding area
1	1	1	1 ft			freeboard
3211.692	1616.5	1616.5	1616.5 sf			Top Area
6466.13	6466	6466	6466 cf			Volume Check
84.465	69.63835	69.63835	69.63835 ft			Top Length
38.02394	23.21278	23.21278	23.21278 ft			Top Width
2.221364	3	3	3 L:W			Top Length:Top Width
0.118	0.118	0.127	0.105 cfs			Off-line WQ design flow rate (modeled 100% impervious in MGSFlood)

Note: Calculations were performed in order from left to right.

Basic Wetvault

KC SWDM Worksheet 8-C



Goal: Maximize drainage area for a facility sized using 40-inch MAP while maintaining bottom area and dimensions from Phase 1, then adjust drainage area for three precipitation factors.

Dimensions from Phase 1		
1615	sf	bottom area
69.6	ft	bottom length
23.2	ft	bottom width

Legend	
Blue text	indicates inputs that were changed during Phase 2
Green text	indicates values to maintain from Phase 1
Orange text	indicates inputs that were changed for the SUSTAIN input transformation
	Design Assumptions
	Toggle value to meet specified condition for blue cells
	Cells to match by toggling values

Parameter		Units	Step in KC Worksheet	Notes
32	40	60 in		Mean Annual Precipitation
1	1	1 unitless	Step 1	f=1 for Basic Size
98	98	98 unitless	Step 2	CN from Table 6.4.1.1.A, assuming 100% impervious
1.15	1.44	2.16 in	Step 3	Precipitation P, 72% of 2-year, 24-hour
0.2	0.2	0.2 in		Potential detention of area S, calculated
0.94	1.23	1.94 in		Runoff depth Qd, calculated
1.8929	1.4465	0.9171 acre	Step 4	Drainage area A, Assumed
6458.953	6458.478	6458.402 cf		Basic volume Vb, calculated
6458.953	6458.478	6458.402 cf		Required volume, calculated
4	4	4 ft		Max ponding depth
2	2	2 ft		Mid depth
3	3	3 L:W		Length-to-width ratio
23.2	23.2	23.2 ft		W, Width
69.6	69.6	69.6 ft		L, Length
1614.72	1614.72	1614.72 sf		Footprint
3	3	3 ft		freeboard, doesn't affect area
6458.88	6458.88	6458.88 cf		Volume Check
0.127	0.118	0.105 cfs		Off-line WQ design flow rate (modeled 100% impervious in MGSFlood)

High Rate Underground Filter System



Goal: Using a ratio of drainage area to treatment capacity, determine unit Action Drainage area for three defined precipitation regions.

Design Assumptions	
Footprint	16 sf
Treatment capacity ^a	0.065 cfs

Mean Annual Precipitation (in)	Off-line WQ Design Flow from MGSFlood (cfs) ^b	Drainage Area for Unit Action Footprint (ac)	Drainage Area for Unit Action Footprint (sf)
32	0.067	0.9701	42259.70
40	0.081	0.8025	34955.56
60	0.114	0.5702	24836.84

Note:

a Treatment capacity provided by Contech; see table below.

b Off-line WQ Design Flow Rate computed in MGSFlood with 1 acre of impervious drainage area and a 15-minute time step.

Filterra Treatment Capacity, provided by Contech

Maximum Treatment Flow for Filterra (175" / hr)	
Basic and Enhanced Treatment Only	
Unit Size (ft x ft)	Treatment Capacity (cfs)
4x4	0.065
4x6	0.097
4x8	0.13
6x6	0.146
6x8	0.194
6x10	0.243
6x12	0.292
7x13	0.369
8x12	0.389
8x14	0.454
8x16	0.519
8x18	0.583
8x20	0.648

High Rate Underground Filter System as Pretreatment^a

Goal: Using a ratio of drainage area to treatment capacity, determine Unit Action Drainage area for three precipitation regions.

Design Assumptions	
Footprint	24 sf
Treatment capacity ^b	0.097 cfs

Mean Annual Precipitation (in)	Off-line WQ Design Flow from MGS Flood (cfs) ^c	Drainage Area for Unit Action Footprint (ac)	Drainage Area for Unit Action Footprint (sf)
32	0.067	1.4478	63064.48
40	0.081	1.1975	52164.44
60	0.114	0.8509	37064.21

Notes:

- a The 24 sf high-rate underground filter system is used as pre-treatment for the deep UIC well, infiltration pond, and infiltration vault Actions. When used as pre-treatment, the contributing drainage area is determined by the pre-treatment capacity.
- b Treatment capacity provided by Contech; see table below.
- c Off-line WQ Design Flow Rate computed in MGSFlood with 1 acre of impervious drainage area and a 15-minute time step.

Filterra Treatment Capacity, provided by Contech

Maximum Treatment Flow for Filterra (175"/ hr)	
Basic and Enhanced Treatment Only	
Unit Size (ft x ft)	Treatment Capacity (cfs)
4x4	0.065
4x6	0.097
4x8	0.13
6x6	0.146
6x8	0.194
6x10	0.243
6x12	0.292
7x13	0.369
8x12	0.389
8x14	0.454
8x16	0.519
8x18	0.583
8x20	0.648

Offline flow rate

Regional Vegetated Media Filtration Facility



Goal: Using the following formula, determine Unit Action Drainage area for each of the three defined precipitation regions:

$$\text{Unit Action Drainage Area} = \frac{\frac{\text{Manchester WQ Design Flow Rate}}{\text{WQBE WQ Design Flow Rate}} * \text{Drainage Area} * \frac{\text{Ecology GULD Infiltration Rate for Filterra}}{\text{Manchester Design Infiltration Rate for Filterra}}}{\text{Factor of Safety}}$$

Design Assumptions		
Footprint ^a	5940	sf
Drainage Area ^a	73	ac
Ecology GULD infiltration rate for Filterra (in/hr)	175	in/hr
Manchester design infiltration rate for Filterra (in/hr) ^a	24.8	in/hr
Factor of safety	1.3	
Manchester Mean Annual Precipitation ^b	40	in
Off-line Water Quality Design Flow Rate, Manchester ^{b, c}	2.643	cfs

Mean Annual Precipitation (in) ^{b, c}	Off-line WQ Design Flow Rate (cfs) ^c	Unit Action Drainage Area (ac)
32	2.173	482
40	2.643	396
60	3.839	273

Notes:

a

From Kitsap County Manchester Stormwater Park Report (Parametrix 2014).

b

Manchester, WA lies in the 40-inch MAP region. See Washington Mean Annual Precipitation isopluvial map below.

c

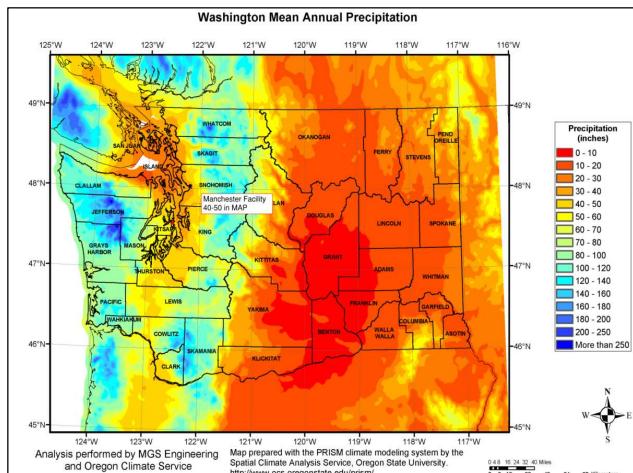
Manchester used the following land use assumptions to determine off-line WQ design flow rate in WWHM:

- 2.01 ac Forest flat
- 2.01 ac Forest mod
- 18.04 ac Lawn flat
- 17.29 ac Lawn mod
- 9.39 ac roads mod
- 10.24 ac rooftops flat
- 13.66 ac driveways mod

However, for purposes of WQBE precipitation sizing, the above WWHM assumptions were represented in MGSFlood with equivalent assumptions below to calculate off-line WQ Design Flow Rate:

- 4.02 ac Till forest
- 35.33 ac Till Grass
- 33.29 ac Impervious

Mean Annual Precipitation, Washington State (<http://www.mgsengr.com/>)



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ATTACHMENT I

Precipitation Analysis Summary

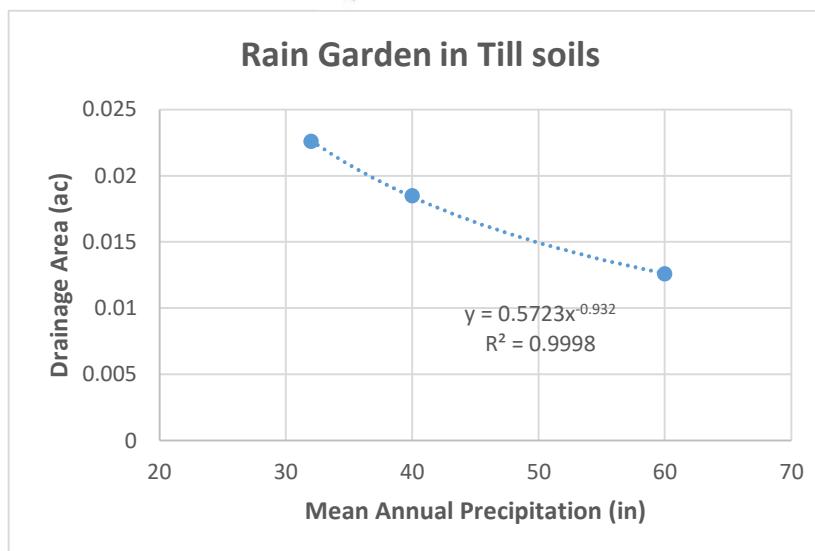
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Rain Garden on Till Soils		
Unit Action Footprint Area = 25 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.0226	984
40	0.0185	806
60	0.0126	549

Notes

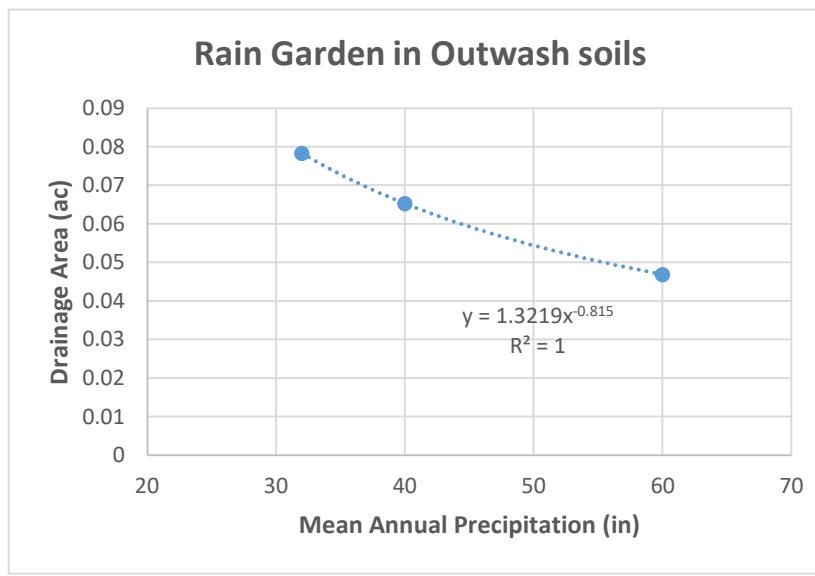
a Unit Action Footprint transformed to 33 SF for SUSTAIN input



Rain Garden on Outwash Soils		
Unit Action Footprint Area = 25 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.0783	3411
40	0.0653	2844
60	0.0469	2043

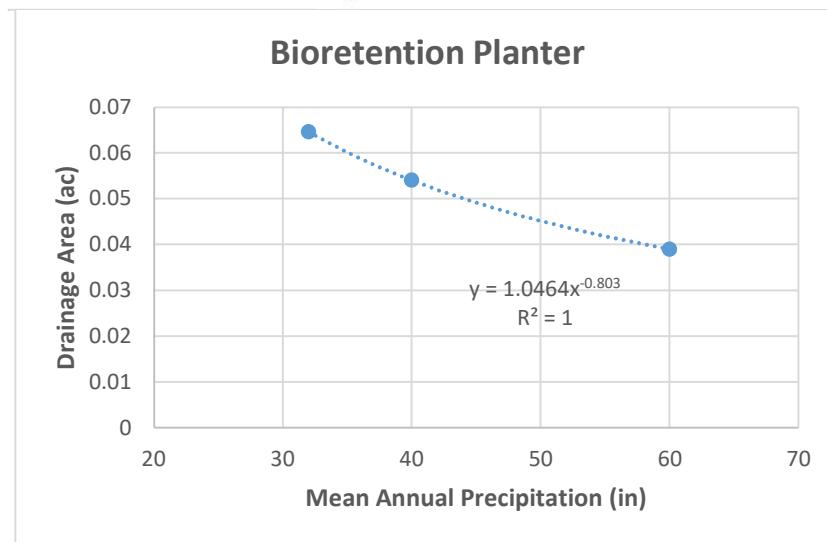
Notes

a Unit Action Footprint transformed to 65 SF for SUSTAIN input





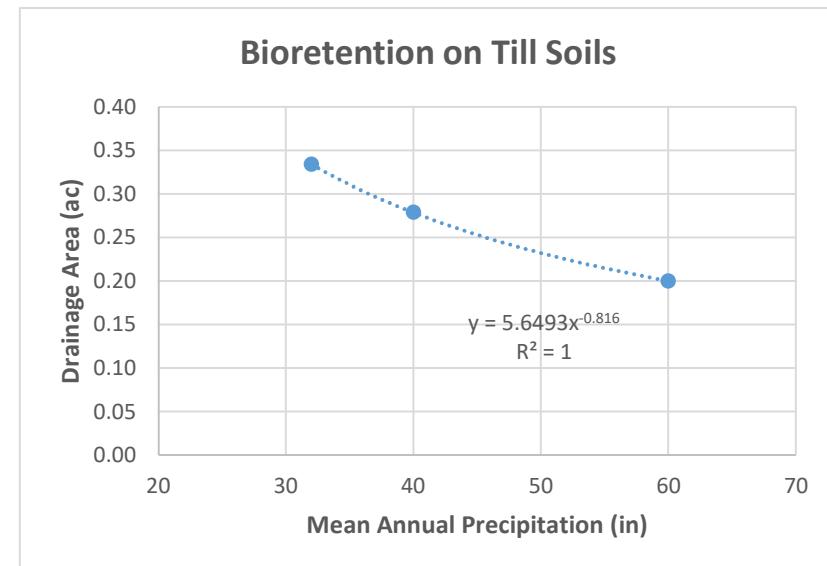
Bioretention Planter		
Unit Action Footprint Area = 25 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.0646	2814
40	0.0541	2357
60	0.0390	1699



Bioretention on Till Soils		
Unit Action Footprint Area = 85 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac) ^b	Unit Drainage Area (sf) ^b
32	0.3339	14545
40	0.2789	12148
60	0.2000	8712

Notes

- a Unit Action Footprint transformed to 137 SF for SUSTAIN input
- b Drainage Area includes 5% increase of drainage area modeled to account for storage and infiltration area under the elevated underdrain

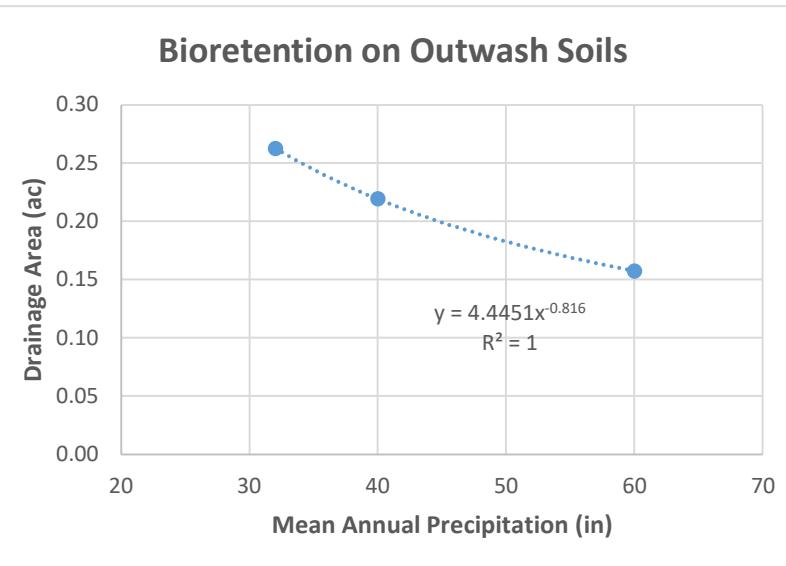




Bioretention on Outwash Soils		
Unit Action Footprint Area = 85 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.2627	11443
40	0.2197	9570
60	0.1574	6856

Notes

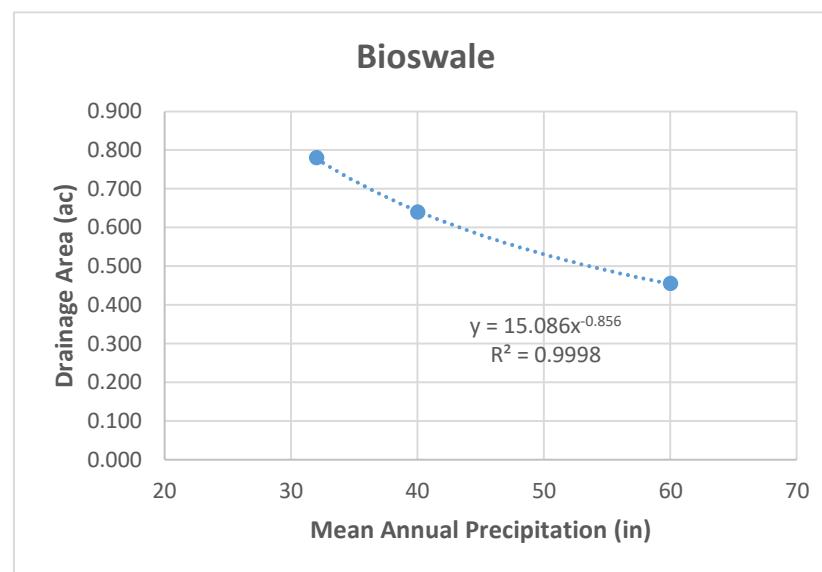
a Unit Action Footprint transformed to 206 SF for SUSTAIN input



Bioswale		
Unit Action Footprint Area = 200 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.780	33977
40	0.640	27878
60	0.455	19820

Notes

a Unit Action Footprint transformed to 236 SF for SUSTAIN input



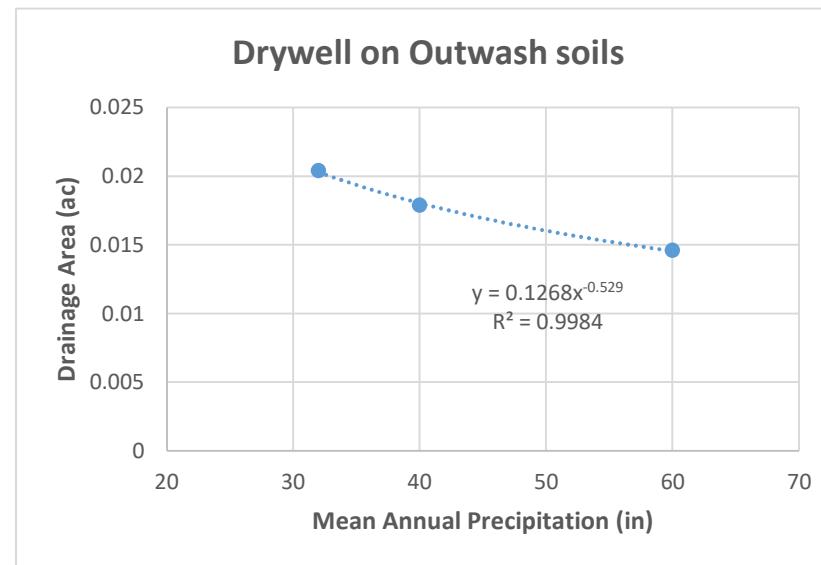
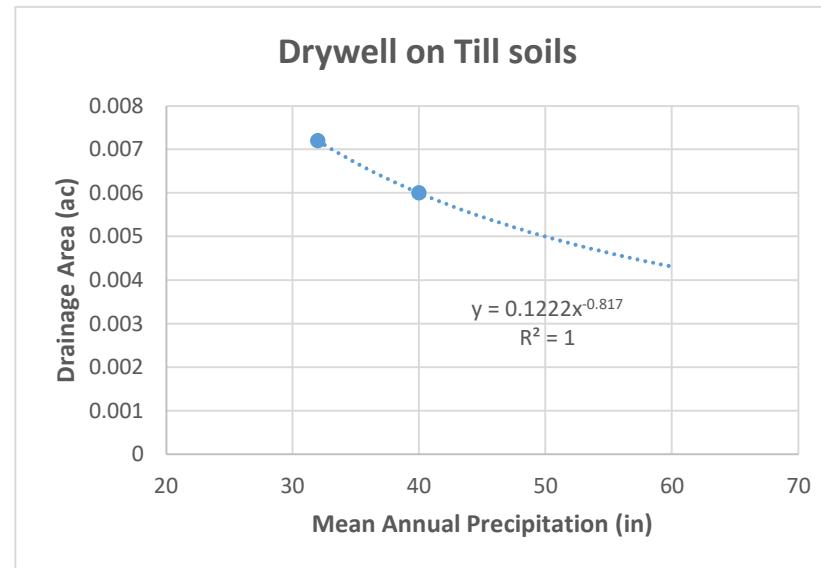


Drywell on Till Soils		
Unit Action Footprint Area = 13 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.0072	314
40	0.0060	261
60 ^a	0	0

Notes

- a Cannot run model; MGSFlood limits minimum contributing area to 0.005 acres

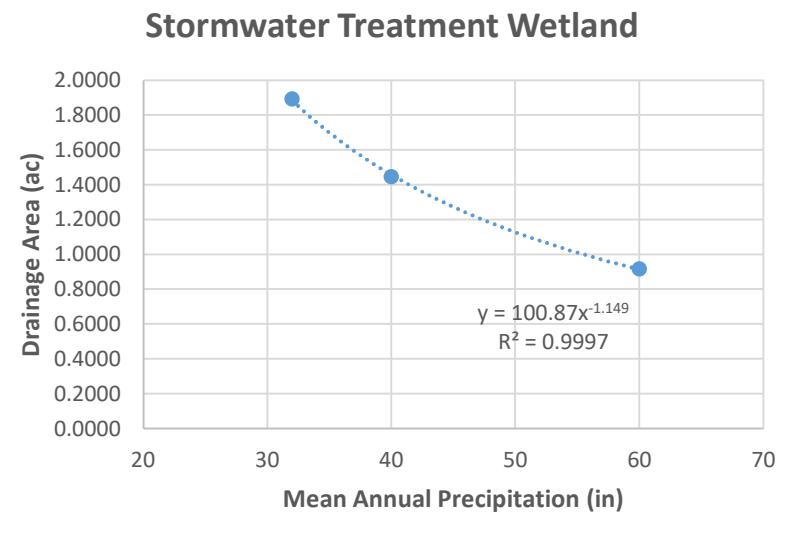
Drywell on Outwash Soils		
Unit Action Footprint Area = 13 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.0204	889
40	0.0179	780
60	0.0146	636





Stormwater Treatment Wetland		
Unit Action Footprint Area = 503 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	1.8920	82416
40	1.4460	62988
60	0.9170	39945

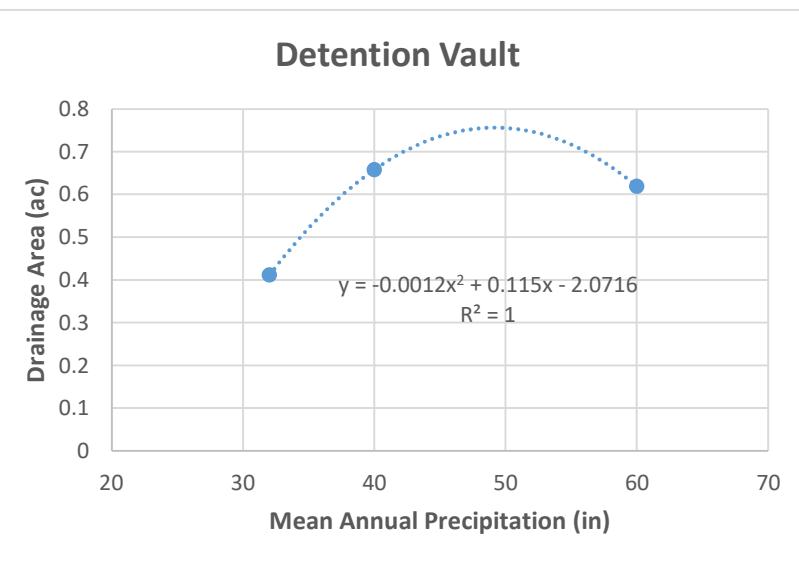
a Unit Action Footprint transformed to 2152 SF for SUSTAIN input



Detention Vault		
Unit Action Footprint Area = 2592 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac) ^a	Unit Drainage Area (sf) ^a
32	0.4114	17921
40	0.6579	28658
60	0.6192	26972

Note

a Unit drainage area is the modeled drainage area scaled down by a factor of 10





Detention Pond		
Unit Action Footprint Area = 4500 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac) ^b	Unit Drainage Area (sf) ^b
32	0.5262	22921
40	0.8395	36569
60	0.7987	34791

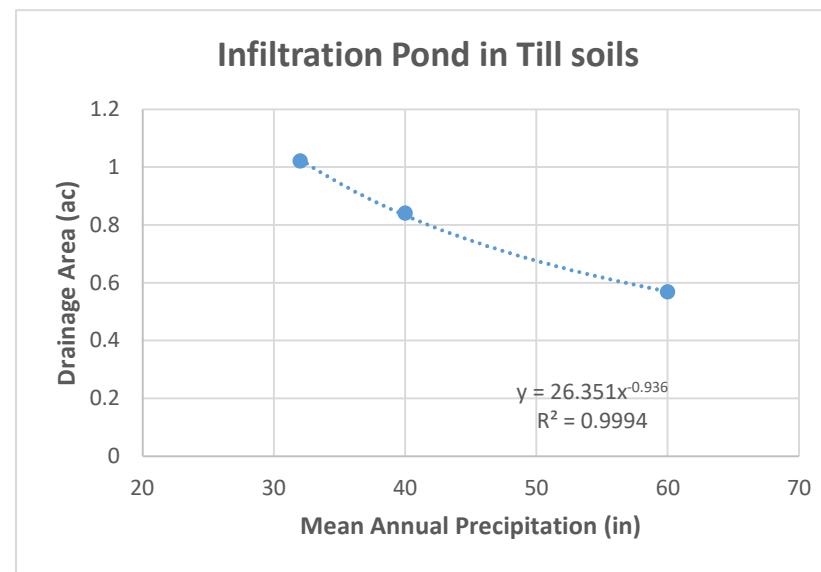
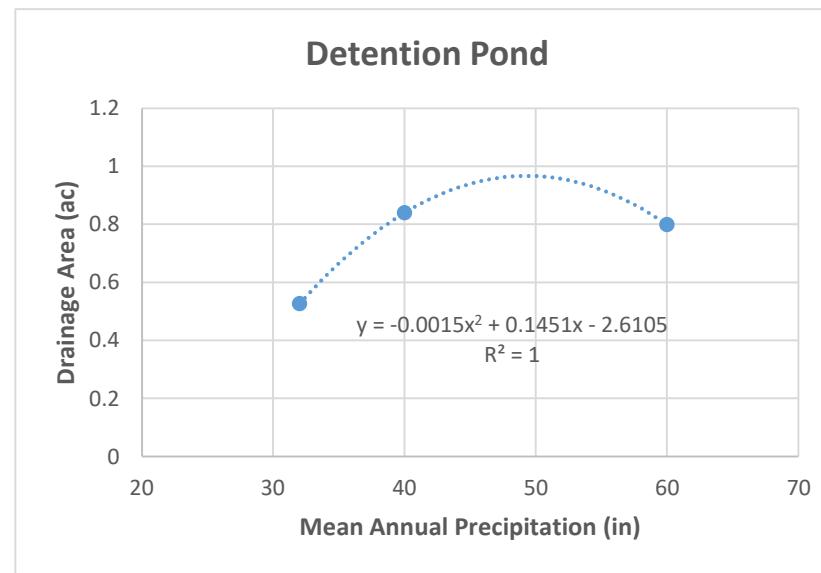
Note

- a Unit Action Footprint transformed to 4971 SF for SUSTAIN input
- b Unit drainage area is the modeled drainage area scaled down by a factor of 10

Infiltration Pond in Till Soils		
Unit Action Footprint Area = 2785 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac) ^b	Unit Drainage Area (sf) ^b
32	1.0213	44488
40	0.8401	36595
60	0.5683	24755

Note

- a Unit Action Footprint transformed to 3299 SF for SUSTAIN input
- b Unit drainage area is the modeled drainage area scaled down by a factor of 10





Infiltration Pond in Outwash Soils		
Unit Action Footprint Area = 1479 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac) ^b	Unit Drainage Area (sf) ^b
32	1.1768	51261
40	1.0651	46396
60	0.7870	34282

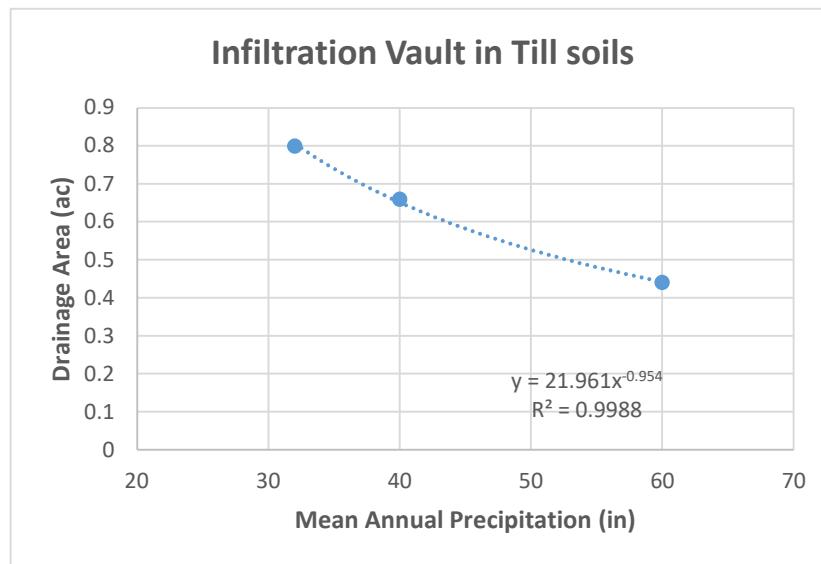
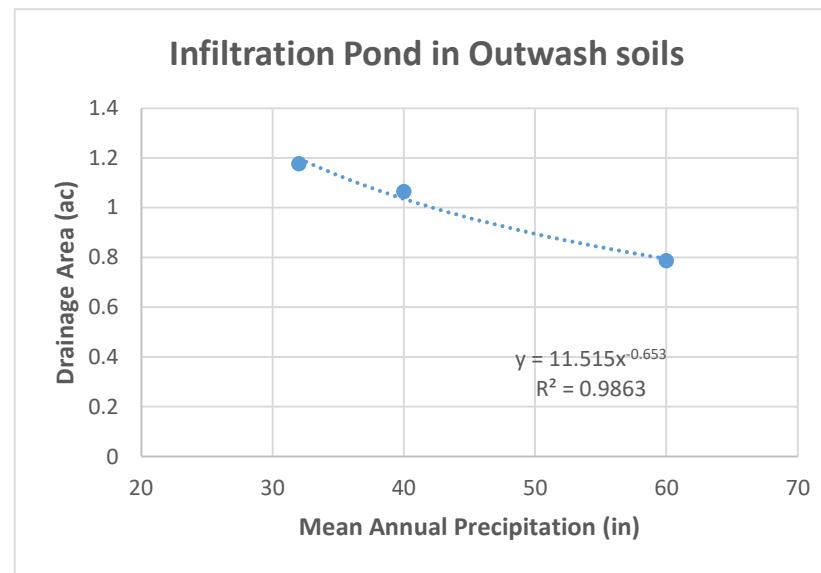
Note

- a Unit Action Footprint transformed to 1803 SF for SUSTAIN input
- b Unit drainage area is the modeled drainage area scaled down by a factor of 10

Infiltration Vault in Till Soils		
Unit Action Footprint Area = 1836 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac) ^a	Unit Drainage Area (sf) ^a
32	0.7994	34822
40	0.6593	28719
60	0.4405	19188

Note

- a Unit drainage area is the modeled drainage area scaled down by a factor of 10





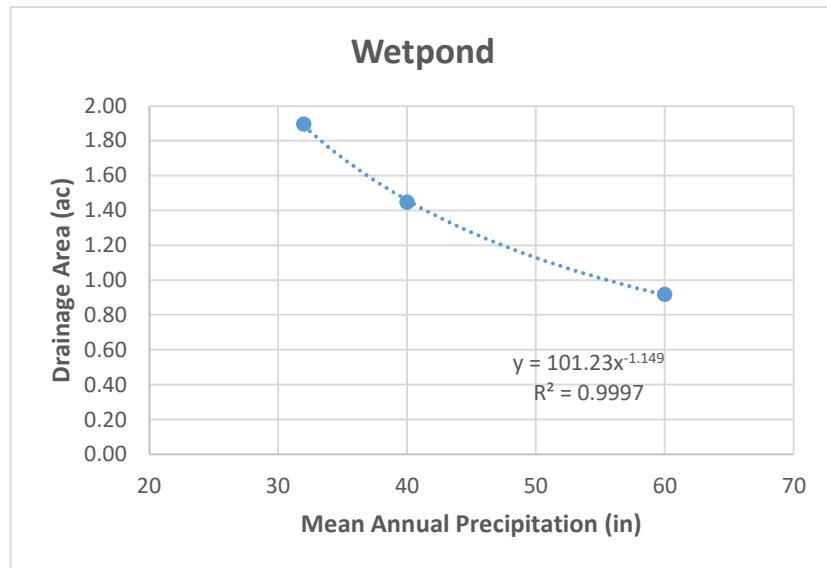
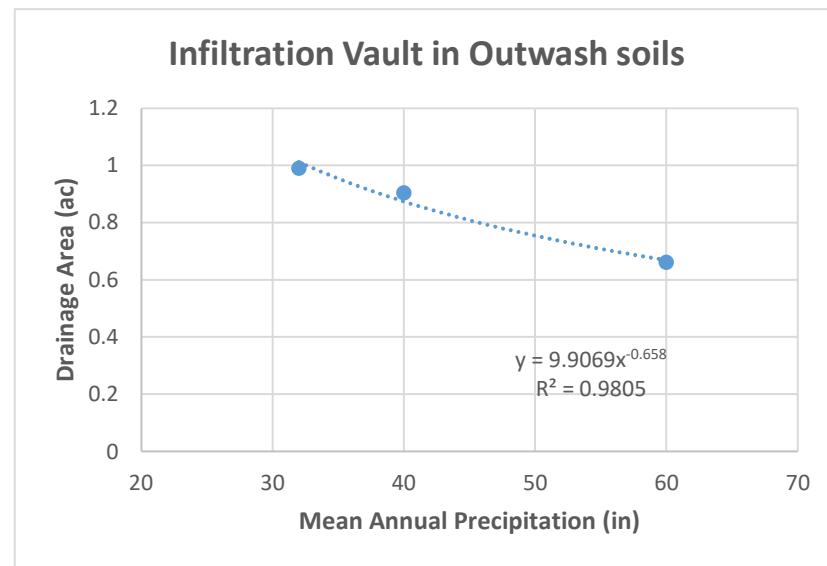
Infiltration Vault in Outwash Soils		
Unit Action Footprint Area = 1156 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac) ^a	Unit Drainage Area (sf) ^a
32	0.9902	43133
40	0.9037	39365
60	0.6611	28798

Note

a Unit drainage area is the modeled drainage area scaled down by a factor of 10

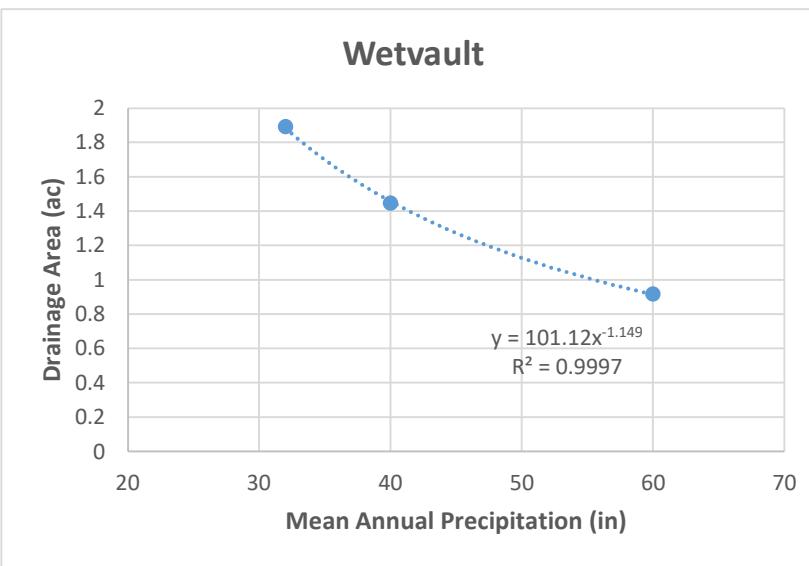
Wetpond		
Unit Action Footprint Area = 553 SF ^a		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	1.90	82546
40	1.45	63075
60	0.92	39992

a Unit Action Footprint transformed to 1616 SF for SUSTAIN input

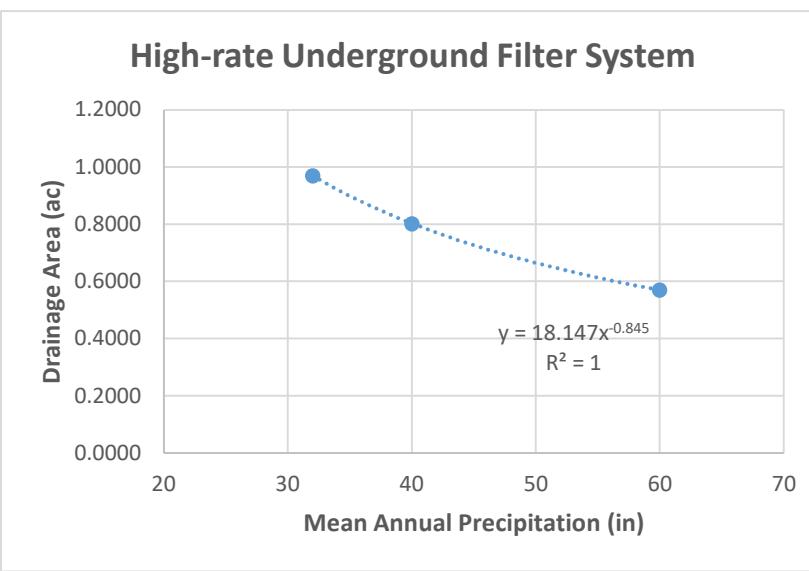




Wetvault		
Unit Action Footprint Area = 1615 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	1.8929	82455
40	1.4465	63010
60	0.9171	39949

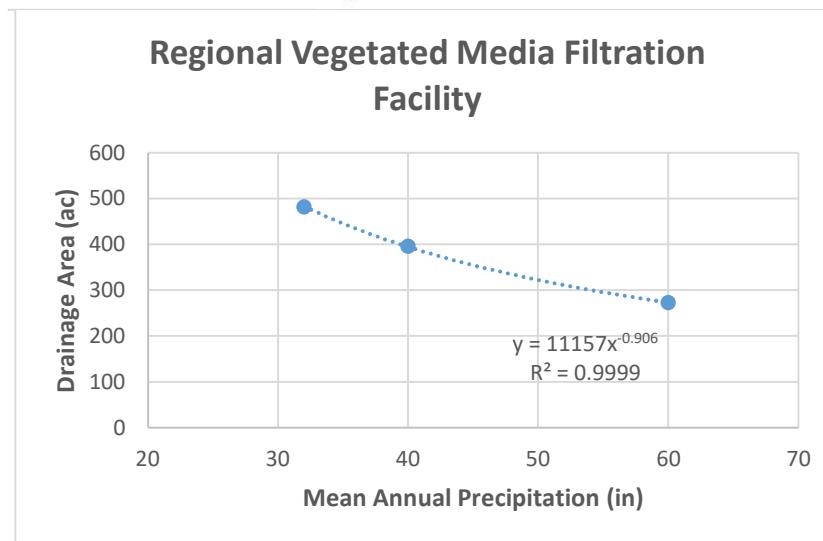


High-rate Underground Filter System		
Unit Action Footprint Area = 16 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.9701	42260
40	0.8025	34956
60	0.5702	24837

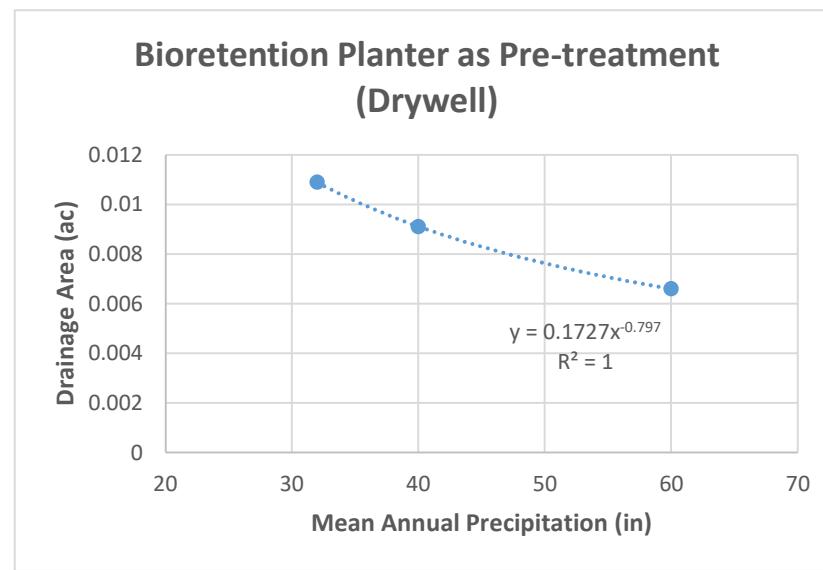




Regional Vegetated Media Facility		
Unit Action Footprint Area = 5940 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	482	5940
40	396	5940
60	273	5940



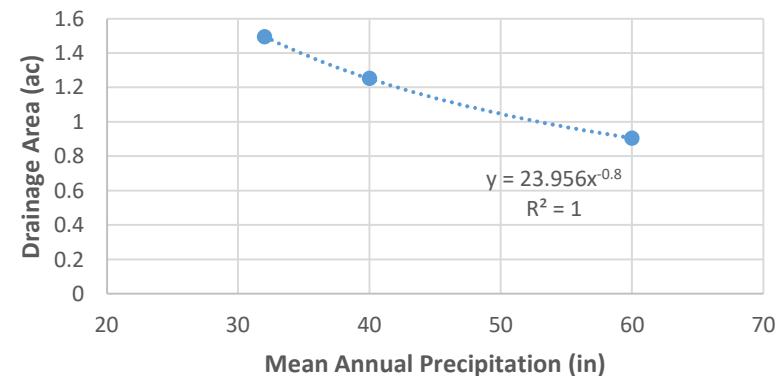
Bioretention Planter as Pre-treatment (Drywell)		
Unit Action Footprint Area = 4.3 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	0.0109	475
40	0.0091	396
60	0.0066	287



Bioretention Planter as Pre-treatment (UIC)		
Unit Action Footprint Area = 579 SF		
Mean Annual Precipitation (in)	Unit Drainage Area (ac)	Unit Drainage Area (sf)
32	1.4957	65153
40	1.2522	54546
60	0.9046	39404



Bioretention Planter as Pre-treatment (UIC)

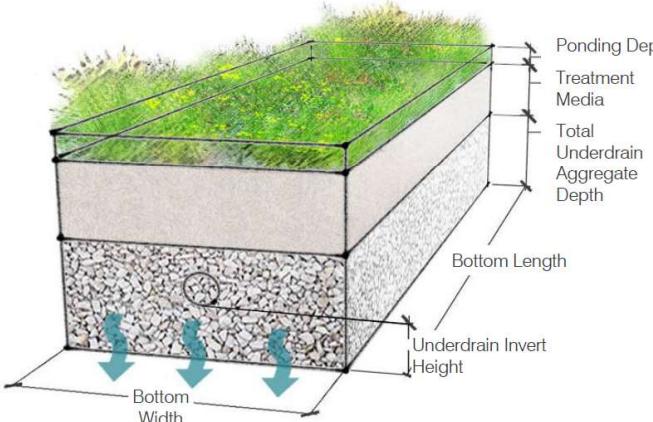


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ATTACHMENT J

Annotated Fact Sheet

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Action name	<h1>BIORETENTION</h1> <h2>Water Quality Benefits Evaluation Action Fact Sheet</h2>																																																	
	 <p>Phase 2</p>																																																	
General description of the Action including major assumptions and benefits provided	<p>ACTION DESCRIPTION</p> <p>Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.</p>																																																	
Photo depicting real-world application	 <p>City of Redmond Overlake Village LID Retrofit Project Photo courtesy of RKI</p>	<p>01/14/2022</p> <p>TREATMENT AREAS</p> <table border="1"> <tr> <td> Land Uses: <ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural Property Types: <ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way </td> <td> Surface Types: <ul style="list-style-type: none"> Roofs Lawns Driveways Parking Lots Sidewalk Plazas <ul style="list-style-type: none"> Local Roads Arterial Roads Highways </td> </tr> </table> <p>Summary of where the Action can be applied, informing cost estimates and SUSTAIN model assumptions on implementation</p>		Land Uses: <ul style="list-style-type: none"> Residential Commercial Industrial Highway Agricultural Property Types: <ul style="list-style-type: none"> Private Parcel Public Parcel Public Right-of-Way 	Surface Types: <ul style="list-style-type: none"> Roofs Lawns Driveways Parking Lots Sidewalk Plazas <ul style="list-style-type: none"> Local Roads Arterial Roads Highways 																																													
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Summary of Action design parameters	<p>DESIGN PARAMETERS</p> <table border="1"> <thead> <tr> <th rowspan="2">Parameter</th> <th colspan="2">Soil Type</th> </tr> <tr> <th>Till</th> <th>Outwash</th> </tr> </thead> <tbody> <tr> <td>Unit Footprint Area</td> <td>85 SF</td> <td>85 SF</td> </tr> <tr> <td>Unit Drainage Area</td> <td>12,148 SF</td> <td>9,570 SF</td> </tr> <tr> <td>Ponding Depth</td> <td>6 in</td> <td>6 in</td> </tr> <tr> <td>Bottom Length</td> <td>16 ft</td> <td>16 ft</td> </tr> <tr> <td>Bottom Width</td> <td>5.33 ft</td> <td>5.33 ft</td> </tr> <tr> <td>Side Slope</td> <td>3H : 1V</td> <td>3H : 1V</td> </tr> <tr> <td>Treatment Media Depth</td> <td>18 in</td> <td>18 in</td> </tr> <tr> <td>Treatment Media Porosity</td> <td>30%</td> <td>30%</td> </tr> <tr> <td>Treatment Media Infiltration Rate</td> <td>6 in/hr</td> <td>6 in/hr</td> </tr> <tr> <td>Total Underdrain Aggregate Depth</td> <td>26 in</td> <td>N/A</td> </tr> <tr> <td>Underdrain Invert Height</td> <td>12 in</td> <td>N/A</td> </tr> <tr> <td>Underdrain Diameter</td> <td>8 in</td> <td>N/A</td> </tr> <tr> <td>Underdrain Aggregate Porosity</td> <td>40%</td> <td>N/A</td> </tr> <tr> <td>Native Soil Design Infiltration Rate</td> <td>0.3 in/hr</td> <td>2.5 in/hr</td> </tr> </tbody> </table> <p>Design is based on 2016 King County Surface Water Design Manual (KCSWDM) Section C.2.6.1.</p> <p>Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.</p> <p>Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.</p> <p>The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.</p> <p>For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6" cover, 8" underdrain pipe, and 12" bedding.</p> <p>For bioretention installed on outwash soils, no underdrain is included.</p>			Parameter	Soil Type		Till	Outwash	Unit Footprint Area	85 SF	85 SF	Unit Drainage Area	12,148 SF	9,570 SF	Ponding Depth	6 in	6 in	Bottom Length	16 ft	16 ft	Bottom Width	5.33 ft	5.33 ft	Side Slope	3H : 1V	3H : 1V	Treatment Media Depth	18 in	18 in	Treatment Media Porosity	30%	30%	Treatment Media Infiltration Rate	6 in/hr	6 in/hr	Total Underdrain Aggregate Depth	26 in	N/A	Underdrain Invert Height	12 in	N/A	Underdrain Diameter	8 in	N/A	Underdrain Aggregate Porosity	40%	N/A	Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr
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Schematic illustration of major components included in SUSTAIN model	<p>UNIT ACTION SCHEMATIC</p> 	<p>Basis of design summary</p>																																																
	<p>N/A: Not Applicable</p> <p>Page 1 of 2</p> <p>Visit kingcounty.gov/WQBE for more information.</p>	<p>A project for Clean Water Healthy Habitat</p> <p>HERRERA</p> <p>RKI planning engineering</p> <p>HDR</p> <p>King County</p>																																																

BIORETENTION

Water Quality Benefits Evaluation Action Fact Sheet



Phase 2

Summary of
SUSTAIN modeling
processes

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).

PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	Median Effluent Concentration ^a
Total Copper	62.3%	10.5 µg/L
Dissolved Copper	57.6%	6.4 µg/L
Total Zinc	91.0%	10.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L ^b
Total Phosphorus	54.9%	0.113 mg-P/L
Total Nitrogen	51.3%	1.33 mg/L
Total Suspended Solids	78.0%	21.5 mg/L
Total PCBs	78.0% ^c	572 pg/L ^c
Total PBDEs	67.1% ^c	0.054 ng/L ^c
Total PAHs	95.0%	<0.01 µg/L ^b
Bis(2-ethylhexyl)phthalate	63.2% ^c	0.070 µg/L ^c
Fecal Coliform	61.5 %	240 CFU

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash

b. Method detection limit

c. Values derived from TSS translator equations. See methods section of 431-TM1 Appendix C.

Page 2 of 2

Visit kingcounty.gov/WQBE for more information.

UNIT ACTION COSTS

01/14/2022

Costs/Unit Action ^{a, b}	With Underdrain			No Underdrain		
	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$100,000	\$85,000	\$139,000	\$98,000	\$83,000	\$135,000
Total Direct Construction	\$59,000	\$59,000	\$97,000	\$57,000	\$57,000	\$94,000
Total Indirect Non-Construction	\$42,000	\$26,000	\$42,000	\$41,000	\$25,000	\$41,000
Operation and Maintenance	\$2,800/year	\$2,800/year	\$2,800/year	\$2,800/year	\$2,800/year	\$2,800/year
Property Acquisition ^c	\$14,000	\$0	\$0	\$14,000	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2019 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs.

Median percent
removal and median
effluent
concentrations for
target pollutants
analyzed in SUSTAIN

Total project,
operation and
maintenance, and
property acquisition
cost estimates for
various model
configurations

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the 2016 King County Surface Water Design Manual

Considerations for
program
implementation and
siting of individual
Actions in SUSTAIN

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Appendix C

Phase 3 Action Design Assumptions and Modeling Parameters

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TECHNICAL MEMORANDUM

Date: October 4, 2024
To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division
From: Alice Lancaster, Herrera Environmental Consultants, Inc.
Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc.
Subject: WQBE Phase 3 Action Development (Appendix C to 439-TM1)

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Attachments

- Attachment A Stormwater Field and Park Detention Concept Plan and Section
- Attachment B ADS StormTech Chamber (SC-740) Array Specifications
- Attachment C Sports Field and Park Detention Modeling Assumptions and Stage-Storage-Discharge Routing Table

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Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages", for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020):** Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021–2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- **Phase 3 (2023–2024):** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the Actions developed in Phase 3 for the WQBE Toolkit. The following information is provided: the Action development process, an overview of the WQBE Actions and Action Fact Sheets, the design assumptions and technical basis for the new Action Fact Sheet content, and key limitations/future considerations.

Action Development Process

The Core Team (Consultant and County staff directly overseeing WQBE toolkit development) held a workshop with King County staff on April 18, 2023, to select and define the Actions to be developed under Phase 3. The results of this workshop are summarized in a companion memorandum (Herrera 2023). The following Actions were recommended for development.

- Sports Fields and Parks Detention
- Blue Roofs
- Compost Amendment
- Reforestation
- Tree Planting in the Right of Way
- Continuous Monitoring and Active Control (CMAC system)
- Floodplain Storage
- High-flow Bypass (tightline of stormwater to bottom of watershed)
- Retrofit Existing Flow Control Facilities

Subsequent to the workshop, the Core Team decided to eliminate the following Actions from further consideration: tree planting in the right of way, floodplain storage, high-flow bypass, and CMAC system. Tree planting in the right of way was not advanced because this Action would provide minimal flow control. Floodplain storage and high-flow bypass were not advanced due to modeling complexities and budget limitations. CMAC system was not advanced because SUSTAIN currently does not have the functionality to represent the flow control benefits of this Action.

Upon further investigation, the retrofitting existing facilities Action was also eliminated from further consideration due to the difficulty representing this Action in SUSTAIN. An exploratory analysis was completed to size a “mini-pond” and outlet structure that represents the difference between a pond meeting 1990 King County flow control standards and the same 1990 pond with an optimized flow control structure, ideally achieving a pasture or forested flow control standard. The following steps were completed during this analysis:

1. Using Western Washington Hydrology Model (WWHM2012), size a pond for a 10-acre tributary area (60% impervious, 40% pervious) to 1990 King County standards.

2. Optimize the 1990 pond outlet structure (assuming no change in pond volume or depth) to achieve a pasture standard to the greatest extent feasible.
3. Identify if there is a relationship between the discharge of the 1990 and the optimized-1990 ponds. This would inform the feasibility of developing a small pond representing the difference in the two ponds for inclusion in the SUSTAIN optimization.

A meaningful relationship between the discharge of the two ponds could not be identified to facilitate the creation of a modified discharge curve or mini-pond for input into SUSTAIN. Therefore, a SUSTAIN representation for this Action could not be developed.

While the retrofitting existing facilities, CMAC, floodplain storage, and high-flow bypass Actions are not being advanced in connection with Phase 3, the County may choose to use other means to evaluate the cost-effectiveness of these likely beneficial Actions.

Action Overview

This section provides a high-level description of the WQBE Actions, Action Fact Sheets, and WQBE Programs.

Actions

"Actions" are structural or nonstructural stormwater controls that improve water quality and/or provide flow control. The nineteen Actions developed under Phase 2 are listed below. These Actions are documented under a separate memorandum in Appendix B of Herrera (2024).

- **Green Stormwater Infrastructure (GSI) practices** include rain gardens, HPBSM¹ bioretention, bioretention HPBSM planters, bioswales, media filter drains, drywells, deep underground injection (UIC) wells, permeable pavement, depaving, and stormwater treatment wetlands.
- **Stormwater retention/detention/infiltration practices** include detention vaults, detention ponds, infiltration ponds, infiltration vaults, and cisterns.
- **Gray practices** include wetponds, wetvaults, high-rate underground filter systems, and regional vegetated media filtration facilities.

Five new flow control-focused Actions were developed under Phase 3. A high-level description of each Program is provided below.

- **Sports Fields and Parks Detention** is subsurface storage at an existing sport field or park to provide flow control while preserving recreational site use. An underground chamber array will detain the

¹ HPBSM is high-performance bioretention soil media.

water draining from the overlying area and offsite contributing drainage area. The stored stormwater runoff is released through a control structure at an attenuated rate.

- **Blue Roof** is rooftop detention designed to provide temporary storage and slow release of stormwater runoff. This technique is most commonly used in dense urban areas where other methods of stormwater detention are impractical.
- **Compost Amendment** includes amending soil under existing lawn surfaces with compost to increase water holding capacity and infiltration. Amended area is revegetated with turf.
- **Reforest High Density Development** converts existing impervious surface and buildings to forest by uncompacting/ amending soil and planting trees and understory vegetation. The costs for this Action assume demolition and disposal of buildings, pavement and utilities. While the benefits of this Action would increase over time as the trees and vegetation become established, the performance of this Action is represented as a mature forest.
- **Reforest Pervious** converts existing pervious surface to forest by uncompacting/ amending soil and planting trees and understory vegetation. While the benefits of this Action would increase over time as the trees and vegetation become established, its performance is represented as a mature forest.

This memorandum is focused on documenting these Actions developed in Phase 3.

Action Fact Sheets

Action Fact Sheets were prepared to compile Action descriptions and the information used to develop modeling inputs for the SUSTAIN model, including design, performance, and cost assumptions. Fact Sheets include the following:

- Description and photo of Action
- Potential areas managed, including land uses, property types, and surface types
- Design parameters for unit Action, including footprint area, drainage area, and design section
- Schematic for unit Action, illustrating section and dimensions
- Design assumptions, including basis for sizing
- Representation of hydrologic and treatment performance in the SUSTAIN model
- Action treatment performance parameters, including median percent removal and median effluent concentration
- Planning-level cost estimates for unit Action
- Programmatic feasibility and siting considerations

Phase 3 Action Fact Sheets are included in Appendix G of Herrera (2024). In Phase 3, updates were made to the original Fact Sheets from Phase 2 (Herrera 2022) to refine Action costs and improve their accuracy and clarity.

Aggregating Actions into Programs

Actions provide the unit building blocks (or “unit Actions”) that are aggregated and combined to develop “Programs,” or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. The Programs developed in Phase 3 focus on flow control and include a mix of Actions developed under Phase 2 and Phase 3. Phase 3 Program Fact Sheets can be found in Appendix H of Herrera (2024).

Action Assumptions and Technical Basis

The key assumptions and technical basis for information included in the Action Fact Sheets are provided below.

Action Benefits and Areas Managed

Table 1 provides a description for each Action and lists the flow control and water quality treatment benefits provided. The table also summarizes the potential areas managed by the Action, including land uses (e.g., residential, commercial), surface types (e.g., roof, pervious), and property ownership (e.g., public, private) to inform Program development and SUSTAIN modeling.

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Table 1. Action Description, Benefits, and Area Managed

Action	Description	WQBE Phase	Benefits Provided	Potential Area Managed		
				Land Use	Surface Type	Property Ownership
Rain garden	A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile. Provides volume and peak flow reduction and water quality treatment.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial	● Roofs ● Lawns ● Driveways ● Sidewalks ● Parking Lots	● Private Parcel ● Public Parcel
Bioretention HPBSM	A shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.	Developed in Phase 2; costs updated in Phase 3; Previously named "bioretention" in Phase 2	● Volume Reduction ● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial ● Industrial ● Highway ● Agricultural	● Roofs ● Lawn ● Driveways ● Parking Lots ● Sidewalks ● Plazas ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way
Bioretention HPBSM planter	Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. Provides water quality treatment and peak flow reduction. For this analysis, the Action is assumed to have an underdrain and closed bottom.	Developed in Phase 2; costs updated in Phase 3; Previously named "bioretention planter" in Phase 2	● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial ● Industrial	● Roofs ● Driveways ● Parking Lots ● Sidewalks ● Plazas ● Local Roads ● Arterial Roads	● Private Parcel ● Public Parcel ● Public Right-of-Way
Bioswale	An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. Provides water quality treatment, peak flow reduction, and conveyance. These are designed to "filter" water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism.	Developed in Phase 2; costs updated in Phase 3	● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial ● Industrial ● Highway ● Agricultural	● Parking Lots ● Arterial Roads ● Local Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way
Media Filter Drain (MFD)	A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction ● Water Quality Treatment	● Highway ● Agricultural	● Arterial Roads ● Local Roads ● Highways	● Public Right-of-Way
Drywell	A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction. Pretreatment is required for this Action.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction	● Residential ● Commercial ● Industrial ● Agricultural	● Roofs ● Sidewalks ● Driveways ● Parking Lots ● Lawns	● Private Parcel ● Public Parcel

Table 1 (continued). Action Description, Benefits, and Area Managed

Action	Description	WQBE Phase	Benefits Provided	Land Use	Potential Area Managed	Property Ownership
					Surface Type	
Deep Underground Injection Control (UIC) Well	A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action. Provides volume and peak flow reduction. Pretreatment is required for this Action.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction	● Residential ● Commercial	● Roofs ● Sidewalks ● Lawns ● Local Roads ● Arterial Roads	● Private Parcel ● Public Parcel ● Public Right-of-Way
Permeable pavement	Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides volume and peak flow reduction. Provides water quality treatment when sand treatment layer is provided.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial	● Low Volume Residential Driveways ● Sidewalks ● Plazas ● Trails ● Pedestrian and Bike Paths ● Parking Lots	● Private Parcel ● Public Parcel ●
Depaving	Depaving, or removal of impervious surfaces down to bare soil. The area is amended with soil and planted with low lying ground cover. To allow continued site use, the area is retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit". Provides volume and peak flow reduction.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction	● Residential ● Commercial ● Industrial	● Driveways ● Sidewalks ● Parking Lots	● Private Parcel ● Public Parcel ●
Stormwater treatment wetland	Similar to a wet pond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal. Provides water quality treatment and peak flow reduction.	Developed in Phase 2; costs updated in Phase 3	● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial ● Industrial ● Highway ● Agricultural ● Forest	● Roofs ● Lawns ● Sidewalks ● Driveways ● Parking Lots ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way
Detention vault	A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate. Provides peak flow reduction.	Developed in Phase 2; costs updated in Phase 3	● Peak Flow Reduction	● Residential ● Commercial ● Industrial ● Highway ● Agricultural ● Forest	● Roofs ● Lawns ● Sidewalks ● Driveways ● Parking Lots ● Plazas ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way
Detention pond	A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events. Provides peak flow reduction.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction	● Residential ● Commercial ● Industrial ● Highway ● Agricultural ● Forest	● Roofs ● Lawns ● Sidewalks ● Driveways ● Parking Lots ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way

Table 1 (continued). Action Description, Benefits, and Area Managed

Action	Description	WQBE Phase	Benefits Provided	Land Use	Potential Area Managed	Property Ownership
					Surface Type	
Infiltration pond	A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration. Provides volume and peak flow reduction. Pretreatment is required for this Action.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction	● Residential ● Commercial ● Industrial ● Highway ● Agricultural ● Forest	● Roofs ● Lawns ● Sidewalks ● Driveways ● Parking Lots ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way
Infiltration vault	An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom. Provides volume reduction and peak flow reduction. Pretreatment is required for this Action.	Developed in Phase 2; costs updated in Phase 3	● Volume Reduction ● Peak Flow Reduction	● Residential ● Commercial ● Industrial ● Highway ● Agricultural ● Forest	● Roofs ● Lawns ● Sidewalks ● Driveways ● Parking Lots ● Plazas ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way
Cistern	A tank designed to provide temporary storage and slow release of rooftop stormwater runoff. Provides peak flow reduction.	Developed in Phase 2; costs updated in Phase 3	● Peak Flow Reduction	● Residential ● Commercial ● Industrial	● Roofs	● Private Parcel ● Public Parcel
Wetpond	A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants. Provides water quality treatment and peak flow reduction.	Developed in Phase 2; costs updated in Phase 3	● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial ● Industrial ● Highway ● Agricultural ● Forest	● Roofs ● Lawns ● Sidewalks ● Driveways ● Parking Lots ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way
Wetvault	An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. Provides water quality treatment and peak flow reduction.	Developed in Phase 2; costs updated in Phase 3	● Peak Flow Reduction ● Water Quality Treatment	● Residential ● Commercial ● Industrial ● Highway ● Agricultural ● Forest	● Roofs ● Lawns ● Sidewalks ● Driveways ● Parking Lots ● Plazas ● Local Roads ● Arterial Roads ● Highways	● Private Parcel ● Public Parcel ● Public Right-of-Way

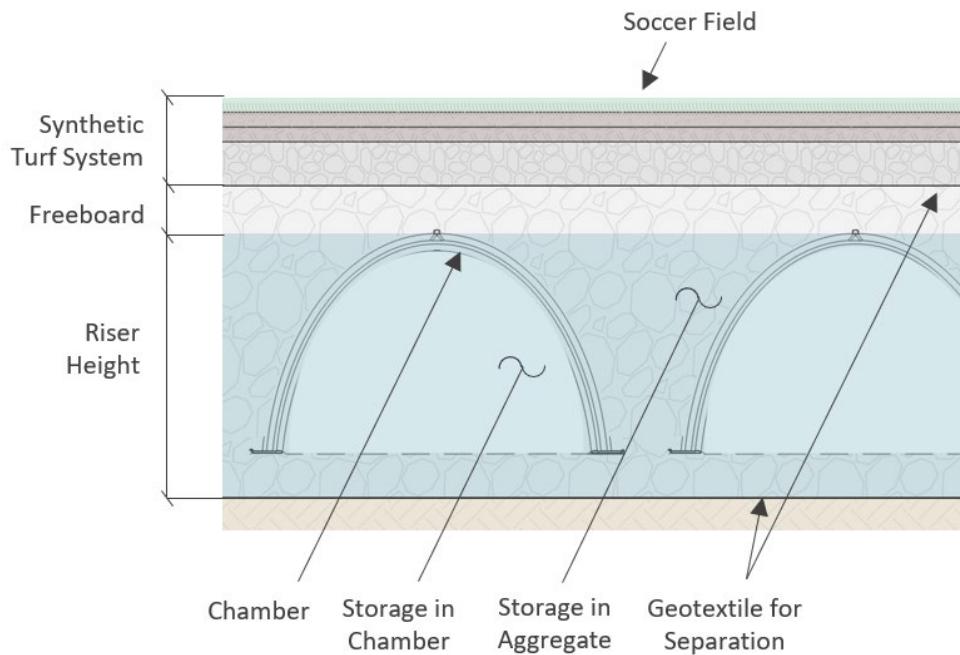
Table 1 (continued). Action Description, Benefits, and Area Managed

Action	Description	WQBE Phase	Benefits Provided	Land Use	Potential Area Managed	Property Ownership
					Surface Type	
High-rate underground filter system	An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary. Provides water quality treatment.	Developed in Phase 2; costs updated in Phase 3	• Water Quality Treatment	• Commercial • Industrial • Highway	• Roofs • Sidewalks • Driveways • Parking Lots • Plazas • Local Roads • Arterial Roads	• Private Parcel • Public Parcel • Public Right-of-Way
Stormwater park (water quality treatment)	A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area. Provides water quality treatment through a Filterra® treatment media.	Developed in Phase 2; costs updated in Phase 3; Previously named "Regional stormwater treatment facility" in Phase 2	• Water Quality Treatment	• Residential • Commercial • Industrial • Highway • Agricultural • Forest	• Roofs • Lawns • Sidewalks • Driveways • Parking Lots • Plazas • Local Roads • Arterial Roads • Highways	• Private Parcel • Public Parcel
Sports field and park detention	Subsurface storage at existing sport field or park to provide flow control while preserving recreational site use. An underground chamber array will detain the water draining from the overlying area and offsite contributing drainage area. The stored stormwater runoff is released through a control structure at an attenuated rate.	Developed in Phase 3	• Peak Flow Reduction	• Residential • Commercial • Industrial • Highway • Agricultural • Forest	• Roofs • Lawns • Sidewalks • Driveways • Parking Lots • Plazas • Local Roads • Arterial Roads • Highways	• Private Parcel • Public Parcel
Blue roof	Rooftop detention designed to provide temporary storage and slow release of stormwater runoff. This technique is most commonly used in dense urban areas where other methods of stormwater detention are impractical.	Developed in Phase 3	• Peak Flow Reduction	• Commercial • Industrial	• Roofs	• Private Parcel • Public Parcel
Compost amendment	Amending existing pervious surfaces with compost to increase water holding capacity.	Developed in Phase 3	• Volume Reduction • Peak Flow Reduction	• Residential • Commercial • Industrial	• Lawns	• Private Parcel • Public Parcel
Reforest High Density Development	Converting existing impervious surfaces and buildings to forest.	Developed in Phase 3	• Volume Reduction • Peak Flow Reduction	• Commercial • Industrial	• Parking lots • Walkways • Driveways • Buildings • Lawn	• Private Parcel • Public Parcel
Reforest Pervious Area	Converting pervious surfaces to forest.	Developed in Phase 3	• Volume Reduction • Peak Flow Reduction	• Residential	• Lawn	• Private Parcel

Action Design

Table 2 provides the design basis and major assumptions for the new Flow Control Actions developed in Phase 3. These assumptions impact Action performance, cost, and feasibility. For some Actions, schematics are provided to illustrate the section and dimensions (see Figure 1 for example).

Figure 1. Unit Action Schematic for Sports Field and Park Detention.



The design basis for Actions originally developed under Phase 2 are provided in Appendix B of Herrera (2024).

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Table 2. Representative Design and Assumptions for New Phase 3 Flow Control Actions.

Action	Design Basis/Assumptions	Notes
Sports field and park detention	<ul style="list-style-type: none"> ● Representative Action assumes an array of subsurface storage chambers under one half of a standard soccer field to detain water draining from the overlying area and offsite contributing drainage area. Implementation also includes: <ul style="list-style-type: none"> ○ ADS StormTech Chamber (SC-740) array ○ Field restoration with artificial turf and paint ○ Conveyance from upstream drainage area and to downstream drainage system ● No infiltration to underlying soil ● No additional site improvements (e.g., lighting, seating) are included ● No property acquisition 	<ul style="list-style-type: none"> ● Artificial turf was used to increase the potential for participation/partnering. Costs for natural turf would be lower. ● Storage chamber model (SC-740) is relatively shallow and selected to increase feasibility and allow for downstream tie in. ● Facility assumed to be non-infiltrating to increase feasibility (i.e., can be sited where infiltration is not feasible). However, an open bottom configuration sited in infiltrating soil would allow for a larger offsite drainage area and be more cost effective. ● See Attachment A for concept plan and section. ● See Attachment B for ADS StormTech Chamber (SC-740) array specifications.
Blue roof	<ul style="list-style-type: none"> ● Representative Action assumes retrofitting an existing flat roof (with parapet) to provide up to 4 inches of storage. Implementation includes: <ul style="list-style-type: none"> ○ Waterproof lining installed ○ Roof drainage reconfigured to direct runoff from 1,000 sf to control structure at roof drain ○ HVAC/utilities on roof raised 6 inches ○ Control structure has 0.25-inch orifice and redundant overflow with protective screening (e.g., sand filter to protect orifice from clogging) ● Building does not require structural upgrades ● No property acquisition 	<ul style="list-style-type: none"> ● Assumes simple blue roof design with roof sub areas draining to multiple orifice-controlled discharge points. Other blue roof configurations can include check dams across the roofs deck, modular tray systems, hybrid green/blue roofs, and water harvesting for reuse.
Compost amendment	<ul style="list-style-type: none"> ● Representative Action assumes amending soil under existing lawn surfaces and revegetating with turf. Implementation includes: <ul style="list-style-type: none"> ○ Remove lawn vegetation and scarify (loosen) subgrade to 8 inches depth ○ Place 1.75 inches of compost and rototill into 6.25 inches of soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches) ○ Scarify (loosen) subsoil 4 inches below the amended layer to produce a 12-inch depth of uncompacted soil ○ Water or roll to compact to 85% of maximum dry density ○ Rake to level and remove surface woody debris and rocks larger than 1 inch diameter ○ Revegetate with turf lawn (not seeded) 	<ul style="list-style-type: none"> ● Design is based on Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13" Option 2 (amending existing site soil or subsoil).
Reforest High Density Development	<ul style="list-style-type: none"> ● Representative Action assumes replacing a typical strip mall building and parking lot with forest. Implementation includes: <ul style="list-style-type: none"> ○ Property acquisition, if on private property ○ Demolish/remove structure and parking lot surface ○ Scarify subsoil to 6" depth and place 18 inches of topsoil type A ○ Plant multi-layer native plant communities and trees ○ Build simple trail through forested area and install signage ○ Maintain plants during 3-year plant establishment period ● Assumes one acre parcel coverage is 60% parking and 40% structure 	<ul style="list-style-type: none"> ● The existing land condition is assumed to be a typical strip mall. If a less impervious parcel type was selected, the costs would be lower and the hydrologic and treatment performance would be reduced.
Reforest Pervious Area	<ul style="list-style-type: none"> ● Representative Action assumes replacing a pervious area with forest. Implementation includes: <ul style="list-style-type: none"> ○ Scarify subsoil to 6" depth and place 18 inches of topsoil type A ○ Plant multi-layer native plant communities and trees ○ Maintain plants during 3-year plant establishment period 	<ul style="list-style-type: none"> ● The existing land condition is assumed to be pervious areas on residential property.

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Action Sizing and Performance

Table 3 summarizes the sizing and performance of the Phase 3 Flow Control Actions, including the basis of Action sizing, the size of the unit Action (i.e., footprint area), the size of the contributing drainage area, and how hydrologic (flow control) and treatment performance is represented in the SUSTAIN model.

Sports Field and Park Detention Sizing and Performance

The unit area for the sports field and park detention Action was assumed to be half of a standard soccer field (29,600 square feet). The Action includes an array of model SC-740 ADS StormTech Chambers to provide subsurface storage and detention under the field. The space between and around the chambers is filled with aggregate. Detention storage is provided in both the open chamber areas and within the interstices of the aggregate (see Figure 1). Therefore, the storage capacity varies by stage and was modeled using a stage-storage-discharge table (FTABLE).

The maximum off-site contributing impervious area that could be routed to the unit was evaluated using MGSFlood Version 4.58 using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The drainage area was maximized while meeting the King County Surface Water Design Manual (KCSWDM) (King County 2021) Level 2 Flow Control standard for both the field and offsite areas. This standard requires matching:

- developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow, and
- developed peak discharge rates to predeveloped peak discharge rates for the 2- and 10-year return periods.

A till forested historic site condition was assumed. While some areas in the WQBE target basins have different predeveloped conditions, this sizing basis was used for all areas. Therefore, the facility sizes will overperform in some locations (i.e., areas with outwash soil or a predeveloped pasture condition).

Based on this modeling, it was determined that the maximum offsite impervious area that can be managed using this unit Action is 76,230 square feet, for a total of 103,800 square feet (29,600 SF overlying field + 74,200 SF offsite drainage area).

A table of design and modeling parameters (including orifice sizing) is provided in the Action Fact Sheet (see Appendix G of Herrera 2024).

Blue Roof

Simple blue roof configurations were modeled using MGSFlood to assess potential performance. It was assumed that the most likely design configuration would involve roof sub areas draining to multiple discharge points on a roof, each controlled by a 0.25-inch diameter orifice (the minimum allowed per the KCSWDM). It was determined that the King County flow control performance standards could not be achieved for these smaller contributing areas due to orifice sizing limitations. So, the Core Team

evaluated a range of contributing areas to crudely optimize performance for a 0.25-inch orifice and a unit Action area of 1,000 square feet of roof was selected.

Compost Amendment

The compost amendment Action assumes amendment of soil under existing lawn and revegetating with turf settled depth of 8 inches. The Action is represented as a 500 square foot unit with a depth of 8 inches. A table of design and modeling parameters and assumptions is provided in the Action Fact Sheet (see Appendix G of Herrera 2024).

Reforest High Density Development and Reforest Pervious Area

Reforest high density development and reforest pervious area Actions are represented in the SUSTAIN model by converting the existing surface type to forest over the underlying soil type (till or outwash). The flow control and treatment performance will be based on the different hydrologic and pollutant loading characteristics of the new surface type.

Table 3 Sizing and Performance Basis for New Phase 3 Flow Control Actions.

Action	Sizing Method and Flow Control Performance Standard	Unit Action Size (Footprint)	Contributing Drainage Area	SUSTAIN Model Representation	
				Flow Control	Treatment
Sports field and park detention	Sized for KCSWDM Level 2 Flow Control standard assuming pre-developed till forest condition	29,600 SF	103,800 SF (29,600 SF overlying field + 74,200 SF offsite drainage area)	Stage-storage-discharge routing (FTABLE). Not feasible to model explicitly in SUSTAIN because storage capacity varies by stage. See Attachment C for modeling assumptions and Ftable.	Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation. See Treatment Performance Parameter table in Action Fact Sheet for median percent removal and median effluent concentration for several target pollutants. Parameters are based on detention pond and vault treatment performance which provide similar unit processes for pollutant removal.
Blue roof	Cannot achieve flow control performance standards; unit area crudely optimized for 0.25-inch orifice control	1,000 SF	N/A	Model explicitly represents ponding, orifice flow, and overflow.	Action provides negligible treatment.
Compost amendment	Not sized	500 SF	N/A	Model explicitly represents the amended soil depth and porosity, native soil infiltration rate, and overflow.	All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Reforest High Intensity Development	Not sized	1 acre	N/A	Model converts the surface type from existing impervious surface to forest over underlying soil type (i.e., till or outwash). Action is modeled as a mature forest. However, hydrologic benefits of reforestation would increase over time as the trees and understory become mature.	Pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type (i.e., existing surface to forest).
Reforest Pervious Area	Not sized	1 acre	N/A	Model converts the surface type from existing pervious surface to forest over underlying soil type (i.e., till or outwash). Action is modeled as a mature forest. However, hydrologic benefits of reforestation would increase over time as the trees and understory become mature.	Pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type (i.e., existing surface to forest).

N/A – not applicable

SF – square feet

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Action Feasibility and Siting

The feasibility and siting considerations for each Action are provided in the Action Fact Sheets (see Appendix G of Herrera 2024). These include both technical feasibility considerations for applying the Actions across the drainage areas (e.g., available space, slope conditions) and participation considerations (e.g., ability to engage willing partners and private property owners).

The Action feasibility and siting considerations informed the Action implementation factors developed for Programs (Herrera 2024).

Action Costs

The Action Fact Sheets provide the Unit Action cost components. In Phase 3, the Action costs were refined to reflect a simplified costing approach and better meet the County's needs; hence, the basis of estimate documentation was updated in HDR and Herrera (2024).

The Unit Action costs include the total project cost which are equal to the sum of total direct construction costs and total indirect non-construction costs, annual operation and maintenance costs, and property acquisition costs. The property acquisition costs are itemized separately but included in the total indirect non-construction costs. The property acquisition costs are included for the Actions that likely require property acquisition if implemented on private property. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The Action Fact Sheets display the medium acquisition costs (Appendix G of Herrera 2024). The basis of estimate documentation provides details on the different cost categories for property acquisition costs (HDR and Herrera 2024).

Key Limitations and Future Considerations

This document provides an overview of the assumptions and technical basis for the Phase 3 Action Fact Sheet content; these assumptions generally apply to the Phase 2 Actions as well. Below is a summary of key limitations of this work and considerations for future work.

- To simplify modeling, a representative design was developed for each Action and assumed to be applicable county-wide. In fact, Action design would vary based on site conditions and stakeholder interests. The representative design selected impacts Action performance, costs, and feasibility. Design modifications could be explored to evaluate tradeoffs. For example, adjustments could be made to make an Action more cost effective, but that could reduce overall feasibility.
- Consider adjusting Action to account for climate change (e.g., sizing Actions using a precipitation series that is perturbed for a future climate year).
- Consider developing additional Actions identified under previous WQBE brainstorming workshops (tree planting in the right of way, floodplain storage, high-flow bypass (tightline of stormwater to bottom of watershed), sand filters, creosote wood piling removal, and enhanced street sweeping).

References

HDR and Herrera. 2024. Phase 3 Unit Cost Basis for Water Quality Benefits Evaluation (Appendix G to 439-TM1). Technical Memorandum prepared for King County Wastewater Treatment Division by HDR Engineering, Inc. March.

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May.

Herrera. 2023. Proposed Flow Control Actions and Programs Assessment (TM #438-TM1). Prepared for King County Wastewater Treatment Division by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2024. WQBE Phase 3 Action and Program Fact Sheet Development (439-TM1). Prepared for King County Wastewater Treatment Division by Herrera Environmental Consultants, Inc., Seattle, Washington.

King County. 2021. Surface Water Design Manual. Department of Natural Resources and Parks.

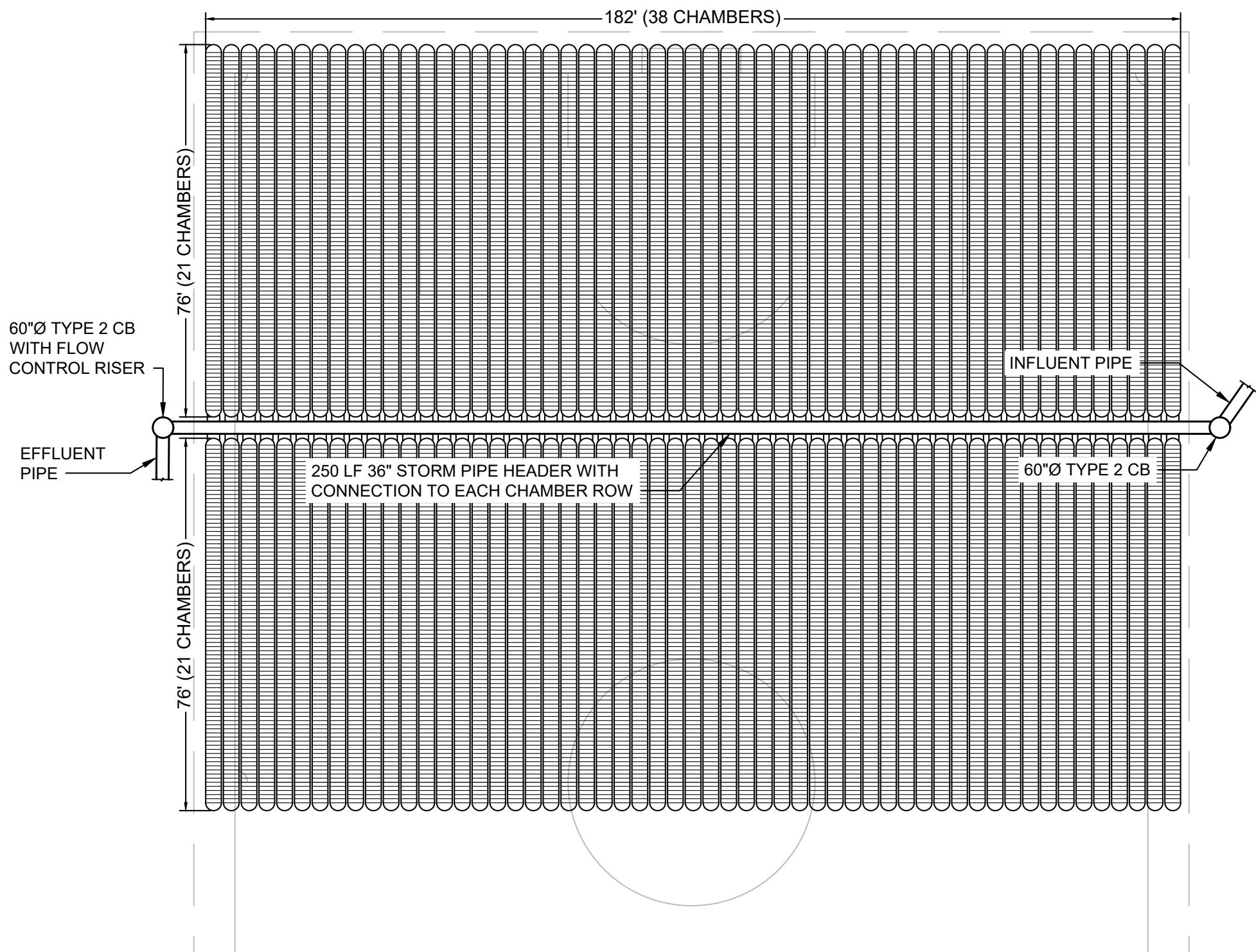
Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December.

Attachment A

Stormwater Field and Park Detention Concept Plan and Section

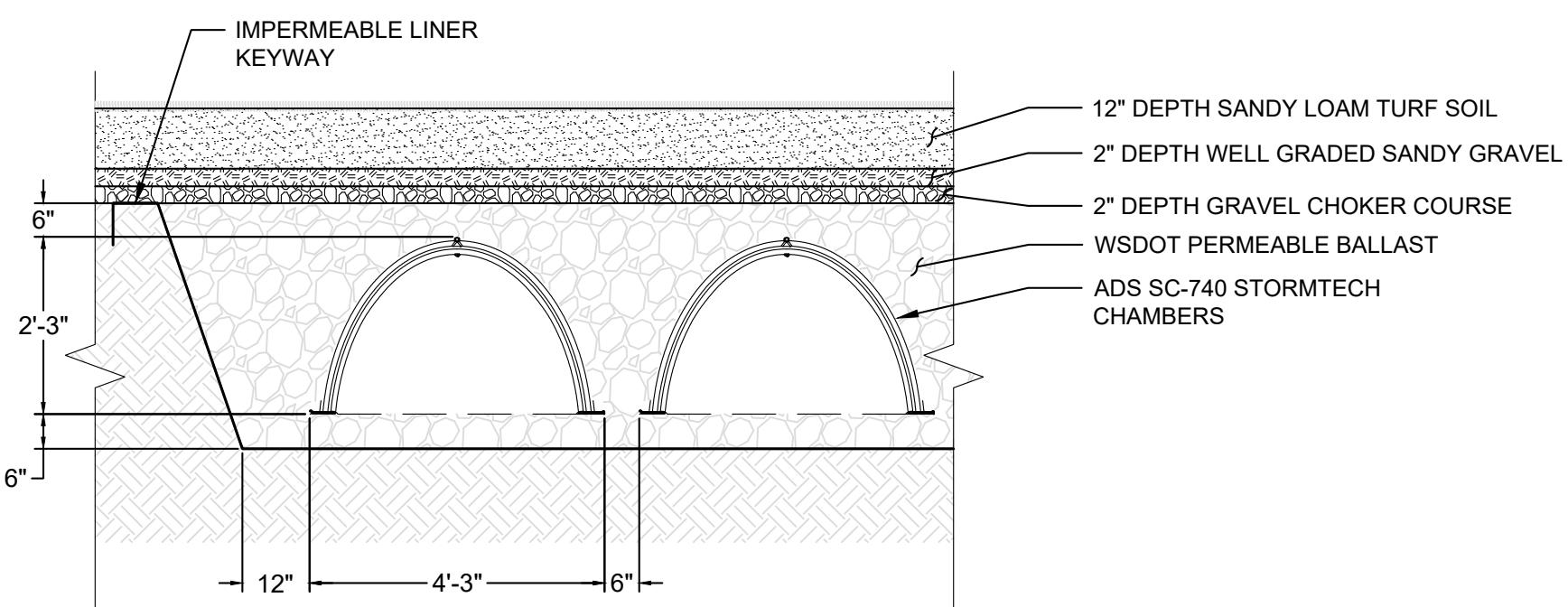
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Figure A1
Sports Field Detention Action



PLAN

SCALE: NONE



SECTION

SCALE: NONE

Attachment B

ADS StormTech Chamber (SC-740) Array Specifications

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ADS
SiteAssist
FOR STORMTECH
INSTALLATION INSTRUCTIONS
VISIT OUR APP



SC-740 STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH SC-740.
2. CHAMBERS SHALL BE ARCH-SHAPED AND SHALL BE MANUFACTURED FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE COPOLYMERS.
3. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
4. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORTS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION.
5. THE STRUCTURAL DESIGN OF THE CHAMBERS, THE STRUCTURAL BACKFILL, AND THE INSTALLATION REQUIREMENTS SHALL ENURE THAT THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS SECTION 12.12, ARE MET FOR 1) LONG-DURATION LIVE LOADS AND 2) SHORT-DURATION LIVE LOADS, BASED ON THE AASHTO DESIGN TRUCK WITH CONSIDERATION FOR IMPACT AND MULTIPLE VEHICLE PRESENCE.
6. CHAMBERS SHALL BE DESIGNED, TESTED AND ALLOWABLE LOAD CONFIGURATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787 - STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS*. LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (<1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER 2) MAXIMUM PERMANENT (75-YR) COVER LOAD AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK.
7. REQUIREMENTS FOR HANDLING AND INSTALLATION:
 - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL INTERLOCKING STACKING LUGS.
 - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 6" (150 mm).
 - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 550 LB/SFT%, THE ASC IS DEFINED IN SECTION 6.2.8 OF ASTM F2418, AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.
8. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED, UPON REQUEST BY THE SITE DESIGN ENGINEER OR OWNER, THE CHAMBER MANUFACTURER SHALL SUBMIT A STRUCTURAL EVALUATION FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE AS FOLLOWS:
 - THE STRUCTURAL EVALUATION SHALL BE SEALED BY A REGISTERED PROFESSIONAL ENGINEER.
 - THE TEST DERIVED CREEP MODULUS FOR STRESS DEFORMATION THAT THE END FACTORS ARE GREATER THAN OR EQUAL TO 1.95 FOR DEAD LOAD AND 1.75 FOR LIVE LOAD, THE MINIMUM REQUIRED BY ASTM F2787 AND BY SECTIONS 3 AND 12.12 OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR THERMOPLASTIC PIPE.
 - THE TEST DERIVED CREEP MODULUS AS SPECIFIED IN ASTM F2418 SHALL BE USED FOR PERMANENT DEAD LOAD DESIGN EXCEPT THAT IT SHALL BE THE 75-YEAR MODULUS USED FOR DESIGN.
9. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.

IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF THE SC-740 SYSTEM

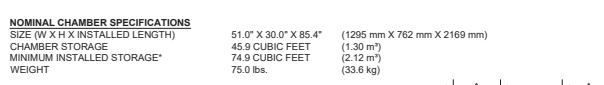
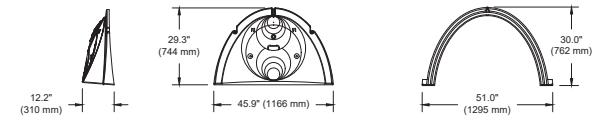
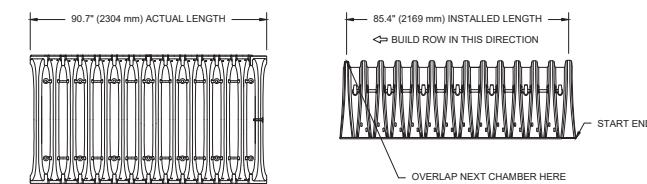
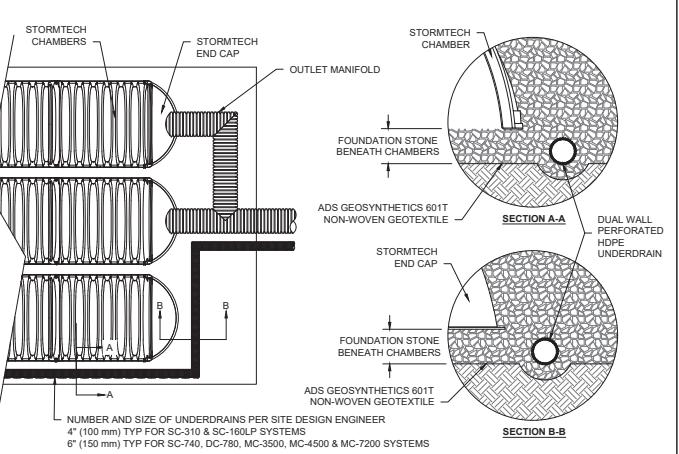
1. STORMTECH SC-740 CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS.
2. STORMTECH SC-740 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. CHAMBERS ARE NOT TO BE BACKFILLED WITH A DOZER OR AN EXCAVATOR SITUATED OVER THE CHAMBERS.
 - STONESHOOTER LOCATED OFF THE CHAMBER BED.
 - ROWS ARE BUILT USING AN EXCAVATOR ON THE FOUNDATION STONE OR SUBGRADE.
 - BACKFILL FROM OUTSIDE THE EXCAVATION USING A LONG BOOM HOE OR EXCAVATOR.
4. THE FOUNDATION STONE SHALL BE LEVELED AND COMPAKTED PRIOR TO PLACING CHAMBERS.
5. JOINTS BETWEEN CHAMBERS SHALL BE PROPERLY SEALED PRIOR TO PLACING STONE.
6. MAINTAIN MINIMUM - 6" (150 mm) SPACING BETWEEN THE CHAMBER ROWS.
7. EMBEDMENT STONE SURROUNDING CHAMBERS MUST BE A CLEAN, CRUSHED, ANGULAR STONE 3/4"-2" (20-50 mm).
8. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES WITH CHAMBER FOUNDATION MATERIALS BEARING CAPACITIES TO THE SITE DESIGN ENGINEER.
9. ADS RECOMMENDS THE USE OF "FLEXSTORM CATCH IT" INSERTS DURING CONSTRUCTION FOR ALL INLETS TO PROTECT THE SUBSURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.

NOTES FOR CONSTRUCTION EQUIPMENT

1. STORMTECH SC-740 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
2. THE USE OF CONSTRUCTION EQUIPMENT OVER SC-740 CHAMBERS IS LIMITED:
 - NO EQUIPMENT IS ALLOWED ON BARE CHAMBERS.
 - NO RUBBER TIRED LOADERS, DUMP TRUCKS, OR EXCAVATORS ARE ALLOWED UNTIL PROPER FILL DEPTHS ARE REACHED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
 - WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT CAN BE FOUND IN THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. FULL 36" (900 mm) OF STABILIZED COVER MATERIALS OVER THE CHAMBERS IS REQUIRED FOR DUMP TRUCK TRAVEL OR DUMPING.

USE OF A DOZER TO PUSH EMBEDMENT STONE BETWEEN THE ROWS OF CHAMBERS MAY CAUSE DAMAGE TO THE CHAMBERS AND IS NOT AN ACCEPTABLE BACKFILL METHOD. ANY CHAMBERS DAMAGED BY THE "DUMP AND PUSH" METHOD ARE NOT COVERED UNDER THE STORMTECH STANDARD WARRANTY.

CONTACT STORMTECH AT 1-888-892-2694 WITH ANY QUESTIONS ON INSTALLATION REQUIREMENTS OR WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT.



*ASSUMES 6" (150 mm) STONE ABOVE, BELOW, AND BETWEEN CHAMBERS

PRE-FAB STUB AT BOTTOM OF END CAP WITH FLAMP END WITH "B"
PRE-FAB STUBS AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
PRE-FAB STUBS AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
PRE-CORED END CAPS END WITH "PC"

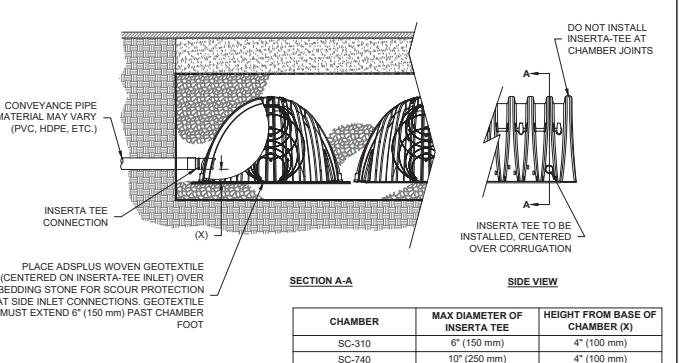
PART #	STUB	A	B	C
SC740EP060T / SC740EP060TPC	6" (150 mm)	10.9" (277 mm)	18.5" (470 mm)	0.5" (13 mm)
SC740EP060B / SC740EP060BPC	8" (200 mm)	12.2" (310 mm)	16.5" (419 mm)	0.6" (15 mm)
SC740EP080B / SC740EP080BPC	10" (250 mm)	13.4" (340 mm)	14.5" (368 mm)	—
SC740EP10T / SC740EP10TPC	10" (250 mm)	13.4" (340 mm)	—	0.7" (18 mm)
SC740EP10B / SC740EP10BPC	12" (300 mm)	14.7" (373 mm)	12.5" (318 mm)	—
SC740EP12T / SC740EP12TPC	12" (300 mm)	14.7" (373 mm)	12.5" (318 mm)	1.2" (30 mm)
SC740EP15T / SC740EP15TPC	15" (375 mm)	18.4" (467 mm)	9.0" (229 mm)	1.3" (33 mm)
SC740EP18T / SC740EP18TPC	18" (450 mm)	19.7" (500 mm)	5.0" (127 mm)	1.6" (41 mm)
SC740EP24B / SC740EP24BPC	24" (600 mm)	24" (600 mm)	—	0.1" (3 mm)
SC740EP24BR*	24" (600 mm)	18.5" (470 mm)	—	0.1" (3 mm)

ALL STUBS, EXCEPT FOR THE SC740EP24B/SC740EP24BR ARE PLACED AT BOTTOM OF END CAP SUCH THAT THE OUTSIDE DIAMETER OF THE STUB IS FLUSH WITH THE BOTTOM OF THE END CAP. FOR ADDITIONAL INFORMATION CONTACT STORMTECH AT 1-888-892-2694.

* FOR THE SC740EP24B/SC740EP24BR THE 24" (600 mm) STUB LIES BELOW THE BOTTOM OF THE END CAP APPROXIMATELY 1.75" (44 mm). BACKFILL MATERIAL SHOULD BE REMOVED FROM BELOW THE N-12 STUB SO THAT THE FITTING SITS LEVEL.

NOTE: ALL DIMENSIONS ARE NOMINAL

UNDERDRAIN DETAIL



CHAMBER	MAX DIAMETER OF INSERTA TEE	HEIGHT FROM BASE OF CHAMBER (X)
SC-310	6" (150 mm)	4" (100 mm)
SC-740	10" (250 mm)	4" (100 mm)
DC-780	10" (250 mm)	4" (100 mm)
MC-3500	12" (300 mm)	6" (150 mm)
MC-4500	12" (300 mm)	8" (200 mm)
MC-7200	12" (300 mm)	8" (200 mm)

INSERTA TEE FITTINGS AVAILABLE FOR SDR 26, SDR 35, SCH 40 IPS, GASKETED & SOLVENT WELD, N-12, HP STORM, C-900 OR DUCTILE IRON

NOTES:

- PART NUMBERS WILL VARY BASED ON INLET PIPE MATERIALS. CONTACT STORMTECH FOR MORE INFORMATION.
- CONTACT ADS ENGINEERING SERVICES IF INSERTA TEE INLET MUST BE RAISED AS NOT ALL INVERTS ARE POSSIBLE.

SECTION A-A

SIDE VIEW

DO NOT INSTALL INSERTA-TEE AT CHAMBER JOINTS

CONVEYANCE PIPE MATERIAL MAY VARY (PVC, HDPE, ETC.)

PLACE ADSPLUS WOVEN GEOTEXTILE (CENTERED ON INSERTA-TEE INLET) OVER BEDDING STONE FOR SCOUR PROTECTION AT SIDE INLET CONNECTIONS. GEOTEXTILE MUST EXTEND 6" (150 mm) PAST CHAMBER FOOT

NOTES:

- PART NUMBERS WILL VARY BASED ON INLET PIPE MATERIALS. CONTACT STORMTECH FOR MORE INFORMATION.
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Attachment C

Sports Field and Park Detention Modeling Assumptions and Stage-Storage-Discharge Routing Table

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WQBE Sports Field Detention Action**Performance Modeling**

12/12/2023 Neil Schaner

Goal

Size chamber detention for an area equal to half a soccer field. Determine contributing area that can be mitigated to KCSWDM Level 2 Flow Control (forested) std (50% 2yr to 50yr and match 2yr and 10yr peaks).

Assumptions/Methodology

Area/field sizing and slope per National Federation of State High School Associations (NFHS)		
Soccer Field Area	Width (ft)	185
	Length (ft)	320
	Half Area (sf)	29600
Detention Chamber	Use ADS StormTech SC-740	
	Chamber Width (ft)	4.25
	Perimeter Width (ft)	1
	Spacing (ft)	0.5
	Chamber Installed Length (ft)	7.117
	Number of Chamber rows	38
	*across width	
	Facility Width (ft)	182.0
	Chambers in Each Row	21
	*along length, leave 6ft for header/piping	
	Facility Length (ft)	151.5
	Facility Area (ft)	27563.9
	Aggregate Depth Below Chambers (ft)	0.5
Chamber Model Representation	Chamber Height (ft)	2.5
	Aggregate Depth Above Chambers (ft)	0.5
	Total Facility Height (ft)	3.5
	Use WWHM to create SSD table	
	Model Width (ft)	4.75
	*ignore 12" agg on perimeter, assume 6" between rows	
	Model Length (ft)	5679.10
	*number of chambers times chamber length (ignores end caps and perimeter agg)	
	Number of Chambers	798
	Number of End Caps	4
Control Structure	Aggregate Porosity	0.4
	Orifices as needed	
	Riser Height (ft)	3
	*freeboard within top 6" of aggregate	
	Riser Diameter (in)	12
MGSFlood Version 4.58		
158-year, Puget East 40in MAP precip (no climate change perturbation)		
15 min time step		
Predeveloped Scenario: till forest		
Post-Developed Scenario: impervious area of equal size		
HSPF Parameters (MGSFlood Defaults)	Till Forest	
	NSUR	0.35
	SLSUR	0.01
	LSUR	400
	Impervious	
	NSUR	0.10
	SLSUR	0.01
	LSUR	400

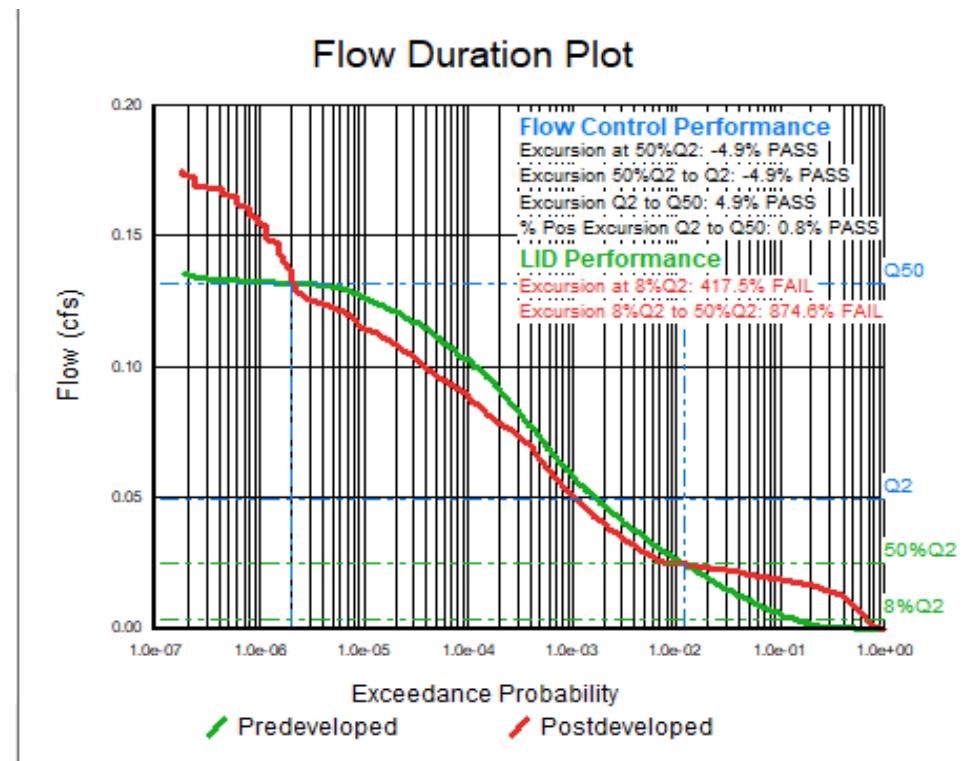
Model Input

Tributary Area (ac)	1.75
Facility Area (ac)	0.633
Contributing Area (ac)	2.383
Orifice 1 El	0.00
Orifice 1 Diam (in)	0.840
Orifice 2 El	NA
Orifice 2 Diam (in)	NA
Notch El	1.80
Notch Width (in)	0.33
Notch Height (in)	14.40
Riser Common L (ft)	0.03

Model Results

100yr WSEL (ft)	2.964
Flow Control Std	PASS

Recurrence Interval Flow Rate	2-year (cfs)	10-year (cfs)
Predeveloped Scenario	0.0494	0.0997
Post-developed Scenario	0.02362	0.07352
2yr/10yr Flow Control Std.	PASS	PASS



Stage-Storage-Discharge Tables for Chamber Facility

From WWHM

*assumes agg porosity of 0.4

stage	area	storage	area (sf)	storage (cf)
0	0.619278	0	26975.75	0.00
0.083333	0.619278	0.020668	26975.75	900.30
0.166667	0.619278	0.041336	26975.75	1800.60
0.25	0.619278	0.062084	26975.75	2704.38
0.333333	0.619278	0.082746	26975.75	3604.42
0.416667	0.619278	0.103447	26975.75	4506.15
0.5	0.619278	0.124148	26975.75	5407.89
0.583333	0.619278	0.169075	26975.75	7364.91
0.666667	0.619278	0.213859	26975.75	9315.70
0.75	0.619278	0.258432	26975.75	11257.30
0.833333	0.619278	0.302748	26975.75	13187.70
0.916667	0.619278	0.346824	26975.75	15107.65
1	0.619278	0.390603	26975.75	17014.67
1.083333	0.619278	0.434053	26975.75	18907.35
1.166667	0.619278	0.477174	26975.75	20785.70
1.25	0.619278	0.519908	26975.75	22647.19
1.333333	0.619278	0.56226	26975.75	24492.05
1.416667	0.619278	0.60416	26975.75	26317.21
1.5	0.619278	0.645612	26975.75	28122.86
1.583333	0.619278	0.686643	26975.75	29910.17
1.666667	0.619278	0.727102	26975.75	31672.56
1.75	0.619278	0.767012	26975.75	33411.04
1.833333	0.619278	0.806336	26975.75	35124.00
1.916667	0.619278	0.845029	26975.75	36809.46
2	0.619278	0.883064	26975.75	38466.27
2.083333	0.619278	0.920467	26975.75	40095.54
2.166667	0.619278	0.957092	26975.75	41690.93
2.25	0.619278	0.992629	26975.75	43238.92
2.333333	0.619278	1.027183	26975.75	44744.09
2.416667	0.619278	1.060801	26975.75	46208.49
2.5	0.619278	1.093255	26975.75	47622.19
2.583333	0.619278	1.124347	26975.75	48976.56
2.666667	0.619278	1.153802	26975.75	50259.62
2.75	0.619278	1.181083	26975.75	51447.98
2.833333	0.619278	1.204824	26975.75	52482.13
2.916667	0.619278	1.227258	26975.75	53459.36
3	0.619278	1.248505	26975.75	54384.88
3.083333	0.619278	1.269174	26975.75	55285.22
3.166667	0.619278	1.289842	26975.75	56185.52
3.25	0.619278	1.31059	26975.75	57089.30
3.333333	0.619278	1.331252	26975.75	57989.34
3.416667	0.619278	1.351952	26975.75	58891.03
3.5	0.619278	1.372653	26975.75	59792.76

MGSFlood SSD Table based on WWHM Table

**Pond surface area increases by 0.1 sf per row to meet software needs*

Row	Elev (ft)	Surf Area (sf)	Volume (cf)
1	0	26975.75	0.00
2	0.083333	26975.85	900.30
3	0.166667	26975.95	1800.60
4	0.25	26976.05	2704.38
5	0.333333	26976.15	3604.42
6	0.416667	26976.25	4506.15
7	0.5	26976.35	5407.89
8	0.583333	26976.45	7364.91
9	0.666667	26976.55	9315.70
10	0.75	26976.65	11257.30
11	0.833333	26976.75	13187.70
12	0.916667	26976.85	15107.65
13	1	26976.95	17014.67
14	1.083333	26977.05	18907.35
15	1.166667	26977.15	20785.70
16	1.25	26977.25	22647.19
17	1.333333	26977.35	24492.05
18	1.416667	26977.45	26317.21
19	1.5	26977.55	28122.86
20	1.583333	26977.65	29910.17
21	1.666667	26977.75	31672.56
22	1.75	26977.85	33411.04
23	1.833333	26977.95	35124.00
24	1.916667	26978.05	36809.46
25	2	26978.15	38466.27
26	2.083333	26978.25	40095.54
27	2.166667	26978.35	41690.93
28	2.25	26978.45	43238.92
29	2.333333	26978.55	44744.09
30	2.416667	26978.65	46208.49
31	2.5	26978.75	47622.19
32	2.583333	26978.85	48976.56
33	2.666667	26978.95	50259.62
34	2.75	26979.05	51447.98
35	2.833333	26979.15	52482.13
36	2.916667	26979.25	53459.36
37	3	26979.35	54384.88
38	3.083333	26979.45	55285.22
39	3.166667	26979.55	56185.52
40	3.25	26979.65	57089.30
41	3.333333	26979.75	57989.34
42	3.416667	26979.85	58891.03
43	3.5	26979.95	59792.76

Appendix D

Phase 3 Action Performance Parameters

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TECHNICAL MEMORANDUM

Date: October 4, 2024

To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

From: Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc.

Subject: WQBE Phase 3 Water Quality Performance Parameter Data Compilation (Appendix D to 439-TM1)

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Attachment

Attachment A Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions

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Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources. Included in the suite of integrated pollutant loading models is a watershed model for estimating runoff volumes and pollutant loads that are delivered via stormwater and baseflow.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages," for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020):** Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021-2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022a). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).

- **Phase 3 (2023-2024):** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the technical basis for pollutant removal performance parameter (performance parameter) data for the Actions developed in Phase 2 and Phase 3. It begins with a description of the methods that were used to compile and review these data. It then documents the approach used to fill gaps where existing data were not available for specific combinations of Actions and pollutants. Finally, the performance parameter data that are recommended as input for SUSTAIN models and included in the Action Fact Sheets are summarized.

Methodology

The Actions in the WQBE toolkit were developed in two Phases. The following Actions were developed in Phase 2.

- Bioretention
- Raingarden
- Bioretention planter
- Bioswale
- Media Filter Drain
- Drywell
- Deep underground injection control (UIC) well
- Permeable pavement
- Depaving
- Detention vault
- Detention pond
- Infiltration vault
- Infiltration pond
- Cistern
- Stormwater treatment wetland
- Wetpond
- Wetvault
- High rate underground filter system (underground filter system)

- Regional vegetated media filtration stormwater facility [Stormwater park (water quality treatment)]
- The following Actions were developed in Phase 3:
- Sports field and park detention
- Compost amendment
- Blue roof
- Reforest High Density Development
- Reforest Pervious Area

See Appendix B and Appendix C of Herrera (2024) for the design details of the Actions developed in Phase 2 and Phase 3, respectively.

The SUSTAIN model simulates Action performance through the following three treatment pathways:

- Untreated bypass. Any water that overflows an Action or exceeds the capacity of an Action results in bypass. This water receives no treatment and retains the influent concentration.
- Retention, detention and filtration. Water that receives treatment through retention, detention and filtration that also discharges through a pipe to receiving waters is assigned a percent removal down to a minimum effluent concentration, or irreducible concentration. This reduction is applied to the water discharging through an orifice or an underdrain.
- Infiltration to groundwater. Runoff that infiltrates to groundwater is lost from SUSTAIN, the surface water model. SUSTAIN model results can be put back into the watershed model where the increased volume from infiltration to subsurface flow and groundwater can be assigned a pollutant concentration.

This section presents the methods used to compile and review the performance parameter data for each Action needed to model their performance using the SUSTAIN model. Also discussed are methods used to fill gaps when no data could be found for an Action and pollutant combination.

Data Compilation

The Actions were screened and categorized into one of four groups to determine if performance parameter data would be needed to support SUSTAIN model development:

1. Actions that are expected to provide negligible water quality benefit. Actions in this category include:
 - Cistern
 - Blue roof

2. Actions that will not require compilation of performance parameter data for representation in SUSTAIN models. Actions in this category include:
 - Depaving
 - Reforest high density development
 - Reforest pervious area
3. Actions that provide pollutant removal through infiltration. All water that infiltrates is lost from the SUSTAIN model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Actions in this category include:
 - Raingarden
 - Drywell
 - Deep UIC well
 - Permeable pavement
 - Infiltration vault
 - Infiltration pond
 - Compost amendment
4. Actions that provide treatment via a combination of unit processes (e.g., filtration, sedimentation, sorption, etc.) and have the potential for a direct discharge to a receiving water via an outlet or underdrain pipe; hence, the associated influent and effluent pollutants will be included in the surface water model. Actions in this category include:
 - Bioretention
 - Bioretention planter
 - Bioswale
 - Media filter drain
 - Stormwater treatment wetland
 - Detention vault
 - Detention pond
 - Wetpond
 - Wetvault
 - Underground filter system
 - Stormwater park (water quality treatment)
 - Sports field and park detention

Attachment A presents a matrix that documents the results from this screening process with explanations for why Actions were categorized in specific groups.

No performance parameter data are required for Actions categorized in the first, second, and third groups based on their representation in the SUSTAIN models. Performance parameter data are required for Actions categorized in the fourth group to allow their representation in these models in one of two ways depending on their physical configuration:

- For Actions with an underdrain, the influent flow concentration is assigned a percent removal and an irreducible concentration for each pollutant.
- Water that flows through a pond or vault outlet is assigned a percent removal to the influent flow concentration and an irreducible concentration for each pollutant.

For Actions falling in category 4, Herrera (2022b) performed a literature review for the following suite of pollutants for the WQBE Toolkit:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- Total suspended solids (TSS)
- Total polychlorinated biphenyls (total PCB)
- Total polybrominated diphenyl ethers (total PBDE)
- Total polycyclic aromatic hydrocarbons (total PAH)
- Bis(2-ethylhexyl) phthalate (BEHP)
- Fecal Coliform

This literature review specifically focused on obtaining measured percent removal and effluent concentration (used as a surrogate for irreducible concentration) data for each Action using the following stepwise process:

- The International Stormwater Best Management Practices Database (ISBMPD) was queried on May 13, 2020 (ISBMPD 2019) to obtain all available influent and effluent data for each Action and pollutant combination. Because the ISBMPD is considered a highly consistent and complete source for these data, results from this query were prioritized in the compilation of performance parameter

data for each Action. If no data were identified for a specific Action and pollutant combination through this query, the following additional step was performed.

- Additional sources for performance parameter data were identified using online literature search engines (Web of Science, UW library, internet searches) and knowledge of local/regional studies. These sources included peer reviewed papers, consultant reports, white papers, and agency reports. The additional data sources identified through this process are documented in Attachment A for specific Action and pollutant combinations where relevant.

In all cases, the following criteria were used to guide the compilation of performance parameter data during the literature review:

- Data must represent the performance of each Action individually (i.e., not in a treatment train).
- Data from both laboratory and field studies were included in the review.
- Data ideally consisted of influent and effluent concentrations from individual sampling events.

The data obtained from this literature review were subsequently compiled in a database for additional processing. Influent and effluent concentration data from individual sampling events were specifically processed as follows:

1. Influent and effluent concentration data from individual sampling events were excluded from subsequent analysis if the influent concentration was below the applicable reporting limit for the pollutant. These data were excluded because they cannot provide a meaningful assessment of treatment performance.
2. For each Action and pollutant combination, the influent and effluent concentration data from individual sampling events were analyzed to compute the median percent removal to represent the typical performance of an Action. The 25th percentile effluent concentration was calculated to represent the irreducible concentration for each Action and pollutant combination. In these computations, the reporting limit was used when the effluent concentration was below the applicable reporting limit for the pollutant. This resulted in a conservative estimate of performance in relation to using other substitution methods (e.g., 1/2 the reporting limit) in these computations.

The number of sampling events with influent and effluent concentration data for these computations is documented in Table 1 for each Action and pollutant combination; this table also identifies where significant data gaps exist for these combinations. The following section describes the process that was used to fill these data gaps where feasible.

**Table 1. Number of Sampling Events with Influent and Effluent Concentration Data
for each Action and Pollutant Combination.**

Parameter	Bioretention/ Bioretention Planter ^a	Bioswale	Media Filter Drain ^b	Stormwater Treatment Wetland	Detention Pond	Detention Vault	Wetpond	Wetvault	Under Ground Filter Systems/Stormwater Park ^c	Sports Field and Park Detention
Copper, Dissolved	30	139	27	51	179	NF	287	NF	39	NF
Copper, Total	28	243	27	270	249	NF	712	NF	49	NF
BEHP	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Fecal Coliform	15	84	NF	82	145	NF	163	NF	3	NF
Nitrogen, Total	10	204	NF	539	153	NF	533	NF	38	NF
PBDE	NF	NF	NF	NF	NF	1	NF	NF	NF	NF
Total PAHs	15	NF	NF	18	NF	6	NF	NF	NF	NF
Total PCBs	NF	NF	NF	15	NF	NF	NF	NF	4	NF
Total Phosphorus	44	364	39	714	414	NF	911	NF	109	NF
Total Suspended Solids	14	377	39	632	432	NF	967	NF	107	NF
Zinc, Dissolved	29	132	39	81	128	NF	238	NF	39	NF
Zinc, Total	29	281	39	327	269	NF	778	NF	54	NF

^a Bioretention and bioretention planters are assumed to have equivalent performance (see assumptions in Attachment A).

^b Media filter drain data includes samples with unpaired influent and effluent concentrations from WSDOT (2013). Median percent removal was calculated for paired data only. 13 paired influent and effluent concentration data were available for total copper and dissolved copper, and 25 paired influent and effluent concentration data were available for total phosphorus, total suspended solids, total zinc, and dissolved zinc.

^c Underground filter systems and stormwater parks (water quality treatment) are assumed to have equivalent performance (see assumptions in Attachment A).

NF = No data found

Data Gaps

This section describes the processes used to fill data gaps when performance parameter data were not identified through the literature review described in the previous section for a given Action and pollutant combination. These processes involved filling data gaps based on data obtained from surrogate Actions or surrogate pollutants.

Surrogate Actions

Where feasible, data gaps for specific Action and pollutant combinations were filled based on data obtained from surrogate Actions that are expected to provide equivalent treatment based on their unit processes (i.e., pollutant removal mechanisms). The surrogate Actions that were used to fill data gaps were discussed with King County and are presented below.

Detention Pond, Detention Vault, and Sports Field and Park Detention: Sedimentation is the primary unit process for pollutant removal in a detention pond. The ISBMPD contains a substantial amount of data for this Action, but data were unavailable for detention vaults and sports field and park detention, which also use sedimentation as their primary unit process for pollutant removal and have as similar structural geometry to detention ponds. Therefore, detention pond performance parameter data obtained from the ISBMPD for the following pollutants were also used for detention vaults and stormwater field and park detention:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- TSS

It is likely that the performance of detention vaults and sports field and park detention may be overestimated based on this approach due to these Actions lacking all of the unit processes present in a detention pond.

Similarly, performance parameter data for total PBDEs and total PAHs were summarized in Sebastian et al. (2014) for detention vaults but not detention ponds or sport fields and parks detention. Hence, these data were also used for detention ponds and sports fields and parks detention.

Wetpond and Wetvault: The primary unit processes for pollutant removal in a wetpond are sedimentation and biological uptake. Biological uptake is only an important unit process for those wetponds with abundant vegetation in the littoral zone. Many ponds lack this biologically active area and

rely primarily on sedimentation for treatment; this makes them similar to wet vaults. Wetpond performance parameter data obtained from the ISBMPD for the following pollutants were also used for wet vaults:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- TSS
- Fecal coliform bacteria

It is likely that the performance of wet vaults may be overestimated based on this approach due to wet vaults lacking all of the unit processes present in a wetpond.

Surrogate Parameters

As Table 1 demonstrates, performance parameter data were identified for most of the Actions through the literature review described above for TSS, most nutrients, and metals. However, data were not identified through this effort for most of the following organic pollutants:

- Total PCBs
- Total PAHs
- Total PBDE
- BEHP

In addition, performance parameter data were also not identified for some of the following additional pollutants:

- Total nitrogen
- Fecal coliform bacteria.

The sections below describe the methods used to fill these data gaps where possible.

Organic Chemicals

Because the organic pollutants identified above are all strongly associated with suspended solids in stormwater due to their hydrophobic properties (Schueler and Youngk 2015), TSS was considered as a suitable surrogate for estimating their removal via treatment with the various Actions. Table 2

summarizes results from research on the affinity of the organic pollutants identified above for sediments. As is apparent, the fraction of organic pollutants associated with suspended sediments ranges from 78 to 86 percent. This implies that the removal of a large percentage of suspended sediment from stormwater by an Action will also result in the effective removal of these organic chemicals.

Given this consideration, the results in Table 2 were used to develop equations for estimating effluent organic pollutant concentrations (total PCBs, total PAHs, total PBDEs and BEHP) based on the effluent TSS concentrations obtained from the literature review described above. Specifically, the 25th percentile effluent TSS concentration (in mg/L) for each Action was multiplied by the estimated concentration of the organic pollutant in the associated sediment from Table 2. This resulted in an estimate of the organic chemical associated with the TSS. However, not all the organic pollutant will be associated with the sediment, a smaller fraction will also be in solution. Using data from Table 2 that quantifies the partitioning of the organic pollutant between the solid and aqueous phase in stormwater, the following correction factor was therefore applied to derive a final estimate of the effluent organic pollutant concentration from the Action:

Ratio_{TD} = 1 + (1 - % in Sed/100). The % in Sed values are derived from Table 2.

The resultant equations are as follows:

Action effluent total PCB concentration (pg/L) =

$$\text{TSS} \left(\frac{\text{mg}}{\text{L}} \right) \times \text{Sed}_C \times \text{Ratio}_{\text{TD}}$$

Where:

Sed_C = 21.8 ug/kg. The estimated total PCB concentration in the suspended solids (Table 2)

Ratio_{TD} = 1.22. The ratio of total PCB associated with the liquid versus the solid phase.

Action effluent total PAH concentration (μg/L) =

$$\text{TSS} \left(\frac{\text{mg}}{\text{L}} \right) \times \text{Sed}_C \times \text{Ratio}_{\text{TD}}$$

Where:

Sed_C = 108 ug/kg. The estimated total PAH concentration in the suspended solids (Table 2)

Ratio_{TD} = 1.15×10^{-6} . The ratio of total PAH associated with the liquid versus the solid phase, with unit adjustment.

Action effluent PBDE concentration (ng/L) =

$$\text{TSS} \left(\frac{\text{mg}}{\text{L}} \right) \times \text{Sed}_C \times \text{Ratio}_{\text{TD}}$$

Where:

$\text{Sed}_C = 2.2 \text{ ug/kg}$. The estimated PBDE concentration in the suspended solids (Table 2)

$\text{Ratio}_{\text{TD}} = 1.14 \times 10^{-3}$. The ratio of PBDE associated with the liquid versus the solid phase, with unit adjustment.

Action effluent BEHP concentration ($\mu\text{g/L}$) =

$$\text{TSS} \left(\frac{\text{mg}}{\text{L}} \right) \times \text{Sed}_C \times \text{Ratio}_{\text{TD}}$$

Where:

$\text{Sed}_C = 2,743 \text{ ug/kg}$. The estimated BEHP concentration in the suspended solids (Table 2)

$\text{Ratio}_{\text{TD}} = 1.19 \times 10^{-6}$. The ratio of BEHP associated with the liquid versus the solid phase, with unit adjustment.

Table 2. Organic Chemical Associations with Suspended Solids.

Study	Source	Total PCBs (ug/kg)^a	Total PCBs % in Sed^b	Total PAHs (ug/kg)	Total PAHs % in Sed	PBDE (ug/kg)	PBDE % in Sed	BEHP (ug/kg)	BEHP % in Sed
Ecology (2009)	Lower Duwamish stormwater	14.5	–	143.5	–	–	–	–	–
CSN (2015)	Norway sediment traps (PCB), Wisconsin stormwater suspended sediment (PAH), France urban and river sediment (PBDE and BEHP)	29	–	72.85	–	2.2	–	1,230	–
Ko and Baker (2004)	Major tributaries to Chesapeake Bay	–	75	–	80	–	–	–	–
Bressy et al. (2012)	Paris storm drains	–	85	–	90	–	–	–	–
ZWW (2017)	Seattle catch basins	–	–	–	–	–	–	2,000	–
Zgheib et al. (2011)	Paris storm drains	–	–	–	–	–	–	5,000	81
King County (2013)	Storm and stream discharging to Lake Washington	–	73.7	–	–	–	85.5	–	–
Average		21.8	78	108	85	2.2	86	2,743	81

^a ug/kg columns indicate the concentration of the organic chemical in collected sediment (typically from sediment traps or catch basin sumps).

^b % in Sed = the portion of the organic chemical associated with suspended solids in collected water samples.

Percent removal of the organic pollutants via treatment with the Actions was estimated based on research by Schueler and Youngk (2015) that established simple, relative relationships between TSS removal using stormwater treatment best management practices and the removal of various pollutants. This research established these specific relationships for TSS and the organic pollutants:

- Total PCB removal = TSS removal
- Total PAH removal > TSS removal
- PBDE removal < TSS removal
- BEHP removal < TSS removal

Based on these relationships, total PCB and total PAH percent removal was assumed to be equivalent to the TSS percent removal identified for each Action through the literature review. Percent removal for PBDE and BEHP was reduced relative to the TSS percent removal based on the partitioning values from Table 3 as follows:

- PBDE removal = TSS removal * 0.86
- BEHP removal = TSS removal * 0.81

These equations assume that PBDE and BEHP in the aqueous phase act conservatively as the Action treats the stormwater. While this is an oversimplification, the resultant values from these equations are considered acceptable given the lack of data directly related to these pollutants.

Total Nitrogen and Fecal Coliform

TSS is not strongly related to total nitrogen and fecal coliform bacteria in stormwater; therefore, TSS was not considered a suitable surrogate for estimating effluent concentrations and percent removal of these pollutants via treatment with the Actions. Other pollutants were also not considered suitable for this purpose. Therefore, data gap still exists in the performance parameter data for the following combinations of Actions and pollutants:

- Total nitrogen treatment with the media filter drain.
- Fecal coliform bacteria treatment with the media filter drain, underground filter system, and stormwater park (water quality treatment).

Summary of Compiled Performance Parameter Data

Tables 3 through 12 in this section document the performance parameter data compiled for each Action and pollutant combination through the methods described above. These data will be used as SUSTAIN model input to estimate percent reductions and effluent concentrations for Actions that will be evaluated in specific Programs with the WQBE toolkit. During future phases, the performance parameter data for this set of Actions may be updated and refined and data for new Actions may be added.

Table 3. Bioretention/Bioretention Planter Performance Parameter Data.

Target Pollutants	Median Percent Removal^{a,b}	25th Percentile Effluent Concentration^{a,b}
Total Copper	62.3%	7.1 µg/L
Dissolved Copper	57.6%	4.6 µg/L
Total Zinc	91.0%	5.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L ^c
Total Phosphorus	54.9%	0.024 mg/L
Total Nitrogen	51.3%	1.2 mg/L
Total Suspended Solids	78.0%	13.5 mg/L
Total PCBs	78.0%	358 pg/L
Total PBDEs	67.1%	0.034 ng/L
Total PAHs	95.1%	<0.01 µg/L ^c
BEHP	63.2%	0.044 µg/L
Fecal Coliform	61.5%	31.5 CFU/100 mL

^a Bioretention and bioretention planters are assumed to have equivalent performance (see assumptions in Attachment A).

^b Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash.

^c Method detection limit.

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 4. Bioswale Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	33.9%	4.8 µg/L
Dissolved Copper	8.99%	3.6 µg/L
Total Zinc	33.3%	20.0 µg/L
Dissolved Zinc	29.0%	15.0 µg/L
Total Phosphorus	-37.2%	0.100 mg/L
Total Nitrogen	-7.63%	0.562 mg/L
Total Suspended Solids	27.9%	10.0 mg/L
Total PCBs	27.9%	265 pg/L
Total PBDEs	24.0%	0.025 ng/L
Total PAHs	27.9%	0.0012 µg/L
BEHP	23.0%	0.033 µg/L
Fecal Coliform	6.25%	1,775 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 5. Media Filter Drain Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	86.2%	9.45 µg/L
Dissolved Copper	40.8%	6.25 µg/L
Total Zinc	85.1%	22.0 µg/L
Dissolved Zinc	80.8%	16.0 µg/L
Total Phosphorus	85.7%	0.033 mg/L
Total Nitrogen	NF	NF
Total Suspended Solids	94.1%	2.8 mg/L
Total PCBs	94.1%	74.3 pg/L
Total PBDEs	80.9%	0.007 ng/L
Total PAHs	94.1%	0.00035 µg/L
BEHP	76.2%	0.0091 µg/L
Fecal Coliform	NF	NF

NF = No data found

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 6. Stormwater Treatment Wetland Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	25.0%	3.0 µg/L
Dissolved Copper	0.0%	2.0 µg/L
Total Zinc	45.9%	12.0 µg/L
Dissolved Zinc	0.0%	10.0 µg/L
Total Phosphorus	24.2%	0.071 mg/L
Total Nitrogen	5.81%	0.932 mg/L
Total Suspended Solids	52.4%	6.81 mg/L
Total PCBs	78.1%	165 pg/L
Total PBDEs	45.1%	0.017 ng/L
Total PAHs	85.6%	0.024 µg/L
BEHP	42.4%	0.022 µg/L
Fecal Coliform	19.1%	425 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 7. Detention Pond Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	26.2%	4.17 µg/L
Dissolved Copper	3.23%	3.0 µg/L
Total Zinc	44.0%	18.0 µg/L
Dissolved Zinc	13.6%	16.1 µg/L
Total Phosphorus	17.7%	0.113 mg/L
Total Nitrogen	7.80%	0.674 mg/L
Total Suspended Solids	57.6%	12.9 mg/L
Total PCBs	57.6%	342 pg/L
Total PBDEs	56.9%	93.5 ng/L
Total PAHs	52.1%	0.228 µg/L
BEHP	46.7%	0.042 µg/L
Fecal Coliform	31.5%	500 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Italicized values derived from surrogate BMP (Detention vault).

Table 8. Detention Vault Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	26.2%	4.17 µg/L
Dissolved Copper	3.23%	3.0 µg/L
Total Zinc	44.0%	18.0 µg/L
Dissolved Zinc	13.6%	16.1 µg/L
Total Phosphorus	17.7%	0.113 mg/L
Total Nitrogen	7.80%	0.674 mg/L
Total Suspended Solids	57.6%	12.9 mg/L
Total PCBs	57.6%	342 pg/L
Total PBDEs	56.9%	93.5 ng/L
Total PAHs	52.1%	0.228 µg/L
BEHP	46.7%	0.042 µg/L
Fecal Coliform	31.5%	500 CFU/100 mL

Italicized values derived from surrogate BMP (Detention pond).

Table 9. Wetpond Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	45.0%	3.0 µg/L
Dissolved Copper	22.7%	3.0 µg/L
Total Zinc	62.5%	13.0 µg/L
Dissolved Zinc	36.8%	10.0 µg/L
Total Phosphorus	49.5%	0.071 mg/L
Total Nitrogen	27.6%	0.904 mg/L
Total Suspended Solids	76.2%	7.5 mg/L
Total PCBs	76.2%	199 pg/L
Total PBDEs	65.5%	0.019 ng/L
Total PAHs	76.2%	0.00093 µg/L
BEHP	61.7%	0.025 µg/L
Fecal Coliform	60.0%	85.5 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 10. Wetvault Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	45.0%	3.0 µg/L
Dissolved Copper	22.7%	3.0 µg/L
Total Zinc	62.5%	13.0 µg/L
Dissolved Zinc	36.8%	10.0 µg/L
Total Phosphorus	49.5%	0.071 mg/L
Total Nitrogen	27.6%	0.904 mg/L
Total Suspended Solids	76.2%	7.5 mg/L
Total PCBs	76.2%	199 pg/L
Total PBDEs	65.5%	0.019 ng/L
Total PAHs	76.2%	0.00093 µg/L
BEHP	61.7%	0.025 µg/L
Fecal Coliform	60.0%	85.5 CFU/100 mL

Italicized values derived from surrogate BMP (Wetpond).

Table 11. Underground Filter System Performance/Stormwater Park (Water Quality Treatment) Performance Parameter Data.

Target Pollutants	Median Percent Removal^{a,b}	25th Percentile Effluent Concentration^{a,b}
Total Copper	51.6%	3.1 µg/L
Dissolved Copper	34.2%	2.0 µg/L
Total Zinc	56.4%	20.1 µg/L
Dissolved Zinc	53.4%	26.0 µg/L
Total Phosphorus	42.4%	0.034 mg/L
Total Nitrogen	45.8%	0.422 mg/L
Total Suspended Solids	86.4%	2.45 mg/L
Total PCBs	84.1%	414.1 pg/L
Total PBDEs	74.3%	0.0061 ng/L
Total PAHs	86.4%	0.00031 µg/L
BEHP	70.0%	0.008 µg/L
Fecal Coliform	NF	NF

^a Underground filter systems and stormwater park (water quality treatment) are assumed to have equivalent performance (see assumptions in Attachment A).

^b Performance based on proprietary Filterra® engineered media.

NF = No data found; Assigned a value of 0 in SUSTAIN since no data was found.

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 12. Sports Field and Parks Detention

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	26.2%	4.17 µg/L
Dissolved Copper	3.23%	3.0 µg/L
Total Zinc	44.0%	18.0 µg/L
Dissolved Zinc	13.6%	16.1 µg/L
Total Phosphorus	17.7%	0.113 mg/L
Total Nitrogen	7.80%	0.674 mg/L
Total Suspended Solids	57.6%	12.9 mg/L
Total PCBs	57.6%	342 pg/L
Total PBDEs	56.9%	93.5 ng/L
Total PAHs	52.1%	0.228 µg/L
BEHP	46.7%	0.042 µg/L
Fecal Coliform	31.5%	500 CFU/100 mL

Italicized values derived from surrogate BMP (Detention pond).

Limitations and Future Considerations

This document summarizes the pollutant removal performance data and approach used to represent the typical performance of the Actions included in the WQBE toolkit. The following text provides a summary of the limitations in the data available:

- When performance parameter data were not identified through the literature review, data gaps were filled based on data from surrogate Actions and pollutants as appropriate. Periodic reviews should be conducted to identify new data that could be used to quantify the pollutant removal performance of an Action.
- To simplify modeling assumptions, the 25th percentile effluent concentration was used as a surrogate for the irreducible concentration for each pollutant based on best professional judgement.
- The influent and effluent concentration data from individual sampling events were analyzed to compute the median percent removal for each Action and pollutant combination. These data were then used to represent the typical pollutant removal performance of each Action. However, these data do not capture complex dynamics that occur in association with specific unit processes for pollutant removal. For example, these data do not reflect variations in pollutant removal performance stemming from biological processes that may be influenced by seasonal factors (e.g., nutrient capture in plants during the growing season and subsequent release with plant senescence). Due to model limitations, it is generally not possible to capture the influence of these complex dynamics in the model output.
- Correction factors were derived using the data from Table 2 to quantify the partitioning of organic pollutants between the solid and aqueous phase in stormwater. These correction factors were then used to derive a final estimate of the effluent organic pollutant concentration for each Action. These estimates could be refined in future phases of the project using partition coefficient (K_{ow}) that are derived from literature.

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Attachment A

Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions

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Table A-1. Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.

Action	WQBE Phase	Primary Unit Processes	Screening Process Category	Data Source	Modeling and Performance Assumptions
Bioretention	2	Sedimentation, sorption, filtration, biological uptake, Infiltration	4	Herrera (2015), Herrera (2020)	<p>Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.</p> <p>Performance results were gathered from lab studies, which used the Puget Sound region's new High Performance Bioretention Media (HPBSM) specification, a mixture of sand, coconut coir, and biochar (Herrera 2020).</p>
Rain garden	2	Sedimentation, sorption, filtration, biological uptake, Infiltration	3		<p>All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.</p>
Bioretention Planter	2	Sedimentation, sorption, filtration, biological uptake, Infiltration	4	Herrera (2015), Herrera (2020)	<p>Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.</p> <p>These systems function equivalent to bioretention.</p>
Bioswale	2	Sedimentation, filtration, biological uptake, infiltration	4	ISBMPD (2019)	<p>Bioswales are modelled as a flow through system. Concentration percent reductions from this review are assigned to water that exits the bioswale. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.</p>
Media filter drain	2	Sedimentation, sorption, filtration, infiltration	4	Herrera (2006), WSDOT (2013)	<p>Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.</p>
Dry well	2	Infiltration	3		<p>All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program.</p>

Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.

Action	WQBE Phase	Primary Unit Processes	Screening Process Category	Data Source	Modeling Assumptions
Deep underground injection control (UIC) well	2	Infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program.
Permeable pavement	2	Infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Depaving	2	–	2		Action will be modeled in SUSTAIN by converting the depaved area from an impervious to pervious surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.
Detention vault	2	Sedimentation	4	Sebastian et al. (2014), ISBMPD (2019)	<p>Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.</p> <p>Performance assumed equivalent to a detention pond except for the specific data found for detention vaults for PBDEs and Total PAHs.</p>
Detention pond	2	Sedimentation	4	Sebastian et al. (2014), ISBMPD (2019)	<p>Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.</p> <p>Performance for PBDEs and Total PAHs assumed equivalent to detention vaults.</p>

Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.

Action	WQBE Phase	Primary Unit Processes	Screening Process Category	Data Source	Modeling Assumptions
Infiltration vault	2	Sedimentation, infiltration	3	Sebastian et al. (2014), ISBMPD (2019)	All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program. Assumed same performance as detention pond/vault, but will be part of a treatment train.
Infiltration pond	2	Sedimentation, infiltration	3	Sebastian et al. (2014), ISBMPD (2019)	All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program. Assumed same performance as detention pond/vault, but will be part of a treatment train.
Cistern	2	-	1		Model will assume no treatment provided unless Program includes manual operation of orifice valve by property owner. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Stormwater treatment wetland	2	Sedimentation, sorption, filtration, biological uptake	4	ISBMPD (2019), King County (2019)	Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Wetponds	2	Sedimentation, biological uptake (depends on pond quality)	4	ISBMPD (2019)	Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Wetvaults	2	Sedimentation	4	ISBMPD (2019)	Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Wetpond.

Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.

Action	WQBE Phase	Primary Unit Processes	Screening Process Category	Data Source	Modeling Assumptions
High Rate Underground Filtration System	2	Sedimentation, sorption, filtration	4	Gilbreath et al. (2018), ISBMPD (2019)	Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Filterra®.
Stormwater park (water quality treatment)	2	Sedimentation, sorption, filtration	4	Gilbreath et al. (2018), ISBMPD (2019)	Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Filterra®.
Sports field and park detention	3	Sedimentation	4	Sebastian et al. (2014), ISBMPD (2019)	Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Compost Amendment	3	Sedimentation, sorption, filtration, infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Blue roof	3	–	1		Model will assume no treatment. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Reforest High Density Development	3	–	2		Action will be modeled in SUSTAIN by converting the reforested area from an impervious to forested surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.
Reforest Pervious Area	3	–	2		Action will be modeled in SUSTAIN by converting the reforested area from a pervious to forested surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.

Appendix E

Phase 3 Action Costs

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TECHNICAL MEMORANDUM

Date: October 4, 2024

To: Carly Greyell, King County Department of Natural Resources and Parks,
Water and Land Resources Division

From: Edith Hadler, HDR Engineering, Inc.
Cindy Kinzer, HDR Engineering, Inc.
John Lenth, Herrera Environmental Consultants, Inc.
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Subject: Phase 3 Unit Cost Basis for Water Quality Benefits Evaluation (439-TM1)

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Attachments

- Attachment A Cost Estimates with Life-Cycle Cost Analysis
- Attachment B Cost Estimates with Life-Cycle Cost Analysis Workbooks
- Attachment C Benchmarking Review Form

Glossary of Terms

AACE	Association for the Advancement of Cost Engineering
AFI	allowance for indeterminates
BMP	best management practice
BOE	Basis of Estimate
CCI	Construction Cost Index
CF	cubic foot/feet
County	King County
CSO	combined sewer overflow
CWP	Clean Water Plan
DNR	(Washington State) Department of Natural Resources
Ecology	Washington State Department of Ecology
ENR	<i>Engineering News-Record</i>
FV	future value
GIS	geographic information system
GSI	green stormwater infrastructure
Herrera	Herrera Environmental Consultants, Inc.
in	inch(es)
KCSWDM	<i>King County Surface Water Design Manual</i>
LCC	life-cycle cost
L&I	Washington State Department of Labor & Industries
LSPC	Loading Simulation Program in C++
LTCP	Long-Term Control Plan
mo	month(s)
NLCD	National Land Cover Database
NPV	net present value
O&M	operations and maintenance
PDF	Portable Document Format
PRISM	Project Reporting and Information System Management
PV	present value
RKI	Robin Kirschbaum Inc.
ROW	right-of-way
SDOT	Seattle Department of Transportation
SF	square foot/feet
SPU	Seattle Public Utilities

SUSTAIN	System for Urban Stormwater Treatment and Analysis Integration
SSWM	City of Seattle Stormwater Manual
SWMMWW	<i>Stormwater Management Manual for Western Washington</i>
TM	technical memorandum
UIC	underground injection control
WLRD	Water and Land Resources Division
WQBE	Water Quality Benefits Evaluation
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WTD	(King County) Wastewater Treatment Division
yr	year(s)

Purpose and Background

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for “Actions” composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or “unit Actions”) that are aggregated and combined to develop “Programs,” or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or “Packages,” for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

Phase 1 (2020): Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit. The Action unit costs were developed using the WTD cost estimate workbook, which uses the Project Reporting and Information System Management (PRISM) cost calculators to calculate indirect costs that varies based on construction costs and complexity factors. Appendix D of Herrera (2020) documented the Action cost development, including the estimating basis, methodology, approach, and life-cycle cost (LCC) model assumptions.

Phase 2 (2021–2022): Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The Phase 2 cost-estimating approach was documented in Appendix D of Herrera (2022). Notable recommendations that were implemented include the following:

- The WTD estimate workbook cost allowances were reassigned based on assigned complexity for each Unit Action. Low complexity costs for Unit Actions (such as bioretention) were assigned lower contingency and uncertainty factors than more complex Actions (such as wet vault).
- Property costs were adjusted from Seattle area appraised land values to land values that represented an average cost across King County.
- The Actions were scaled within the WTD workbook to provide indirect costs that were more reflective of the anticipated cost for a suite of Actions or anticipated Program size.

Phase 3 (2023–2024): An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region. Notable updates to the cost models are listed below:

- Replaced the WTD Estimate workbook and WTD Capital Program Life Cycle Cost sheet with a single spreadsheet to provide ease in estimate assumption updates. The updated workbook offers a one-stop view of the cost estimate sheet, Basis of Estimate (BOE) summary tab, and LCC model with operations and maintenance (O&M) documentation. The estimate workbook was designed to be interactive, eliminating the need to toggle between more than 140 individual estimating workbooks used in prior phases.
- Prior phases used the WTD cost estimate workbook, which used PRISM cost calculators to calculate indirect costs that varied based on construction costs and complexity factors. PRISM worksheet costs were not developed from green stormwater infrastructure (GSI) and green projects, contributing to elevated indirect and contingency costs. A new workbook was developed to replace the WTD cost estimate workbook. The Phase 3 estimate workbook offered greater transparency by calculating indirect costs based on the Unit Action assigned complexity and related percentages of construction cost.
- Simplified the LCC estimates by replacing the seven-page WTD Capital Project Life Cycle Cost Workbook with a single sheet in the Phase 3 estimate workbook. The new LCC sheet maintained the WTD standardized financial and economic assumptions. Life cycle cost assumptions inputs from the WTC LCC workbook were used in development of the interactive workbook except for financing, which is not included with the LCC analysis. O&M equipment and labor hours were revisited for drywell and deep UIC Actions.
- Property costs in WQBE Phase 2 were based on an average cost spread across King County. The Phase 3 estimate summary sheet was updated to include three separate property costs that represent a low, medium and high property cost across King County estimated using compiled 2023 total appraised values for parcels in King County, Pierce County and Snohomish County that

fell within the project area. A selection toggle was added to each Unit Action cost summary tab to allow the user to adjust real estate costs based on a targeted region.

- Because of considerable market volatility, construction unit costs were updated or escalated to winter 2023 costs.
- Workshop 410 recommendation to normalize costs for small facilities (i.e., bioretention 25-square-foot [SF] facility) and shallow underground concrete facilities (i.e., wet vault) were implemented. For small facilities, construction costs were calculated based on a "typical" facility size and then the costs were scaled to the assigned facility dimensions. Shallow underground storage vaults, such as wet vault costs, were revisited to assign a typical storage depth, length, and width ratio.

This technical memorandum documents the WQBE Phase 3 estimate approach, assumptions, and methodology. While some approaches may coincide with prior Phase 1 and Phase 2 work, the estimate approach and methodologies contained within this TM are considered specific to the WQBE Phase 3 cost models.

Cost-Estimating Methodology and Approach

This section provides an overview of the methodology and approach used to estimate direct construction cost, indirect non-construction cost, project cost, and LCC for each Action.

Overview

The Herrera team developed modeling assumptions for a suite of Actions comprising structural and non-structural practices that improve water quality and/or provide flow control. A "Unit Action" represents a typical vertical profile, areal footprint, and associated design-drainage area for a specific Action being modeled in SUSTAIN. These Unit Actions provide a representative footprint of an Action defined to be modeled with SUSTAIN.

Planning-level cost estimates were developed based on the following:

- Limited design concepts that were based on engineering judgement and agency design requirements that include the King County Surface Water Design Manual (KCSWDM) (King County 2016), City of Seattle Stormwater Manual (SSWM), Washington State Department of Ecology (Ecology) Stormwater Management Manual for Western Washington (SWMMWW), and proprietary design and detail information from online sources. Details on design concept assumptions and refinement are provided in Appendix B.
- General site assumptions, such as if the installation were in right-of-way, on property, or in outwash or till soils, were provided by Herrera and RKI consultants. The assumptions are documented in the Action Factsheets, located in Appendix G.

- Project complexity factors were used to assign indirect costs based on a percentage of the Unit Action's subtotal construction costs. Table 1 provides the complexity assignment for each Action and a description is provided below.
 - Low complexity indicates a simplified or straightforward cost profile. For example, the Rain Garden Action, which uses a simple, preapproved design with little permitting required, was assigned a low complexity profile.
 - Routine complexity indicates typical design or duties without unique issues or concerns. For example, the Detention Vault Action was assumed to require typical design and construction monitoring. While the Action requires permitting, no unique permitting issues were anticipated with this installation. The Detention Vault Action was assigned a routine complexity profile.
 - Moderate complexity indicates that there will be elevated costs or concerns associated that are higher than normally found with that type of project. For example, the Stormwater Treatment Wetland Action was assumed to require elevated support for permitting, and environmental planning and management. The Stormwater Treatment Wetland Action was assigned a moderate complexity profile.
 - High complexity indicates that the project may have risks associated with it that can require intense support or concerns that may cause significant delivery and schedule delays. For example, a tunnel project that crosses a bay or requires disturbance along the shoreline area may require extensive permitting, have elevated risk associated with the construction, or may require extensive community-relations outreach. The tunnel project may be assigned a high complexity profile. None of the WQBE Actions were considered to have a high complexity profile.

General and specific assumptions that influence estimate costs for each Action are documented in Attachment A. The cost workbook for each Action is located in Attachment B.

The cost estimate for Rain garden was updated from a capital project to a programmatic Unit Action. Costs and allowances were developed based on RainWise program historical data provided by County and City of Seattle staff. All remaining Unit Action costs were developed based on capital improvement costs.

WQBE Phase 3 estimates include a suite of Unit Actions that were carried forward from Phase 2 and include new Unit Actions that are specific to WQBE Phase 3 development. A summary of the planning-level Unit Action cost estimates and variations is listed in Table 1. See Appendix B and C of Herrera (2024) design details and assumptions of the Actions developed in Phase 2 and Phase 3, respectively.

Table 1. WQBE Actions and Variations.

Action	Complexity	Description
Green Stormwater Infrastructure		
Rain garden installation (Program)	Low	WQBE_01_Rain Garden Installation on Property (Program)
Bioretention HPBSM planter (previously named "bioretention planter" in Phase 2)	Low	WQBE_02A_Bioretention Planter on Property
		WQBE_02B_Bioretention Planter in ROW
		WQBE_02C_Bioretention Planter with Property Cost
Bioretention HPBSM installation (previously named "bioretention" in Phase 2)	Low	WQBE_03A_Bioretention Underdrain on Property
		WQBE_03Aa_Bioretention Underdrain with Property Cost
		WQBE_03B_Bioretention No Underdrain on Property
		WQBE_03Bb_Bioretention No Underdrain with Property Cost
		WQBE_03C_Bioretention Underdrain in ROW
		WQBE_03D_Bioretention No Underdrain in ROW
Bioswale installation	Low	WQBE_04A_Bioswale in ROW
		WQBE_04B_Bioswale on Public Property
		WQBE_04C_Bioswale with Property Cost
Media filter drains	Low	WQBE_05A_Media Filter Drain Underdrain
		WQBE_05B_Media Filter Drain No Underdrain
Drywell	Low	WQBE_06A_Drywell on Property
		WQBE_06B_Drywell with Bioretention Planter on Property
Green Stormwater Infrastructure (continued)		
Deep UIC wells	Low	WQBE_07A_Deep UIC Well on Property
		WQBE_07B_Deep UIC Well in ROW
		WQBE_07C_Deep UIC Well with Property Cost
		WQBE_07D_Deep UIC Well with Filter in ROW
		WQBE_07E_Deep UIC Well with Bioretention Planter in ROW
		WQBE_07E_Deep UIC Well with Bioretention Planter in ROW
		WQBE_07F_Deep UIC Well with Bioretention Planter on Property
Permeable pavement	Low	WQBE_08A_Pervious Concrete Sidewalk (no sand layer)
		WQBE_08B_Porous Asphalt Driveway (with sand layer)
		WQBE_08C_Permeable Paver Driveway (with sand layer)
		WQBE_08D_Permeable Paver Plaza (no sand layer)

Table 1 (continued). WQBE Actions and Variations.

Action	Complexity	Description
Stormwater Retention/Detention/Infiltration		
Depaving (removal of impervious surfaces)	Low	WQBE_9A_Removal of Impervious Surfaces on Property (wheel strips)
		WQBE_9B_Removal of Impervious Surfaces on Property (no wheel strips)
Detention vault	Routine	WQBE_11A_Detention Vault on Public Property
		WQBE_11B_Detention Vault in ROW
		WQBE_11C_Detention Vault with Property Cost
Stormwater Retention/Detention/Infiltration (continued)		
Detention pond	Routine	WQBE_12A_Detention Pond on Public Property
		WQBE_12B_Detention Pond with Property Cost
Infiltration pond	Routine	WQBE_13A_Infiltration Pond Till Soil on Public Property
		WQBE_13B_Infiltration Pond Outwash Soil on Public Property
		WQBE_13C_Infiltration Pond Till Soil with Property Cost
		WQBE_13D_Infiltration Pond Outwash Soil with Property Cost
		WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter on Public Property
		WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost
		WQBE_14A_Infiltration Vault Till Soil on Public Property
		WQBE_14B_Infiltration Vault Outwash Soil on Public Property
		WQBE_14C_Infiltration Vault Till Soil in ROW
Infiltration vault	Routine	WQBE_14D_Infiltration Vault Outwash Soil in ROW
		WQBE_14E_Infiltration Vault Till Soil with Property Cost
		WQBE_14F_Infiltration Vault Outwash Soil with Property Cost
		WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW
		WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost
		WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System without Property Cost
Cistern	Low	WQBE_16_Cistern on Property
Gray Stormwater Treatment		
Wet pond	Routine	WQBE_18A_Wet Pond on Public Property
		WQBE_18B_Wet Pond with Property Cost
Wet vault	Routine	WQBE_19A_Wet Vault on Public Property
		WQBE_19B_Wet Vault in ROW
		WQBE_19C_Wet Vault with Property Cost

Table 1 (continued). WQBE Actions and Variations.

Action	Complexity	Description
Gray Stormwater Treatment (continued)		
Stormwater treatment wetland	Routine	WQBE_20A_ Stormwater Treatment Wetland on Public Property
		WQBE_20B_ Stormwater Treatment Wetland with Property Cost
High-rate underground filter system installation	Low	WQBE_21A_High Rate Underground Filter in Urban ROW PCCP
		WQBE_21B_High Rate Underground Filter in Highway ROW PCCP
		WQBE_21C_High Rate Underground Filter in Urban ROW HMA
		WQBE_21D_High Rate Underground Filter in Highway ROW HMA
		WQBE_21E_High Rate Underground Filter on Public Property
		WQBE_21F_High Rate Underground Filter with Property Cost
Gray (Regional) Stormwater Treatment		
Stormwater Park (water quality treatment); previously named Regional stormwater treatment facility in Phase 2	Moderate	WQBE_22A_Regional Vegetated Media Stormwater Facility on Public Property
		WQBE_22B_Regional Vegetated Media Stormwater Facility with Property Cost
WQBE Phase 3 New Actions		
Sports field	Routine	WQBE_23_Sports Field on Public Property
Blue roof	Low	WQBE_24_Blue Roof on Public Property
Compost amendment	Low	WQBE_25_Compost Amendment on Property
Reforest High Density Development	Routine	WQBE_26A_Reforest High Density Development on Property
		WQBE_26B_Reforest High Density Development on Property with Property Cost
Reforest Pervious Area	Routine	WQBE_26C_Reforest Pervious Area on Property
		WQBE_26C_Reforest Pervious Area with Property Cost

Note: "On property" means no property costs included.

Estimating Basis

An assigned conceptual design basis combined with accepted design practice and engineering judgment were used to develop Action Unit costs. It is understood that differing estimating assumptions and approach may meet an acceptable standard of care and still have a significant effect upon cost development. Cost modeling assumptions were assigned for each Action to guide the cost development process and maintain consistency with WQBE goals and accepted design practices. Cost modeling assumption definitions include the following:

- Design standards (e.g., KCSWDM, SSWM, Ecology SWMMWW, etc.)
- Facility assumptions (e.g., treatment media type and depth, drains, piping, location and surface restoration, etc.)

- Facility location and area (e.g., urban roadway, residential property, etc.)

A summary of the Basis of Estimate (BOE) assumptions prepared for each Unit Action cost model is included in Attachment A. BOE information provided includes the following:

- Design basis (specific to cost assumptions)
- Planning basis
- Cost basis
- Allowances (e.g., sales tax, indeterminates, change orders, etc.)
- Estimating assumptions

The BOE is housed on a tab within each estimate workbook, located in Attachment B, and should be considered a "living document" with the information updated when the Unit Action definition or approach is revised or further defined.

Cost Estimate Development

Cost estimates were developed in general conformance with the Association for the Advancement of Cost Engineering (AACE) and King County WTD estimating guidelines. AACE classifies estimates into six class types as outlined in AACE Recommended Practice 18R-97 (AACE 2020). The cost estimate classification varies, depending upon the project definition and primary estimating characteristics. The estimate classification is distinguished by the degree of project definition and the intended purpose or use of the estimate. The AACE guideline matrix for estimate classification system is provided in Table 2 below.

Table 2. AACE Estimate Class and Characteristics.

AACE ^a Estimate	Degree of Project Definition	Typical Estimate Purpose	AACE Expected Accuracy Range
Class 10	0%–2%	Conceptual screening (long range)	Unassigned ^b
Class 5	0%–2%	Conceptual screening	-50% to +100%
Class 4	1%–15%	Concept study, order of magnitude, feasibility study	-30% to +50%
Class 3	10%–40%	Budget, authorization, control	-20% to +30%
Class 2	30%–70%	Control	-15% to +20%
Class 1	70%–100%	Check estimate, bid/tender, change order	-10% to +15%

a Source: AACE International 2005.

b A range of -50% to +100% was assigned for these estimates.

In addition to the estimate classes listed above, AACE recognizes that special considerations apply when developing costs intended for planning-level screening or long-range strategic planning. These estimates were designated as Class 10 estimates in AACE publication Recommended Practice 111R-20 (AACE 2021).

Class 10 estimates can be characterized by a larger accuracy range to communicate potential unpredictable changes in scope and risk challenges over extended long-range planning.

The WQBE Unit Action cost estimates were designated and prepared as Class 10 estimates to provide for comparison and screening between different Unit Actions or a suite of Actions as part of long-term planning activities seeking to predict potential investments years in the future. For this specific project were assigned the same accuracy range, contingency, and uncertainty allowances as the AACE Class 5 estimate.

Unit cost models were developed using design basis information prepared by the Herrera team. The design basis for each Unit Action (located in Attachment A and B) included concept scope description, siting assumptions, dimensions, and applicable design standards.

Referenced requirements and sources used to supplement design BOE information are documented below:

- KCSWDM (2016 & 2021)
- SSWM (*City of Seattle Stormwater Manual 2016 & 2021*)
- Ecology SWMMWW
- Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13"
- Historical agency and vendor design and detail information

The BOE summary sheet prepared for each Unit Action documents key estimating assumptions, design details, estimating factors, and exclusions. A copy of the BOE summary sheet is included with the cost estimate sheets in Attachment A.

Total Project Cost Estimates

The total project cost consists of the following costs:

- Direct construction cost, which represents the probable cost of construction.
- Indirect or non-construction costs, which represent design, permitting, real estate, and other costs associated with the development and administration of a project.

Direct Construction Cost

This section describes the methodologies and assumptions used to estimate direct construction costs for the Unit Actions. Direct construction costs represent the costs associated with physical construction of a project and include the following costs:

- Subtotal construction costs, which is also called the probable cost of construction bid. The subtotal construction costs include the following costs:
 - Contractor overhead and profit and general conditions (included in line-item unit prices)
 - Contractor bonds and insurance (included in line-item unit prices)
 - Contractor mobilization and demobilization (10 percent) based on County experience.
- Allowance for indeterminates (AFI) or design allowance for undefined scope work multipliers were assigned based on Unit Action complexity. Assigned complexities are listed in Table 1 with AFI multipliers listed below:
 - 15 percent for low-complexity Actions
 - 20 percent for routine-complexity Actions
 - 25 percent for moderate-complexity Actions
- Street use permit allowance: Seattle Department of Transportation (SDOT) street use permit fees for work within Seattle right-of-way (ROW) (varies by Unit Action).
- Project contingency multipliers were assigned based on anticipated project complexity (see Table 1) as listed below:
 - 15 percent for low-complexity Actions
 - 30 percent for routine-complexity Actions
 - 25% for Moderate Complexity Actions

Additional Construction Costs

Additional direct construction costs include the following costs:

- Construction change order allowance (10 percent) based on County experience
- Retail sales tax at 10.25 percent in Seattle and 10.10 percent in King County outside of Seattle
- Outside agency construction (e.g., utility relocations; user-defined, varies by Unit Action)

Year of Construction Cost

Engineering News-Record (ENR) monitors construction costs across the country. The ENR Construction Cost Index (CCI) averages the cost of a set amount of labor and materials over a 20-city average of labor rates and material costs. In addition, ENR has specific CCI average values for the Seattle area.

To maintain estimating consistency between Unit Actions, costs that were not directly updated using current construction values were escalated to December 2023 dollars using Seattle ENR CCI values. Should a Unit Action be selected for future development, it is recommended that construction costs be adjusted to the projected mid-year of construction.

Indirect Non-Construction Costs

Indirect costs represent “soft costs,” which are costs outside of those that are directly part of the construction (or installation) but that are required to complete the construction. Examples of indirect costs include design, real estate procurement, etc. Indirect costs for the WQBE Actions were assigned as a percentage of direct construction costs based on assigned project complexity for the categories listed in Table 3.

Table 3. Complexity Categories and Assigned Direct Construction Cost Percentage.

Complexity Factor	Indirect Cost Category			
	Design Engineering & Services During Construction	Construction Management Services	Permitting & Support (if applicable)	WTD Staff Labor (Finance, Community Service, Planning, CM, Controls, etc.)
Low	12%	8%	0.5%	5%
Routine	22%	10%	1%	6%
Moderate	28%	13%	2%	9%
High	34%	16%	3%	11%

Real Estate Costs

A low, medium, and high land acquisition cost was calculated to represent the range of costs across the jurisheds in the project area. A jurished is the result of intersecting the jurisdictional boundaries and the delineated drainage areas. The cost analysis included the following steps:

1. Compiled 2023 total appraised values for each parcel in King, Pierce, and Snohomish Counties that fell within the project area. The cost per square foot was calculated for each parcel.
2. The parcel spatial layer was intersected with the jurished layer to split the parcels along the jurished boundaries and assign the parcel areas along the boundaries to the jurisheds they fall in. The cost per square foot of each parcel was multiplied by the associated area within each jurished.
3. The average area weighted cost per square foot was calculated for each jurished using the total parcel costs calculated in step 2. The area of the parcels with a total appraised value of zero was excluded from the analysis.

4. Based on the jurished area weighted cost per square foot, each jurished within the project area was assigned a low, medium, or high cost category using the natural breaks classification (Jenks) in ArcGIS Pro. Figure 1 displays the range of costs per square foot and the cost categories assigned to jurisheds in the project area.
5. The final step in the analysis was calculating the low, medium, and high cost per square foot representative of each cost category. The Actions being modeled with the WQBE toolkit will not be applied in forested areas and no land acquisition would be needed in public parks. Therefore, based on best professional judgement, jurisheds with greater than 85 percent coverage from a combination of the following data sets were excluded from the land acquisition cost analysis:
 - o State parks: Washington State park boundaries
 - o County parks: King, Pierce, and Snohomish County publicly available park geographic information system (GIS) data sets
 - o National forest: U.S. Forest Service forest administrative boundaries
 - o Wilderness area: U.S. Forest Service national wilderness areas
 - o Forested area: National Land Cover Database (NLCD) land cover 2021 for deciduous, evergreen, and mixed forest

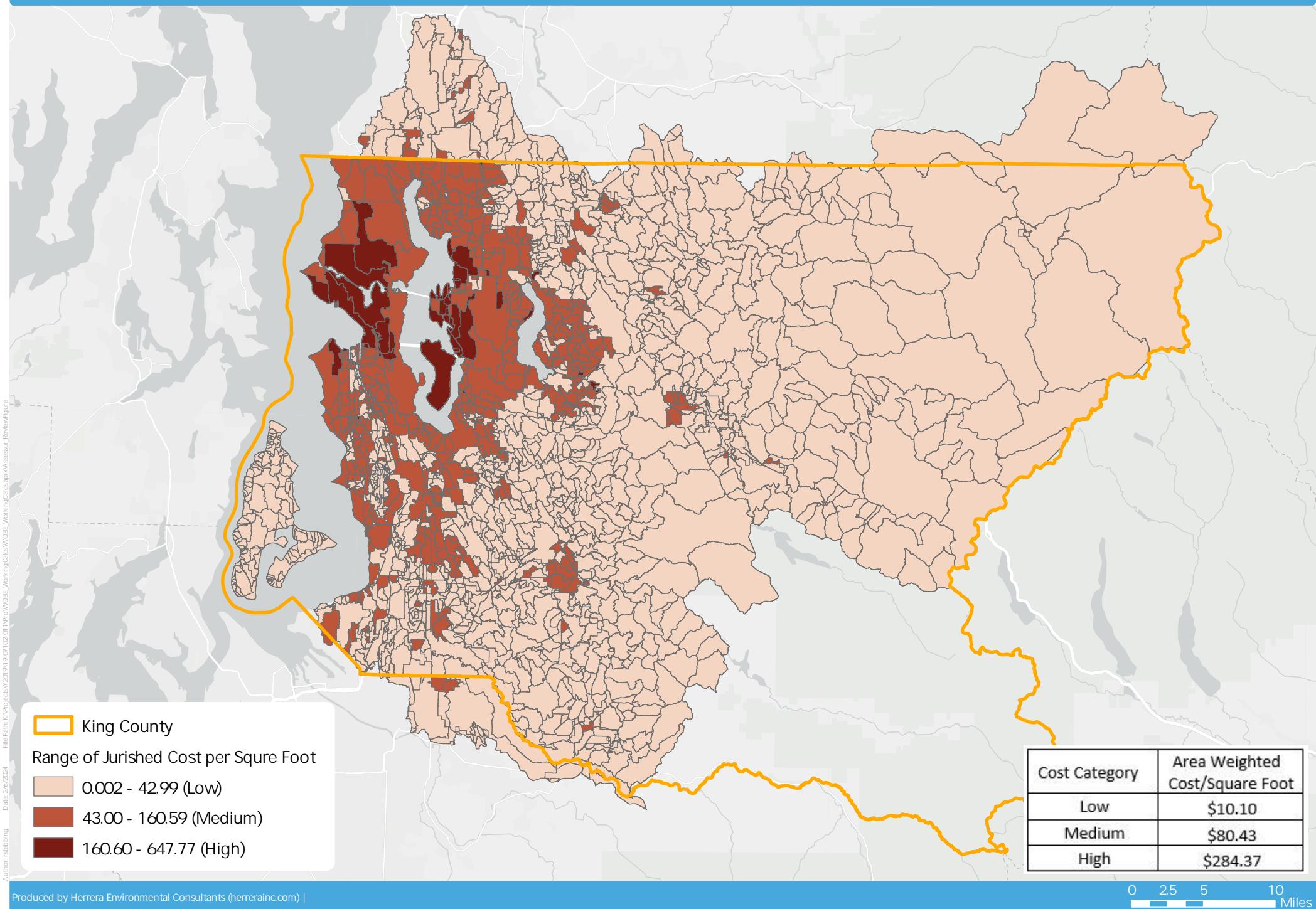
The cost for each category (i.e., low, medium, and high) was calculated by taking the area-weighted average cost per square foot of the remaining jurisheds within each cost category. Table 4 provides the results of this analysis. Although, the jurisheds with greater than 85% coverage from the datasets described above were not included in calculating the area-weighted cost/SF, these jurisheds may still have land uses where Actions may be applied and therefore, were assigned the cost categories associated with them as calculated in step 4.

Table 4. Low, Medium, and High Land Acquisition Costs.

Jurished Cost Category	Area-Weighted Cost/SF
Low	\$10.10
Medium	\$80.43
High	\$284.37

Land acquisition cost assumptions, where used, are documented in Attachment A and included in the cost workbooks located in Attachment B for each Unit Action. Attachment A and B display the medium land acquisition costs. When applying the Unit Action to jurisheds that fall under different cost categories, the user can change the land acquisition costs to low, medium or high in the cost workbooks located in Attachment B.

Figure 1.
Land Acquisition Cost Analysis Results.



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Total Project Costs

Total project costs were estimated for each Unit Action by summing the direct construction costs and indirect non-construction costs and include the following information:

- Total direct construction costs, which include the following costs:
 - Estimated probable cost of construction bid (directly estimated using engineered quantities and unit pricing analysis)
 - AFI
 - Street use permit allowance
 - Additional construction costs (includes change order allowance, construction sales tax, and outside agency construction)
- Total indirect non-construction costs, which include the following costs:
 - Design engineering & construction management consulting services
 - Permitting & support
 - Land purchase, easements, and acquisition cost
 - King County staff costs & non-WTD support

As detailed under the Cost Estimate Development section, the WQBE estimates were prepared as Class 10 estimates intended for planning-level screening or alternative comparison for long-range strategic planning. Attachment A contains Portable Document Format (PDF) files of the cost workbook for each Unit Action cost estimate.

Life-Cycle Cost

A life-cycle cost (LCC) analysis was prepared using standard King County analysis assumptions referenced from the WTD LCC worksheet. The LCC analysis considers initial capital costs and future costs, such as capital replacement and O&M costs. A 30-year analysis period was selected for the LCC analysis.

For the WQBE Actions, the LCC was the total project capital cost plus the net present value (NPV) of ongoing capital replacement and O&M over the analysis period of the project. Project LCCs combine capital replacement and O&M costs to allow reasonable comparisons between concepts with high project costs and those with high O&M costs. Project LCCs were estimated by considering the following factors:

- Total project cost comprising both direct construction cost and indirect project costs
- Capital replacement cost, which was the cost to replace components during the life-cycle period
- Annual O&M costs, which included labor, supplies, and equipment

The LCC estimates are to be considered preliminary level because of the limited information available and the planning-level engineering that has occurred.

Life-Cycle Cost Analysis Assumptions

The following general assumptions were used:

- Initial capital cost:
 - Initial capital cost is input into the LCC analysis sheet as total project cost and not construction cost.
 - Initial capital cost was assumed to occur in a single year.
- Capital replacement schedule assumptions for each Action were documented within the LCC analysis sheet located in Attachment A and B. Capital replacement general assumptions were as follows:
 - GSI replacement costs (e.g., mulch, plants, etc.) were placed on a 10-year schedule.
 - Gray stormwater infrastructure (e.g., weirs, outlets, etc.) were placed on a 20-year schedule.

The following is a general representation of how NPV is calculated within the LCC worksheet:

$$\text{Project net present value (NPV)} =$$

$$PV(\text{initial capital costs}) + PV(\text{capital replacement costs}) + PV(\text{O&M costs})$$

In general, future values (FVs) are converted to present values (PVs) by the following equation:

$$PV = FV \frac{FV}{(1 + i)^n}$$

Where: i = annual interest rate (provided by County), n = year of expenditure.

- Life-cycle assumptions:
 - Period: 30 years
 - Initial year of operations: 2026
 - Year of analysis: 2023
 - Construction start: 2025
- Cost assumptions:
 - Cost estimate dollar basis year: 2023
 - Construction cost escalation: 3.5 percent

- O&M and general cost escalation:
 - Projects: 3.0 percent
 - Programs: 3.5 percent (because it is associated with Program implementation and not necessarily O&M)
 - O&M labor rate growth: 3.2 percent
 - Direct labor rate as of year of analysis: \$54.39
 - Washington (retail) sales tax: 10.25 percent (King County in the City Seattle)
 - WTD labor overhead: 150 percent (this is a County-controlled rate applied to raw labor costs calculated for O&M activities)
 - The O&M labor cost formula is listed below:

$$\text{O\&M labor costs} =$$

$$\text{Labor hours per year} \times \text{direct labor rate} \times \text{WTD overhead rate}$$

- Economic assumptions:
 - Discount rate, WTD (cost of capital): 5.25 percent. The discount rate accounts for both inflation and the time value of money.
 - WTD real discounted rate: 2.18 percent (if O&M escalation is 3.0 percent) or 1.69 percent (if O&M escalation is 3.5 percent).

Attachment A contains a PDF file of the LCC worksheets for each Unit Action.

Operations and Maintenance Cost

Annual O&M cost was estimated for each Unit Action and generally included the following:

- O&M activities were based on the type of activity provided in the most current version of the Cost and Modeling Assumptions worksheet. Activity sources included the following:
 - KCSWDM, (2016 & 2021)
 - SSWM, (2016 & 2021)
 - Ecology SWMMWW, 2019
 - Kitsap County *Manchester Stormwater Retrofit Drainage Report*, 2014
 - Vendor recommendations
- Annual labor hours required by maintenance crews for cleanup after major storm events or for periodic inspections and remediation of materials (grass, plantings, permeable pavement, concrete cracks and joints, etc.) and regular maintenance activities for the specific Unit Action, where applicable.

- Annual material replacement, such as plant replacement, grass seed mix, mulch, etc. for the specific Unit Action, where applicable.
- Annual equipment rentals needed to perform maintenance activities for the specific Action, where applicable. Equipment rates were obtained from EquipmentWatch (Rental Rate Blue Book) adjusted for Seattle pricing or RSMeans.

Capital Replacement Cost

Capital replacement cost (items requiring replacement prior to the 30-year life of the Unit Action) was estimated for each Unit Action. The replacement costs for each action are scheduled and not prorated based on the timelines indicated below. The following was assumed:

- Complete replacement of vegetation along with soils that had been compacted every 10 years, where applicable
- Complete replacement of access gates every 10 years, where applicable
- Complete replacement of mechanical equipment (e.g., flow restrictor, access hatch, outlet structure, baffle, etc.) every 20 years, where applicable

Capital replacement costs were estimated for each Unit Action by summing the construction costs of the specific line items assumed for replacement for the specified interval (e.g., 10 years), including mobilization/demobilization. The replacement schedules identified for each Action were based on the KCSWDM, SSWM and vendor recommendations.

Total Life-Cycle Cost

The total LCC included initial capital costs, capital replacement costs, and regular maintenance costs over the 30-year analysis period. The total LCC is presented as the NPV for each Action.

Cost Sources

This section outlines the process used to collect cost information in support of the WQBE toolkit (construction, program, and O&M costs). The costs for each Unit Action were characterized for a defined unit or footprint specific within the SUSTAIN model. Costs developed for use in the SUSTAIN model were preliminary, planning-level costs, based on limited or generalized engineering design assumptions.

The following sources were reviewed to support development of unit cost data considered representative of the Seattle/King County region. The costs reflect owner's anticipated construction costs (construction contractor pricing) presented in fourth quarter 2023 dollars:

- Washington State Department of Transportation (WSDOT) unit bid analysis: The WSDOT unit bid analysis database contains a bid history for standard unit bid prices from WSDOT projects. This tool contains cost information for excavation, conveyance, best management practices (BMPs), or other

typical roadway construction items. The WSDOT database search can be limited to projects within western Washington or other nearby localities, such as the Olympic Peninsula (WSDOT 2023).

- Puget Sound BMP cost database: The Puget Sound BMP cost database (Herrera 2012) report contains cost information from the Puget Sound region for stormwater treatment and BMP elements (e.g., wet ponds, porous pavement, cisterns, constructed wetlands, etc.). Costs from this database report are based on 2012 dollars.
- King County TMs and reports: King County TMs (e.g., the University GSI projects) and existing reports (e.g., Puget Sound BMP Cost Database, Water Resource Inventory Area [WRIA] 9 reports, and University Green Stormwater Infrastructure with GSI cost benchmarking by CH2M Hill) contain both estimated construction costs and historical maintenance cost data. Construction and other cost data within the reports are based on various dates and any applied escalation or inflationary values should be considered on a case-by-case basis.
- King County and Seattle RainWise Program: King County and the City of Seattle provided historical cost information for both RainWise programmatic costs and cistern costs.
- Internet sources: Internet websites and online data sources were used to estimate or validate contractor quotes on area-specific costs such as King County landfill disposal costs.
- Contractor and vendor quotes: Vendor quotes were used to calculate bid costs or to verify reported unit cost data for specialty items, such as proprietary stormwater treatment (i.e., Filterra), sports field ADS StormTech system, blue roof, and porous asphalt pavement costs. Vendor quotes reflect current market conditions at the time the quote was obtained. Direct vendor quotes were adjusted to account for installation costs and labor, shipping and handling, and contractor markup and profit.
- Estimator and agency historical databases: Herrera, King County (WTD and Water and Land Resources Division [WLRD]), SPU, the Washington State Department of Natural Resources (DNR), Kitsap County, and other agencies within the Puget Sound area maintain and may post contractor bid prices for publicly bid projects. Bid costs from these sources and those from the estimators database of recent projects were used to fill in data gaps from the other sources or for specialty work. Data obtained from these sources were reviewed to ensure that the quantities and other project parameters were relevant. Costs obtained from these sources were based on various dates and any applied escalation or inflationary values were considered on a case-by-case basis.
- EquipmentWatch: HDR Engineering, Inc. maintains a subscription to EquipmentWatch, which provides access to Rental Rate Blue Book pricing. The pricing is kept current by extensive ongoing research. This pricing tool is an industry standard for determining equipment values for both use and rental. The rates can be applied across the country or can be adjusted for a specific region, such as the Seattle area. Additional information on EquipmentWatch is available on its website at equipmentwatch.com.
- Gordian RSMeans (RSMeans): Gordian RSMeans (2020) online, an industry resource used in estimating construction costs, was used to provide construction costs for materials, labor, transportation costs, and equipment rental rates. The rates can be applied across the country or can

be adjusted for a specific region, such as the Seattle area. RSMeans online is available on its website at www.RSMeans.com.

- Labor rates: Craft rates and related benefits were estimated using Washington State Department of Labor & Industries (L&I) prevailing wage rates for King County. These labor rates include base wage rate, all applicable fringe benefits, unemployment insurance, and payroll taxes. Workers' compensation insurance is included separately in each work activity based on risk histories. Additional information is available at the L&I website at <https://lni.wa.gov/licensing-permits/public-works-projects/prevailing-wage-rates/>.

Cost Source Data Summary

The cost sources used in development of the Unit Action costs are summarized in 5 below. The cost estimates and estimating approaches used for the WQBE Phase 3 Actions were evaluated against peer projects and programs.

Table 5. Cost Data Summary.

Action	Cost Source
Rain garden installation	<ul style="list-style-type: none"> ● City of Seattle and King County RainWise program costs; WSDOT unit bid analysis, estimator and historical databases ● Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County ● O&M guidelines per SWMMWW, 2019
Bioretention HPBSM planter	<ul style="list-style-type: none"> ● King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, and historical databases ● Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County ● O&M guidelines per SWMMWW, 2019
Bioretention HPBSM	<ul style="list-style-type: none"> ● King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases ● Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County ● O&M guidelines per SWMMWW, 2019
Bioswale (treatment)	<ul style="list-style-type: none"> ● Construction costs based on WRIA 9 Reports, WSDOT Unit Bid Analysis, SPU/County and estimator and historical databases ● Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County ● O&M guidelines per SWMMWW, 2019
Media filter drains	<ul style="list-style-type: none"> ● King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, and historical databases ● O&M guidelines per SWMMWW, 2019
Drywell	<ul style="list-style-type: none"> ● King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, and historical databases ● O&M guidelines per KCSWDM, 2016 and SSWM 2021

Table 5 (continued). Cost Data Summary.

Action	Cost Source
Deep UIC wells	<ul style="list-style-type: none"> Construction costs based on University GSI report, Puget Sound BMP cost database, and estimator and historical cost database O&M guidelines per KCSWDM, 2016 and SSWM 2021
Permeable pavement	<ul style="list-style-type: none"> Construction costs based on University GSI report and estimator and historical cost database O&M guidelines per SWMMWW, 2019
Depaving (removal of impervious surface)	<ul style="list-style-type: none"> Construction costs based on SPU/County and estimator and historical database O&M minimal and based on professional judgment
Detention vault	<ul style="list-style-type: none"> Construction costs based on WSDOT Unit Bid Analysis, vendor quotes, SPU/County and estimator and historical databases Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates O&M guidelines per SWMMWW, 2019
Detention pond	<ul style="list-style-type: none"> Construction costs based on WSDOT Unit Bid Analysis, vendor quotes, SPU/County and estimator and historical databases Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates O&M guidelines per SWMMWW, 2019
Infiltration pond	<ul style="list-style-type: none"> King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases O&M guidelines per SWMMWW, 2019
Infiltration vault	<ul style="list-style-type: none"> Construction costs based on WSDOT Unit Bid Analysis, tabula, vendor quotes, SPU/County and estimator and historical databases O&M guidelines per SWMMWW, 2019
Cistern	<ul style="list-style-type: none"> City of Seattle and King County RainWise program costs, vendor cost information, and online sources including https://www.700milliongallons.org/rainwise/ (SPU and King County 2020) O&M guidelines per SWMMWW, 2019 and KCSWDM, 2016
Wet pond	<ul style="list-style-type: none"> King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates O&M guidelines per SWMMWW, 2019
Wet vault	<ul style="list-style-type: none"> Construction costs based on WSDOT Unit Bid Analysis, vendor quotes, SPU/County and estimator and historical databases O&M guidelines per SWMMWW, 2019
Stormwater treatment wetland	<ul style="list-style-type: none"> Construction costs based on Manchester Stormwater Retrofit (Kitsap County), King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, Puget Sound BMP Cost Database, SPU/County and estimator and historical databases Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates O&M guidelines per KCSWDM, 2016

Table 5 (continued). Cost Data Summary.

Action	Cost Source
High-rate underground filter system and Stormwater Park	<ul style="list-style-type: none"> Construction cost based on vendor quotes and estimator and historical databases Equipment rates from EquipmentWatch (Blue Book) and personnel costs from LCC model O&M guidelines per Kitsap County Operations and Maintenance Manual: Manchester Stormwater Park, 2015
Sports field and park detention	<ul style="list-style-type: none"> Construction cost based on vendor quotes, King County internet sources, and estimator and historical databases. Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates O&M guidelines per manufacturers requirements and O&M guidelines per SWMMWW. 2019
Blue roof	<ul style="list-style-type: none"> Construction cost based on vendor quotes, internet sources, and estimator and historical databases. Equipment rates from RSMeans and personnel costs from Washington State prevailing wage rates O&M guidelines per Philadelphia Stormwater Management Guidance Manual and online manufacturers requirements, and SWMMWW. 2019
Compost amendment	<ul style="list-style-type: none"> King County University GSI, Puget Sound BMP cost database, WSDOT unit bid analysis, estimator and historical databases. Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County O&M guidelines per SWMMWW, 2019
Reforest High Density Development	<ul style="list-style-type: none"> Puget Sound BMP cost database, WSDOT unit bid analysis, King County internet sources, estimator and historical databases. Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County O&M guidelines per SWMMWW, 2019
Reforest Pervious Area	<ul style="list-style-type: none"> Puget Sound BMP cost database, WSDOT unit bid analysis, King County internet sources, estimator and historical databases. Equipment rates from RSMeans and personnel costs from Washington State L&I prevailing wage rates for King County O&M guidelines per SWMMWW, 2019

Summary of Costs by Unit Action

A summary of the costs for each Unit Action is provided in Table 6. Property acquisition costs, where shown, represent medium property costs as detailed in the Real Estate Cost section of this report.

Table 6. Costs by Unit Action.

Action	Description	Action Unit Footprint Area	Design Drainage Area	Total Direct Construction Cost (a)	Property Acquisition Cost (b)	Total Indirect Non-Construction Cost (c)	Total Project Cost (d)	O&M Costs (Annual) (e)	Net Present Value 30-year Life-Cycle Cost (2023) (f)
Equations									(a)+(b)+(c)
Green Stormwater Infrastructure (GSI)									
Rain garden installation	WQBE_01_Rain Garden Installation on Property (Program)	25 SF	Till 806 SF; Outwash 2,844 SF	\$5,800	\$0	\$2,400	\$8,200	\$2,100	\$56,700
Bioretention HPBSM planter installation	WQBE_02A_Bioretention Planter on Property	25 SF	2,357 SF	\$18,700	\$0	\$7,800	\$26,500	\$2,800	\$86,600
	WQBE_02B_Bioretention Planter in ROW	25 SF	2,357 SF	\$25,800	\$0	\$10,700	\$36,500	\$2,800	\$96,600
	WQBE_02C_Bioretention Planter with Property Cost	25 SF	2,357 SF	\$18,700	\$2,011	\$10,100	\$28,800	\$2,800	\$88,900
Bioretention HPBSM installation	WQBE_03A_Bioretention Underdrain on Property	85 SF	12,148 SF	\$35,400	\$0	\$14,700	\$50,100	\$3,100	\$121,500
	WQBE_03Aa_Bioretention Underdrain with Property Cost	85 SF	12,148 SF	\$35,400	\$19,995	\$37,700	\$73,100	\$3,100	\$144,500
	WQBE_03B_Bioretention No Underdrain on Property	85 SF	9,570 SF	\$32,800	\$0	\$13,700	\$46,500	\$3,100	\$117,900
	WQBE_03Bb_Bioretention No Underdrain with Property Cost	85 SF	9,570 SF	\$32,800	\$19,995	\$36,600	\$69,400	\$3,100	\$140,800
	WQBE_03C_Bioretention Underdrain in ROW	85 SF	12,148 SF	\$63,900	\$0	\$26,400	\$90,300	\$3,100	\$161,700
	WQBE_03D_Bioretention No Underdrain in ROW	85 SF	9,570 SF	\$63,700	\$0	\$26,300	\$90,000	\$3,100	\$161,400
Bioswale installation	WQBE_04A_Bioswale in ROW	200 SF	27,878 SF	\$20,500	\$0	\$8,500	\$29,000	\$2,600	\$85,300
	WQBE_04B_Bioswale on Public Property	200 SF	27,878 SF	\$11,400	\$0	\$4,800	\$16,200	\$2,600	\$72,500
	WQBE_04C_Bioswale with Property Cost	200 SF	27,878 SF	\$11,400	\$59,116	\$72,700	\$84,100	\$2,600	\$140,400
Media filter drains	WQBE_05A_Media Filter Drain Underdrain	200 SF	2,000 SF	\$25,300	\$0	\$10,500	\$35,800	\$2,400	\$90,800
	WQBE_05B_Media Filter Drain No Underdrain	200 SF	2,000 SF	\$23,100	\$0	\$9,500	\$32,600	\$2,400	\$87,600
Drywell	WQBE_06A_Drywell on Property	13 SF	Till 261 SF; Outwash 780 SF	\$14,000	\$0	\$5,800	\$19,800	\$1,000	\$41,400
	WQBE_06B_Drywell on Outwash with Bioretention Planter on Property	Drywell is 13 SF; Planter is 4.3 SF	395 SF	\$30,200	\$0	\$12,600	\$42,800	\$1,500	\$76,000
Deep UIC well	WQBE_07A_Deep UIC Well on Property	42 SF	NA ^a	\$40,400	\$0	\$16,800	\$57,200	\$900	\$75,900
	WQBE_07B_Deep UIC Well in ROW	42 SF	NA ^a	\$58,000	\$0	\$23,900	\$81,900	\$900	\$100,600
	WQBE_07C_Deep UIC Well with Property Cost	42 SF	NA ^a	\$40,400	\$2,011	\$19,100	\$59,500	\$900	\$78,200
	WQBE_07D_Deep UIC Well with Filter in ROW	Well is 42 SF; Filter is 24 SF	52,164 SF	\$158,700	\$0	\$65,400	\$224,100	\$2,400	\$274,000
	WQBE_07E_Deep UIC Well with Bioretention Planter in ROW	Well is 42 SF; Planter is 579 SF	54,546 SF	\$946,600	\$0	\$390,200	\$1,336,800	\$5,900	\$1,466,700
	WQBE_07F_Deep UIC Well with Bioretention Planter on Property	Well is 42 SF; Planter is 579 SF	54,546 SF	\$811,500	\$0	\$337,600	\$1,149,100	\$5,900	\$1,279,600
	WQBE_07G_Deep UIC Well with High Rate Underground Filter on Property	Well is 42 SF; Filter is 24 SF	52,164 SF	\$141,300	\$0	\$58,800	\$200,100	\$2,400	\$250,000
Permeable pavement	WQBE_08A_Pervious Concrete Sidewalk (no sand layer)	200 SF	200 SF	\$11,200	\$0	\$4,600	\$15,800	\$2,300	\$75,700
	WQBE_08B_Porous Asphalt Driveway (with sand layer)	200 SF	200 SF	\$5,900	\$0	\$2,400	\$8,300	\$2,300	\$63,800
	WQBE_08C_Permeable Paver Driveway (with sand layer)	200 SF	200 SF	\$7,800	\$0	\$3,200	\$11,000	\$2,300	\$68,400
	WQBE_08D_Permeable Paver Plaza (no sand layer)	200 SF	200 SF	\$6,700	\$0	\$2,800	\$9,500	\$2,300	\$64,800
Depaving (removal of impervious surfaces)	WQBE_09A_Removal of Impervious Surfaces on Property (wheel strips)	100 SF	100 SF	\$1,800	\$0	\$800	\$2,600	\$700	\$16,800
	WQBE_09B_Removal of Impervious Surfaces on Property (no wheel strips)	100 SF	100 SF	\$1,400	\$0	\$600	\$2,000	\$700	\$16,200

Table 6 (continued). Costs by Unit Action.

Action	Description	Action Unit Footprint Area	Design Drainage Area	Total Direct Construction Cost (a)	Property Acquisition Cost (b)	Total Indirect Non-Construction Cost (c)	Total Project Cost (d)	O&M Costs (Annual) (e)	Net Present Value 30-year Life-Cycle Cost (2023) (f)
Equations				(a)+(b)+(c)					PV(d)+PV(e)
Stormwater Retention/Detention/Infiltration									
Detention vault	WQBE_11A_Detention Vault on Public Property	2,592 SF	28,658 SF	\$3,281,800	\$0	\$2,493,700	\$5,775,500	\$5,200	\$5,905,200
	WQBE_11B_Detention Vault in ROW	2,592 SF	28,658 SF	\$3,638,400	\$0	\$2,664,000	\$6,302,400	\$5,200	\$6,432,100
	WQBE_11C_Detention Vault with Property Cost	2,592 SF	28,658 SF	\$3,281,800	\$422,603	\$3,043,100	\$6,324,900	\$5,200	\$6,454,600
Detention pond	WQBE_12A_Detention Pond on Public Property	4,500 SF	36,569 SF	\$694,600	\$0	\$527,800	\$1,222,400	\$10,000	\$1,444,200
	WQBE_12B_Detention Pond with Property Cost	4,500 SF	36,569 SF	\$694,200	\$1,144,543	\$2,015,400	\$2,709,600	\$10,000	\$2,931,400
Infiltration pond	WQBE_13A_Infiltration Pond Till Soil on Public Property	2,785 SF	36,595 SF	\$500,500	\$0	\$380,300	\$880,800	\$5,900	\$1,016,100
	WQBE_13B_Infiltration Pond Outwash Soil on Public Property	1,479 SF	46,396 SF	\$448,200	\$0	\$340,600	\$788,800	\$3,700	\$878,000
	WQBE_13C_Infiltration Pond Till Soil with Property Cost	2,785 SF	36,595 SF	\$500,500	\$891,189	\$1,538,800	\$2,039,300	\$5,900	\$2,174,600
	WQBE_13D_Infiltration Pond Outwash Soil with Property Cost	1,479 SF	46,396 SF	\$448,200	\$891,189	\$1,499,100	\$1,947,300	\$3,700	\$2,036,500
	WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property	Pond is 1,479 SF; Filter is 24 SF	52,164 SF	\$529,400	\$0	\$402,300	\$931,700	\$6,600	\$1,082,700
	WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost	Pond is 1,479 SF; Filter is 24 SF	52,164 SF	\$529,400	\$893,119	\$1,563,300	\$2,092,700	\$6,600	\$2,243,700
Infiltration vault	WQBE_14A_Infiltration Vault Till Soil on Public Property	1,836 SF	28,719 SF	\$2,262,300	\$0	\$1,719,000	\$3,981,300	\$4,800	\$4,104,000
	WQBE_14B_Infiltration Vault Outwash Soil on Public Property	1,156 SF	39,365 SF	\$1,870,200	\$0	\$1,421,100	\$3,291,300	\$4,800	\$3,414,000
	WQBE_14C_Infiltration Vault Till Soil in ROW	1,836 SF	28,719 SF	\$2,782,300	\$0	\$2,038,800	\$4,821,100	\$4,800	\$4,943,800
	WQBE_14D_Infiltration Vault Outwash Soil in ROW	1,156 SF	39,365 SF	\$2,282,500	\$0	\$1,673,800	\$3,956,300	\$4,800	\$4,079,000
	WQBE_14E_Infiltration Vault Till Soil with Property Cost	1,836 SF	28,719 SF	\$2,262,300	\$340,082	\$2,161,200	\$4,423,500	\$4,800	\$4,546,200
	WQBE_14F_Infiltration Vault Outwash Soil with Property Cost	1,156 SF	39,365 SF	\$1,870,200	\$340,082	\$1,863,200	\$3,733,400	\$4,800	\$3,856,100
	WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW	Vault is 1,156 SF; Filter is 24 SF	52,164 SF	\$2,211,100	\$0	\$1,621,700	\$3,832,800	\$6,600	\$3,992,400
	WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost	Vault is 1,156 SF; Filter is 24 SF	52,164 SF	\$2,175,500	\$342,013	\$2,040,300	\$4,215,800	\$6,600	\$4,375,400
	WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System on Property Cost	Vault is 1,156 SF; Filter is 24 SF	52,164 SF	\$2,175,500	\$0	\$1,595,700	\$3,771,200	\$6,600	\$3,930,800
Cistern	WQBE_16_Cistern on Property	18 SF	1,300 SF	\$21,600	\$0	\$9,000	\$30,600	\$700	\$46,100
Gray Stormwater Treatment									
Wet pond	WQBE_18A_Wet Pond on Public Property	553 SF	63,075 SF	\$493,900	\$0	\$375,300	\$869,200	\$2,200	\$929,200
	WQBE_18B_Wet Pond with Property Cost	553 SF	63,075 SF	\$493,900	\$615,475	\$1,175,400	\$1,669,300	\$2,200	\$1,729,300
Wet vault	WQBE_19A_Wet Vault on Public Property	1,615 SF	63,010 SF	\$2,981,300	\$0	\$2,265,400	\$5,246,700	\$3,100	\$5,333,600
	WQBE_19B_Wet Vault in ROW	1,615 SF	63,010 SF	\$3,342,400	\$0	\$2,447,900	\$5,790,300	\$3,100	\$5,877,200
	WQBE_19C_Wet Vault with Property Cost	1,615 SF	63,010 SF	\$2,981,300	\$347,803	\$2,717,500	\$5,698,800	\$3,100	\$5,785,700
Stormwater treatment wetland	WQBE_20A_Stormwater Treatment Wetland on Public Property	503 SF	62,988 SF	\$463,100	\$0	\$351,900	\$815,000	\$2,500	\$880,800
	WQBE_20B_Stormwater Treatment Wetland with Property Cost	503 SF	62,988 SF	\$463,100	\$555,554	\$1,074,100	\$1,537,200	\$2,500	\$1,603,000

Table 6 (continued). Costs by Unit Action.

Action	Description	Action Unit Footprint Area	Design Drainage Area	Total Direct Construction Cost (a)	Property Acquisition Cost (b)	Total Indirect Non-Construction Cost (c)	Total Project Cost (d)	O&M Costs (Annual) (e)	Net Present Value 30-year Life-Cycle Cost (2023) PV(d)+PV(e)
(a)+(b)+(c)									PV(d)+PV(e)
Equations									
High-rate underground filter system	WQBE_21A_High Rate Underground Filter in Urban ROW PCCP	16 SF	34,956 SF	\$147,500	\$0	\$60,800	\$208,300	\$2,500	\$262,000
	WQBE_21B_High Rate Underground Filter in Highway ROW PCCP	16 SF	34,956 SF	\$108,500	\$0	\$44,800	\$153,300	\$2,500	\$207,000
	WQBE_21C_High Rate Underground Filter in Urban ROW HMA	16 SF	34,956 SF	\$106,000	\$0	\$43,700	\$149,700	\$2,500	\$203,400
	WQBE_21D_High Rate Underground Filter in Highway ROW HMA	16 SF	34,956 SF	\$96,100	\$0	\$39,600	\$135,700	\$2,500	\$189,400
	WQBE_21E_High Rate Underground Filter on Public Property	16 SF	34,956 SF	\$73,300	\$0	\$30,500	\$103,800	\$2,500	\$157,500
	WQBE_21F_High Rate Underground Filter with Property Cost	16 SF	34,956 SF	\$73,300	\$1,287	\$32,000	\$105,300	\$2,500	\$159,000
Stormwater park	WQBE_22A_Regional Vegetated Media SW Facility on Public Property	5,940 SF	17,249,760 SF	\$4,021,600	\$0	\$3,672,400	\$7,694,000	\$11,300	\$8,006,000
	WQBE_22B_Regional Vegetated Media SW Facility with Property Cost	5,940 SF	17,249,760 SF	\$4,021,600	\$583,580	\$4,431,000	\$8,452,600	\$11,300	\$8,764,600
Phase 3 New Actions									
Sports field and park detention	WQBE_23_Sports Field and Park Detention	29,600 SF	103,800 SF	\$10,224,600	\$0	\$7,769,300	\$17,993,900	\$33,300	\$18,700,900
Blue roof	WQBE_24_Blue Roof	1,000 SF	1,000 SF	\$82,300	\$0	\$34,200	\$116,500	\$2,600	\$170,900
Compost amendment	WQBE_25_Compost Amendment	500 SF	500 SF	\$4,200	\$0	\$1,700	\$5,900	300	\$13,400
Reforest High Density Development	WQBE_26A_Reforestation High Density Development - On Property	43,560 SF	43,560 SF	\$11,075,000	\$0	\$8,415,500	\$19,490,500	\$3,300	\$19,577,100
	WQBE_26B_Reforestation High Density Development with Property Cost	43,560 SF	43,560 SF	\$11,075,000	\$3,503,531	\$12,970,100	\$24,045,100	\$3,300	\$24,131,700
Reforest Pervious Area	WQBE_26C_Reforestation Pervious Area on Property	43,560 SF	43,560 SF	\$992,900	\$0	\$754,500	\$1,747,400	\$0	\$1,747,400
	WQBE_26C_Reforestation Pervious Area with Property Cost	43,560 SF	43,560 SF	\$992,900	\$3,503,531	\$5,309,100	\$6,302,000	\$0	\$6,302,000

N/A: Not Applicable

^ Unit Drainage Area based on drainage area of pre-treatment Action

Benchmarking and Cost Comparison

The Phase 3 cost models were compared to national cost modeling using the CLASIC Tool and benchmarked against peer projects and programs.

Benchmark Evaluation

Cost models used for the WQBE Actions were evaluated against peer projects and programs. The results of Phase 1 and Phase 2 benchmarking evaluations prepared by Lotus Water are documented in the *Program Cost Benchmarking TM* (Lotus Water 2021a), hereafter called the Benchmarking TM and Benchmarking TM supplemental (Lotus Water 2021b). A copy of the Benchmarking TM and supplemental TM are included as an attachment to TM 431-TM1 Appendix D.

During Phase 3 Lotus Water provided peer review and input as the prior Action cost models (carried forward from Phase 2) were updated and during cost model development for new Actions (blue roof, composting, sports field, and reforestation).

CLASIC Cost Model Comparison

A high-level comparison was conducted between the CLASIC Tool–reported costs and WQBE Phase 3 cost modeling used to support SUSTAIN modeling. CLASIC is a screening tool that aids to support planning of stormwater infrastructure through the lenses of LCCs, co-benefits, and performance. The CLASIC Tool was used to develop an LCC comparison for two GSI actions, bioretention and wet pond. The CLASIC LCCs were compared to WQBE_02A_Bioretention Planter with Underdrain on Property, and WQBE_13B_Infiltration Pond Outwash Soil on Public Property. Table 7 presents a comparison between the CLASIC Tool and the WQBE LCC cost development assumptions for similar Actions.

Table 7. Facility Model Input Values CLASIC and WQBE.

Model Input Category	CLASIC Bioretention	WQBE 2A Bioretention on Property	CLASIC Wet Pond	WQBE 13B Infiltration Pond on Public Property
Ponding depth (in)	6	6	24	48
Filter media depth (in)	18	18	-	-
Captured depth (in)	0.15	-	1.85	-
Storage capacity (CF)	29	29	7,214	7,214
Maintenance considerations	Diverse vegetation, 3-month irrigation season.	Crew of 2 with 2 visits/year to remove trash and sediment, mulch and plant replacement (no mowing).	Seeded with routine mowing season 6 mo/yr and 3 mo irrigation season.	Crew of 2 with 2 visits/year to remove trash and sediment, tree replacement, fix erosion and reseed (no mowing).

Both the CLASIC Tool and WQBE Action LCC models were developed using a 30-year period. Table 8 provides a comparison between the LCC model values and outlines differences in the model assumptions.

Table 8. CLASIC 30-year LCC Results and WQBE Cost Comparison.

Model type	CLASIC	WQBE 2A	CLASIC	WQBE 13B
Description	Bioretention	Bioretention planter on property	Wet pond	Infiltration pond (outwash soil) on public property
Initial portfolio cost	Part of a capital project \$2,000,000	Part of a capital project (10M to <\$20M)	Part of a capital project \$2,000,000	Part of a capital project (10M to <\$20M)
Number of units	100 SF bottom area	1 unit at 25 SF bottom area	5,000 SF bottom area	1 unit at 2,785 SF bottom area
Construction cost/unit (2023 dollars)	\$14,100	\$18,700	\$67,700	\$500,500
Annual O&M cost	\$367	\$2,800	\$3,400-	\$5,900
NPV/unit	\$19,660	\$85,300	\$119,205	\$1,016,100
No. of units at NPV with \$20M capital investment	1,020	230	170	20

The cost model comparison indicates some similarity between direct construction costs for CLASIC Tool bioretention and WQBE bioretention planter but reported a large cost difference between CLASIC Tool wet pond and WQBE infiltration pond. Noted differences in the cost models for initial capital construction cost, annual O&M cost, and NPV/unit cost were as follows:

- CLASIC Tool and WQBE initial capital cost were driven by design basis assumptions.
 - CLASIC Tool adopts generalized design basis assumptions for both bioretention and wet pond facilities. Costs are based on generalized national costs.
 - WQBE costs were developed based on County design standards and use costs that are specific to King County and the Seattle area.
 - CLASIC bioretention and WQBE bioretention designs appeared to share similar design basis assumptions.
 - CLASIC wet pond and WQBE infiltration pond were not comparable in design basis and construction cost approach.
- CLASIC Tool used an outlined basin area with selections limited to "small, medium, or large" facilities and did not allow for input of a specific facility bottom area footprint size. WQBE facilities were set to a specific (small) bottom area footprint that supported SUSTAIN modeling over a broad area.
- Annual O&M costs for CLASIC Tool were set over a seasonal window (e.g., 3-month window for bioretention). WQBE O&M costs were set over a 12-month window and based on specific activities (including time, equipment, and materials) and based on information provided by King County WTD operations and recommendations from the SWMMWW.
- NPV costs for bioretention was not comparable between CLASIC Tool and WQBE cost models and may be attributed to differences in annual O&M assumptions.

The CLASIC Tool contained few GSI cost selections and was developed to reflect generalized design basis and O&M costs assumptions. Initial capital cost and LCC developed with the CLASIC Tool offered limited comparison or were not considered directly comparable to the area-specific design basis and localized cost model assumptions used are WQBE cost model development.

Recommendations and Considerations

Many of the recommendations to normalize costs for small facilities were implemented with the Phase 3 Action cost models. The Herrera team met with Lotus Water to review the Phase 3 cost modeling approach (see Attachment C for Benchmarking Review Form). Actions that the County may consider taking in future phases of work include:

- Detention Vault unit costs were high compared to Evans Creek. It was recommended that the ratio to dead storage vs. live storage be evaluated for the vault actions (#11 14, & 19), which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King County or western Washington.
- Costs for Detention Pond, Infiltration Pond, Wet Pond, and Stormwater Treatment Wetland Actions (#12, 13, 18, and 20) were driven by coupling a smaller facility footprint with minimum to low storage depth for the facility area. It is recommended that the pond Unit Action cost models design basis and approach be revisited using a larger scale or more regionalized type of facility.
- Life cycle costs include replacement of Actions within the 30 year period. Replacement costs were not prorated for replacement beyond the 30 year period. County may consider calculating prorated replacement costs in future phases of work.

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Attachment A

Cost Estimates with Life-Cycle Cost Analysis





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Attachment B

Cost Estimates with Life-Cycle Cost Analysis Workbooks





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Attachment C

Benchmarking Review Form





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Description: WQBE 01 - Rain Garden Installation On Property (2023 Dollars)

Unit	25 ft ²
Initial Capital Cost	\$ 8,200
Capital cost	\$ 328 \$/Unit
Total Direct O&M/Year	\$ 1,360
Direct O&M cost	\$ 54.39 \$/Unit
Capital Replacement Costs (10 Years)	\$ 3,528 \$/unit
Discount rate (%)	5.25 \$/Unit

Description: WQBE 01 - Rain Garden Installation On Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by 2 a one person using hand tools (1 hour at 2 times per year).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by one person using hand tools (1 hour at 4 times 4 per year).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per 4 visit).

Total Cost (NPV)	\$ 56,700	\$/unit
Annual O&M Cost	\$ 2,100	\$/year
Annualized Cost	\$ 1,220	\$/year

Materials, Supplies, Other Costs

	\$ -	\$/year
Mulch and Media Replacement	2023 dollars	\$ 270 \$/year
	2023 dollars	\$ 500 \$/year

Replacement Assumptions:

Media and Mulch Replacement at \$270/year

Annual plant replacement will cost \$500. Comprised of (10) small plant replacements at \$50/each.

Subtotal	\$770	
Labor		
Remove Trash	2 hr	
Plant Health	4 hr	
Remediation of erosion	4 hr	
	0 hr	
Total hours per year	10	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded)	\$ 544
Labor cost, burdened	O/H 150.0%	\$ 1,360
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30 years	

135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 36,633		\$ 64,691	\$ 116,581	\$ 56,739				
0	1.000	\$ 8,200		\$ 8,200	\$ 8,200	\$ 8,200	\$ 8,200	\$ 8,200	\$ 56,739
1	0.950	\$ 770	-	\$ 1,360	\$ 2,130	\$ 2,024	\$ 10,330	\$ 10,224	\$ 48,539
2	0.903	\$ 793	-	\$ 1,401	\$ 2,194	\$ 1,980	\$ 12,523	\$ 12,204	\$ 46,516
3	0.858	\$ 817	-	\$ 1,443	\$ 2,259	\$ 1,938	\$ 14,783	\$ 14,142	\$ 44,536
4	0.815	\$ 841	-	\$ 1,486	\$ 2,327	\$ 1,896	\$ 17,110	\$ 16,038	\$ 42,598
5	0.774	\$ 867	-	\$ 1,530	\$ 2,397	\$ 1,856	\$ 19,507	\$ 17,894	\$ 40,701
6	0.736	\$ 893	-	\$ 1,576	\$ 2,469	\$ 1,816	\$ 21,976	\$ 19,710	\$ 38,845
7	0.699	\$ 919	-	\$ 1,624	\$ 2,543	\$ 1,777	\$ 24,519	\$ 21,468	\$ 37,029
8	0.664	\$ 947	-	\$ 1,672	\$ 2,619	\$ 1,739	\$ 27,138	\$ 23,227	\$ 35,252
9	0.631	\$ 975	-	\$ 1,722	\$ 2,689	\$ 1,702	\$ 29,836	\$ 24,930	\$ 33,512
10	0.599	\$ 1,005	\$ 3,528	\$ 1,774	\$ 3,607	\$ 3,781	\$ 36,144	\$ 28,711	\$ 31,810
11	0.570	\$ 1,035	\$ -	\$ 1,827	\$ 2,862	\$ 1,630	\$ 39,006	\$ 30,341	\$ 28,029
12	0.541	\$ 1,066	\$ -	\$ 1,882	\$ 2,948	\$ 1,595	\$ 41,954	\$ 31,936	\$ 26,399
13	0.514	\$ 1,098	\$ -	\$ 1,939	\$ 3,037	\$ 1,561	\$ 44,990	\$ 33,498	\$ 24,803
14	0.489	\$ 1,131	\$ -	\$ 1,997	\$ 3,128	\$ 1,528	\$ 48,118	\$ 35,026	\$ 23,242
15	0.464	\$ 1,165	\$ -	\$ 2,057	\$ 3,221	\$ 1,495	\$ 51,339	\$ 36,521	\$ 21,714
16	0.441	\$ 1,200	\$ -	\$ 2,118	\$ 3,318	\$ 1,463	\$ 54,658	\$ 37,984	\$ 20,219
17	0.419	\$ 1,236	\$ -	\$ 2,182	\$ 3,418	\$ 1,432	\$ 58,075	\$ 39,416	\$ 18,755
18	0.398	\$ 1,273	\$ -	\$ 2,247	\$ 3,520	\$ 1,401	\$ 61,595	\$ 40,818	\$ 17,323
19	0.378	\$ 1,311	\$ -	\$ 2,315	\$ 3,626	\$ 1,371	\$ 65,221	\$ 42,189	\$ 15,922
20	0.359	\$ 1,350	\$ 3,528	\$ 2,384	\$ 7,263	\$ 2,610	\$ 72,484	\$ 44,799	\$ 14,550
21	0.341	\$ 1,391	\$ -	\$ 2,456	\$ 3,847	\$ 1,313	\$ 76,331	\$ 46,113	\$ 13,190
22	0.324	\$ 1,432	\$ -	\$ 2,530	\$ 3,962	\$ 1,285	\$ 80,293	\$ 47,398	\$ 10,627
23	0.308	\$ 1,475	\$ -	\$ 2,605	\$ 4,081	\$ 1,258	\$ 84,373	\$ 48,666	\$ 9,341
24	0.293	\$ 1,520	\$ -	\$ 2,684	\$ 4,203	\$ 1,231	\$ 88,577	\$ 49,867	\$ 8,084
25	0.278	\$ 1,565	\$ -	\$ 2,764	\$ 4,329	\$ 1,205	\$ 92,906	\$ 51,092	\$ 6,853
26	0.264	\$ 1,612	\$ -	\$ 2,847	\$ 4,459	\$ 1,179	\$ 97,365	\$ 52,270	\$ 5,648
27	0.251	\$ 1,661	\$ -	\$ 2,932	\$ 4,593	\$ 1,154	\$ 101,958	\$ 53,424	\$ 4,469
28	0.239	\$ 1,710	\$ -	\$ 3,020	\$ 4,731	\$ 1,129	\$ 106,689	\$ 54,553	\$ 3,315
29	0.227	\$ 1,762	\$ -	\$ 3,111	\$ 4,873	\$ 1,105	\$ 111,562	\$ 55,658	\$ 2,186
30	0.215	\$ 1,815	\$ -	\$ 3,204	\$ 5,019	\$ 1,081	\$ 116,581	\$ 56,739	\$ 1,081

Description: WQBE 01 - Rain Garden Installation (On Property) - Program

A shallow, landscaped depression with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile.

Cost Estimating Assumptions:

Facility design is per Seattle Stormwater Manual, "Rain Garden" (Volume 3 Section 5.4.5)

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Treatment media is 3" of compost tilled in to the top 8" of soil depth.

The facility bottom treatment area is 25 sf with a 2:1 L:W ratio and 3:1 (run:rise) minimum side slopes

A maximum ponding depth of 6" with a 6" minimum freeboard depth are assumed.

The facility does not have an underdrain.

Seeded grass restoration is assumed for disturbed areas

Removals are estimated at 4% of the item construction costs.

It is assumed that all stormwater is maintained on the property and not TESC is needed.

The facility is located on property and it is assumed that traffic control is not required

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 02A - Bioretention Planter on Property (2023 Dollars)

Unit	25	R2
Initial Capital Cost	\$ 26,500	
Capital cost	\$ 1,060	/Unit
Total Direct O&M/Year	\$ 2,176	
Direct O&M cost	\$ 87.02	/Unit
Capital Replacement Costs (10 Years)	\$ 636	/unit
Discount rate (%)	5.25	\$/Unit

Description: WQBE 02A - Bioretention Planter on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per 8 year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per 4 visit).

Annual mulch and plan replacements 5 plants at \$54/Plant

Vector Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Total Cost (NPV)	\$ 86,600	\$/unit
Annual O&M Cost	\$ 2,800	\$/year
Annualized Cost	\$ 1,000	\$/year

Materials, Supplies, Other Costs

	\$ -	\$/year
Annual plant replacement	2023 dollars	\$ 270
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360

Subtotal \$630

Labor

Remove Trash	4 hr
Plant Health	8 hr
Remediation of erosion	4 hr
	0 hr
Total hours per year	16
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 870
Labor cost, burdened	O/H 150.0% \$ 2,176
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 29,973		\$ 103,505	\$ 161,250	\$ 86,596			
0	1.000	\$ 26,500		\$ 2,176	\$ 26,500	\$ 26,500	\$ 26,500	\$ 26,500	\$ 86,596
1	0.950	\$ 630	\$ -	\$ 2,241	\$ 2,800	\$ 2,666	\$ 29,306	\$ 29,166	\$ 60,096
2	0.903	\$ 649	\$ -	\$ 2,308	\$ 2,890	\$ 2,609	\$ 32,195	\$ 31,774	\$ 57,431
3	0.858	\$ 668	\$ -	\$ 2,377	\$ 2,976	\$ 2,553	\$ 35,172	\$ 34,327	\$ 54,822
4	0.815	\$ 688	\$ -	\$ 2,449	\$ 3,066	\$ 2,498	\$ 38,238	\$ 36,826	\$ 52,269
5	0.774	\$ 709	\$ -	\$ 2,522	\$ 3,158	\$ 2,445	\$ 41,395	\$ 39,270	\$ 49,771
6	0.736	\$ 730	\$ -	\$ 2,598	\$ 3,262	\$ 2,393	\$ 44,648	\$ 41,663	\$ 47,326
7	0.699	\$ 752	\$ -	\$ 2,676	\$ 3,350	\$ 2,342	\$ 47,998	\$ 44,005	\$ 44,933
8	0.664	\$ 775	\$ -	\$ 2,756	\$ 3,451	\$ 2,291	\$ 51,448	\$ 46,296	\$ 42,592
9	0.631	\$ 798	\$ -	\$ 2,839	\$ 3,554	\$ 2,242	\$ 55,002	\$ 48,539	\$ 40,300
10	0.599	\$ 822	\$ 636	\$ 2,924	\$ 4,297	\$ 2,196	\$ 59,299	\$ 51,115	\$ 38,058
11	0.570	\$ 847	\$ -	\$ 3,012	\$ 3,770	\$ 2,148	\$ 63,070	\$ 53,262	\$ 35,482
12	0.541	\$ 872	\$ -	\$ 3,102	\$ 3,884	\$ 2,102	\$ 66,954	\$ 55,364	\$ 33,334
13	0.514	\$ 898	\$ -	\$ 3,195	\$ 4,000	\$ 2,057	\$ 70,954	\$ 57,421	\$ 31,232
14	0.489	\$ 925	\$ -	\$ 3,291	\$ 4,120	\$ 2,013	\$ 75,074	\$ 59,433	\$ 29,176
15	0.464	\$ 953	\$ -	\$ 3,390	\$ 4,244	\$ 1,970	\$ 79,318	\$ 61,403	\$ 27,163
16	0.441	\$ 982	\$ -	\$ 3,491	\$ 4,371	\$ 1,928	\$ 83,689	\$ 63,331	\$ 25,193
17	0.419	\$ 1,011	\$ -	\$ 3,598	\$ 4,502	\$ 1,886	\$ 88,191	\$ 65,217	\$ 23,265
18	0.398	\$ 1,041	\$ -	\$ 3,704	\$ 4,637	\$ 1,846	\$ 92,828	\$ 67,063	\$ 21,379
19	0.378	\$ 1,073	\$ -	\$ 3,815	\$ 4,776	\$ 1,807	\$ 97,604	\$ 68,870	\$ 19,533
20	0.359	\$ 1,105	\$ 636	\$ 3,929	\$ 5,556	\$ 1,997	\$ 103,160	\$ 70,867	\$ 17,726
21	0.341	\$ 1,138	\$ -	\$ 4,047	\$ 5,607	\$ 1,730	\$ 108,228	\$ 72,597	\$ 15,729
22	0.324	\$ 1,172	\$ -	\$ 4,169	\$ 5,219	\$ 1,693	\$ 113,447	\$ 74,290	\$ 13,999
23	0.308	\$ 1,207	\$ -	\$ 4,294	\$ 5,376	\$ 1,657	\$ 118,823	\$ 76,947	\$ 12,306
24	0.293	\$ 1,243	\$ -	\$ 4,423	\$ 5,537	\$ 1,622	\$ 124,360	\$ 77,569	\$ 10,649
25	0.278	\$ 1,281	\$ -	\$ 4,555	\$ 5,703	\$ 1,587	\$ 130,063	\$ 79,156	\$ 9,027
26	0.264	\$ 1,319	\$ -	\$ 4,692	\$ 5,874	\$ 1,553	\$ 135,937	\$ 80,709	\$ 7,440
27	0.251	\$ 1,359	\$ -	\$ 4,833	\$ 6,051	\$ 1,520	\$ 141,988	\$ 82,229	\$ 5,887
28	0.239	\$ 1,399	\$ -	\$ 4,978	\$ 6,232	\$ 1,487	\$ 148,220	\$ 83,716	\$ 4,367
29	0.227	\$ 1,441	\$ -	\$ 5,127	\$ 6,419	\$ 1,456	\$ 154,639	\$ 85,172	\$ 2,880
30	0.215	\$ 1,485	\$ -	\$ 5,127	\$ 6,612	\$ 1,424	\$ 161,250	\$ 86,596	\$ 1,424

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Steven Van Loo (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 02A - Bioretention Planter On Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Planter on Property Bottom Area	125	SF	\$	-
2	Curbed, vertical sides - Top Area	125	SF	\$	-
3	Bioretention Planter Length	25	LF	\$	-
4	Bioretention Planter: Width	5	LF	\$	-
5	Bioretention Planter: Depth	5.4	LF	\$	-
6	Structural Excavation to Waste	98	CY	\$ 79	\$ 7,753
7	Imported Structural Fill	64	CY	\$ 44	\$ 2,818
8	Formed Concrete Walls (6" Thick)	6	CY	\$ 1,560	\$ 9,386
9	Formed Concrete Base (6" thick)	3	CY	\$ 590	\$ 1,704
10	Treatment Media (18" Thick)w biochar	7	CY	\$ 270	\$ 1,875
11	Mulch Compost (@ 0.3'D)	1	CY	\$ 86	\$ 119
12	Vegetated Entrance	2	SY	\$ 10	\$ 22
13	Trench Shoring Facility (Shallow)	400	SF	\$ 10	\$ 4,000
14				\$	-
15	Underdrain Items:	25	LF	\$	-
16	Underdrain Aggregate (2.2' Thick)	10	CY	\$ 133	\$ 1,355
17	Overflow & Drain Pipe Pipe 8" Dia. (Length + 4')	29	LF	\$ 48	\$ 1,392
18				\$	-
19	Restoration:			\$	-
20	Landscaping, Planting, and Restoration	58	SY	\$ 59	\$ 3,442
21	Trees (Not in Design Basis)	0	EA	\$ 720	\$ -
22				\$	-
23	Outlet Pipe			\$	-
24	Pipe 8" Diameter	50	LF	\$ 80	\$ 4,000
25	5' Wide Trench x 7'D to waste	65	CY	\$ 79	\$ 5,120
26	Trench Box Shoring (Shallow)	800	SF	\$ 10	\$ 8,000
27	Catch Basin	1	EA	\$ 3,900	\$ 3,900
28	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
29				\$	-
30	Additional Costs			\$	-
31	Removals @ 4% Construction Costs	4.0%	LS	\$ 57,358	\$ 2,294
32	TESC @2% Construction Costs	2%	LS	\$ 59,653	\$ 1,193
				\$	-
				\$	-
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>				\$ 60,846	
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	6,085
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>				\$ 66,930	
<i>Direct: Subtotal Construction Costs (125 SF Area)</i>				\$	66,930

Description: WQBE 2A - Bioretention Planter With Underdrain on Property

Designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

Cost Estimating Assumptions:

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Filter fabrics not used between the subgrade and the Bioretention Soil Mix

Facility is sited in an open space with outlet pipe beneath a parking area

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area has curbed, vertical sides.

A bioretention planter with a 125 sf area (5' wide by 10' long) was selected to represent a typical installation size. The 125 s.f. facility subtotal construction costs were then scaled to represent the selected Action Item area of 25 sf.

A maximum ponding depth of 6" and a 6" of freeboard depth are assumed.

Facilities have a closed bottom and include an underdrain.

A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the box.

Trench Box shoring is used.

Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTM.

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Landscape restoration is required for the facility, earth berm and area of disturbance.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on Property and Traffic control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Steven Van Loo (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Description:	WQBE_02B - Bioretention Planter In ROW			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Planter with Underdrain in ROW (25 SF Bottom Area)	25	SF	\$ 710	\$ 17,750
					\$ -
					\$ -
					\$ -
<i>Subtotal Construction Costs</i>					\$ 17,750
Allowance for Indeterminates (Design Allowance)					\$ 2,663
Street Use Permit (Y/N) Y					\$ 700
ESTIMATED PROBABLE COST OF CONSTRUCTION BID					\$ 21,113
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance				\$ 2,041
	Subtotal Primary Construction Amount				\$ 23,154
	Construction Sales Tax				\$ 2,302
	Outside Agency Construction				\$ 355
TOTAL DIRECT CONSTRUCTION COSTS					\$ 25,800
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering				\$ 2,778
	Construction Management				\$ 1,852
	Permitting & Support				\$ 116
s.f. Land Area	None	Land Purchase/ROW Acquisition			\$ -
s.f. Land Area	None	Permanent Easements			\$ -
	WTD Staff Costs & Non-WTD Support				\$ 1,158
Subtotal Non-Construction Costs					\$ 5,904
	Project Contingency				\$ 4,756
TOTAL INDIRECT NON-CONSTRUCTION COSTS					\$ 10,700
TOTAL PROJECT COST					\$ 36,500

Description: WQBE 02B - Bioretention Planter In ROW (2023 Dollars)

Unit	25 ft ²
Initial Capital Cost	\$ 36,500
Capital cost	\$ 1,460 /Unit
Total Direct O&M/Year	\$ 2,176
Direct O&M cost	\$ 87.02 /Unit
Capital Replacement Costs (10 Years)	\$ 636 /unit
Discount rate (%)	5.25 /\$Unit

Description: WQBE 02B - Bioretention Planter In ROW

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Annual mulch and plant replacements 5 plants at \$54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Total Cost (NPV)	\$ 96,600	\$/unit
Annual O&M Cost	\$ 2,800	\$/year
Annualized Cost	\$4,450	\$/year

Materials, Supplies, Other Costs

	\$ -	\$ -	\$/year
Annual plant and mulch replacement	2023 dollars	\$ 270	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$630	
Labor			
Remove Trash		4 hr	
Plant Health		8 hr	
Remediation of erosion		4 hr	
		hr	
Total hours per year		16	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

\$ 135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 29,973		\$ 103,505	\$ 171,250	\$ 96,596			
0	1.000	\$ 36,500			\$ 36,500	\$ 36,500	\$ 36,500	\$ 36,500	\$ 96,596
1	0.950	\$630	\$ -	\$ 2,176	\$ 2,806	\$ 2,666	\$ 39,306	\$ 39,166	\$ 60,096
2	0.903	\$ 649	\$ -	\$ 2,241	\$ 2,890	\$ 2,609	\$ 42,195	\$ 41,774	\$ 57,431
3	0.858	\$ 668	\$ -	\$ 2,308	\$ 2,976	\$ 2,553	\$ 45,172	\$ 44,327	\$ 54,822
4	0.815	\$ 688	\$ -	\$ 2,377	\$ 3,066	\$ 2,498	\$ 48,238	\$ 46,826	\$ 52,269
5	0.774	\$ 709	\$ -	\$ 2,449	\$ 3,158	\$ 2,445	\$ 51,395	\$ 49,270	\$ 49,771
6	0.736	\$ 730	\$ -	\$ 2,522	\$ 3,252	\$ 2,393	\$ 54,648	\$ 51,663	\$ 47,326
7	0.699	\$ 752	\$ -	\$ 2,598	\$ 3,350	\$ 2,342	\$ 57,998	\$ 54,005	\$ 44,933
8	0.664	\$ 775	\$ -	\$ 2,676	\$ 3,451	\$ 2,291	\$ 61,448	\$ 56,296	\$ 42,592
9	0.631	\$ 798	\$ -	\$ 2,756	\$ 3,554	\$ 2,242	\$ 65,002	\$ 58,539	\$ 40,300
10	0.599	\$ 822	\$ 636	\$ 2,839	\$ 4,297	\$ 2,576	\$ 69,299	\$ 61,115	\$ 38,058
11	0.570	\$ 847	\$ -	\$ 2,924	\$ 3,770	\$ 2,448	\$ 73,070	\$ 63,262	\$ 35,482
12	0.541	\$ 872	\$ -	\$ 3,012	\$ 3,864	\$ 2,102	\$ 76,954	\$ 65,364	\$ 33,334
13	0.514	\$ 898	\$ -	\$ 3,102	\$ 4,000	\$ 2,057	\$ 80,954	\$ 67,421	\$ 31,232
14	0.489	\$ 925	\$ -	\$ 3,195	\$ 4,120	\$ 2,013	\$ 85,074	\$ 69,433	\$ 29,176
15	0.464	\$ 953	\$ -	\$ 3,291	\$ 4,244	\$ 1,970	\$ 89,318	\$ 71,403	\$ 27,163
16	0.441	\$ 982	\$ -	\$ 3,390	\$ 4,371	\$ 1,928	\$ 93,689	\$ 73,331	\$ 25,193
17	0.419	\$ 1,011	\$ -	\$ 3,491	\$ 4,502	\$ 1,886	\$ 98,191	\$ 75,217	\$ 23,265
18	0.398	\$ 1,041	\$ -	\$ 3,596	\$ 4,637	\$ 1,846	\$ 102,828	\$ 77,063	\$ 21,379
19	0.378	\$ 1,073	\$ -	\$ 3,704	\$ 4,776	\$ 1,807	\$ 107,604	\$ 78,870	\$ 19,533
20	0.359	\$ 1,105	\$ 636	\$ 3,815	\$ 5,556	\$ 1,997	\$ 113,160	\$ 80,867	\$ 17,726
21	0.341	\$ 1,138	\$ -	\$ 3,929	\$ 5,067	\$ 1,730	\$ 118,228	\$ 82,597	\$ 15,729
22	0.324	\$ 1,172	\$ -	\$ 4,047	\$ 5,219	\$ 1,693	\$ 123,447	\$ 84,290	\$ 13,999
23	0.308	\$ 1,207	\$ -	\$ 4,169	\$ 5,376	\$ 1,657	\$ 128,823	\$ 85,947	\$ 12,306
24	0.293	\$ 1,243	\$ -	\$ 4,294	\$ 5,537	\$ 1,622	\$ 134,360	\$ 87,569	\$ 10,649
25	0.278	\$ 1,281	\$ -	\$ 4,423	\$ 5,703	\$ 1,587	\$ 140,063	\$ 89,156	\$ 9,027
26	0.264	\$ 1,319	\$ -	\$ 4,555	\$ 5,874	\$ 1,553	\$ 145,937	\$ 90,709	\$ 7,440
27	0.251	\$ 1,359	\$ -	\$ 4,692	\$ 6,051	\$ 1,520	\$ 151,988	\$ 92,229	\$ 5,887
28	0.239	\$ 1,399	\$ -	\$ 4,833	\$ 6,232	\$ 1,487	\$ 158,220	\$ 93,716	\$ 4,367
29	0.227	\$ 1,441	\$ -	\$ 4,978	\$ 6,419	\$ 1,456	\$ 164,638	\$ 95,172	\$ 2,880
30	0.215	\$ 1,485	\$ -	\$ 5,127	\$ 6,612	\$ 1,424	\$ 171,250	\$ 96,596	\$ 1,424

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Steven Van Loo (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_02B - Bioretention Planter In ROW		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Planter on Property Bottom Area	125	SF	\$	-
2	Curbed, vertical sides - Top Area	125	SF	\$	-
3	Bioretention Planter Length	25	LF	\$	-
4	Bioretention Planter: Width	5	LF	\$	-
5	Bioretention Planter: Depth	5.4	LF	\$	-
6	Structural Excavation to Waste	98	CY	\$ 79	\$ 7,753
7	Imported Structural Fill	64	CY	\$ 44	\$ 2,818
8	Formed Concrete Walls (6" Thick)	6	CY	\$ 1,560	\$ 9,886
9	Formed Concrete Base (6" thick)	3	CY	\$ 590	\$ 1,704
10	Treatment Media (18" Thick)w biochar	7	CY	\$ 270	\$ 1,875
11	Mulch Compost (@ 0.3'D)	1	CY	\$ 86	\$ 119
12	Vegetated Entrance	2	SY	\$ 10	\$ 22
	Trench Shoring Facility (Shallow)	400	SF	\$ 10	\$ 4,000
13				\$	-
14	Underdrain Items:	25	LF	\$	-
15	Underdrain Aggregate (2.2' Thick)	10	CY	\$ 133	\$ 1,355
16	Overflow & Drain Pipe Pipe 8" Dia. (Length + 4')	29	LF	\$ 48	\$ 1,392
17				\$	-
18	Restoration:	30	LF	\$	-
19	Pavement Patch - Adj. to facility @5'W (6"HMA/6"CSBC)	17	SY	\$ 110	\$ 1,833
20	Sidewalk 6' Wide	20	SY	\$ 125	\$ 2,500
21	Concrete Curb and Gutter	30	LF	\$ 111	\$ 3,330
22	Landscaping (Planter Only)	14	SY	\$ 59	\$ 819
23	Trees (Not in Design Basis)	0	EA	\$ 720	\$ -
24				\$	-
25	Outlet Pipe			\$	-
26	DI CI 50 Pipe 8" Diameter	50	LF	\$ 160	\$ 8,000
27	5' Wide Trench x 7'D to waste	65	CY	\$ 79	\$ 5,120
28	Trench Box Shoring (Shallow)	700	SF	\$ 10	\$ 7,000
29	Catch Basin	1	EA	\$ 3,900	\$ 3,900
30	Pavement Patch - Pipe@5'W (6"HMA/6"CSBC)	28	SY	\$ 110	\$ 3,056
31				\$	-
32	Additional Costs			\$	-
33	Removals @ 4% Construction Costs	4.0%	LS	\$ 66,483	\$ 2,659
34	Traffic Control (Heavy)	0.5	MO	\$ 20,000	\$ 10,000
35	TESC @2% Construction Costs	2%	LS	\$ 79,142	\$ 1,583
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>				\$	80,725
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	8,072
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>				\$	88,797
<i>Direct: Subtotal Construction Costs (125 SF Area)</i>				\$	88,797

Description: WQBE 2B - Bioretention Planter in ROW

Designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

Cost Estimating Assumptions:

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)

Installation is in ROW and does not require easements or acquisition

Filter fabrics not used between the subgrade and the Bioretention Soil Mix

Facility is sited in an open space with outlet pipe beneath a parking area

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area has curbed, vertical sides.

A bioretention planter with a 125 sf area (5' wide by 25' long) was selected to represent a typical installation size. The 125 s.f. facility subtotal construction costs were then scaled to represent the selected Action item area of 25 sf.

A maximum ponding depth of 6" and a 6" of freeboard depth are assumed.

Facilities have a closed bottom and include an underdrain.

A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the box.

Trench Box shoring is used.

Roadway patching and restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTC

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

Landscape restoration is required for the facility, earth berm and area of disturbance.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is in a ROW on an urban street and traffic control is required.

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Steven Van Loo (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Description:	WQBE 02C_Bioretention Planter With Property Cost			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Planter with Underdrain on Property (25 SF Bottom Area)	25	SF	\$ 535	\$ 13,375
					\$ -
					\$ -
					\$ -
Subtotal Construction Costs					\$ 13,375
Allowance for Indeterminates (Design Allowance)					\$ 2,006
Street Use Permit (Y/N)					N \$ -
ESTIMATED PROBABLE COST OF CONSTRUCTION BID					\$ 15,381
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
Construction Change Order Allowance					\$ 1,538
Subtotal Primary Construction Amount					\$ 16,919
Construction Sales Tax					\$ 1,734
Outside Agency Construction					\$ -
TOTAL DIRECT CONSTRUCTION COSTS					\$ 18,700
INDIRECT: NON-CONSTRUCTION COSTS					
Design Engineering					\$ 2,030
Construction Management					\$ 1,354
Permitting & Support					\$ 85
25	s.f. Land Area	Medium	Land Purchase/ROW Acquisition	\$	2,011
	s.f. Land Area	None	Permanent Easements	\$	-
WTD Staff Costs & Non-WTD Support					\$ 846
Subtotal Non-Construction Costs					\$ 6,325
Project Contingency					\$ 3,754
TOTAL INDIRECT NON-CONSTRUCTION COSTS					\$ 10,100
TOTAL PROJECT COST					
					\$ 28,800

Description: WQBE 02C - Bioretention Planter W/Property Cost (2023 Dollars)

Unit	25 ft ²
Initial Capital Cost	\$ 28,800
Capital cost	\$ 1,152 \$/Unit
Total Direct O&M/Year	\$ 2,176
Direct O&M cost	\$ 87.02 \$/Unit
Capital Replacement Costs (10 Years)	\$ 636 \$/unit
Discount rate (%)	5.25 \$/Unit

Description: WQBE 02C - Bioretention Planter W/Property Cost

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per 8 year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per 4 visit).

Annual mulch and plan replacements 5 plants at \$54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Total Cost (NPV)	\$ 88,900	\$/unit
Annual O&M Cost	\$ 2,800	\$/year
Annualized Cost	\$1,000	\$/year

Materials, Supplies, Other Costs		\$ -	\$/year
Annual plant replacement	2023 dollars	\$ 270	
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$630	
Labor			
Remove Trash	4 hr		
Plant Health	8 hr		
Remediation of erosion	4 hr		
	hr		
Total hours per year	16		
Raw Labor Rate/Hr	\$ 54		
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 29,973	\$ 28,800	\$ 103,505	\$ 163,550	\$ 88,896				
0	1.000	\$ 28,800							
1	0.950	\$ 630	\$ -	\$ 2,176	\$ 2,806	\$ 2,666	\$ 31,606	\$ 31,466	\$ 60,096
2	0.903	\$ 649	\$ -	\$ 2,241	\$ 2,890	\$ 2,609	\$ 34,495	\$ 34,074	\$ 57,431
3	0.858	\$ 668	\$ -	\$ 2,308	\$ 2,976	\$ 2,553	\$ 37,472	\$ 36,627	\$ 54,822
4	0.815	\$ 688	\$ -	\$ 2,377	\$ 3,066	\$ 2,498	\$ 40,538	\$ 39,126	\$ 52,269
5	0.774	\$ 709	\$ -	\$ 2,449	\$ 3,158	\$ 2,445	\$ 43,695	\$ 41,570	\$ 49,771
6	0.736	\$ 730	\$ -	\$ 2,522	\$ 3,262	\$ 2,393	\$ 46,948	\$ 43,963	\$ 47,326
7	0.699	\$ 752	\$ -	\$ 2,596	\$ 3,350	\$ 2,342	\$ 50,298	\$ 46,305	\$ 44,933
8	0.664	\$ 775	\$ -	\$ 2,676	\$ 3,451	\$ 2,291	\$ 53,748	\$ 48,598	\$ 42,592
9	0.631	\$ 798	\$ -	\$ 2,756	\$ 3,554	\$ 2,242	\$ 57,302	\$ 50,834	\$ 40,300
10	0.599	\$ 822	\$ 636	\$ 2,839	\$ 4,297	\$ 2,576	\$ 61,599	\$ 53,415	\$ 38,058
11	0.570	\$ 847	\$ -	\$ 2,924	\$ 3,770	\$ 2,148	\$ 65,370	\$ 55,562	\$ 35,482
12	0.541	\$ 872	\$ -	\$ 3,012	\$ 3,884	\$ 2,102	\$ 69,254	\$ 57,664	\$ 33,334
13	0.514	\$ 898	\$ -	\$ 3,102	\$ 4,000	\$ 2,057	\$ 73,254	\$ 59,721	\$ 31,232
14	0.489	\$ 925	\$ -	\$ 3,195	\$ 4,120	\$ 2,013	\$ 77,374	\$ 61,733	\$ 29,176
15	0.464	\$ 953	\$ -	\$ 3,291	\$ 4,244	\$ 1,970	\$ 81,618	\$ 63,703	\$ 27,163
16	0.441	\$ 982	\$ -	\$ 3,390	\$ 4,371	\$ 1,928	\$ 85,989	\$ 65,631	\$ 25,193
17	0.419	\$ 1,011	\$ -	\$ 3,491	\$ 4,502	\$ 1,886	\$ 90,491	\$ 67,517	\$ 23,265
18	0.398	\$ 1,041	\$ -	\$ 3,596	\$ 4,637	\$ 1,846	\$ 95,128	\$ 69,363	\$ 21,379
19	0.378	\$ 1,073	\$ -	\$ 3,704	\$ 4,776	\$ 1,807	\$ 99,904	\$ 71,170	\$ 19,533
20	0.359	\$ 1,105	\$ 636	\$ 3,815	\$ 5,556	\$ 1,997	\$ 105,460	\$ 73,167	\$ 17,726
21	0.341	\$ 1,138	\$ -	\$ 3,929	\$ 5,067	\$ 1,730	\$ 110,528	\$ 74,897	\$ 15,729
22	0.324	\$ 1,172	\$ -	\$ 4,047	\$ 5,219	\$ 1,693	\$ 115,747	\$ 76,590	\$ 13,999
23	0.308	\$ 1,207	\$ -	\$ 4,169	\$ 5,376	\$ 1,657	\$ 121,123	\$ 78,247	\$ 12,306
24	0.293	\$ 1,243	\$ -	\$ 4,294	\$ 5,537	\$ 1,622	\$ 126,660	\$ 79,869	\$ 10,649
25	0.278	\$ 1,281	\$ -	\$ 4,423	\$ 5,703	\$ 1,587	\$ 132,363	\$ 81,456	\$ 9,027
26	0.264	\$ 1,319	\$ -	\$ 4,555	\$ 5,874	\$ 1,553	\$ 138,237	\$ 83,009	\$ 7,440
27	0.251	\$ 1,359	\$ -	\$ 4,692	\$ 6,051	\$ 1,520	\$ 144,288	\$ 84,529	\$ 5,887
28	0.239	\$ 1,399	\$ -	\$ 4,833	\$ 6,232	\$ 1,487	\$ 150,520	\$ 86,016	\$ 4,367
29	0.227	\$ 1,441	\$ -	\$ 4,978	\$ 6,419	\$ 1,456	\$ 156,939	\$ 87,472	\$ 2,880
30	0.215	\$ 1,485	\$ -	\$ 5,127	\$ 6,612	\$ 1,424	\$ 163,550	\$ 88,896	\$ 1,424

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Steven Van Loo (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 02C_Bioretention Planter With Property Cost		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Planter on Property Bottom Area	125	SF	\$	-
2	Curbed, vertical sides - Top Area	125	SF	\$	-
3	Bioretention Planter Length	25	LF	\$	-
4	Bioretention Planter: Width	5	LF	\$	-
5	Bioretention Planter: Depth	5.4	LF	\$	-
6	Structural Excavation to Waste	98	CY	\$ 79	\$ 7,753
7	Imported Structural Fill	64	CY	\$ 44	\$ 2,818
8	Formed Concrete Walls (6" Thick)	6	CY	\$ 1,560	\$ 9,886
9	Formed Concrete Base (6" thick)	3	CY	\$ 590	\$ 1,704
10	Treatment Media (18" Thick)w biochar	7	CY	\$ 270	\$ 1,875
11	Mulch Compost (@ 0.3'D)	1	CY	\$ 86	\$ 119
12	Vegetated Entrance	2	SY	\$ 10	\$ 22
	Trench Shoring Facility (Shallow)	400	SF	\$ 10	\$ 4,000
13				\$	-
14	Underdrain Items:	25	LF	\$	-
15	Underdrain Aggregate (2.2' Thick)	10	CY	\$ 133	\$ 1,355
16	Overflow & Drain Pipe Pipe 8" Dia. (Length + 4')	29	LF	\$ 48	\$ 1,392
17				\$	-
18	Restoration:			\$	-
19	Landscaping, Planting, and Restoration	58	SY	\$ 59	\$ 3,442
20	Trees (Not in Design Basis)	0	EA	\$ 720	\$ -
21				\$	-
22	Outlet Pipe			\$	-
23	Pipe 8" Diameter	50	LF	\$ 80	\$ 4,000
24	5' Wide Trench x 7'D to waste	65	CY	\$ 79	\$ 5,120
25	Trench Box Shoring (Shallow)	800	SF	\$ 10	\$ 8,000
26	Catch Basin	1	EA	\$ 3,900	\$ 3,900
27	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
28				\$	-
29	Additional Costs			\$	-
30	Removals @ 4% Construction Costs	4.0%	LS	\$ 57,358	\$ 2,294
31	TESC @2% Construction Costs	2%	LS	\$ 59,653	\$ 1,193
				\$	-
				\$	-
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)				\$ 60,846	
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	6,085
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)				\$ 66,930	
Direct: Subtotal Construction Costs (125 SF Area)				\$ 66,930	

Description: WQBE 02C - Bioretention Planter With Property Cost

Designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

Cost Estimating Assumptions:

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)
It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.
Filter fabrics not used between the subgrade and the Bioretention Soil Mix
Facility is sited an open space with outlet pipe beneath a parking area
18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.
0.3' of composted media is included.
The facility treatment area has curbed, vertical sides.
A bioretention planter with a 125 sf area (5' wide by 10' long) was selected to represent a typical installation size. The 125 s.f. facility subtotal construction costs were then scaled to represent the selected Action item area of 25 sf.
A maximum ponding depth of 6" and a 6" of freeboard depth are assumed.
Facilities have a closed bottom and include an underdrain.
A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the box.
Trench Box shoring is used.
Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTC.
Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.
Landscape restoration is required for the facility, earth berm and area of disturbance.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on Property and Traffic control is not required.
A street use permit is not required.
Property and easement acquisition are included.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Benchmarking:

Real estate property values and easement costs, where used, were based on KC Assessor property values combined with information provided by WTD in July 2020 for use on the CSO LTCP cost estimates. Property costs were assigned based on general property values for the assumed land use category being estimated. Property costs were escalated by 15%.

Description: WQBE 03A - Bioretention Underdrain on Property (2023 Dollars)

Unit	85 ft ²
Initial Capital Cost	\$ 50,100
Capital cost	\$ 589 \$/Unit
Total Direct O&M/Year	\$ 2,176
Direct O&M cost	\$ 25.60 \$/Unit
Capital Replacement Costs (10 Years)	\$ 6,495 \$/unit
Discount rate (%)	5.25 \$/Unit

Description: WQBE 03A - Bioretention Underdrain on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Annual mulch and plan replacements 10 plants at \$54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Total Cost (NPV)	\$ 121,500	\$/unit
Annual O&M Cost	\$ 3,100	\$/year
Annualized Cost	\$1,430	\$/year

Materials, Supplies, Other Costs

Annual plant replacement	2023 dollars	\$ 540	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$900	
Labor			
Remove Trash		4 hr	
Plant Health		8 hr	
Remediation of erosion		4 hr	
		0 hr	
Total hours per year		16	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 42,818	\$ 103,505	\$ 209,412	\$ 121,538					
0	1.000	\$ 50,100		\$ 50,100	\$ 50,100	\$ 50,100	\$ 50,100	\$ 50,100	\$ 121,538
1	0.950	\$ 900		\$ 2,176	\$ 3,076	\$ 2,922	\$ 53,176	\$ 53,022	\$ 71,438
2	0.903	\$ 927		\$ 2,241	\$ 3,168	\$ 2,860	\$ 56,343	\$ 55,882	\$ 68,516
3	0.858	\$ 955		\$ 2,308	\$ 3,263	\$ 2,799	\$ 59,606	\$ 58,680	\$ 65,656
4	0.815	\$ 983		\$ 2,377	\$ 3,361	\$ 2,739	\$ 62,967	\$ 61,419	\$ 62,858
5	0.774	\$ 1,013		\$ 2,449	\$ 3,462	\$ 2,680	\$ 66,429	\$ 64,099	\$ 60,119
6	0.736	\$ 1,043		\$ 2,522	\$ 3,565	\$ 2,623	\$ 69,994	\$ 66,722	\$ 57,439
7	0.699	\$ 1,075		\$ 2,594	\$ 3,672	\$ 2,567	\$ 73,667	\$ 69,289	\$ 54,816
8	0.664	\$ 1,107		\$ 2,676	\$ 3,783	\$ 2,512	\$ 77,449	\$ 71,801	\$ 52,249
9	0.631	\$ 1,140		\$ 2,756	\$ 3,896	\$ 2,458	\$ 81,345	\$ 74,259	\$ 49,737
10	0.599	\$ 1,174	\$ 6,495	\$ 2,839	\$ 10,508	\$ 6,299	\$ 91,853	\$ 80,559	\$ 47,279
11	0.570	\$ 1,210		\$ 2,924	\$ 4,133	\$ 2,354	\$ 95,986	\$ 82,913	\$ 40,980
12	0.541	\$ 1,246		\$ 3,012	\$ 4,287	\$ 2,304	\$ 100,244	\$ 85,217	\$ 38,625
13	0.514	\$ 1,283		\$ 3,102	\$ 4,385	\$ 2,255	\$ 104,629	\$ 87,471	\$ 36,321
14	0.489	\$ 1,322		\$ 3,195	\$ 4,517	\$ 2,207	\$ 109,145	\$ 89,678	\$ 34,067
15	0.464	\$ 1,361		\$ 3,291	\$ 4,652	\$ 2,159	\$ 113,797	\$ 91,837	\$ 31,860
16	0.441	\$ 1,402		\$ 3,390	\$ 4,792	\$ 2,113	\$ 118,589	\$ 93,950	\$ 29,701
17	0.419	\$ 1,444		\$ 3,491	\$ 4,935	\$ 2,068	\$ 123,524	\$ 96,018	\$ 27,588
18	0.398	\$ 1,488		\$ 3,596	\$ 5,083	\$ 2,024	\$ 128,608	\$ 98,042	\$ 25,520
19	0.378	\$ 1,532		\$ 3,704	\$ 5,236	\$ 1,981	\$ 133,844	\$ 100,023	\$ 23,496
20	0.359	\$ 1,578	\$ 6,495	\$ 3,815	\$ 11,888	\$ 4,272	\$ 145,732	\$ 104,295	\$ 21,515
21	0.341	\$ 1,626		\$ 3,929	\$ 5,555	\$ 1,897	\$ 151,286	\$ 106,192	\$ 17,243
22	0.324	\$ 1,674		\$ 4,047	\$ 5,722	\$ 1,856	\$ 157,008	\$ 108,048	\$ 15,346
23	0.308	\$ 1,724		\$ 4,168	\$ 5,893	\$ 1,817	\$ 162,901	\$ 109,864	\$ 13,490
24	0.293	\$ 1,776		\$ 4,294	\$ 6,070	\$ 1,778	\$ 168,971	\$ 111,642	\$ 11,674
25	0.278	\$ 1,830		\$ 4,423	\$ 6,252	\$ 1,740	\$ 175,223	\$ 113,382	\$ 9,896
26	0.264	\$ 1,884		\$ 4,555	\$ 6,440	\$ 1,702	\$ 181,663	\$ 115,084	\$ 8,156
27	0.251	\$ 1,941		\$ 4,692	\$ 6,633	\$ 1,666	\$ 188,296	\$ 116,750	\$ 6,454
28	0.239	\$ 1,999		\$ 4,833	\$ 6,832	\$ 1,630	\$ 195,127	\$ 118,381	\$ 4,788
29	0.227	\$ 2,059		\$ 4,979	\$ 7,037	\$ 1,596	\$ 202,164	\$ 119,977	\$ 3,157
30	0.215	\$ 2,121		\$ 5,127	\$ 7,248	\$ 1,562	\$ 209,412	\$ 121,538	\$ 1,562

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 03A_Bioretention Underdrain on Property		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Facility w/underdrain on Property	175	SF	\$	-
2	GSI Facility (Length - bottom dimensions)	35	LF		
2	GSI Facility (5'W bottom dimensions)	5	LF		
3	Top Dimensions @ 3:1 Side Slopes	675	SF		
4	Facility Excavation to Berm and Waste @ 2.8'D	44	CY	\$ 79	\$ 3,482
5	Mulch Compost (@ 0.3'D)	8	CY	\$ 86	\$ 645
6	Treatment Media - biochar @ 18" D	38	CY	\$ 270	\$ 10,125
7	Rocked Spillway (2'WX5'L)	10	SF	\$ 43	\$ 430
8					
9	Underdrain Items:	35	LF		
10	Underdrain Aggregate (2.5'X2.5')	8	CY	\$ 133	\$ 1,078
11	Pipe 8" Diameter Overflow/Drain	35	LF	\$ 48	\$ 1,680
12	Trench Exc to Waste	8	CY	\$ 79	\$ 640
13					
14	Facility Removals and Restoration:				
15	Landscaping and Restoration (surface area of disturbance)	111	SY	\$ 59	\$ 6,556
16	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -
17				\$	-
18	Outlet Pipe			\$	-
19	Pipe 8" Dia.	50	LF	\$ 80	\$ 4,000
20	5' Wide Trench x 6'D to waste	56	CY	\$ 79	\$ 4,389
21	Trench Box Shoring (Shallow)	600	SF	\$ 10	\$ 6,000
22	Catch Basin	1	EA	\$ 3,900	\$ 3,900
23	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
24					
25	Additional Costs			\$	-
26	Removals @ 4% Construction Costs	4.0%	LS	\$ 44,896	\$ 1,796
27	TESC @2% Construction Costs	2%	LS	\$ 46,692	\$ 934
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 47,626
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	4,763
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 52,388
<i>Direct: Subtotal Construction Costs (175 SF Area)</i>					\$ 52,388

Description: WQBE 3A - Bioretention with Underdrain on Property

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section C2.6.1

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Facility is sited in an open space with pipe outlet beneath a parking area.

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selected to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.

A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.

Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.

A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.

A rocked spillway is included.

The excavated material is unsuitable for use as backfill.

An excavation width of 3-feet is assumed on each side of the precast box.

Trench Box shoring is used.

Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Landscape restoration is required for the facility, earth berm and area of disturbance.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located outside of ROW and Traffic control is not required

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 03Aa - Bioretention Underdrain With Property Cost (2023 Dollars)	
Unit	85 ft ²
Initial Capital Cost	\$ 73,100
Capital cost	\$ 860 /Unit
Total Direct O&M/year	\$ 2,176
Direct O&M cost	\$ 25.60 /Unit
Capital Replacement Costs (10 Years)	\$ 6,495 /unit
Discount rate (%)	5.25 /Unit

Description: WQBE 03Aa - Bioretention Underdrain With Property Cost

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Annual mulch and plan replacements 10 plants at \$54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Total Cost (NPV)	\$ 144,500	/unit
Annual O&M Cost	\$ 3,100	/year
Annualized Cost	\$1,430	/year

Materials, Supplies, Other Costs		\$ -	/year
Annual plant replacement	2023 dollars	\$ 540	
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	/year
Subtotal		\$900	
Labor			
Remove Trash	4 hr		
Plant Health	8 hr		
Remediation of erosion	4 hr		
	0 hr		
Total hours per year	16		
Raw Labor Rate/Hr	\$ 54		
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 42,818	\$ 103,505	\$ 232,412	\$ 144,538					
0	1.000	\$ 73,100	\$ 73,100	\$ 73,100	\$ 73,100	\$ 73,100	\$ 73,100	\$ 73,100	\$ 144,538
1	0.950	\$ 900	\$ -	\$ 2,176	\$ 3,076	\$ 2,922	\$ 76,176	\$ 76,022	\$ 71,438
2	0.903	\$ 927	\$ -	\$ 2,241	\$ 3,168	\$ 2,860	\$ 79,343	\$ 78,882	\$ 68,516
3	0.858	\$ 955	\$ -	\$ 2,308	\$ 3,263	\$ 2,799	\$ 82,606	\$ 81,680	\$ 65,656
4	0.815	\$ 983	\$ -	\$ 2,377	\$ 3,361	\$ 2,739	\$ 85,967	\$ 84,419	\$ 62,858
5	0.774	\$ 1,013	\$ -	\$ 2,449	\$ 3,462	\$ 2,680	\$ 89,429	\$ 87,099	\$ 60,119
6	0.736	\$ 1,043	\$ -	\$ 2,522	\$ 3,565	\$ 2,623	\$ 92,994	\$ 89,722	\$ 57,439
7	0.699	\$ 1,075	\$ -	\$ 2,598	\$ 3,672	\$ 2,567	\$ 96,667	\$ 92,289	\$ 54,816
8	0.664	\$ 1,107	\$ -	\$ 2,676	\$ 3,783	\$ 2,512	\$ 100,449	\$ 94,801	\$ 52,249
9	0.631	\$ 1,140	\$ -	\$ 2,756	\$ 3,896	\$ 2,458	\$ 104,345	\$ 97,259	\$ 49,737
10	0.599	\$ 1,174	\$ 6,495	\$ 2,839	\$ 10,508	\$ 6,299	\$ 114,853	\$ 103,559	\$ 47,279
11	0.570	\$ 1,210	\$ -	\$ 2,924	\$ 4,133	\$ 2,354	\$ 118,886	\$ 105,913	\$ 40,980
12	0.541	\$ 1,246	\$ -	\$ 3,012	\$ 4,257	\$ 2,304	\$ 123,244	\$ 108,217	\$ 38,625
13	0.514	\$ 1,283	\$ -	\$ 3,102	\$ 4,385	\$ 2,255	\$ 127,626	\$ 110,471	\$ 36,321
14	0.489	\$ 1,322	\$ -	\$ 3,195	\$ 4,517	\$ 2,207	\$ 132,145	\$ 112,678	\$ 34,067
15	0.464	\$ 1,361	\$ -	\$ 3,291	\$ 4,652	\$ 2,159	\$ 136,797	\$ 114,837	\$ 31,860
16	0.441	\$ 1,402	\$ -	\$ 3,390	\$ 4,792	\$ 2,113	\$ 141,589	\$ 116,950	\$ 29,701
17	0.419	\$ 1,444	\$ -	\$ 3,491	\$ 4,935	\$ 2,068	\$ 146,524	\$ 119,018	\$ 27,588
18	0.398	\$ 1,488	\$ -	\$ 3,596	\$ 5,083	\$ 2,024	\$ 151,608	\$ 121,042	\$ 25,520
19	0.378	\$ 1,532	\$ -	\$ 3,704	\$ 5,236	\$ 1,981	\$ 156,844	\$ 123,023	\$ 23,496
20	0.359	\$ 1,578	\$ 6,495	\$ 3,815	\$ 11,888	\$ 4,272	\$ 168,732	\$ 127,295	\$ 21,515
21	0.341	\$ 1,626	\$ -	\$ 3,929	\$ 5,555	\$ 1,897	\$ 174,286	\$ 129,192	\$ 17,243
22	0.324	\$ 1,674	\$ -	\$ 4,047	\$ 5,722	\$ 1,856	\$ 180,008	\$ 131,048	\$ 15,346
23	0.308	\$ 1,724	\$ -	\$ 4,169	\$ 5,893	\$ 1,817	\$ 185,901	\$ 132,864	\$ 13,490
24	0.293	\$ 1,776	\$ -	\$ 4,294	\$ 6,070	\$ 1,778	\$ 191,971	\$ 134,642	\$ 11,674
25	0.278	\$ 1,830	\$ -	\$ 4,423	\$ 6,252	\$ 1,740	\$ 198,223	\$ 136,382	\$ 9,896
26	0.264	\$ 1,884	\$ -	\$ 4,555	\$ 6,440	\$ 1,702	\$ 204,663	\$ 138,084	\$ 8,156
27	0.251	\$ 1,941	\$ -	\$ 4,692	\$ 6,633	\$ 1,666	\$ 211,296	\$ 139,750	\$ 6,454
28	0.239	\$ 1,999	\$ -	\$ 4,833	\$ 6,832	\$ 1,630	\$ 218,127	\$ 141,381	\$ 4,788
29	0.227	\$ 2,059	\$ -	\$ 4,978	\$ 7,037	\$ 1,596	\$ 225,164	\$ 142,977	\$ 3,157
30	0.215	\$ 2,121	\$ -	\$ 5,127	\$ 7,248	\$ 1,562	\$ 232,412	\$ 144,538	\$ 1,562

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2027	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 03Aa_Bioretention Underdrain With Property Cost		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Facility w/underdrain on Property	175	SF		
2	GSI Facility (Length - bottom dimensions)	35	LF		
2	GSI Facility (5'W bottom dimensions)	5	LF		
3	Top Dimensions @ 3:1 Side Slopes	675	SF		
4	Facility Excavation to Berm and Waste @ 2.8'D	44	CY	\$ 79	\$ 3,482
5	Mulch Compost (@ 0.3'D)	8	CY	\$ 86	\$ 645
6	Treatment Media - biochar @ 18" D	38	CY	\$ 270	\$ 10,125
7	Rocked Spillway (2'WX5'L)	10	SF	\$ 43	\$ 430
8					
9	Underdrain Items:	35	LF		
10	Underdrain Aggregate (2.5'X2.5')	8	CY	\$ 133	\$ 1,078
11	Pipe 8" Diameter Overflow/Drain	35	LF	\$ 48	\$ 1,680
12	Trench Exc to Waste	8	CY	\$ 79	\$ 640
13					
14	Facility Removals and Restoration:				
15	Landscaping and Restoration	111	SY	\$ 59	\$ 6,556
16	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -
17				\$	\$ -
18	Outlet Pipe			\$	\$ -
19	Pipe 8" Dia.	50	LF	\$ 80	\$ 4,000
20	5' Wide Trench x 6'D to waste	56	CY	\$ 79	\$ 4,389
21	Trench Box Shoring (Shallow)	600	SF	\$ 10	\$ 6,000
22	Catch Basin	1	EA	\$ 3,900	\$ 3,900
23	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
24					
25	Additional Costs			\$	\$ -
26	Removals @ 4% Construction Costs	4.0%	LS	\$ 44,896	\$ 1,796
27	TESC @2% Construction Costs	2%	LS	\$ 46,692	\$ 934
				\$	\$ -
				\$	\$ -
Item Subtotal Construction Costs (Year 2023)				\$ 47,626	
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	4,763
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)				\$ 52,388	
Direct: Subtotal Construction Costs (175 SF Area)				\$ 52,388	

Description: WQBE 03Aa - Bioretention Underdrain With Property Cost

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section C2.6.1

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Facility is sited in an open space with pipe outlet beneath a parking area.

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selected to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.

A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.

Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.

A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.

A rocked spillway is included.

The excavated material is unsuitable for use as backfill.

An excavation width of 3-feet is assumed on each side of the precast box.

Trench Box shoring is used.

Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Landscape restoration is required for the facility, earth berm and area of disturbance.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located outside of ROW and Traffic control is not required

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 3B - Bioretention No UnderDrain on Property (2023 Dollars)

Unit	85 ft ²
Initial Capital Cost	\$ 46,500
Capital cost	\$ 547 /Unit
Total Direct O&M/Year	\$ 2,176
Direct O&M cost	\$ 25.60 /Unit
Capital Replacement Costs (10 Years)	\$ 6,495 /Unit
Discount rate (%)	5.25 /Unit

Description: WQBE 3B - Bioretention No UnderDrain on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per 8 year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per 8 visit).

Annual mulch and plan replacements 10 plants at \$54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Total Cost (NPV)	\$ 117,900	\$/unit
Annual O&M Cost	\$ 3,100	/year
Annualized Cost	\$ 1,430	/year

Materials, Supplies, Other Costs		\$ -	\$/year
Annual plant replacement	2023 dollars	\$ 540	
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$900	
Labor			
Remove Trash	4 hr		
Plant Health	8 hr		
Remediation of erosion	4 hr		
	0 hr		
Total hours per year	16		
Raw Labor Rate/Hr	\$ 54		
Raw labor cost (embedded)	\$ 870		
Labor cost, burdened	O/H 150.0% \$ 2,176		
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 42,818	\$ 46,500	\$ 103,505	\$ 205,612	\$ 117,938				
0	1.000	\$ 46,500	\$ 46,500	\$ 46,500	\$ 46,500	\$ 46,500	\$ 46,500	\$ 117,938	
1	0.950	\$ 900	\$ -	\$ 2,176	\$ 3,076	\$ 2,922	\$ 49,576	\$ 49,422	\$ 71,438
2	0.903	\$ 927	\$ -	\$ 2,241	\$ 3,168	\$ 2,860	\$ 52,743	\$ 52,282	\$ 68,516
3	0.858	\$ 955	\$ -	\$ 2,308	\$ 3,263	\$ 2,799	\$ 56,006	\$ 55,080	\$ 65,656
4	0.815	\$ 983	\$ -	\$ 2,377	\$ 3,361	\$ 2,739	\$ 59,367	\$ 57,819	\$ 62,858
5	0.774	\$ 1,013	\$ -	\$ 2,449	\$ 3,462	\$ 2,680	\$ 62,829	\$ 60,499	\$ 60,118
6	0.736	\$ 1,043	\$ -	\$ 2,522	\$ 3,565	\$ 2,623	\$ 66,394	\$ 63,122	\$ 57,438
7	0.699	\$ 1,075	\$ -	\$ 2,598	\$ 3,672	\$ 2,567	\$ 70,067	\$ 65,689	\$ 54,816
8	0.664	\$ 1,107	\$ -	\$ 2,676	\$ 3,783	\$ 2,512	\$ 73,849	\$ 68,201	\$ 52,249
9	0.631	\$ 1,140	\$ -	\$ 2,756	\$ 3,896	\$ 2,458	\$ 77,745	\$ 70,659	\$ 49,737
10	0.599	\$ 1,174	\$ 6,495	\$ 2,839	\$ 10,508	\$ 6,298	\$ 88,253	\$ 76,958	\$ 47,279
11	0.570	\$ 1,210	\$ -	\$ 2,924	\$ 4,133	\$ 2,354	\$ 92,386	\$ 79,313	\$ 40,990
12	0.541	\$ 1,246	\$ -	\$ 3,012	\$ 4,257	\$ 2,304	\$ 96,644	\$ 81,617	\$ 38,625
13	0.514	\$ 1,283	\$ -	\$ 3,102	\$ 4,385	\$ 2,255	\$ 101,029	\$ 83,871	\$ 36,321
14	0.489	\$ 1,322	\$ -	\$ 3,195	\$ 4,517	\$ 2,207	\$ 105,545	\$ 86,078	\$ 34,067
15	0.464	\$ 1,361	\$ -	\$ 3,291	\$ 4,652	\$ 2,159	\$ 110,197	\$ 88,237	\$ 31,860
16	0.441	\$ 1,402	\$ -	\$ 3,390	\$ 4,792	\$ 2,113	\$ 114,989	\$ 90,350	\$ 29,701
17	0.419	\$ 1,444	\$ -	\$ 3,491	\$ 4,935	\$ 2,068	\$ 119,924	\$ 92,418	\$ 27,588
18	0.398	\$ 1,488	\$ -	\$ 3,596	\$ 5,083	\$ 2,024	\$ 125,008	\$ 94,442	\$ 25,520
19	0.378	\$ 1,532	\$ -	\$ 3,704	\$ 5,236	\$ 1,981	\$ 130,244	\$ 96,423	\$ 23,496
20	0.359	\$ 1,578	\$ 6,495	\$ 3,815	\$ 11,888	\$ 4,272	\$ 142,132	\$ 100,695	\$ 21,515
21	0.341	\$ 1,626	\$ -	\$ 3,929	\$ 5,555	\$ 1,897	\$ 147,686	\$ 102,592	\$ 17,243
22	0.324	\$ 1,674	\$ -	\$ 4,047	\$ 5,722	\$ 1,856	\$ 153,408	\$ 104,448	\$ 15,346
23	0.308	\$ 1,724	\$ -	\$ 4,169	\$ 5,893	\$ 1,817	\$ 159,301	\$ 106,264	\$ 13,490
24	0.293	\$ 1,776	\$ -	\$ 4,294	\$ 6,070	\$ 1,778	\$ 165,371	\$ 108,042	\$ 11,674
25	0.278	\$ 1,830	\$ -	\$ 4,423	\$ 6,252	\$ 1,740	\$ 171,623	\$ 109,782	\$ 9,896
26	0.264	\$ 1,884	\$ -	\$ 4,555	\$ 6,440	\$ 1,702	\$ 178,063	\$ 111,484	\$ 8,156
27	0.251	\$ 1,941	\$ -	\$ 4,692	\$ 6,633	\$ 1,666	\$ 184,696	\$ 113,150	\$ 6,454
28	0.239	\$ 1,999	\$ -	\$ 4,833	\$ 6,832	\$ 1,630	\$ 191,527	\$ 114,781	\$ 4,788
29	0.227	\$ 2,059	\$ -	\$ 4,978	\$ 7,037	\$ 1,596	\$ 198,564	\$ 116,377	\$ 3,157
30	0.215	\$ 2,121	\$ -	\$ 5,127	\$ 7,248	\$ 1,562	\$ 205,812	\$ 117,938	\$ 1,562

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 03B_Bioretention No Underdrain on Property		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Facility w/underdrain on Property	175	SF	\$ 79	\$ -
2	GSI Facility (Length - bottom dimensions)	35	LF	\$ 86	\$ 645
2	GSI Facility (5'W bottom dimensions)	5	LF	\$ 270	\$ 10,125
3	Top Dimensions @ 3:1 Side Slopes	675	SF	\$ 43	\$ 430
4	Facility Excavation to Berm and Waste @2.8'D	44	CY	\$ 79	\$ 3,482
5	Mulch Compost (@ 0.3'D)	8	CY	\$ 86	\$ 645
6	Treatment Media - biochar @ 18" D	38	CY	\$ 270	\$ 10,125
7	Rocked Spillway (2'WX5'L)	10	SF	\$ 43	\$ 430
8				\$	\$ -
14	Facility Removals and Restoration:			\$	\$ -
15	Landscaping and Restoration (surface area of disturbance)	111	SY	\$ 59	\$ 6,556
16	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -
17				\$	\$ -
18	Outlet Pipe			\$	\$ -
19	Pipe 8" Dia.	50	LF	\$ 80	\$ 4,000
20	5' Wide Trench x 6'D to waste	56	CY	\$ 79	\$ 4,389
21	Trench Box Shoring (Shallow)	600	SF	\$ 10	\$ 6,000
22	Catch Basin	1	EA	\$ 3,900	\$ 3,900
23	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
24				\$	\$ -
25	Additional Costs			\$	\$ -
26	Removals @ 4% Construction Costs	4.0%	LS	\$ 41,499	\$ 1,660
27	TESC @2% Construction Costs	2%	LS	\$ 43,158	\$ 863
				\$	\$ -
				\$	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 44,022
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	\$ -
	Mobilization/Demobilization	10%	1.1	\$	\$ 4,402
	Overhead & Profit (OHP)	0%	1	\$	\$ -
	Insurance	0.0%	1	\$	\$ -
	Bonding	0.0%	1	\$	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 48,424
<i>Direct: Subtotal Construction Costs (175 SF Area)</i>					\$ 48,424

Description: WQBE 3B - Bioretention No UnderDrain on Property

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section C2.6.1

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Facility is sited in an open space with pipe outlet beneath a parking area.

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selected to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.

A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.

Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.

A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.

A rocked spillway is included.

The excavated material is unsuitable for use as backfill.

An excavation width of 3-feet is assumed on each side of the precast box.

Trench Box shoring is used.

Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Landscape restoration is required for the facility, earth berm and area of disturbance.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located outside of ROW and Traffic control is not required

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 03Bb - Bioretention No Underdrain
With Property Cost (2023 Dollars)

Unit	85 ft ²
Initial Capital Cost	\$ 69,400
Capital cost	\$ 816 /\$Unit
Total Direct O&M/Year	\$ 2,175.6000
Direct O&M cost	\$ 25.60 /\$Unit
Capital Replacement Costs (10 Years)	\$ 6,495 /\$unit
Discount rate (%)	5.25 /\$Unit

Total Cost (NPV)	\$ 140,800	\$/unit
Annual O&M Cost	\$ 3,100	\$/year
Annualized Cost	\$ 1,430	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Annual plant replacement	2023 dollars	\$ 540	
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$900	
Labor			
Remove Trash		4 hr	
Plant Health		8 hr	
Remediation of erosion		4 hr	
		0 hr	
Total hours per year		16	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:		30 years	

135.98

Description: WQBE 03Bb - Bioretention No Underdrain With Property Cost

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Annual mulch and plan replacements 10 plants at \$54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 42,818		\$ 103,505	\$228,712	\$ 140,838			
0	1.000	\$ 69,400			\$69,400	\$ 69,400	\$ 69,400	\$ 69,400	\$ 140,838
1	0.950	\$ 900	\$ -	\$ 2,176	\$ 3,076	\$ 2,922	\$ 72,476	\$ 72,322	\$ 71,438
2	0.903	\$ 927	\$ -	\$ 2,241	\$ 3,168	\$ 2,860	\$ 75,643	\$ 75,182	\$ 68,516
3	0.858	\$ 955	\$ -	\$ 2,308	\$ 3,263	\$ 2,799	\$ 78,906	\$ 77,980	\$ 65,656
4	0.815	\$ 983	\$ -	\$ 2,377	\$ 3,361	\$ 2,739	\$ 82,267	\$ 80,719	\$ 62,858
5	0.774	\$ 1,013	\$ -	\$ 2,449	\$ 3,462	\$ 2,680	\$ 85,729	\$ 83,399	\$ 60,119
6	0.736	\$ 1,043	\$ -	\$ 2,522	\$ 3,565	\$ 2,623	\$ 89,294	\$ 86,022	\$ 57,439
7	0.699	\$ 1,075	\$ -	\$ 2,598	\$ 3,672	\$ 2,567	\$ 92,967	\$ 88,589	\$ 54,816
8	0.664	\$ 1,107	\$ -	\$ 2,676	\$ 3,783	\$ 2,512	\$ 96,749	\$ 91,101	\$ 52,249
9	0.631	\$ 1,140	\$ -	\$ 2,756	\$ 3,896	\$ 2,458	\$ 100,645	\$ 93,559	\$ 49,737
10	0.599	\$ 1,174	\$ 6,495	\$ 2,839	\$ 10,508	\$ 6,299	\$ 111,153	\$ 99,859	\$ 47,279
11	0.570	\$ 1,210	\$ -	\$ 2,924	\$ 11,333	\$ 2,354	\$ 115,286	\$ 102,213	\$ 40,980
12	0.541	\$ 1,246	\$ -	\$ 3,012	\$ 12,267	\$ 2,304	\$ 119,544	\$ 104,517	\$ 38,625
13	0.514	\$ 1,283	\$ -	\$ 3,102	\$ 13,205	\$ 2,255	\$ 123,929	\$ 106,771	\$ 36,321
14	0.489	\$ 1,322	\$ -	\$ 3,195	\$ 14,157	\$ 2,207	\$ 128,445	\$ 108,978	\$ 34,067
15	0.464	\$ 1,361	\$ -	\$ 3,291	\$ 14,652	\$ 2,159	\$ 133,097	\$ 111,137	\$ 31,860
16	0.441	\$ 1,402	\$ -	\$ 3,390	\$ 14,792	\$ 2,113	\$ 137,889	\$ 113,250	\$ 29,701
17	0.419	\$ 1,444	\$ -	\$ 3,491	\$ 14,935	\$ 2,068	\$ 142,824	\$ 115,318	\$ 27,588
18	0.398	\$ 1,488	\$ -	\$ 3,596	\$ 15,083	\$ 2,024	\$ 147,908	\$ 117,342	\$ 25,520
19	0.378	\$ 1,532	\$ -	\$ 3,704	\$ 15,236	\$ 1,981	\$ 153,144	\$ 119,323	\$ 23,496
20	0.359	\$ 1,578	\$ 6,495	\$ 3,815	\$ 11,888	\$ 4,272	\$ 165,032	\$ 123,595	\$ 21,515
21	0.341	\$ 1,626	\$ -	\$ 3,929	\$ 5,555	\$ 1,897	\$ 170,586	\$ 125,492	\$ 17,243
22	0.324	\$ 1,674	\$ -	\$ 4,047	\$ 5,722	\$ 1,856	\$ 176,308	\$ 127,348	\$ 15,346
23	0.308	\$ 1,724	\$ -	\$ 4,169	\$ 5,893	\$ 1,817	\$ 182,201	\$ 129,164	\$ 13,490
24	0.293	\$ 1,776	\$ -	\$ 4,294	\$ 6,070	\$ 1,778	\$ 188,271	\$ 130,942	\$ 11,674
25	0.278	\$ 1,830	\$ -	\$ 4,423	\$ 6,252	\$ 1,740	\$ 194,523	\$ 132,682	\$ 9,896
26	0.264	\$ 1,884	\$ -	\$ 4,555	\$ 6,440	\$ 1,702	\$ 200,963	\$ 134,384	\$ 8,156
27	0.251	\$ 1,941	\$ -	\$ 4,692	\$ 6,633	\$ 1,666	\$ 207,596	\$ 136,050	\$ 6,454
28	0.239	\$ 1,999	\$ -	\$ 4,833	\$ 6,832	\$ 1,630	\$ 214,427	\$ 137,681	\$ 4,788
29	0.227	\$ 2,059	\$ -	\$ 4,978	\$ 7,037	\$ 1,596	\$ 221,464	\$ 139,277	\$ 3,157
30	0.215	\$ 2,121	\$ -	\$ 5,127	\$ 7,248	\$ 1,562	\$ 228,712	\$ 140,838	\$ 1,562

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_03Bb_Bioretention No Underdrain With Property Cost		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Facility w/underdrain on Property	175	SF	\$	-
2	GSI Facility (Length - bottom dimensions)	35	LF	\$	
2	GSI Facility (5'W bottom dimensions)	5	LF	\$	
3	Top Dimensions @ 3:1 Side Slopes	675	SF	\$	
4	Facility Excavation to Berm and Waste @2.8'D	44	CY	\$ 79	\$ 3,482
5	Mulch Compost (@ 0.3'D)	8	CY	\$ 86	\$ 645
6	Treatment Media - biochar @ 18" D	38	CY	\$ 270	\$ 10,125
7	Rocked Spillway (2'WX5'L)	10	SF	\$ 43	\$ 430
8				\$	
14	Facility Removals and Restoration:			\$	
15	Landscaping and Restoration (30'X50' area of disturbance)	111	SY	\$ 59	\$ 6,556
16	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -
17				\$	-
18	Outlet Pipe			\$	-
19	Pipe 8" Dia.	50	LF	\$ 80	\$ 4,000
20	5' Wide Trench x 6'D to waste	56	CY	\$ 79	\$ 4,389
21	Trench Box Shoring (Shallow)	600	SF	\$ 10	\$ 6,000
22	Catch Basin	1	EA	\$ 3,900	\$ 3,900
23	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
24				\$	
25	Additional Costs			\$	-
26	Removals @ 4% Construction Costs	4.0%	LS	\$ 41,499	\$ 1,660
27	TESC @2% Construction Costs	2%	LS	\$ 43,158	\$ 863
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 44,022
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	4,402
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 48,424
Direct: Subtotal Construction Costs (175 SF Area)					\$ 48,424

Description: WQBE 03Bb - Bioretention No Underdrain With Property Cost

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section C2.6.1

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Facility is sited in an open space with pipe outlet beneath a parking area.

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selected to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.

A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.

Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.

A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.

A rocked spillway is included.

The excavated material is unsuitable for use as backfill.

An excavation width of 3-feet is assumed on each side of the precast box.

Trench Box shoring is used.

Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTS

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Landscape restoration is required for the facility, earth berm and area of disturbance.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located outside of ROW and Traffic control is not required

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 3C - Bioretention Facility With Underdrain
in ROW (2023 Dollars)

Unit	85 [ft2]
Initial Capital Cost	\$ 90,300
Capital cost	\$ 1,062 \$/Unit
Total Direct O&M/Year	\$ 2,175.60
Direct O&M cost	\$ 25.60 \$/Unit
Capital Replacement Costs (10 Years)	\$ 6,495 \$/unit
Discount rate (%)	5.25 \$/Unit

Total Cost (NPV)	\$ 161,700	\$/unit
Annual O&M Cost	\$ 3,100	\$/year
Annualized Cost	\$ 1,430	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Annual plant replacement	2023 dollars	\$ 540	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$900	
Labor			
Remove Trash		4 [hr]	
Plant Health		8 [hr]	
Remediation of erosion		4 [hr]	
		0 [hr]	
Total hours per year		16	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:		30 years	

135.98

Description: WQBE 3C - Bioretention Facility With Underdrain in ROW

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Annual mulch and plan replacements 10 plants at \$54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 42,818		\$ 103,505	\$ 249,612	\$ 161,738			
0	1.000	\$ 90,300			\$ 90,300	\$ 90,300	\$ 90,300	\$ 90,300	\$ 161,738
1	0.950	\$ 900	\$ -	\$ 2,176	\$ 3,076	\$ 2,922	\$ 93,376	\$ 93,222	\$ 71,438
2	0.903	\$ 927	\$ -	\$ 2,241	\$ 3,168	\$ 2,860	\$ 96,543	\$ 96,082	\$ 68,516
3	0.858	\$ 955	\$ -	\$ 2,308	\$ 3,263	\$ 2,799	\$ 99,806	\$ 98,880	\$ 65,656
4	0.815	\$ 983	\$ -	\$ 2,377	\$ 3,361	\$ 2,739	\$ 103,167	\$ 101,619	\$ 62,858
5	0.774	\$ 1,013	\$ -	\$ 2,449	\$ 3,462	\$ 2,680	\$ 106,629	\$ 104,299	\$ 60,119
6	0.736	\$ 1,043	\$ -	\$ 2,522	\$ 3,565	\$ 2,623	\$ 110,194	\$ 106,922	\$ 57,439
7	0.699	\$ 1,075	\$ -	\$ 2,598	\$ 3,672	\$ 2,567	\$ 113,867	\$ 109,489	\$ 54,816
8	0.664	\$ 1,107	\$ -	\$ 2,676	\$ 3,783	\$ 2,512	\$ 117,649	\$ 112,001	\$ 52,249
9	0.631	\$ 1,140	\$ -	\$ 2,756	\$ 3,896	\$ 2,458	\$ 121,545	\$ 114,459	\$ 49,737
10	0.599	\$ 1,174	\$ 6,495	\$ 2,839	\$ 10,508	\$ 6,299	\$ 132,053	\$ 120,759	\$ 47,279
11	0.570	\$ 1,210	\$ -	\$ 2,924	\$ 4,133	\$ 2,354	\$ 136,186	\$ 123,113	\$ 40,980
12	0.541	\$ 1,246	\$ -	\$ 3,012	\$ 4,257	\$ 2,304	\$ 140,444	\$ 125,417	\$ 38,625
13	0.514	\$ 1,283	\$ -	\$ 3,102	\$ 4,385	\$ 2,255	\$ 144,829	\$ 127,671	\$ 36,321
14	0.489	\$ 1,322	\$ -	\$ 3,195	\$ 4,517	\$ 2,207	\$ 149,345	\$ 129,878	\$ 34,067
15	0.464	\$ 1,361	\$ -	\$ 3,291	\$ 4,652	\$ 2,159	\$ 153,997	\$ 132,037	\$ 31,860
16	0.441	\$ 1,402	\$ -	\$ 3,390	\$ 4,792	\$ 2,113	\$ 158,789	\$ 134,150	\$ 29,701
17	0.419	\$ 1,444	\$ -	\$ 3,491	\$ 4,935	\$ 2,068	\$ 163,724	\$ 136,218	\$ 27,588
18	0.398	\$ 1,488	\$ -	\$ 3,596	\$ 5,083	\$ 2,024	\$ 168,806	\$ 136,242	\$ 25,520
19	0.378	\$ 1,532	\$ -	\$ 3,704	\$ 5,236	\$ 1,981	\$ 174,044	\$ 140,223	\$ 23,496
20	0.359	\$ 1,578	\$ 6,495	\$ 3,815	\$ 11,888	\$ 4,272	\$ 185,932	\$ 144,495	\$ 21,515
21	0.341	\$ 1,626	\$ -	\$ 3,929	\$ 5,555	\$ 1,897	\$ 191,486	\$ 146,392	\$ 17,243
22	0.324	\$ 1,674	\$ -	\$ 4,047	\$ 5,722	\$ 1,856	\$ 197,208	\$ 148,248	\$ 15,346
23	0.308	\$ 1,724	\$ -	\$ 4,169	\$ 5,893	\$ 1,817	\$ 203,101	\$ 150,064	\$ 13,490
24	0.293	\$ 1,776	\$ -	\$ 4,294	\$ 6,070	\$ 1,778	\$ 209,171	\$ 151,842	\$ 11,674
25	0.278	\$ 1,830	\$ -	\$ 4,423	\$ 6,252	\$ 1,740	\$ 215,423	\$ 153,582	\$ 9,896
26	0.264	\$ 1,884	\$ -	\$ 4,555	\$ 6,440	\$ 1,702	\$ 221,863	\$ 155,284	\$ 8,156
27	0.251	\$ 1,941	\$ -	\$ 4,692	\$ 6,633	\$ 1,666	\$ 228,496	\$ 156,950	\$ 6,454
28	0.239	\$ 1,999	\$ -	\$ 4,833	\$ 6,832	\$ 1,630	\$ 235,327	\$ 158,581	\$ 4,788
29	0.227	\$ 2,059	\$ -	\$ 4,978	\$ 7,037	\$ 1,596	\$ 242,364	\$ 160,177	\$ 3,157
30	0.215	\$ 2,121	\$ -	\$ 5,127	\$ 7,248	\$ 1,562	\$ 249,612	\$ 161,738	\$ 1,562

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_03C_Bioretention_Underdrain_In ROW		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Facility with Underdrain in ROW (Roadside)	175	SF	\$	-
2	GSI Facility (Length - bottom dimensions)	35	LF	\$	
3	GSI Facility (5'W bottom dimensions)	5	LF	\$	
4	Top Dimensions @ 3:1 Side Slopes	675	SF	\$	
5	Facility Excavation to Bern and Waste @ 2.8'D	44	CY	\$ 79	\$ 3,482
6	Mulch Compost (@ 0.3'D)	8	CY	\$ 86	\$ 645
7	Treatment Media - biochar @ 18" D	38	CY	\$ 270	\$ 10,125
8	Rocked Spillway (2'WX5'L)	10	SF	\$ 43	\$ 430
9				\$	
10	Underdrain Items:	35	LF	\$	
11	Underdrain Aggregate (2.5'X2.5')	8	CY	\$ 133	\$ 1,078
12	Pipe 8" Diameter Overflow/Drain	35	LF	\$ 48	\$ 1,680
13	Trench Exc to Waste	8	CY	\$ 79	\$ 640
14				\$	
15	Facility Removals and Restoration:	35	LF	\$	
16	Pavement Patch - Facility (6"HMA/6"CSTC)	39	SY	\$ 110	\$ 4,278
17	Sidewalk 6'Wide	23	SY	\$ 125	\$ 2,917
18	Concrete Curb and Gutter	35	LF	\$ 111	\$ 3,885
19	Landscaping and Restoration (surface area of disturbance)	111	SY	\$ 59	\$ 6,556
20	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -
21				\$	-
22	Outlet Pipe			\$	-
23	DI CL 50 Pipe 8" Dia.	50	LF	\$ 160	\$ 8,000
24	5' Wide Trench x 6'D to waste	56	CY	\$ 79	\$ 4,389
25	Trench Box Shoring (Shallow)	600	SF	\$ 10	\$ 6,000
26	Catch Basin	1	EA	\$ 3,900	\$ 3,900
27	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
28				\$	
29	Additional Costs			\$	-
30	Removals @ 4% Construction Costs	4.0%	LS	\$ 59,976	\$ 2,399
31	Traffic Control (Heavy)	1	MO	\$ 20,000	\$ 20,000
32	TESC @2% Construction Costs	2%	LS	\$ 62,375	\$ 1,247
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 83,622
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	8,362
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 91,984
Direct: Subtotal Construction Costs (175 SF Area)					\$ 91,984

Description: WQBE 3C - Bioretention Facility With Underdrain in ROW

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section C2.6.1

Installation is in ROW on the roadside and does not require easements or acquisition

Facility is sited on the roadside and assumes curb and gutter and pavement restoration to accommodate the facility width.

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selected to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.

A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.

Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.

A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.

A rocked spillway is included.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

Trench Box shoring is used.

Arterial Roadway restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTS

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

Landscape restoration is required for the facility area.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 3D - Bioretention no Underdrain in ROW (2023 Dollars)

	Unit	85 ft2
Initial Capital Cost	\$	90,000
Capital cost	\$	1,059 \$/Unit
Total Direct O&M/Year	\$	2,176
Direct O&M cost	\$	25.60 \$/Unit
Capital Replacement Costs (10 Years)	\$	6,495 \$/unit
Discount rate (%)	\$	5.25 \$/Unit

Total Cost (NPV)	\$ 161,400	\$/unit
Annual O&M Cost	\$ 3,100	\$/year

Materials, Supplies, Other Costs

Annual plant replacement	2023 dollars	\$ 540	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$900	
Labor			
Remove Trash		4 hr	
Plant Health		8 hr	
Remediation of erosion		4 hr	
		0 hr	
Total hours per year		16	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:		30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 42,818		\$ 103,505	\$ 249,312	\$ 161,438			
0	1.000	\$ 90,000		\$ 90,000	\$ 90,000	\$ 90,000	\$ 90,000	\$ 90,000	\$ 161,438
1	0.950	\$ 900	\$ -	\$ 2,176	\$ 3,076	\$ 2,922	\$ 93,076	\$ 92,922	\$ 71,438
2	0.903	\$ 927	\$ -	\$ 2,241	\$ 3,168	\$ 2,860	\$ 96,243	\$ 95,782	\$ 68,516
3	0.858	\$ 955	\$ -	\$ 2,308	\$ 3,263	\$ 2,799	\$ 99,506	\$ 98,580	\$ 65,656
4	0.815	\$ 983	\$ -	\$ 2,377	\$ 3,361	\$ 2,739	\$ 102,867	\$ 101,319	\$ 62,858
5	0.774	\$ 1,013	\$ -	\$ 2,449	\$ 3,462	\$ 2,680	\$ 106,329	\$ 103,999	\$ 60,119
6	0.736	\$ 1,043	\$ -	\$ 2,522	\$ 3,565	\$ 2,623	\$ 109,894	\$ 106,622	\$ 57,439
7	0.699	\$ 1,075	\$ -	\$ 2,594	\$ 3,672	\$ 2,567	\$ 113,567	\$ 109,189	\$ 54,816
8	0.664	\$ 1,107	\$ -	\$ 2,676	\$ 3,783	\$ 2,512	\$ 117,349	\$ 111,701	\$ 52,249
9	0.631	\$ 1,140	\$ -	\$ 2,756	\$ 3,893	\$ 2,458	\$ 121,245	\$ 114,159	\$ 49,737
10	0.599	\$ 1,174	\$ 6,495	\$ 2,839	\$ 10,508	\$ 6,299	\$ 131,753	\$ 120,459	\$ 47,279
11	0.570	\$ 1,210	\$ -	\$ 2,924	\$ 4,133	\$ 2,354	\$ 135,886	\$ 122,613	\$ 40,980
12	0.541	\$ 1,246	\$ -	\$ 3,012	\$ 4,257	\$ 2,304	\$ 140,144	\$ 125,117	\$ 38,625
13	0.514	\$ 1,283	\$ -	\$ 3,102	\$ 4,385	\$ 2,255	\$ 144,529	\$ 127,371	\$ 36,321
14	0.489	\$ 1,322	\$ -	\$ 3,195	\$ 4,517	\$ 2,207	\$ 149,045	\$ 129,578	\$ 34,067
15	0.464	\$ 1,361	\$ -	\$ 3,291	\$ 4,652	\$ 2,159	\$ 153,697	\$ 131,737	\$ 31,860
16	0.441	\$ 1,402	\$ -	\$ 3,390	\$ 4,792	\$ 2,113	\$ 158,489	\$ 133,850	\$ 29,701
17	0.419	\$ 1,444	\$ -	\$ 3,491	\$ 4,935	\$ 2,068	\$ 163,424	\$ 135,918	\$ 27,588
18	0.398	\$ 1,488	\$ -	\$ 3,596	\$ 5,083	\$ 2,024	\$ 168,508	\$ 137,942	\$ 25,520
19	0.378	\$ 1,532	\$ -	\$ 3,704	\$ 5,236	\$ 1,981	\$ 173,744	\$ 139,923	\$ 23,496
20	0.359	\$ 1,578	\$ 6,495	\$ 3,815	\$ 11,888	\$ 4,272	\$ 185,632	\$ 144,195	\$ 21,515
21	0.341	\$ 1,626	\$ -	\$ 3,929	\$ 5,555	\$ 1,897	\$ 191,186	\$ 146,092	\$ 17,243
22	0.324	\$ 1,674	\$ -	\$ 4,047	\$ 5,722	\$ 1,856	\$ 196,908	\$ 147,948	\$ 15,346
23	0.308	\$ 1,724	\$ -	\$ 4,168	\$ 5,893	\$ 1,817	\$ 202,801	\$ 149,764	\$ 13,499
24	0.293	\$ 1,776	\$ -	\$ 4,294	\$ 6,070	\$ 1,778	\$ 208,871	\$ 151,542	\$ 11,674
25	0.278	\$ 1,830	\$ -	\$ 4,423	\$ 6,252	\$ 1,740	\$ 215,123	\$ 153,282	\$ 9,896
26	0.264	\$ 1,884	\$ -	\$ 4,555	\$ 6,440	\$ 1,702	\$ 221,563	\$ 154,984	\$ 8,156
27	0.251	\$ 1,941	\$ -	\$ 4,692	\$ 6,633	\$ 1,666	\$ 228,196	\$ 156,650	\$ 6,454
28	0.239	\$ 1,999	\$ -	\$ 4,833	\$ 6,832	\$ 1,630	\$ 235,027	\$ 158,281	\$ 4,788
29	0.227	\$ 2,059	\$ -	\$ 4,978	\$ 7,037	\$ 1,596	\$ 242,064	\$ 159,877	\$ 3,157
30	0.215	\$ 2,121	\$ -	\$ 5,127	\$ 7,248	\$ 1,562	\$ 249,312	\$ 161,438	\$ 1,562

Description: WQBE 3D - Bioretention no Underdrain in ROW

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by
trash, sediment and debris removal to occur annually and after major storm events. Work to be
performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive
vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed
biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour
per visit).

Annual mulch and plan replacements 10 plants at \$54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost
(including labor) \$360.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_03D_Bioretention_ROW_No Underdrain		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioretention Facility with Underdrain in ROW (Roadside)	175	SF	\$	-
2	GSI Facility (Length - bottom dimensions)	35	LF		
3	GSI Facility (5'W bottom dimensions)	5	LF		
4	Top Dimensions @ 3:1 Side Slopes	675	SF		
5	Facility Excavation to Berm and Waste @2.8'D	44	CY	\$ 79	\$ 3,482
6	Mulch Compost (@ 0.3'D)	8	CY	\$ 86	\$ 645
7	Treatment Media - biochar @ 18" D	38	CY	\$ 270	\$ 10,125
8	Rocked Spillway (2'WX5'L)	10	SF	\$ 43	\$ 430
9					
10	Facility Removals and Restoration:	45	LF		
11	Pavement Patch - Facility (6"HMA/6"CSTC)	50	SY	\$ 110	\$ 5,500
12	Sidewalk 6'Wide	30	SY	\$ 125	\$ 3,750
13	Concrete Curb and Gutter	45	LF	\$ 111	\$ 4,995
14	Landscaping and Restoration (surface area of disturbance)	111	SY	\$ 59	\$ 6,556
15	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -
16				\$	-
17	Outlet Pipe			\$	-
18	DI CL 50 Pipe 8" Dia.	50	LF	\$ 160	\$ 8,000
19	5' Wide Trench x 6'D to waste	56	CY	\$ 79	\$ 4,389
20	Trench Box Shoring (Shallow)	600	SF	\$ 10	\$ 6,000
21	Catch Basin	1	EA	\$ 3,900	\$ 3,900
22	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	28	SY	\$ 71	\$ 1,972
23				\$	-
24	Additional Costs			\$	-
25	Removals @ 4% Construction Costs	4.0%	LS	\$ 59,744	\$ 2,390
26	Traffic Control (Heavy)	1	MO	\$ 20,000	\$ 20,000
27	TESC @2% Construction Costs	2%	LS	\$ 62,133	\$ 1,243
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 83,376
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	8,338
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 91,714
<i>Direct: Subtotal Construction Costs (175 SF Area)</i>					\$ 91,714

Description: WQBE 3D - Bioretention no Underdrain in ROW

Shallow earthen depressions or vertical walled open bottom boxes with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section C2.6.1

Installation is in ROW on the roadside and does not require easements or acquisition

Facility is sited on the roadside and assumes curb and gutter and pavement restoration to accommodate the facility width.

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 85 sf with a 3:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 175 sf area (5' wide by 35' long) was selected to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 85 sf treatment area.

A maximum ponding depth of 6-inches with a minimum of 6-inches of freeboard are assumed.

Facilities located in outwash soils do not require an underdrain.

A total of 50 linear feet of 8-inch storm pipe is required to connect to the downstream facility or main.

A rocked spillway is included.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

Trench Box shoring is used.

Arterial Roadway restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTS

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

Landscape restoration is required for the facility area.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 04A - Bioswale in ROW (2023 Dollars)

	Unit	200 ft ²
Initial Capital Cost	\$ 29,000	
Capital cost	\$ 145	/Unit
Total Direct O&M/Year	\$ 2,175.60	
Direct O&M cost	\$ 10.88	/Unit
Capital Replacement Costs (10 Years)	\$ 707	/unit
Discount rate (%)	5.25	/Unit

Total Cost (NPV)	\$ 85,300	\$/unit
Annual O&M Cost	\$ 2,600	\$/year
Annualized Cost	\$710	\$/year

Materials, Supplies, Other Costs		
Grass seed, gravel & soil spot repairs, grass health supplies.	\$ -	\$/year
2023 dollars	\$ 450	\$/year
2023 dollars	\$ -	\$/year
Subtotal Labor		\$450
Remove Trash	4	hr
Plant Health	8	hr
Remediation of erosion	4	hr
Activity	0	hr
Total hours per year	16	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded) \$ 870	
Labor cost, burdened	O/H 150.0% \$ 2,176	
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 21,409		\$ 103,505	\$ 155,328	\$ 85,347			
0	1.000	\$ 29,000		\$ 2,176	\$ 29,000	\$ 29,000	\$ 29,000	\$ 29,000	\$ 85,347
1	0.950	\$ 450	\$ -	\$ 2,176	\$ 2,626	\$ 2,495	\$ 31,626	\$ 31,495	\$ 56,347
2	0.903	\$ 464	\$ -	\$ 2,241	\$ 2,704	\$ 2,441	\$ 34,330	\$ 33,936	\$ 53,853
3	0.858	\$ 477	\$ -	\$ 2,308	\$ 2,785	\$ 2,389	\$ 37,115	\$ 36,325	\$ 51,411
4	0.815	\$ 492	\$ -	\$ 2,377	\$ 2,869	\$ 2,338	\$ 39,985	\$ 38,663	\$ 49,022
5	0.774	\$ 506	\$ -	\$ 2,449	\$ 2,955	\$ 2,288	\$ 42,940	\$ 40,951	\$ 46,684
6	0.736	\$ 522	\$ -	\$ 2,522	\$ 3,044	\$ 2,239	\$ 45,983	\$ 43,190	\$ 44,396
7	0.699	\$ 537	\$ -	\$ 2,598	\$ 3,135	\$ 2,191	\$ 49,119	\$ 45,382	\$ 42,157
8	0.664	\$ 553	\$ -	\$ 2,676	\$ 3,229	\$ 2,144	\$ 52,348	\$ 47,526	\$ 39,966
9	0.631	\$ 570	\$ -	\$ 2,756	\$ 3,326	\$ 2,099	\$ 55,674	\$ 49,625	\$ 37,821
10	0.599	\$ 587	\$ 707	\$ 2,839	\$ 4,133	\$ 2,477	\$ 59,806	\$ 52,102	\$ 35,723
11	0.570	\$ 605	\$ -	\$ 2,924	\$ 3,529	\$ 2,010	\$ 63,335	\$ 54,112	\$ 33,245
12	0.541	\$ 623	\$ -	\$ 3,012	\$ 3,634	\$ 1,967	\$ 66,969	\$ 56,079	\$ 31,235
13	0.514	\$ 642	\$ -	\$ 3,102	\$ 3,743	\$ 1,925	\$ 70,713	\$ 58,004	\$ 29,268
14	0.489	\$ 661	\$ -	\$ 3,195	\$ 3,856	\$ 1,884	\$ 74,569	\$ 59,887	\$ 27,344
15	0.464	\$ 681	\$ -	\$ 3,291	\$ 3,971	\$ 1,843	\$ 78,540	\$ 61,731	\$ 25,460
16	0.441	\$ 701	\$ -	\$ 3,390	\$ 4,091	\$ 1,804	\$ 82,631	\$ 63,535	\$ 23,617
17	0.419	\$ 722	\$ -	\$ 3,491	\$ 4,213	\$ 1,765	\$ 86,844	\$ 65,300	\$ 21,813
18	0.398	\$ 744	\$ -	\$ 3,596	\$ 4,340	\$ 1,728	\$ 91,184	\$ 67,028	\$ 20,047
19	0.378	\$ 766	\$ -	\$ 3,704	\$ 4,470	\$ 1,691	\$ 95,654	\$ 68,718	\$ 18,320
20	0.359	\$ 789	\$ 707	\$ 3,815	\$ 5,311	\$ 1,699	\$ 100,964	\$ 70,627	\$ 16,629
21	0.341	\$ 813	\$ -	\$ 3,929	\$ 4,742	\$ 1,619	\$ 105,707	\$ 72,246	\$ 14,720
22	0.324	\$ 837	\$ -	\$ 4,047	\$ 4,884	\$ 1,585	\$ 110,591	\$ 73,831	\$ 13,101
23	0.308	\$ 862	\$ -	\$ 4,169	\$ 5,031	\$ 1,551	\$ 115,622	\$ 75,382	\$ 11,516
24	0.293	\$ 888	\$ -	\$ 4,294	\$ 5,182	\$ 1,518	\$ 120,804	\$ 76,899	\$ 9,966
25	0.278	\$ 915	\$ -	\$ 4,423	\$ 5,337	\$ 1,485	\$ 126,141	\$ 78,384	\$ 8,448
26	0.264	\$ 942	\$ -	\$ 4,555	\$ 5,497	\$ 1,453	\$ 131,638	\$ 79,838	\$ 6,963
27	0.251	\$ 970	\$ -	\$ 4,692	\$ 5,662	\$ 1,422	\$ 137,301	\$ 81,260	\$ 5,509
28	0.239	\$ 1,000	\$ -	\$ 4,833	\$ 5,832	\$ 1,392	\$ 143,133	\$ 82,652	\$ 4,087
29	0.227	\$ 1,030	\$ -	\$ 4,978	\$ 6,007	\$ 1,362	\$ 149,140	\$ 84,014	\$ 2,695
30	0.215	\$ 1,060	\$ -	\$ 5,127	\$ 6,187	\$ 1,333	\$ 155,328	\$ 85,347	\$ 1,333

Description: WQBE 04A - Bioswale in ROW

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost. Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Grass seed, gravel & soils spot repairs, grass health supplies at \$450/year total.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Estimate - AACEI Class 10						
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024	
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 04A - Bioswale_ROW			Version:	3	
CONSTRUCTION COSTS						
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost	
1	Bioswale in ROW	375	SF	\$	\$ -	
2	Bioswale Facility (Length - bottom dimensions)	75	LF	\$	\$ -	
3	Bioswale Facility (5'W bottom dimensions)	5	LF	\$	\$ -	
4	Top Dimensions @ 3:1 Side Slopes	800	SF	\$	\$ -	
5	Facility Excavation to Berm and Waste @2.8'D	61	CY	\$ 79	\$	4,813
6	Mulch Compost (@ 0.3'D)	9	CY	\$ 86	\$	764
7	Flow Spreader (Inlet, Mid and Outlet)	3	EA	\$ 1,480	\$	4,440
8				\$	\$ -	
9	Facility Removals and Restoration:			\$	\$ -	
10	Concrete Curb and Gutter (in curb cut areas only)	15	LF	\$ 111	\$	1,665
11	Grass Seeding and Restoration	142	SY	\$ 10	\$	1,417
12	Trees (None noted in Design Basis)	0	EA	\$ 720	\$	-
13				\$	\$ -	
14				\$	\$ -	
15	Additional Costs			\$	\$ -	
16	Removals @ 4% Construction Costs	4.0%	LS	\$ 13,099	\$	524
17	Traffic Control (Heavy)	0.5	MO	\$ 20,000	\$	10,000
18	TESC @2% Construction Costs	2%	LS	\$ 13,623	\$	272
				\$	\$ -	
				\$	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	23,896
DIRECT: CONSTRUCTION COST MARK-UPS						
	General Conditions	0%	1	\$	\$ -	
	Mobilization/Demobilization	10%	1.1	\$	\$ 2,390	
	Overhead & Profit (OHP)	0%	1	\$	\$ -	
	Insurance	0.0%	1	\$	\$ -	
	Bonding	0.0%	1	\$	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	26,285
Direct: Subtotal Construction Costs (375 SF Area)					\$	26,285

Description: WQBE 04A - Bioswale in ROW

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section 6.3.1

Installation is in ROW on the roadside or highway and does not require easements or acquisition.

Pretreatment is not included in the cost model.

Treatment media is not included in the cost model.

0.2 feet of composted media is tilled into the top 6 inches of soil.

The facility treatment area is 200 sf with a 50:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 375 sf area (5' wide by 75' long) was selected to represent a typical installation. The facility subtotal construction costs were then scaled to represent the selected 200 sf treatment area. A maximum ponding depth of 4" and a 6" minimum freeboard depth are assumed. The longitudinal gradient is less than 6% and check dams are not required.

No underdrain is required

Surface flows enter the swale via curb openings.

Flow spreaders are required at the inlet, mid-swale, and outlet.

It is assumed that the facility fits within the roadside and that pavement removal and restoration is not required.

The excavated material is unsuitable for use as backfill.

Dewatering is not required

Shoring is not required.

No piping is needed to convey flows to or from the facility.

The concrete curb and gutter restoration is assumed only at the swale inlet and outlet areas.

There is sufficient area along the roadside to construct the swales without pavement patching or sidewalk restoration.

Seeded grass restoration is required for the facility area.

Tree plantings are not included in the cost model.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 4B - Bioswale On Public Property (2023 Dollars)

Unit	200 ft ²
Initial Capital Cost	\$ 16,200
Capital cost	\$ 81 /Unit
Total Direct O&M/year	\$ 2,176
Direct O&M cost	\$ 10.88 /Unit
Capital Replacement Costs (10 Years)	\$ 707 /Unit
Discount rate (%)	5.25 /Unit

Description: WQBE 4B - Bioswale On Public Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Grass seed, gravel & soils spot repairs, grass health supplies at \$450/year total.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Total Cost (NPV)	\$ 72,500	/unit
Annual O&M Cost	\$ 2,600	/year
Annualized Cost	\$710	/year

Materials, Supplies, Other Costs		\$ -	\$/year
Grass seed, gravel & soil spot repairs, grass health supplies.	2023 dollars	\$ 450	\$/year
	2023 dollars	\$ -	\$/year
Subtotal			\$450
Labor			
Remove Trash		4 hr	
Plant Health		8 hr	
Remediation of erosion		4 hr	
Activity		0 hr	
Total hours per year		16	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 870	
Labor cost, burdened	O/H 150.0%	\$ 2,176	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 21,409		\$ 103,505	\$ 142,528	\$ 72,547			
0	1.000	\$ 16,200		\$ 16,200	\$ 16,200	\$ 16,200	\$ 16,200	\$ 16,200	\$ 72,547
1	0.950	\$ 450	\$ -	\$ 2,176	\$ 2,626	\$ 2,495	\$ 18,826	\$ 18,695	\$ 56,347
2	0.903	\$ 464	\$ -	\$ 2,241	\$ 2,704	\$ 2,441	\$ 21,530	\$ 21,136	\$ 53,853
3	0.858	\$ 477	\$ -	\$ 2,308	\$ 2,785	\$ 2,389	\$ 24,315	\$ 23,525	\$ 51,411
4	0.815	\$ 492	\$ -	\$ 2,377	\$ 2,869	\$ 2,338	\$ 27,185	\$ 25,863	\$ 49,022
5	0.774	\$ 506	\$ -	\$ 2,449	\$ 2,955	\$ 2,288	\$ 30,140	\$ 28,151	\$ 46,684
6	0.736	\$ 522	\$ -	\$ 2,522	\$ 3,044	\$ 2,238	\$ 33,183	\$ 30,390	\$ 44,396
7	0.699	\$ 537	\$ -	\$ 2,598	\$ 3,135	\$ 2,191	\$ 36,319	\$ 32,582	\$ 42,157
8	0.664	\$ 553	\$ -	\$ 2,676	\$ 3,229	\$ 2,144	\$ 39,548	\$ 34,726	\$ 39,966
9	0.631	\$ 570	\$ -	\$ 2,756	\$ 3,326	\$ 2,099	\$ 42,874	\$ 36,825	\$ 37,821
10	0.599	\$ 587	\$ 707	\$ 2,839	\$ 4,133	\$ 2,477	\$ 47,006	\$ 39,302	\$ 35,723
11	0.570	\$ 605	\$ -	\$ 2,924	\$ 3,529	\$ 2,010	\$ 50,535	\$ 41,312	\$ 33,245
12	0.541	\$ 623	\$ -	\$ 3,012	\$ 3,634	\$ 1,967	\$ 54,161	\$ 43,279	\$ 31,235
13	0.514	\$ 642	\$ -	\$ 3,102	\$ 3,743	\$ 1,925	\$ 57,913	\$ 45,204	\$ 29,268
14	0.489	\$ 661	\$ -	\$ 3,195	\$ 3,856	\$ 1,884	\$ 61,769	\$ 47,087	\$ 27,344
15	0.464	\$ 681	\$ -	\$ 3,291	\$ 3,971	\$ 1,843	\$ 65,740	\$ 48,931	\$ 25,460
16	0.441	\$ 701	\$ -	\$ 3,390	\$ 4,091	\$ 1,804	\$ 69,831	\$ 50,735	\$ 23,617
17	0.419	\$ 722	\$ -	\$ 3,491	\$ 4,213	\$ 1,765	\$ 74,044	\$ 52,500	\$ 21,813
18	0.398	\$ 744	\$ -	\$ 3,596	\$ 4,340	\$ 1,728	\$ 78,384	\$ 54,228	\$ 20,047
19	0.378	\$ 766	\$ -	\$ 3,704	\$ 4,470	\$ 1,691	\$ 82,854	\$ 55,918	\$ 18,320
20	0.359	\$ 789	\$ 707	\$ 3,815	\$ 5,311	\$ 1,909	\$ 88,164	\$ 57,827	\$ 16,629
21	0.341	\$ 813	\$ -	\$ 3,929	\$ 4,742	\$ 1,619	\$ 92,907	\$ 59,446	\$ 14,720
22	0.324	\$ 837	\$ -	\$ 4,047	\$ 4,884	\$ 1,585	\$ 97,791	\$ 61,031	\$ 13,101
23	0.308	\$ 862	\$ -	\$ 4,169	\$ 5,031	\$ 1,551	\$ 102,622	\$ 62,582	\$ 11,516
24	0.293	\$ 888	\$ -	\$ 4,294	\$ 5,182	\$ 1,518	\$ 108,004	\$ 64,099	\$ 9,966
25	0.278	\$ 915	\$ -	\$ 4,423	\$ 5,337	\$ 1,485	\$ 113,341	\$ 65,584	\$ 8,448
26	0.264	\$ 942	\$ -	\$ 4,555	\$ 5,497	\$ 1,453	\$ 118,838	\$ 67,038	\$ 6,963
27	0.251	\$ 970	\$ -	\$ 4,692	\$ 5,662	\$ 1,422	\$ 124,501	\$ 68,460	\$ 5,509
28	0.239	\$ 1,000	\$ -	\$ 4,833	\$ 5,832	\$ 1,392	\$ 130,333	\$ 69,852	\$ 4,087
29	0.227	\$ 1,030	\$ -	\$ 4,978	\$ 6,007	\$ 1,362	\$ 136,340	\$ 71,214	\$ 2,695
30	0.215	\$ 1,060	\$ -	\$ 5,127	\$ 6,187	\$ 1,333	\$ 142,528	\$ 72,547	\$ 1,333

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE 04B - Bioswale_On_Public_Property			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Bioswale in ROW	375	SF	\$	-
2	Bioswale Facility (Length - bottom dimensions)	75	LF	\$	
3	Bioswale Facility (5'W bottom dimensions)	5	LF	\$	
4	Top Dimensions @ 3:1 Side Slopes (11'WX23'L)	800	SF	\$	
5	Facility Excavation to Berm and Waste @2.8'D	61	CY	\$ 79	\$ 4,813
6	Mulch Compost (@ 0.3'D)	9	CY	\$ 86	\$ 764
7	Flow Spreader (Inlet, Mid and Outlet)	3	EA	\$ 1,480	\$ 4,440
8				\$	
9	Facility Removals and Restoration:			\$	
10	Concrete Curb and Gutter (in curb cut areas only)	15	LF	\$ 111	\$ 1,665
11	Grass Seeding and Restoration	142	SY	\$ 10	\$ 1,417
12	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -
13				\$	-
14				\$	-
15	Additional Costs			\$	-
16	Removals @ 4% Construction Costs	4.0%	LS	\$ 13,099	\$ 524
17	TESC @2% Construction Costs	2%	LS	\$ 13,623	\$ 272
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 13,896
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	1,390
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 15,285
Direct: Subtotal Construction Costs (375 SF Area)					\$ 15,285

Description: WQBE 4B - Bioswale On Public Property

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section 6.3.1

Installation is in ROW on the roadside or highway and does not require easements or acquisition.

Pretreatment is not included in the cost model.

Treatment media is not included in the cost model.

0.2 feet of composted media is tilled into the top 6 inches of soil.

The facility treatment area is 200 sf with a 50:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 375 sf area (5' wide by 75' long) was selected to represent a typical installation. The facility subtotal construction costs were then scaled to represent the selected 200 sf treatment area. A maximum ponding depth of 4" and a 6" minimum freeboard depth are assumed. The longitudinal gradient is less than 6% and check dams are not required.

No underdrain is required

Surface flows enter the swale via curb openings.

Flow spreaders are required at the inlet, mid-swale, and outlet.

It is assumed that the facility fits within the roadside and that pavement removal and restoration is not required.

The excavated material is unsuitable for use as backfill.

Dewatering is not required

Shoring is not required.

No piping is needed to convey flows to or from the facility.

The concrete curb and gutter restoration is assumed only at the swale inlet and outlet areas.

There is sufficient area along the roadside to construct the swales without pavement patching or sidewalk restoration.

Seeded grass restoration is required for the facility area.

Tree plantings are not included in the cost model.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and Traffic Control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 04C - Bioswale_With Property Cost (2023 Dollars)

Unit	200 ft ²
Initial Capital Cost	\$ 84,100
Capital cost	\$ 421 /\$Unit
Total Direct O&M/year	\$ 2,176
Direct O&M cost	\$ 10.88 /\$Unit
Capital Replacement Costs (10 Years)	\$ 707 /\$Unit
Discount rate (%)	5.25 /\$Unit

Description: WQBE 04C - Bioswale_With Property Cost

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by
trash, sediment and debris removal to occur annually and after major storm events. Work to be
4 performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive
vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4
8 visits per year, 1 hour per visit).
Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed
biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour
4 per visit).

Grass seed, gravel & soils spot repairs, grass health supplies at \$450/year total.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Total Cost (NPV)	\$ 140,400	\$/unit
Annual O&M Cost	\$ 2,600	\$/year
Annualized Cost	\$710	\$/year

Materials, Supplies, Other Costs		\$	-	\$/year
Grass seed, gravel & soil spot repairs, grass health supplies.		2023 dollars	\$ 450	\$/year
		2023 dollars	\$ -	\$/year
Subtotal				\$450
Labor				
Remove Trash		4	hr	
Plant Health		8	hr	
Remediation of erosion		4	hr	
Activity		0	hr	
Total hours per year		16		
Raw Labor Rate/Hr		\$ 54		
Raw labor cost	(embedded)	\$ 870		
Labor cost, burdened	O/H 150.0%	\$ 2,176		\$ 135.98
General and Labor Cost Escalation/Year	3.0%			
Life Cycle Period:	30	years		

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 21,409	\$ 103,505	\$ 210,428	\$ 140,447				
0	1.000	\$ 84,100		\$ 84,100	\$ 84,100	\$ 84,100	\$ 84,100	\$ 84,100	\$ 140,447
1	0.950	\$ 450	\$ -	\$ 2,176	\$ 2,626	\$ 2,495	\$ 86,726	\$ 86,595	\$ 56,347
2	0.903	\$ 464	\$ -	\$ 2,241	\$ 2,704	\$ 2,441	\$ 89,430	\$ 89,036	\$ 53,853
3	0.858	\$ 477	\$ -	\$ 2,308	\$ 2,785	\$ 2,389	\$ 92,215	\$ 91,425	\$ 51,411
4	0.815	\$ 492	\$ -	\$ 2,377	\$ 2,869	\$ 2,338	\$ 95,085	\$ 93,763	\$ 49,022
5	0.774	\$ 506	\$ -	\$ 2,449	\$ 2,955	\$ 2,288	\$ 98,040	\$ 96,051	\$ 46,684
6	0.736	\$ 522	\$ -	\$ 2,522	\$ 3,044	\$ 2,239	\$ 101,083	\$ 98,290	\$ 44,396
7	0.699	\$ 537	\$ -	\$ 2,598	\$ 3,135	\$ 2,191	\$ 104,219	\$ 100,482	\$ 42,157
8	0.664	\$ 553	\$ -	\$ 2,676	\$ 3,229	\$ 2,144	\$ 107,448	\$ 102,626	\$ 39,966
9	0.631	\$ 570	\$ -	\$ 2,756	\$ 3,326	\$ 2,099	\$ 110,774	\$ 104,725	\$ 37,821
10	0.599	\$ 587	\$ 707	\$ 2,839	\$ 4,133	\$ 2,477	\$ 114,906	\$ 107,202	\$ 35,723
11	0.570	\$ 605	\$ -	\$ 2,924	\$ 3,529	\$ 2,010	\$ 118,435	\$ 109,212	\$ 33,245
12	0.541	\$ 623	\$ -	\$ 3,012	\$ 3,634	\$ 1,967	\$ 122,069	\$ 111,179	\$ 31,235
13	0.514	\$ 642	\$ -	\$ 3,102	\$ 3,743	\$ 1,925	\$ 125,813	\$ 113,104	\$ 29,268
14	0.489	\$ 661	\$ -	\$ 3,195	\$ 3,856	\$ 1,884	\$ 129,669	\$ 114,987	\$ 27,344
15	0.464	\$ 681	\$ -	\$ 3,291	\$ 3,971	\$ 1,843	\$ 133,640	\$ 116,831	\$ 25,460
16	0.441	\$ 701	\$ -	\$ 3,390	\$ 4,091	\$ 1,804	\$ 137,731	\$ 118,635	\$ 23,617
17	0.419	\$ 722	\$ -	\$ 3,491	\$ 4,213	\$ 1,765	\$ 141,944	\$ 120,400	\$ 21,813
18	0.398	\$ 744	\$ -	\$ 3,596	\$ 4,340	\$ 1,728	\$ 146,284	\$ 122,128	\$ 20,047
19	0.378	\$ 766	\$ -	\$ 3,704	\$ 4,470	\$ 1,691	\$ 150,754	\$ 123,818	\$ 18,320
20	0.359	\$ 789	\$ 707	\$ 3,815	\$ 5,311	\$ 1,909	\$ 156,064	\$ 125,727	\$ 16,629
21	0.341	\$ 813	\$ -	\$ 3,929	\$ 4,742	\$ 1,619	\$ 160,807	\$ 127,346	\$ 14,720
22	0.324	\$ 837	\$ -	\$ 4,047	\$ 4,884	\$ 1,585	\$ 165,691	\$ 128,331	\$ 13,101
23	0.308	\$ 862	\$ -	\$ 4,169	\$ 5,031	\$ 1,551	\$ 170,722	\$ 130,482	\$ 11,516
24	0.293	\$ 888	\$ -	\$ 4,294	\$ 5,182	\$ 1,518	\$ 175,904	\$ 131,999	\$ 9,966
25	0.278	\$ 915	\$ -	\$ 4,423	\$ 5,337	\$ 1,485	\$ 181,241	\$ 133,484	\$ 8,448
26	0.264	\$ 942	\$ -	\$ 4,555	\$ 5,497	\$ 1,453	\$ 186,738	\$ 134,938	\$ 6,963
27	0.251	\$ 970	\$ -	\$ 4,692	\$ 5,662	\$ 1,422	\$ 192,401	\$ 136,360	\$ 5,509
28	0.239	\$ 1,000	\$ -	\$ 4,833	\$ 5,832	\$ 1,392	\$ 198,233	\$ 137,752	\$ 4,087
29	0.227	\$ 1,030	\$ -	\$ 4,978	\$ 6,007	\$ 1,362	\$ 204,240	\$ 139,114	\$ 2,695
30	0.215	\$ 1,060	\$ -	\$ 5,127	\$ 6,187	\$ 1,333	\$ 210,428	\$ 140,447	\$ 1,333

Estimate - AACEI Class 10						
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024	
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 04C - Bioswale_With Property Cost			Version:	3	
CONSTRUCTION COSTS						
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost	
1	Bioswale in ROW	375	SF	\$	\$ -	
2	Bioswale Facility (Length - bottom dimensions)	75	LF	\$	\$ -	
3	Bioswale Facility (5'W bottom dimensions)	5	LF	\$	\$ -	
4	Top Dimensions @ 3:1 Side Slopes	800	SF	\$	\$ -	
5	Facility Excavation to Berm and Waste @ 2.8'D	61	CY	\$ 79	\$ 4,813	
6	Mulch Compost (@ 0.3'D)	9	CY	\$ 86	\$ 764	
7	Flow Spreader (Inlet, Mid and Outlet)	3	EA	\$ 1,480	\$ 4,440	
8				\$	\$ -	
9	Facility Removals and Restoration:			\$	\$ -	
10	Concrete Curb and Gutter (in curb cut areas only)	15	LF	\$ 111	\$ 1,665	
11	Grass Seeding and Restoration	142	SY	\$ 10	\$ 1,417	
12	Trees (None noted in Design Basis)	0	EA	\$ 720	\$ -	
13				\$	\$ -	
14				\$	\$ -	
15	Additional Costs			\$	\$ -	
16	Removals @ 4% Construction Costs	4.0%	LS	\$ 13,099	\$ 524	
17	TESC @2% Construction Costs	2%	LS	\$ 13,623	\$ 272	
				\$	\$ -	
				\$	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	13,896
DIRECT: CONSTRUCTION COST MARK-UPS						
	General Conditions	0%	1	\$	\$ -	
	Mobilization/Demobilization	10%	1.1	\$	\$ 1,390	
	Overhead & Profit (OHP)	0%	1	\$	\$ -	
	Insurance	0.0%	1	\$	\$ -	
	Bonding	0.0%	1	\$	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	15,285
Direct: Subtotal Construction Costs (375 SF Area)					\$	15,285

Description: WQBE 04C - Bioswale_With Property Cost

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated.

Cost Estimating Assumptions:

Facility design is per KC SWDM Section 6.3.1

Pretreatment is not included in the cost model.

Treatment media is not included in the cost model.

0.2 feet of composted media is tilled into the top 6 inches of soil.

The facility treatment area is 200 sf with a 50:1 L:W ratio and 3:1 (run:rise) minimum side slopes. A facility with 375 sf area (5' wide by 75' long) was selected to represent an typical installation. The facility subtotal construction costs were then scaled to represent the selected 200 sf treatment area. A maximum ponding depth of 4" and a 6" minimum freeboard depth are assumed. The longitudinal gradient is less than 6% and check dams are not required.

No underdrain is required

Surface flows enter the swale via curb openings.

Flow spreaders are required at the inlet, mid-swale, and outlet.

It is assumed that the facility fits within the roadside and that pavement removal and restoration is not required.

The excavated material is unsuitable for use as backfill.

Dewatering is not required

Shoring is not required.

No piping is needed to convey flows to or from the facility.

The concrete curb and gutter restoration is assumed only at the swale inlet and outlet areas.

There is sufficient area along the roadside to construct the swales without pavement patching or sidewalk restoration.

Seeded grass restoration is required for the facility area.

Tree plantings are not included in the cost model.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and Traffic Control is not required.

A street use permit is not required.

The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 05A - Media_Filter_Drain_ROW_Underdrain (2023 Dollars)

Unit	200 ft ²
Initial Capital Cost	\$ 35,800
Capital cost	\$ 179 /Unit
Total Direct O&M/Year	\$ 2,176
Direct O&M cost	\$ 10.88 /Unit
Capital Replacement Costs (10 Years)	\$ 4,309 /unit
Discount rate (%)	5.25 /Unit

Total Cost (NPV)	\$ 90,800	\$/unit
Annual O&M Cost	\$ 2,400	\$/year
Annualized Cost	\$360	\$/year

Materials, Supplies, Other Costs

Grass seed & gravel for spot repairs	\$ -	\$/year
2023 dollars	\$ 225	\$/year
2023 dollars	\$ 225	\$/year

Subtotal \$ 225

Labor

Remove Trash	4 hr
Grass Health	8 hr
Remediation of erosion	4 hr
Activity	0 hr
Total hours per year	16
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 870
Labor cost, burdened	O/H 150.0% \$ 2,176
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Description: WQBE 05A - Media_Filter_Drain_ROW_Underdrain

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Inspection and remediation of grass health (sparse growth, excessive growth, weed growth).

4 Assumed work completed quarterly by a crew of two at 1 hour per visit.
Inspection and remediation of eroded or scoured areas due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12". Assumed work completed twice annually by a crew of 2 at 1 hour per visit. Work to be performed by hand.

Grass seed and gravel for spot repairs at \$225/year total.
5 hour per visit. Work to be performed by hand.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 10,704	\$ 103,505	\$ 158,628	\$ 90,831	\$	\$			
0	1.000	\$ 35,800	\$ 35,800	\$ 35,800	\$ 35,800	\$ 35,800	\$ 35,800	\$ 35,800	\$ 90,831
1	0.950	\$ 225	\$ -	\$ 2,176	\$ 2,401	\$ 2,281	\$ 38,201	\$ 38,081	\$ 55,031
2	0.903	\$ 232	\$ -	\$ 2,241	\$ 2,473	\$ 2,232	\$ 40,673	\$ 40,313	\$ 52,750
3	0.858	\$ 239	\$ -	\$ 2,308	\$ 2,547	\$ 2,184	\$ 43,220	\$ 42,497	\$ 50,518
4	0.815	\$ 246	\$ -	\$ 2,377	\$ 2,623	\$ 2,138	\$ 45,843	\$ 44,635	\$ 48,334
5	0.774	\$ 253	\$ -	\$ 2,449	\$ 2,702	\$ 2,092	\$ 48,545	\$ 46,727	\$ 46,196
6	0.736	\$ 261	\$ -	\$ 2,522	\$ 2,783	\$ 2,047	\$ 51,328	\$ 48,774	\$ 44,104
7	0.699	\$ 269	\$ -	\$ 2,598	\$ 2,866	\$ 2,003	\$ 54,195	\$ 50,778	\$ 42,057
8	0.664	\$ 277	\$ -	\$ 2,676	\$ 2,952	\$ 1,961	\$ 57,147	\$ 52,738	\$ 40,053
9	0.631	\$ 285	\$ -	\$ 2,756	\$ 3,041	\$ 1,919	\$ 60,188	\$ 54,657	\$ 38,093
10	0.599	\$ 294	\$ 4,309	\$ 2,839	\$ 7,442	\$ 4,461	\$ 67,629	\$ 59,118	\$ 36,174
11	0.570	\$ 302	\$ -	\$ 2,924	\$ 3,226	\$ 1,838	\$ 70,856	\$ 60,956	\$ 31,713
12	0.541	\$ 311	\$ -	\$ 3,012	\$ 3,323	\$ 1,798	\$ 74,179	\$ 62,754	\$ 29,875
13	0.514	\$ 321	\$ -	\$ 3,102	\$ 3,423	\$ 1,760	\$ 77,601	\$ 64,514	\$ 28,077
14	0.489	\$ 330	\$ -	\$ 3,195	\$ 3,525	\$ 1,722	\$ 81,127	\$ 66,236	\$ 26,317
15	0.464	\$ 340	\$ -	\$ 3,291	\$ 3,631	\$ 1,685	\$ 84,758	\$ 67,922	\$ 24,595
16	0.441	\$ 351	\$ -	\$ 3,390	\$ 3,740	\$ 1,649	\$ 88,498	\$ 69,571	\$ 22,909
17	0.419	\$ 361	\$ -	\$ 3,491	\$ 3,852	\$ 1,614	\$ 92,350	\$ 71,185	\$ 21,260
18	0.398	\$ 372	\$ -	\$ 3,596	\$ 3,968	\$ 1,580	\$ 96,318	\$ 72,765	\$ 19,646
19	0.378	\$ 383	\$ -	\$ 3,704	\$ 4,087	\$ 1,546	\$ 100,405	\$ 74,311	\$ 18,066
20	0.359	\$ 395	\$ 4,309	\$ 3,815	\$ 8,519	\$ 3,062	\$ 108,924	\$ 77,372	\$ 16,520
21	0.341	\$ 406	\$ -	\$ 3,929	\$ 4,336	\$ 1,480	\$ 113,259	\$ 78,853	\$ 13,459
22	0.324	\$ 419	\$ -	\$ 4,047	\$ 4,466	\$ 1,449	\$ 117,725	\$ 80,302	\$ 11,978
23	0.308	\$ 431	\$ -	\$ 4,169	\$ 4,600	\$ 1,418	\$ 122,325	\$ 81,719	\$ 10,529
24	0.293	\$ 444	\$ -	\$ 4,294	\$ 4,738	\$ 1,388	\$ 127,063	\$ 83,107	\$ 9,112
25	0.278	\$ 457	\$ -	\$ 4,423	\$ 4,880	\$ 1,358	\$ 131,943	\$ 84,465	\$ 7,724
26	0.264	\$ 471	\$ -	\$ 4,555	\$ 5,026	\$ 1,329	\$ 136,969	\$ 85,794	\$ 6,366
27	0.251	\$ 485	\$ -	\$ 4,692	\$ 5,177	\$ 1,300	\$ 142,146	\$ 87,094	\$ 5,037
28	0.239	\$ 500	\$ -	\$ 4,833	\$ 5,332	\$ 1,273	\$ 147,479	\$ 88,367	\$ 3,737
29	0.227	\$ 515	\$ -	\$ 4,978	\$ 5,492	\$ 1,245	\$ 152,971	\$ 89,612	\$ 2,464
30	0.215	\$ 530	\$ -	\$ 5,127	\$ 5,657	\$ 1,219	\$ 158,628	\$ 90,831	\$ 1,219

Estimate - AACEI Class 10						
Project Name:			Date:		6/7/2024	
Location: King County, WA			Estimator:		Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description: WQBE 05A - Media_Filter_Drain_ROW_Underdrain			Version:		3	
CONSTRUCTION COSTS						
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost	
1	Media Filter Drain (MFD) - Till Soils	200	SF	\$	\$ -	
2	Facility Length	50	LF	\$	\$ -	
3	Facility Width	4	LF	\$	\$ -	
4	Shaping and compacting crushed gravel in non-vegetation zone @ 2'W X 50'LX0.5'D	2	CY	\$ 52	\$	96
5	Seeded Grass Strip @3'W X 50'L	17	SY	\$ 10	\$	167
6	Excavation to Waste - Grass Strip @ 3'W X 1'D X50'L	6	CY	\$ 79	\$	439
7	Soil Mix for Grass Strip @ 3'W X 1'D X50'L	6	CY	\$ 105	\$	583
8	Excavation to Waste MFD @4'WX50'LX1.25' Ave. Depth	9	CY	\$ 79	\$	731
9	Media Filter Drain Mix (dolomite, gypsum, perlite)	9	CY	\$ 197	\$	1,824
10				\$	\$ -	
11	Underdrain Items	50	LF	\$	\$ -	
12	Trench Excavation to Waste	6	CY	\$ 79	\$	497
13	8-inch diameter underdrain pipe	2	LF	\$ 48	\$	96
14	Gravel for underdrain (2'WX1.7'L)	6	CY	\$ 133	\$	837
15	Geotextile	41	SY	\$ 4	\$ -	
16				\$	\$ -	
17	Additional Costs			\$	\$ -	
18	Traffic Control (Heavy)	0.50	MO	\$ 20,000	\$	10,000
19	Removals @ 4% Construction Costs	4.0%	LS	\$ 5,272	\$	211
20	TESC @2% Construction Costs	2%	LS	\$ 15,482	\$	310
				\$	\$ -	
				\$	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	15,792
DIRECT: CONSTRUCTION COST MARK-UPS						
General Conditions			0%	1	\$	-
Mobilization/Demobilization			10%	1.1	\$	1,579
Overhead & Profit (OHP)			0%	1	\$	-
Insurance			0.0%	1	\$	-
Bonding			0.0%	1	\$	-
Escalation Multiplier from ENR-CCI			0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	17,371
<i>Direct: Subtotal Construction Costs (200 SF Area)</i>					\$	17,371

Description: WQBE 5A - Media Filter Drain - In ROW_Underdrain

A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians (dual MFD), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per Ecology BMP T8.40
Installation is in ROW on the roadside and does not require easements or acquisition
Facility is sited on the roadside and assumes pavement restoration to accommodate the facility width.
A minimum of 12 inches of treatment media with mix of crushed rock, dolomite, gypsum and perlite (see table V-6.4) is used.
Treatment media mixture is assumed to be 75% crushed rock and 25% dolomite, gypsum and perlite (see quantities on table V-6.4 of Ecology manual)
The facility treatment area is 200 sf with a length of 50 linear feet and width of 4 feet
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 2 LF of 8-inch diameter storm pipe is required to connect to the storm or CSO main.
The excavated material is unsuitable for use as backfill.
A 3' wide grass strip will be installed next to treatment media
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 1% of the construction costs.
The facility is located within the ROW and Traffic control is required
A street use permit is required.
Underdrains are assumed for till soils.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 5B - Media Filter Drain - In ROW
- No Underdrain (2023 Dollars)

Unit	200 ft ²
Initial Capital Cost	\$ 32,600
Capital cost	\$ 163 /Unit
Total Direct O&M/Year	\$ 2,176
Direct O&M cost	\$ 10.88 /Unit
Capital Replacement Costs (10 Years)	\$ 4,309 /unit
Discount rate (%)	5.25 /\$Unit

Total Cost (NPV)	\$ 87,600	\$/unit
Annual O&M Cost	\$ 2,400	\$/year
Annualized Cost	\$360	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Grass seed & gravel for spot repairs	2023 dollars	\$ 225	\$/year
	2023 dollars		\$/year

Subtotal Labor

Remove Trash	4 hr
Plant Health	8 hr
Remediation of erosion	4 hr
Activity	0 hr
Total Hours per year	16
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 870
Labor cost, burdened	O/H 150.0% \$ 2,176
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Description: WQBE 5B - Media Filter Drain - In ROW - No Underdrain

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools (2 visits per year, 1 hour per visit).
Inspection and remediation of grass health (sparse growth, excessive growth, weed growth).
Assumed work completed quarterly by a crew of two at 1 hour per visit.
Inspection and remediation of eroded or scoured areas due to flow channelization, or higher flows. Remediation includes filling area with gravel for areas less than 12" wide, and regrading and reseeding for areas larger than 12". Assumed work completed twice annually by a crew of 2 at 1 hour per visit. Work to be performed by hand.
Grass seed and gravel for spot repairs at \$225/year total.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 10,704		\$ 103,505	\$ 155,428	\$ 87,631			
0	1.000	\$ 32,600		\$ 225	\$ 32,600	\$ 32,600	\$ 32,600	\$ 32,600	\$ 87,631
1	0.950	\$ 225		\$ -	\$ 2,176	\$ 2,401	\$ 2,281	\$ 35,001	\$ 34,881
2	0.903	\$ 232		\$ -	\$ 2,241	\$ 2,473	\$ 2,232	\$ 37,473	\$ 37,113
3	0.858	\$ 239		\$ -	\$ 2,308	\$ 2,547	\$ 2,184	\$ 40,020	\$ 39,297
4	0.815	\$ 246		\$ -	\$ 2,377	\$ 2,623	\$ 2,138	\$ 42,643	\$ 41,435
5	0.774	\$ 253		\$ -	\$ 2,449	\$ 2,702	\$ 2,092	\$ 45,345	\$ 43,527
6	0.736	\$ 261		\$ -	\$ 2,522	\$ 2,783	\$ 2,047	\$ 48,128	\$ 45,574
7	0.699	\$ 269		\$ -	\$ 2,598	\$ 2,866	\$ 2,003	\$ 50,995	\$ 47,578
8	0.664	\$ 277		\$ -	\$ 2,676	\$ 2,952	\$ 1,961	\$ 53,947	\$ 49,538
9	0.631	\$ 285		\$ -	\$ 2,756	\$ 3,041	\$ 1,919	\$ 56,988	\$ 51,457
10	0.599	\$ 294		\$ 4,309	\$ 2,839	\$ 4,461	\$ 7,442	\$ 64,429	\$ 55,918
11	0.570	\$ 302		\$ -	\$ 2,924	\$ 3,226	\$ 1,838	\$ 67,656	\$ 57,756
12	0.541	\$ 311		\$ -	\$ 3,012	\$ 3,323	\$ 1,798	\$ 70,979	\$ 59,554
13	0.514	\$ 321		\$ -	\$ 3,102	\$ 3,423	\$ 1,760	\$ 74,401	\$ 61,314
14	0.489	\$ 330		\$ -	\$ 3,195	\$ 3,525	\$ 1,722	\$ 77,927	\$ 63,036
15	0.464	\$ 340		\$ -	\$ 3,291	\$ 3,631	\$ 1,685	\$ 81,558	\$ 64,722
16	0.441	\$ 351		\$ -	\$ 3,390	\$ 3,740	\$ 1,649	\$ 85,298	\$ 66,371
17	0.419	\$ 361		\$ -	\$ 3,491	\$ 3,852	\$ 1,614	\$ 89,150	\$ 67,985
18	0.398	\$ 372		\$ -	\$ 3,596	\$ 3,968	\$ 1,580	\$ 93,118	\$ 69,565
19	0.378	\$ 383		\$ -	\$ 3,704	\$ 4,087	\$ 1,546	\$ 97,205	\$ 71,111
20	0.359	\$ 395		\$ 4,309	\$ 3,815	\$ 8,519	\$ 3,062	\$ 105,724	\$ 74,172
21	0.341	\$ 406		\$ -	\$ 3,929	\$ 4,336	\$ 1,480	\$ 110,059	\$ 75,653
22	0.324	\$ 419		\$ -	\$ 4,047	\$ 4,466	\$ 1,449	\$ 114,525	\$ 77,102
23	0.308	\$ 431		\$ -	\$ 4,169	\$ 4,600	\$ 1,418	\$ 119,125	\$ 78,519
24	0.293	\$ 444		\$ -	\$ 4,294	\$ 4,738	\$ 1,388	\$ 123,863	\$ 79,907
25	0.278	\$ 457		\$ -	\$ 4,423	\$ 4,880	\$ 1,358	\$ 128,743	\$ 81,265
26	0.264	\$ 471		\$ -	\$ 4,555	\$ 5,026	\$ 1,329	\$ 133,769	\$ 82,594
27	0.251	\$ 485		\$ -	\$ 4,692	\$ 5,177	\$ 1,300	\$ 138,946	\$ 83,894
28	0.239	\$ 500		\$ -	\$ 4,833	\$ 5,332	\$ 1,273	\$ 144,279	\$ 85,167
29	0.227	\$ 515		\$ -	\$ 4,978	\$ 5,492	\$ 1,245	\$ 149,771	\$ 86,412
30	0.215	\$ 530		\$ -	\$ 5,127	\$ 5,657	\$ 1,219	\$ 155,428	\$ 87,631

Estimate - AACEI Class 10						
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024	
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Andrew Staples (HDR) Troy Gibbs (HDR)	
Description:	WQBE 05B - Media_Filter_Drain_ROW_No_Underdrain			Version:	Jess Dexheimer (HDR) 3	
CONSTRUCTION COSTS						
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost	
1	Media Filter Drain (MFD) - Till Soils	200	SF	\$	\$ -	
2	Facility Length	50	LF	\$	\$ -	
3	Facility Width	4	LF	\$	\$ -	
4	Shaping and compacting crushed gravel in non-vegetation zone @ 2'W X 50'LX0.5'D	2	CY	\$ 52	\$ 96	
5	Seeded Grass Strip @3'W X 50'L	17	SY	\$ 10	\$ 167	
6	Excavation to Waste - Grass Strip @ 3'W X 1'D X50'L	6	CY	\$ 79	\$ 439	
7	Soil Mix for Grass Strip @ 3'W X 1'D X50'L	6	CY	\$ 105	\$ 583	
8	Excavation to Waste MFD @4'WX50'LX1.25' Ave. Depth	9	CY	\$ 79	\$ 731	
9	Media Filter Drain Mix (dolomite, gypsum, perlite)	9	CY	\$ 197	\$ 1,824	
10						
11	Additional Costs				\$	-
12	Traffic Control (Heavy)	0.50	MO	\$ 20,000	\$ 10,000	
13	Removals @ 4% Construction Costs	4.0%	LS	\$ 3,841	\$ 154	
14	TESC @2% Construction Costs	2%	LS	\$ 13,994	\$ 280	
					\$	-
					\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	14,274
DIRECT: CONSTRUCTION COST MARK-UPS						
	General Conditions	0%	1	\$	\$ -	
	Mobilization/Demobilization	10%	1.1	\$	\$ 1,427	
	Overhead & Profit (OHP)	0%	1	\$	\$ -	
	Insurance	0.0%	1	\$	\$ -	
	Bonding	0.0%	1	\$	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$	15,702
<i>Direct: Subtotal Construction Costs (200 SF Area)</i>					\$	15,702

Description: WQBE 5B - Media Filter Drain - In ROW - No Underdrain

A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians (dual MFD), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system.

Cost Estimating Assumptions:

Facility design is per Ecology BMP T8.40
Installation is in ROW on the roadside and does not require easements or acquisition
Facility is sited on the roadside and assumes pavement restoration to accommodate the facility width.
A minimum of 12 inches of treatment media with mix of crushed rock, dolomite, gypsum and perlite (see table V-6.4) is used.
Treatment media mixture is assumed to be 75% crushed rock and 25% dolomite, gypsum and perlite (see quantities on table V-6.4 of Ecology manual)
The facility treatment area is 200 sf with a length of 50 linear feet and width of 4 feet
Facilities placed in till soils require an underdrain system, facilities located in outwash soils do not require an underdrain.
A total of 2 LF of 8-inch diameter storm pipe is required to connect to the storm or CSO main.
The excavated material is unsuitable for use as backfill.
A 3' wide grass strip will be installed next to treatment media
Removals are estimated at 3.5% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 1% of the construction costs.
The facility is located within the ROW and Traffic control is required
A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 16_Cistern_On Property (2023 Dollars)

Unit	1 Each
Initial Capital Cost	\$ 30,600
Capital cost	\$ 30,600 \$/Unit
Total Direct O&M/year	\$ 680
Direct O&M cost	\$ 680 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

No capital replacement cost

Description: WQBE 16_Cistern_On Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

2 Removal of all sediment and debris from storage area by crew of two, 1-hour of work annually.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch, crew of two, 3-hour work day
3 once every two years. Annual cost of cement patching mix or joint replacement of \$50

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Materials, Supplies, Other Costs

	\$ -	\$/year
Mulch and Media Replacement	2023 dollars	\$ 50 \$/year
	2023 dollars	\$ - \$/year
Subtotal		\$50
Labor		
Remove sediment and debris	2 hr	
Inspection and repair of piping, joints, and concrete	3 hr	
	hr	
	0 hr	
Total hours per year	5	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded) \$ 272	
Labor cost, burdened	O/H 150.0% \$ 680	\$
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30 years	

135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 2,379	\$ 32,345	\$ 65,324	\$ 46,075					
0	1.000	\$ 30,600		\$ 30,600	\$ 30,600	\$ 30,600	\$ 30,600	\$ 30,600	\$ 46,075
1	0.950	\$ 50		\$ 680	\$ 730	\$ 693	\$ 31,330	\$ 31,293	\$ 15,475
2	0.903	\$ 52		\$ 700	\$ 762	\$ 679	\$ 32,082	\$ 31,972	\$ 14,782
3	0.858	\$ 53		\$ 721	\$ 774	\$ 664	\$ 32,856	\$ 32,636	\$ 14,103
4	0.815	\$ 55		\$ 743	\$ 798	\$ 650	\$ 33,654	\$ 33,286	\$ 13,439
5	0.774	\$ 56		\$ 765	\$ 821	\$ 636	\$ 34,475	\$ 33,922	\$ 12,789
6	0.736	\$ 58		\$ 788	\$ 846	\$ 622	\$ 35,321	\$ 34,545	\$ 12,153
7	0.699	\$ 60		\$ 812	\$ 872	\$ 609	\$ 36,193	\$ 35,154	\$ 11,531
8	0.664	\$ 61		\$ 836	\$ 898	\$ 596	\$ 37,090	\$ 35,750	\$ 10,921
9	0.631	\$ 63		\$ 861	\$ 925	\$ 583	\$ 38,015	\$ 36,333	\$ 10,325
10	0.599	\$ 65		\$ 887	\$ 952	\$ 571	\$ 38,967	\$ 36,904	\$ 9,742
11	0.570	\$ 67		\$ 914	\$ 981	\$ 559	\$ 39,948	\$ 37,463	\$ 9,171
12	0.541	\$ 69		\$ 941	\$ 1,010	\$ 547	\$ 40,958	\$ 38,010	\$ 8,612
13	0.514	\$ 71		\$ 969	\$ 1,041	\$ 535	\$ 41,999	\$ 38,545	\$ 8,066
14	0.489	\$ 73		\$ 998	\$ 1,072	\$ 524	\$ 43,071	\$ 39,068	\$ 7,530
15	0.464	\$ 76		\$ 1,028	\$ 1,104	\$ 512	\$ 44,175	\$ 39,581	\$ 7,007
16	0.441	\$ 78		\$ 1,059	\$ 1,137	\$ 501	\$ 45,312	\$ 40,082	\$ 6,494
17	0.419	\$ 80		\$ 1,091	\$ 1,171	\$ 491	\$ 46,483	\$ 40,573	\$ 5,993
18	0.398	\$ 83		\$ 1,124	\$ 1,206	\$ 480	\$ 47,690	\$ 41,053	\$ 5,502
19	0.378	\$ 85		\$ 1,157	\$ 1,243	\$ 470	\$ 48,932	\$ 41,523	\$ 5,022
20	0.359	\$ 88		\$ 1,192	\$ 1,280	\$ 460	\$ 50,212	\$ 41,983	\$ 4,552
21	0.341	\$ 90		\$ 1,228	\$ 1,318	\$ 450	\$ 51,530	\$ 42,433	\$ 4,092
22	0.324	\$ 93		\$ 1,265	\$ 1,358	\$ 440	\$ 52,888	\$ 42,874	\$ 3,642
23	0.308	\$ 96		\$ 1,303	\$ 1,399	\$ 431	\$ 54,287	\$ 43,305	\$ 3,201
24	0.293	\$ 99		\$ 1,342	\$ 1,440	\$ 422	\$ 55,727	\$ 43,727	\$ 2,770
25	0.278	\$ 102		\$ 1,382	\$ 1,484	\$ 413	\$ 57,211	\$ 44,140	\$ 2,348
26	0.264	\$ 105		\$ 1,424	\$ 1,528	\$ 404	\$ 58,739	\$ 44,544	\$ 1,936
27	0.251	\$ 108		\$ 1,466	\$ 1,574	\$ 395	\$ 60,313	\$ 44,939	\$ 1,532
28	0.239	\$ 111		\$ 1,510	\$ 1,621	\$ 387	\$ 61,934	\$ 45,326	\$ 1,136
29	0.227	\$ 114		\$ 1,556	\$ 1,670	\$ 379	\$ 63,604	\$ 45,705	\$ 749
30	0.215	\$ 118		\$ 1,602	\$ 1,720	\$ 371	\$ 65,324	\$ 46,075	\$ 371

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Jeremy Hollingsworth (HDR) Ryan Oberg (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 16_Cistern_On Property		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
	Cistern On Property	1	EA	\$	-
	Cistern pad excavation and installation, hand (6'W x 6'L x 8"D)	0.9	CY	\$ 5,000	\$ 4,467
	Pipe excavation, shallow trench (40'L x 3'D x 1'W)	4.4	CY	\$ 53	\$ 236
	Cistern pad base rock (4")	0.4	CY	\$ 52	\$ 23
	Cistern pad reinforced concrete (6")	0.7	CY	\$ 950	\$ 633
				\$	-
	4" PVC piping			\$	-
	Down spout piping	10	FT	\$ 72	\$ 720
	Discharge piping	50	FT	\$ 72	\$ 3,600
	90 degree elbows	4	EA	\$ 120	\$ 480
	45 degree elbows	1	EA	\$ 86	\$ 86
	Tee	2	EA	\$ 120	\$ 240
	True union ball valve	1	EA	\$ 580	\$ 580
	Flanges	2	EA	\$ 100	\$ 200
	Orifice plate gasket	1	EA	\$ 185	\$ 185
				\$	-
	Cistern tank (56"D x 70"H, polyethylene water storage tank)	1	EA	\$ 2,600	\$ 2,600
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 14,049
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	1,405
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 15,454
Direct: Subtotal Construction Costs (1 EA)					\$ 15,454

Description: WQBE 16_Cistern_On Property

A shallow, landscaped depression with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile.

Cost Estimating Assumptions:

Cisterns are installed in accordance with Seattle Stormwater Manual and meet RainWise requirements.

Cistern is based on a vertical polyethylene water storage tank (+660 gallons).

Costs include delivery, which may vary by location.

Base for cistern is 6'H x 6'L x 6'W reinforced concrete pad. Pad is 4" above grade. Aggregate base layer for concrete pad is 6".

Pipe is 4" PVC pipe

Roof downspout is assumed to be 4" PVC pipe, 10' L with one 45 deg elbow.

Discharge and overflow piping is assumed to be 50'L to discharge point, with four 90 degree elbows, and one tee.

Flow control valve is a true union ball valve.

Excavation equals depth of pad and aggregate, size is footprint of concrete pad. Vertical excavation.

Excavation costs based on shallow trench excavation costs.

Discharge connection is to existing lateral, install 6" PVC tee with flange to connect to discharge piping.

No insulation is provided.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Updated on: 06/07/24

Updated on 7/21/24

Phase 2 Updated on: 5/6/21

Item No.	Action	Class	Difficulty	Description	Sub-Action Number	Subcategory	PHASE 3 COSTS (2023 dollars)							PHASE 2 COSTS (2019 Dollars)							
							Action Unit	Design Drainage Area	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)	Action Unit	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)
6	Drywell	Class 10	Low	WQBE_06A_Drywell on Property	6A	On property without Acquisition	1 Each	Till 261 SF; Outwash 780 SF	\$14,000	\$0	\$5,800	\$19,800	\$1,000	\$41,400	1 Each	\$11,000	\$0	\$5,000	\$16,000	\$1,800	\$53,000
				WQBE_06B_Drywell with Bioretention Planter on Property	6B	On property without Acquisition with Bioretention Planter	1 Each	Till 261 SF; Outwash 780 SF	\$30,200	\$0	\$12,600	\$42,800	\$1,500	\$76,000	1 Each	\$50,000	\$0	\$22,000	\$72,000	\$1,900	\$112,000
7	Deep UIC Wells	Class 10	Low	WQBE_07A_Deep UIC Well On Property	7A	On property without Acquisition	1 Each	NA	\$40,400	\$0	\$16,800	\$57,200	\$900	\$75,900	1 Each	\$32,000	\$0	\$14,000	\$46,000	\$2,000	\$86,000
				WQBE_07B_Deep UIC Well in ROW	7B	In ROW/Highway	1 Each	NA	\$58,000	\$0	\$23,900	\$81,900	\$900	\$100,600	1 Each	\$46,000	\$0	\$20,000	\$66,000	\$2,000	\$106,000
				WQBE_07C_Deep UIC Well With Property Cost	7C	On property with Acquisition	1 Each	NA	\$40,400	\$2,011	\$19,100	\$59,500	\$900	\$78,200	1 Each	\$32,000	\$1,400	\$16,000	\$48,000	\$2,000	\$88,000
				WQBE_07D_Deep UIC Well with Filter in ROW	7D	In ROW/Highway with High Rate Media Filter	1 EA/24 SF	52,164 SF	\$158,700	\$0	\$65,400	\$224,100	\$2,400	\$274,000	1 Each	\$142,000	\$0	\$62,000	\$204,000	\$4,900	\$303,000
				WQBE_07E_Deep UIC Well with Bioretention Planter in ROW	7E	In ROW/Highway with Bioretention Planter	1 EA/580 SF	54,546 SF	\$946,600	\$0	\$390,200	\$1,336,800	\$5,900	\$1,466,700	1 Each	\$762,000	\$0	\$333,000	\$1,095,000	\$6,800	\$1,239,000
				WQBE_07F_Deep UIC Well with Bioretention Planter on Property	7F	On property without Acquisition	1 Each/580 SF	54,546 SF	\$811,500	\$0	\$337,600	\$1,149,100	\$5,900	\$1,279,600							\$1,083,000
				WQBE_07G_Deep UIC Well with Filter on Property	7G	On property without Acquisition	1 Each/25 SF	52,164 SF	\$141,300	\$0	\$58,800	\$200,100	\$2,400	\$250,000	1 Each	\$650,000	\$0	\$287,000	\$938,000	\$6,800	\$1,083,000
8	Permeable Pavement	Class 10	Low	WQBE_08A_Pervious Concrete Sidewalk (no sand layer)	8A	Pervious Conc. Sidewalk (no sand layer)	200 SF	200 SF	\$11,200	\$0	\$4,600	\$15,800	\$2,300	\$75,700	200 SF	\$8,000	\$0	\$4,000	\$12,000	\$2,100	\$78,000
				WQBE_08B_Porous Asphalt Driveway (with sand layer)	8B	Porous Asp. Driveway (with sand layer)	200 SF	200 SF	\$5,900	\$0	\$2,400	\$8,300	\$2,300	\$63,800	200 SF	\$4,000	\$0	\$2,000	\$6,000	\$2,200	\$60,000
				WQBE_08C_Permeable Paver Driveway (with sand layer)	8C	Permeable Paver Driveway (with sand layer)	200 SF	200 SF	\$7,800	\$0	\$3,200	\$11,000	\$2,300	\$68,400	200 SF	\$3,000	\$0	\$1,000	\$4,000	\$2,100	\$55,000
				WQBE_08D_Permeable Paver Plaza (no sand layer)	8D	Permeable Paver Plaza (no sand layer)	200 SF	200 SF	\$6,700	\$0	\$2,800	\$9,500	\$2,300	\$64,800	200 SF	\$3,000	\$0	\$1,000	\$4,000	\$2,100	\$54,000
9	Depaving	Class 10	Low	WQBE_9A_Depaving on Property (wheel strips)	9A	Driveway Depaving w/Wheel Strips	100 SF	100 SF	\$1,800	\$0	\$800	\$2,600	\$700	\$16,800	100 SF	\$1,000	\$0	\$1,000	\$2,000	\$600	\$15,000
				WQBE_9B_Depaving on Property (no wheel strips)	9B	Driveway Depaving without Alt. Surface	100 SF	100 SF	\$1,400	\$0	\$600	\$2,000	\$700	\$16,200	100 SF	\$1,000	\$0	\$1,000	\$2,000	\$600	\$15,000
21	High Rate Underground Filter System	Class 10	Low	WQBE_21A_High Rate Underground Filter in Urban ROW CCP	21A	Public ROW with CCP - Urban ROW	1 Each	34,956 SF	\$147,500	\$0	\$60,800	\$208,300	\$2,500	\$262,000	1 Each	\$120,000	\$0	\$75,000	\$195,000	\$2,900	\$254,000
				WQBE_21B_High Rate Underground Filter In Highway ROW CCP	21B	Public ROW with CCP - Highway ROW	1 Each	34,956 SF	\$108,500	\$0	\$44,800	\$153,300	\$2,500	\$207,000	1 Each	\$89,000	\$0	\$56,000	\$145,000	\$2,900	\$204,000
				WQBE_21C_High Rate Underground Filter In Urban ROW HMA	21C	Public ROW with HMA - Urban ROW	1 Each	34,956 SF	\$106,000	\$0	\$43,700	\$149,700	\$2,500	\$203,400	1 Each	\$86,000	\$0	\$54,000	\$140,000	\$2,900	\$199,000
				WQBE_21D_High Rate Underground Filter In Highway ROW HMA	21D	Public ROW with HMA - Highway ROW	1 Each	34,956 SF	\$96,100	\$0	\$39,600	\$135,700	\$2,500	\$189,400	1 Each	\$79,000	\$0	\$50,000	\$129,000	\$2,900	\$188,000
				WQBE_21E_High Rate Underground Filter On Public Property	21E	On property without Acquisition	1 Each	34,956 SF	\$73,300	\$0	\$30,500	\$103,800	\$2,500	\$157,500	1 Each	\$64,000	\$0	\$42,000	\$106,000	\$2,900	\$165,000
				WQBE_21F_High Rate Underground Filter with Property Cost	21F	On Property with Acquisition	1 Each	34,956 SF	\$73,300	\$1,287	\$32,000	\$105,300	\$2,500	\$159,000	1 Each	\$64,000	\$900	\$43,000	\$107,000	\$2,900	\$166,000

MANDATORY INPUTS		
Input Category	Inputs	Comments
Retail Sales Tax Rate	10.25%	Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle
Allowance for Indeterminates (AFI), Dependent Upon Project Phase	15%	Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%)
Construction Change Order Allowance	10%	
Project Contingency	15%	<Override Value due to lack of complexity, controlled location and application with developed design and construction methods.

SECONDARY INPUTS		
Input Category	Inputs	Comments
Street Use Permit	\$ 700	In ROW only - Arterial @ \$700/Unit; Non-Arterial @use \$300/unit
Outside Agency Construction	2%	For Projects in ROW Utility coordination assumed to be at 2% construction cost.

PROJECT CATEGORY AND INDIRECT PROJECT INPUTS		
Input Category	Inputs	Comments

PROPERTY COST

Cost Category	\$/sf
Low	\$ 10.10
Medium	\$ 80.43
High	\$ 284.37
None	\$ -

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Royce Robertson (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_06A_Drywell_on Property		Version:	3	
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Drywell on Property (4 Ft Dia. and 6 Ft. Depth)	1	EA	\$ 10,052	\$ 10,052
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				<i>Subtotal Construction Costs</i>	\$ 10,052
				Allowance for Indeterminates (Design Allowance)	\$ 1,508
				Street Use Permit (Y/N) N	\$ -
				<i>ESTIMATED PROBABLE COST OF CONSTRUCTION BID</i>	\$ 11,559
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
				Construction Change Order Allowance	\$ 1,156
				<i>Subtotal Primary Construction Amount</i>	\$ 12,715
				Construction Sales Tax	\$ 1,303
				Outside Agency Construction	\$ -
				<i>TOTAL DIRECT CONSTRUCTION COSTS</i>	\$ 14,000
INDIRECT: NON-CONSTRUCTION COSTS					
				Design Engineering	\$ 1,526
				Construction Management	\$ 1,017
				Permitting & Support	\$ 64
	s.f. Land Area	None		Land Purchase/ROW Acquisition	\$ -
				WTD Staff Costs & Non-WTD Support	\$ 636
				<i>Subtotal Non-Construction Costs</i>	\$ 3,242
				Project Contingency	\$ 2,586
				<i>TOTAL INDIRECT NON-CONSTRUCTION COSTS</i>	\$ 5,800
				<i>TOTAL PROJECT COST (2023 Dollars)</i>	\$ 19,800

Description: WQBE 06A Drywell on Property (2023 Dollars)

	Unit	1	Each
Initial Capital Cost	\$	19,800	
Capital cost	\$	19,800	/Unit
Total Direct O&M/year	\$	544	
Direct O&M cost	\$	544	/Unit
Capital Replacement Costs (10 Years)	\$	-	/unit
Discount rate (%)		5.25	

Replacement Costs (N/A for drywell)

Description: WQBE 06A Drywell on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm
2 events by a crew of two w/vactor truck (2 visits per year, 0.5 hour per visit). Total for equipment \$360.
Inspection and removal of roots that reduce free movement of water through pipes by a crew of two (1 visits
1 per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year.

Total Cost (NPV)	\$ 41,400	\$/unit
Annual O&M Cost	\$ 1,000	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

	2023 dollars	\$ -	\$/year
Annual Costs	2023 dollars	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$473	
Labor			
Remove Trash from structure & roots from piping	4 hr		
	0 hr		
	0 hr		
	hr		
Total hours per year	4		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 218	
Labor cost, burdened	O/H 150.0%	\$ 544	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Replacement Assumptions:

No capital replacement costs with this Action.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 22,503		\$ 25,876	\$ 68,179	\$ 41,361				
0	1.000	\$ 19,800		\$ 19,800	\$ 19,800	\$ 19,800	\$ 19,800	\$ 19,800	\$ 41,361
1	0.950	\$ 473	\$ -	\$ 544	\$ 1,017	\$ 966	\$ 20,817	\$ 20,766	\$ 21,561
2	0.903	\$ 487	\$ -	\$ 560	\$ 1,047	\$ 946	\$ 21,864	\$ 21,712	\$ 20,595
3	0.858	\$ 502	\$ -	\$ 577	\$ 1,079	\$ 925	\$ 22,943	\$ 22,637	\$ 19,649
4	0.815	\$ 517	\$ -	\$ 594	\$ 1,111	\$ 906	\$ 24,054	\$ 23,543	\$ 18,724
5	0.774	\$ 532	\$ -	\$ 612	\$ 1,145	\$ 886	\$ 25,199	\$ 24,429	\$ 17,818
6	0.736	\$ 548	\$ -	\$ 631	\$ 1,179	\$ 867	\$ 26,378	\$ 25,296	\$ 16,932
7	0.699	\$ 565	\$ -	\$ 649	\$ 1,214	\$ 849	\$ 27,592	\$ 26,145	\$ 16,065
8	0.664	\$ 582	\$ -	\$ 669	\$ 1,251	\$ 831	\$ 28,843	\$ 26,975	\$ 15,216
9	0.631	\$ 599	\$ -	\$ 689	\$ 1,288	\$ 813	\$ 30,131	\$ 27,788	\$ 14,386
10	0.599	\$ 617	\$ -	\$ 710	\$ 1,327	\$ 795	\$ 31,458	\$ 28,583	\$ 13,573
11	0.570	\$ 636	\$ -	\$ 731	\$ 1,367	\$ 778	\$ 32,824	\$ 29,362	\$ 12,773
12	0.541	\$ 655	\$ -	\$ 753	\$ 1,408	\$ 762	\$ 34,233	\$ 30,124	\$ 11,993
13	0.514	\$ 674	\$ -	\$ 775	\$ 1,450	\$ 745	\$ 35,682	\$ 30,869	\$ 11,237
14	0.489	\$ 695	\$ -	\$ 799	\$ 1,493	\$ 730	\$ 37,175	\$ 31,599	\$ 10,492
15	0.464	\$ 715	\$ -	\$ 823	\$ 1,538	\$ 714	\$ 38,713	\$ 32,313	\$ 9,762
16	0.441	\$ 737	\$ -	\$ 847	\$ 1,584	\$ 699	\$ 40,299	\$ 33,011	\$ 9,048
17	0.419	\$ 759	\$ -	\$ 873	\$ 1,632	\$ 684	\$ 41,929	\$ 33,695	\$ 8,350
18	0.398	\$ 782	\$ -	\$ 899	\$ 1,681	\$ 669	\$ 43,610	\$ 34,364	\$ 7,666
19	0.378	\$ 805	\$ -	\$ 926	\$ 1,731	\$ 655	\$ 45,341	\$ 35,019	\$ 6,997
20	0.359	\$ 829	\$ -	\$ 954	\$ 1,783	\$ 641	\$ 47,124	\$ 35,660	\$ 6,342
21	0.341	\$ 854	\$ -	\$ 982	\$ 1,837	\$ 627	\$ 48,961	\$ 36,287	\$ 5,707
22	0.324	\$ 880	\$ -	\$ 1,012	\$ 1,892	\$ 614	\$ 50,853	\$ 36,901	\$ 5,074
23	0.308	\$ 906	\$ -	\$ 1,042	\$ 1,948	\$ 601	\$ 52,801	\$ 37,501	\$ 4,460
24	0.293	\$ 934	\$ -	\$ 1,073	\$ 2,007	\$ 588	\$ 54,808	\$ 38,089	\$ 3,860
25	0.278	\$ 962	\$ -	\$ 1,106	\$ 2,067	\$ 575	\$ 56,875	\$ 38,664	\$ 3,272
26	0.264	\$ 990	\$ -	\$ 1,139	\$ 2,129	\$ 563	\$ 59,005	\$ 39,227	\$ 2,697
27	0.251	\$ 1,020	\$ -	\$ 1,173	\$ 2,193	\$ 551	\$ 61,198	\$ 39,778	\$ 2,134
28	0.239	\$ 1,051	\$ -	\$ 1,208	\$ 2,259	\$ 539	\$ 63,456	\$ 40,317	\$ 1,583
29	0.227	\$ 1,082	\$ -	\$ 1,244	\$ 2,327	\$ 528	\$ 65,783	\$ 40,845	\$ 1,044
30	0.215	\$ 1,115	\$ -	\$ 1,282	\$ 2,396	\$ 516	\$ 68,179	\$ 41,361	\$ 516

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE_06A_Drywell_on Property			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Drywell on Property (4' Diameter)	6	VF	\$ 79	\$ -
2	Drywell Footprint Area	13	SF	\$ -	\$ -
3	Top Excavation Area Footprint @ 0.5:1	50	SF	\$ -	\$ -
4	Facility Excavation to Backfill and to Waste @ 8' D w/0.5:1 slope	9	CY	\$ 79	\$ 737
5	Drywell Washed Drain Rock	3	CY	\$ 118	\$ 341
6	Geotextile - Drywell Filter Fabric (assumed covers entire surface area w/overlap)	11	SY	\$ 4	\$ 45
7	Observation Port	1	EA	\$ 677	\$ 677
8	Grass Seeding and Restoration (disturbed area @ 15'X15')	25	SY	\$ 10	\$ 250
9				\$ -	\$ -
10	Pipe Inlet Items:			\$ -	\$ -
11	Catch Basin/Yard Drain	1	EA	\$ 3,900	\$ 3,900
12	8" PVC pipe from Yard Drain to Drywell	25	LF	\$ 80	\$ 2,000
13	Trench Exc and Backfill (3'W X 3' D)	8	CY	\$ 79	\$ 658
14	Grass Seeding and Restoration (pipe area)	1	SY	\$ 10	\$ 6
15				\$ -	\$ -
16	Additional Costs			\$ -	\$ -
17	Removals @4% Construction Costs	4.0%	LS	\$ 8,614	\$ 345
18	TESC @2% Construction Costs	2%	LS	\$ 8,959	\$ 179
				\$ -	\$ -
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 9,138
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	
	Mobilization/Demobilization	10%	1.1	\$ 914	
	Overhead & Profit (OHP)	0%	1	\$ -	
	Insurance	0.0%	1	\$ -	
	Bonding	0.0%	1	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 10,052
<i>Direct: Subtotal Construction Costs</i>					\$ 10,052

Description: WQBE_06A_Drywell_on Property

A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

Cost Estimating Assumptions:

Facility design is per Seattle SW Manual Section 5.4.3.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

It is assumed that the insitu soils and location will be suitable for drywell installation.

It is assumed that groundwater conditions will be suitable for drywell installation.

Pretreatment is not included in the cost model.

The drywell facility is 4 feet in diameter and 6 feet in depth.

Excavation is by open trench with temporary construction slopes assumed a 0.5:1. Slopes design may vary based on conditions and shall conform to OSHA, L&I and other safety requirements.

There is approximately 2 feet of cover over the drywell.

A catch basin (yard drain) and approximately 25 LF of 8" PVC are included in the cost model.

The excavated material will be suitable for use as backfill. Material not used for backfill will be disposed of in accordance with applicable regulations.
Dewatering is not required

The trenches are shallow and it is assumed that shoring is not required.

Seeded grass restoration is required for areas disturbed during construction.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE 06B Drywell with Bioretention Planter on Property			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Drywell on Property with Bioretention Planter (4 s.f. bottom area)	1	EA	\$ 21,633	\$ 21,633
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 21,633
	Allowance for Indeterminates (Design Allowance)			\$	3,245
	Street Use Permit (Y/N)		N	\$	-
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID			\$	24,878
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	2,488
	Subtotal Primary Construction Amount			\$	27,366
	Construction Sales Tax			\$	2,805
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	30,200
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	3,284
	Construction Management			\$	2,189
	Permitting & Support			\$	137
	s.f. Land Area	None	Land Purchase/ROW Acquisition	\$	-
	WTD Staff Costs & Non-WTD Support			\$	1,368
	Subtotal Non-Construction Costs			\$	6,978
	Project Contingency			\$	5,577
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	12,600
	TOTAL PROJECT COST (2023 Dollars)			\$	42,800

Description: WQBE 06B Drywell with Bioretention Planter on Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 42,800
Capital cost	\$ 42,800 \$/Unit
Total Direct O&M/Year	\$ 952
Direct O&M cost	\$ 952 \$/Unit
Capital Replacement Costs (10 Years)	\$ 763 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 76,000	\$/unit
Annual O&M Cost	\$ 1,500	\$/year
Annualized Cost	\$920	\$/year

Materials, Supplies, Other Costs

Miscellaneous drainage parts in drywell	2023 dollars	\$ 113	\$/year
Remediation of mulch/media and planting & Misc Drainage Parts	2023 dollars	\$ 106	
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$ 581	
Labor			
Drywell O&M		3 hr	
Bioretention Planter O&M		4 hr	
		hr	
Activity		0 hr	
Total hours per year		7	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 381	
Labor cost, burdened	O/H 150.0%	\$ 952	\$ 135.98
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 27,641		\$ 45,283	\$ 117,250	\$ 76,031			
0	1.000	\$ 42,800			\$ 42,800	\$ 42,800	\$ 42,800	\$ 42,800	\$ 76,031
1	0.950	\$581	\$ -	\$ 952	\$ 1,533	\$ 1,456	\$ 44,333	\$ 44,256	\$ 33,231
2	0.903	\$ 598	\$ -	\$ 980	\$ 1,579	\$ 1,425	\$ 45,912	\$ 45,682	\$ 31,775
3	0.858	\$ 616	\$ -	\$ 1,010	\$ 1,626	\$ 1,395	\$ 47,538	\$ 47,076	\$ 30,350
4	0.815	\$ 635	\$ -	\$ 1,040	\$ 1,675	\$ 1,365	\$ 49,213	\$ 48,441	\$ 28,955
5	0.774	\$ 654	\$ -	\$ 1,071	\$ 1,725	\$ 1,336	\$ 50,938	\$ 49,777	\$ 27,590
6	0.736	\$ 674	\$ -	\$ 1,103	\$ 1,777	\$ 1,307	\$ 52,715	\$ 51,084	\$ 26,254
7	0.699	\$ 694	\$ -	\$ 1,137	\$ 1,830	\$ 1,279	\$ 54,545	\$ 52,364	\$ 24,947
8	0.664	\$ 715	\$ -	\$ 1,171	\$ 1,885	\$ 1,252	\$ 56,430	\$ 53,615	\$ 23,668
9	0.631	\$ 736	\$ -	\$ 1,206	\$ 1,942	\$ 1,225	\$ 58,372	\$ 54,841	\$ 22,416
10	0.599	\$ 758	\$ 763	\$ 1,242	\$ 2,763	\$ 1,656	\$ 61,135	\$ 56,497	\$ 21,191
11	0.570	\$ 781	\$ -	\$ 1,279	\$ 2,060	\$ 1,173	\$ 63,195	\$ 57,670	\$ 19,534
12	0.541	\$ 804	\$ -	\$ 1,318	\$ 2,122	\$ 1,148	\$ 65,317	\$ 58,818	\$ 18,361
13	0.514	\$ 828	\$ -	\$ 1,357	\$ 2,185	\$ 1,124	\$ 67,502	\$ 59,942	\$ 17,213
14	0.489	\$ 853	\$ -	\$ 1,398	\$ 2,251	\$ 1,100	\$ 69,753	\$ 61,042	\$ 16,089
15	0.464	\$ 879	\$ -	\$ 1,440	\$ 2,319	\$ 1,076	\$ 72,072	\$ 62,118	\$ 14,989
16	0.441	\$ 905	\$ -	\$ 1,483	\$ 2,388	\$ 1,053	\$ 74,460	\$ 63,171	\$ 13,913
17	0.419	\$ 932	\$ -	\$ 1,527	\$ 2,460	\$ 1,031	\$ 76,919	\$ 64,202	\$ 12,860
18	0.398	\$ 960	\$ -	\$ 1,573	\$ 2,534	\$ 1,009	\$ 79,453	\$ 65,210	\$ 11,829
19	0.378	\$ 989	\$ -	\$ 1,620	\$ 2,610	\$ 987	\$ 82,063	\$ 66,198	\$ 10,821
20	0.359	\$ 1,019	\$ 763	\$ 1,669	\$ 3,451	\$ 1,240	\$ 85,513	\$ 67,438	\$ 9,834
21	0.341	\$ 1,049	\$ -	\$ 1,719	\$ 2,768	\$ 945	\$ 88,282	\$ 68,383	\$ 8,594
22	0.324	\$ 1,081	\$ -	\$ 1,771	\$ 2,852	\$ 925	\$ 91,133	\$ 69,308	\$ 7,648
23	0.308	\$ 1,113	\$ -	\$ 1,824	\$ 2,937	\$ 905	\$ 94,070	\$ 70,213	\$ 6,723
24	0.293	\$ 1,147	\$ -	\$ 1,879	\$ 3,025	\$ 886	\$ 97,095	\$ 71,099	\$ 5,818
25	0.278	\$ 1,181	\$ -	\$ 1,935	\$ 3,116	\$ 867	\$ 100,211	\$ 71,966	\$ 4,932
26	0.264	\$ 1,216	\$ -	\$ 1,993	\$ 3,209	\$ 848	\$ 103,421	\$ 72,815	\$ 4,065
27	0.251	\$ 1,253	\$ -	\$ 2,053	\$ 3,306	\$ 830	\$ 106,726	\$ 73,645	\$ 3,216
28	0.239	\$ 1,291	\$ -	\$ 2,114	\$ 3,405	\$ 813	\$ 110,131	\$ 74,458	\$ 2,386
29	0.227	\$ 1,329	\$ -	\$ 2,178	\$ 3,507	\$ 795	\$ 113,638	\$ 75,253	\$ 1,573
30	0.215	\$ 1,369	\$ -	\$ 2,243	\$ 3,612	\$ 778	\$ 117,250	\$ 76,031	\$ 778

Description: WQBE 06B Drywell with Bioretention Planter on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost. Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions (Drywell):

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two w/vactor truck (2 visits per year, 0.5 hour per visit). Total for equipment \$360. Inspection and removal of roots that reduce free movement of water through pipes by a crew of two (1 visits 1 per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year.

O&M Estimating Assumptions (Planter):

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. This task will be executed in the same hours as already set aside for Drywell maintenance. Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth). This task will be executed in the same hours as already set aside for Drywell maintenance.

- 4 Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events. This task will be executed in the same hours as already set aside for Drywell maintenance. Annual plant replacement will cost \$54. Comprised of (1) small plant replacement at \$54/each.

Replacement Assumptions:

Replacement of treatment media, compost, and vegetation will take place every ten years.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE 06B Drywell with Bioretention Planter on Property			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Drywell on Property (4' Diameter)	6	VF	\$	-
2	Drywell Footprint Area	13	SF	\$	-
3	Top Excavation Area Footprint @ 0.5:1	50	SF	\$	-
4	Facility Excavation to Backfill and to Waste @ 8' D w/0.5:1 slope	9	CY	\$ 79	\$ 737
5	Drywell Washed Drain Rock	3	CY	\$ 118	\$ 341
6	Geotextile - Drywell Filter Fabric (assumed covers entire surface area w/overlap)	11	SY	\$ 4	\$ 45
7	Observation Port	1	EA	\$ 677	\$ 677
8	Grass Seeding and Restoration (disturbed area @ 15'X15')	25	SY	\$ 10	\$ 250
9			\$	-	\$ -
10	Drywell Pipe Inlet Items (Also Bioretention Planter Outlet Pipe):		\$	-	\$ -
11	Catch Basin/Yard Drain	1	EA	\$ 3,900	\$ 3,900
12	8" PVC pipe from Yard Drain to Drywell	50	LF	\$ 80	\$ 4,000
13	Trench Exc and Backfill (3'W X 3' D)	65	CY	\$ 79	\$ 5,120
14	Grass Seeding and Restoration (pipe area)	1	SY	\$ 10	\$ 6
15			\$	-	\$ -
16	Bioretention Planter - Property	4	SF	\$ -	\$ -
17	Bioretention Planter Unit: 2'W X 2'L X 2'D	2	LF	\$ -	\$ -
18	Curbed, vertical sides - Top Area	4	SF	\$ -	\$ -
19	Structural Excavation to Waste (8'W X8'L X 6'D)	14	CY	\$ 79	\$ 1,124
20	Imported Structural Fill (Bioretention Planter: 2'W X 2'L X 4.7'D)	1	CY	\$ 44	\$ 31
21	Formed Concrete Walls (4" walls: 8'L X 4.7'D)	0.5	CY	\$ 1,560	\$ 724
22	Formed Concrete Base (4" base: 2.6'W X 2.6'L)	0.1	CY	\$ 590	\$ 49
23	Treatment Media (2'W X 2'L X 1.5'D) w/ biochar	0.2	CY	\$ 270	\$ 60
24	Mulch Compost (@ 0.3'D)	0.04	CY	\$ 86	\$ 4
25	Vegetated Entrance	0.4	SY	\$ 2	\$ 1
26	Trench Shoring Facility	72	SF	\$ 10	\$ 720
27			\$	-	\$ -
28	Underdrain Items:	2	LF	\$ -	\$ -
29	Underdrain Aggregate (2'W X 2' LX 2.2'D)	0.3	CY	\$ 133	\$ 43
30	Overflow & Drain Pipe 8" Dia. (4' + 2')	6	LF	\$ 48	\$ 288
31			\$	-	\$ -
32	Bioretention Planter Restoration:		\$	-	\$ -
33	Landscaping, Planting, and Restoration (10'X10')	7	SY	\$ 59	\$ 420
34	Trees (Not in Design Basis)	0	EA	\$ 720	\$ -
41					
42					\$ -
43	Additional Costs				\$ -
44	Removals @ 4% Construction Costs	4.0%	LS	\$ 18,539	\$ 742
45	TESC @2% Construction Costs	2.0%	LS	\$ 19,281	\$ 386
					\$ -
Item Subtotal Construction Costs (Year 2023)					\$ 19,667
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	1,967
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 21,633
Direct: Subtotal Construction Costs					\$ 21,633

Description: WQBE 6B - Drywell with Bioretention Planter on Property

A shallow, landscaped depression with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile. The drywell component conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

Cost Estimating Assumptions:**General:**

Dewatering is not required

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

A street use permit is not required.

Bioretention Planter:

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)

Filter fabrics not used between the subgrade and the Bioretention Soil Mix

Bioretention Planter facility is sited in an open space with outlet pipe beneath a parking area

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The bioretention facility treatment area is 4 sf with curbed, vertical sides.

A maximum bioretention ponding depth of 6" and a 12" of freeboard depth are assumed.

Bioretention Planter facilities have a closed bottom and include an underdrain.

A catch basin (yard drain) and a total of 50 LF of 8" storm pipe is required to connect the bioretention planter to the drywell structure.

The bioretention planter excavated material is unsuitable for use as backfill.

Bioretention excavation width of 3 feet is assumed on each side of the box.

The piping is on open property and assumed can be constructed with open cut.

Parking lot restoration is assumed for the bioretention outlet pipe and consists of 4" HMA/4" CSTM.

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Landscape restoration is required for the bioretention facility, earth berm and area of disturbance. Assume landscape and restoration area of disturbance @ 10'X10'.

Drywell:

Drywell Facility design is per Seattle SW Manual Section 5.4.3.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

It is assumed that the insitu soils and location will be suitable for drywell installation.

It is assumed that groundwater conditions will be suitable for drywell installation.

It is assumed that pretreatment is included in the cost model.

The drywell facility is 4 feet in diameter and 6 feet in depth.

Excavation is by open trench with temporary construction slopes assumed a 0.5:1. Slopes design may vary based on conditions and shall conform to OSHA, L&I and other safety requirements.

There is approximately 2 feet of cover over the drywell.

The drywell catch basin and piping are combined with piping to connect to the bioretention planter.

The drywell excavated material will be suitable for use as backfill. Material not used for backfill will be disposed of in accordance with applicable regulations.

Dewatering is not required

The trenches are shallow and it is assumed that shoring is not required.

Seeded grass restoration is required for areas disturbed during construction.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE 07_A - Deep UIC Well On Property			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Deep UIC Well Installation (20 VF Depth) - On property	1	EA	\$ 28,941	\$ 28,941
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 28,941
	Allowance for Indeterminates (Design Allowance)			\$	4,341
	Street Use Permit (Y/N)	N		\$	-
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID			\$	33,282
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	3,328
	Subtotal Primary Construction Amount			\$	36,610
	Construction Sales Tax			\$	3,753
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	40,400
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	4,393
	Construction Management			\$	2,929
	Permitting & Support			\$	183
	s.f. Land Area	None		Land Purchase/ROW Acquisition	\$ -
	WTD Staff Costs & Non-WTD Support			\$	1,831
	Subtotal Non-Construction Costs			\$	9,336
	Project Contingency			\$	7,460
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	16,800
	TOTAL PROJECT COST (2023 Dollars)			\$	57,200

Description: WQBE 07A - Deep UIC Well On Property (2023 Dollars)

	Unit	1 EA
Initial Capital Cost	\$ 57,200	
Capital cost	\$ 57,200.00	/Unit
Total Direct O&M/year	\$ 408	
Direct O&M/cost	\$ 408	/Unit
Capital Replacement Costs (10 Years)	\$ -	/unit
Discount rate (%)	5.25	

Replacement Costs (N/A for UIC well)

Total Cost (NPV)	\$ 75,900	\$/unit
Annual O&M Cost	\$ 900	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

Material, Equipment, Other Costs	Cost Details	\$ -	\$/year
Annual Costs	2023 dollars	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal			\$473
Labor			
Remove Trash from structure & roots from piping		3 hr	
		0 hr	
		0 hr	
Activity		0 hr	
Total hours per year		3	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 163	
Labor cost, burdened	O/H 150.0%	\$ 408	\$
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

Description: WQBE 07A - Deep UIC Well_On_Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost. Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.

2 Total for equipment \$360.

Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of 1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 19,407	\$ 99,110	\$ 75,878			
0	1.00	\$ 57,200			\$ 57,200	\$ 57,200	\$ 57,200	\$ 57,200	\$ 75,878
1	0.950	\$ 473	\$ -	\$ 408	\$ 881	\$ 837	\$ 58,081	\$ 58,037	\$ 18,678
2	0.903	\$ 487	\$ -	\$ 420	\$ 907	\$ 819	\$ 58,988	\$ 58,856	\$ 17,841
3	0.858	\$ 502	\$ -	\$ 433	\$ 935	\$ 802	\$ 59,923	\$ 59,658	\$ 17,022
4	0.815	\$ 517	\$ -	\$ 446	\$ 963	\$ 784	\$ 60,885	\$ 60,442	\$ 16,220
5	0.774	\$ 532	\$ -	\$ 459	\$ 991	\$ 768	\$ 61,877	\$ 61,210	\$ 15,436
6	0.736	\$ 548	\$ -	\$ 473	\$ 1,021	\$ 751	\$ 62,898	\$ 61,961	\$ 14,668
7	0.699	\$ 565	\$ -	\$ 487	\$ 1,052	\$ 735	\$ 63,950	\$ 62,698	\$ 13,917
8	0.664	\$ 582	\$ -	\$ 502	\$ 1,083	\$ 719	\$ 65,033	\$ 63,416	\$ 13,182
9	0.631	\$ 599	\$ -	\$ 517	\$ 1,116	\$ 704	\$ 66,148	\$ 64,120	\$ 12,462
10	0.599	\$ 617	\$ -	\$ 532	\$ 1,149	\$ 684	\$ 67,299	\$ 64,809	\$ 11,758
11	0.570	\$ 636	\$ -	\$ 548	\$ 1,184	\$ 674	\$ 68,483	\$ 65,483	\$ 11,069
12	0.541	\$ 655	\$ -	\$ 565	\$ 1,219	\$ 660	\$ 69,702	\$ 66,143	\$ 10,395
13	0.514	\$ 674	\$ -	\$ 582	\$ 1,256	\$ 646	\$ 70,958	\$ 66,789	\$ 9,735
14	0.489	\$ 695	\$ -	\$ 599	\$ 1,294	\$ 632	\$ 72,252	\$ 67,421	\$ 9,089
15	0.464	\$ 715	\$ -	\$ 617	\$ 1,332	\$ 618	\$ 73,584	\$ 68,039	\$ 8,457
16	0.441	\$ 737	\$ -	\$ 636	\$ 1,372	\$ 605	\$ 74,957	\$ 68,645	\$ 7,838
17	0.419	\$ 759	\$ -	\$ 655	\$ 1,414	\$ 592	\$ 76,370	\$ 69,237	\$ 7,233
18	0.398	\$ 782	\$ -	\$ 674	\$ 1,456	\$ 580	\$ 77,826	\$ 69,817	\$ 6,641
19	0.378	\$ 805	\$ -	\$ 694	\$ 1,500	\$ 567	\$ 79,326	\$ 70,384	\$ 6,061
20	0.359	\$ 829	\$ -	\$ 715	\$ 1,545	\$ 555	\$ 80,871	\$ 70,939	\$ 5,494
21	0.341	\$ 854	\$ -	\$ 737	\$ 1,591	\$ 543	\$ 82,462	\$ 71,482	\$ 4,939
22	0.324	\$ 880	\$ -	\$ 759	\$ 1,639	\$ 532	\$ 84,101	\$ 72,014	\$ 4,396
23	0.308	\$ 906	\$ -	\$ 782	\$ 1,688	\$ 520	\$ 85,789	\$ 72,534	\$ 3,864
24	0.293	\$ 934	\$ -	\$ 805	\$ 1,739	\$ 509	\$ 87,527	\$ 73,043	\$ 3,344
25	0.278	\$ 962	\$ -	\$ 829	\$ 1,791	\$ 498	\$ 89,318	\$ 73,542	\$ 2,834
26	0.264	\$ 990	\$ -	\$ 854	\$ 1,844	\$ 488	\$ 91,162	\$ 74,029	\$ 2,336
27	0.251	\$ 1,020	\$ -	\$ 880	\$ 1,900	\$ 477	\$ 93,062	\$ 74,507	\$ 1,848
28	0.239	\$ 1,051	\$ -	\$ 906	\$ 1,957	\$ 467	\$ 95,019	\$ 74,974	\$ 1,371
29	0.227	\$ 1,082	\$ -	\$ 933	\$ 2,015	\$ 457	\$ 97,034	\$ 75,431	\$ 904
30	0.215	\$ 1,115	\$ -	\$ 961	\$ 2,076	\$ 447	\$ 99,110	\$ 75,878	\$ 447

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE 07_A - Deep UIC Well_On_Property			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	20 FT Deep UIC Well - On Property	20	VF	\$ -	\$ -
2	Well - Borehole Diameter (12")	1	FT	\$ -	\$ -
3	Well - Casing Diameter	0.7	FT	\$ -	\$ -
4	Drilling (12" Diameter Borehole)	20	VF	\$ 135	\$ 2,700
5	Well Casing (8-inch Diameter)	3	VF	\$ 59	\$ 177
6	Well Screen	20	VF	\$ 353	\$ 7,060
7	Maintenance Hole, Type 204A	1	EA	\$ 6,780	\$ 6,780
8	Misc Deep Well Costs	1	EA	\$ 3,710	\$ 3,710
9				\$ -	\$ -
10	Facility Removals and Restoration:			\$ -	\$ -
11	Clearing and Grubbing	69	SY	\$ 4	\$ 278
12	Landscaping and Restoration (25'WX25'L)	69	SY	\$ 59	\$ 4,097
13				\$ -	\$ -
14	Additional Costs			\$ -	\$ -
15	Removals @ 4% Construction Costs	4.0%	LS	\$ 24,802	\$ 992
16	TESC @2% Construction Costs	2%	LS	\$ 25,794	\$ 516
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 26,310
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%		1	\$ -
	Mobilization/Demobilization	10%		1.1	\$ 2,631
	Overhead & Profit (OHP)	0%		1	\$ -
	Insurance	0.0%		1	\$ -
	Bonding	0.0%		1	\$ -
	Escalation Multiplier from ENR-CCI	0%		1.0000	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 28,941
Direct: Subtotal Construction Costs					\$ 28,941

Description: WQBE 07A - Deep UIC Well_On_Property

Wells that extend below an upper confining layer and discharge into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below.

Cost Estimating Assumptions:

Facility design is per 2019 Ecology Stormwater Management Manual.

Assumed depth of facility is 20 feet with a 12" diameter borehole.

All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

Cost is for Deep UIC well only and the cost for an inlet pipe or required pretreatment are not included.

The excavated material is unsuitable for use as backfill.

Landscape restoration is required for the area of disturbance.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on Property and Traffic control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE_07B_Deep UIC Well in_ROW			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Deep UIC Well in ROW (20 VF Depth)	1	EA	\$ 40,484	\$ 40,484
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 40,484
				Allowance for Indeterminates (Design Allowance)	\$ 6,073
				Street Use Permit (Y/N)	Y \$ 700
				ESTIMATED PROBABLE COST OF CONSTRUCTION BID	\$ 47,257
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
				Construction Change Order Allowance	\$ 4,656
				Subtotal Primary Construction Amount	\$ 51,912
				Construction Sales Tax	\$ 5,249
				Outside Agency Construction	\$ 810
				TOTAL DIRECT CONSTRUCTION COSTS	\$ 58,000
INDIRECT: NON-CONSTRUCTION COSTS					
				Design Engineering	\$ 6,229
				Construction Management	\$ 4,153
				Permitting & Support	\$ 260
	s.f. Land Area		None	Land Purchase/ROW Acquisition	\$ -
				WTD Staff Costs & Non-WTD Support	\$ 2,596
				Subtotal Non-Construction Costs	\$ 13,238
				Project Contingency	\$ 10,686
				TOTAL INDIRECT NON-CONSTRUCTION COSTS	\$ 23,900
				TOTAL PROJECT COST (2023 Dollars)	\$ 81,900

Description: WQBE 07B - Deep UIC Well in ROW (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 81,900
Capital cost	\$ 81,900.00 \$/Unit
Total Direct O&M/year	\$ 408
Direct O&M cost	\$ 408 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25

Replacement Costs (N/A for UIC well)

Description: WQBE 07B - Deep UIC Well in_ROW

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.
2 Total for equipment \$360.

Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year.

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Total Cost (NPV)	\$ 100,600	\$/unit
Annual O&M Cost	\$ 900	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs		2023 dollars
		\$ -
Annual Costs (misc drainage parts)	2023 dollars	\$ 113 \$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360 \$/year
Subtotal	\$473	
Labor		
Remove Trash from structure & roots from piping	3 hr	
	hr	
	hr	
Activity	0 hr	
Total hours per year	3	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded) \$ 163	
Labor cost, burdened	O/H 150.0% \$ 408	\$ 135.98
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 22,503	\$ 81,900	\$ 19,407	\$ 123,810	\$ 100,578	\$ 100,578			
0	1.000	\$ 81,900		\$ 81,900	\$ 81,900	\$ 81,900	\$ 81,900	\$ 81,900	\$ 100,578
1	0.950	\$ 473	\$ -	\$ 408	\$ 881	\$ 837	\$ 82,781	\$ 82,737	\$ 16,678
2	0.903	\$ 487	\$ -	\$ 420	\$ 907	\$ 819	\$ 83,688	\$ 83,556	\$ 17,841
3	0.858	\$ 502	\$ -	\$ 433	\$ 935	\$ 802	\$ 84,623	\$ 84,358	\$ 17,022
4	0.815	\$ 517	\$ -	\$ 446	\$ 963	\$ 784	\$ 85,588	\$ 85,142	\$ 16,222
5	0.774	\$ 532	\$ -	\$ 459	\$ 991	\$ 768	\$ 86,577	\$ 85,910	\$ 15,436
6	0.736	\$ 548	\$ -	\$ 473	\$ 1,021	\$ 751	\$ 87,598	\$ 86,661	\$ 14,668
7	0.699	\$ 565	\$ -	\$ 487	\$ 1,052	\$ 735	\$ 88,650	\$ 87,396	\$ 13,917
8	0.664	\$ 582	\$ -	\$ 502	\$ 1,083	\$ 719	\$ 89,733	\$ 88,116	\$ 13,182
9	0.631	\$ 599	\$ -	\$ 517	\$ 1,116	\$ 704	\$ 90,849	\$ 88,820	\$ 12,462
10	0.599	\$ 617	\$ -	\$ 532	\$ 1,149	\$ 689	\$ 91,999	\$ 89,509	\$ 11,758
11	0.570	\$ 636	\$ -	\$ 548	\$ 1,184	\$ 674	\$ 93,183	\$ 90,183	\$ 11,061
12	0.541	\$ 655	\$ -	\$ 565	\$ 1,219	\$ 660	\$ 94,402	\$ 90,843	\$ 10,395
13	0.514	\$ 674	\$ -	\$ 582	\$ 1,256	\$ 646	\$ 95,658	\$ 91,489	\$ 9,735
14	0.489	\$ 695	\$ -	\$ 599	\$ 1,294	\$ 632	\$ 96,952	\$ 92,121	\$ 9,089
15	0.464	\$ 715	\$ -	\$ 617	\$ 1,332	\$ 618	\$ 98,284	\$ 92,739	\$ 8,457
16	0.441	\$ 737	\$ -	\$ 636	\$ 1,372	\$ 605	\$ 99,657	\$ 93,345	\$ 7,838
17	0.419	\$ 759	\$ -	\$ 655	\$ 1,414	\$ 592	\$ 101,070	\$ 93,937	\$ 7,233
18	0.398	\$ 782	\$ -	\$ 674	\$ 1,456	\$ 580	\$ 102,526	\$ 94,517	\$ 6,641
19	0.378	\$ 805	\$ -	\$ 694	\$ 1,500	\$ 567	\$ 104,026	\$ 95,084	\$ 6,061
20	0.359	\$ 829	\$ -	\$ 715	\$ 1,545	\$ 555	\$ 105,571	\$ 95,639	\$ 5,494
21	0.341	\$ 854	\$ -	\$ 737	\$ 1,591	\$ 543	\$ 107,162	\$ 96,182	\$ 4,939
22	0.324	\$ 880	\$ -	\$ 759	\$ 1,639	\$ 532	\$ 108,801	\$ 96,714	\$ 4,396
23	0.308	\$ 906	\$ -	\$ 782	\$ 1,686	\$ 520	\$ 110,489	\$ 97,234	\$ 3,864
24	0.293	\$ 934	\$ -	\$ 805	\$ 1,739	\$ 509	\$ 112,227	\$ 97,743	\$ 3,344
25	0.278	\$ 962	\$ -	\$ 829	\$ 1,791	\$ 498	\$ 114,018	\$ 98,242	\$ 2,834
26	0.264	\$ 990	\$ -	\$ 854	\$ 1,844	\$ 488	\$ 115,862	\$ 98,729	\$ 2,336
27	0.251	\$ 1,020	\$ -	\$ 880	\$ 1,900	\$ 477	\$ 117,762	\$ 99,207	\$ 1,848
28	0.239	\$ 1,051	\$ -	\$ 906	\$ 1,957	\$ 467	\$ 119,719	\$ 99,674	\$ 1,371
29	0.227	\$ 1,082	\$ -	\$ 933	\$ 2,015	\$ 457	\$ 121,734	\$ 100,131	\$ 904
30	0.215	\$ 1,115	\$ -	\$ 961	\$ 2,076	\$ 447	\$ 123,810	\$ 100,578	\$ 447

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jess Dexheimer (HDR)
Description:	WQBE_07B_Deep UIC Well in ROW			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Deep UIC Well - ROW (Urban Roadway)	20	LF	\$ -	\$ -
2	Well - Borehole Diameter	12	FT	\$ -	\$ -
3	Well - Casing Diameter	0.7	FT	\$ -	\$ -
4	Drilling (12" Diameter Borehole)	20	VF	\$ 135	\$ 2,700
5	Well Casing (8-inch Diameter)	3	VF	\$ 59	\$ 177
6	Well Screen	20	VF	\$ 353	\$ 7,060
7	Maintenance Hole, Type 204A	1	EA	\$ 6,780	\$ 6,780
8	Misc Deep Well Costs	1	EA	\$ 3,710	\$ 3,710
9				\$ -	\$ -
10	Facility Removals and Restoration:			\$ -	\$ -
11	Remove Existing Pavement	69	SY	\$ 14	\$ 972
12	Pavement Patch - Area of Disturbance (6"HMA/6"CSTC)	69	SY	\$ 110	\$ 7,639
13				\$ -	\$ -
14	Additional Costs			\$ -	\$ -
15	Removals @ 4% Construction Costs	4%	LS	\$ 29,038	\$ 1,162
16	Traffic Control (Heavy)	0.3	MO	\$ 20,000	\$ 6,000
17	TESC @2% Construction Costs	2%	LS	\$ 30,200	\$ 604
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 36,804
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 3,680
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 40,484
<i>Direct: Subtotal Construction Costs</i>					\$ 40,484

Description: WQBE 07B - Deep UIC Well in_ROW

Wells that extend below an upper confining layer and discharge into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below.

Cost Estimating Assumptions:

Facility design is per 2019 Ecology Stormwater Management Manual.

Assumed depth of facility is 20 feet with a 12" diameter borehole.

All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item
Cost is for Deep UIC well only, any inlet pipe will be accounted for in pretreatment BMP

The excavated material is unsuitable for use as backfill.

Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTS

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Installation is in ROW on the roadside and does not require easements or acquisition

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR)
Description:	WQBE_07C_Deep UIC Well With Property Cost			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Deep UIC Well Installation (20 VF Depth)	1	EA	\$ 28,941	\$ 28,941
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 28,941
	Allowance for Indeterminates (Design Allowance)			\$	4,341
	Street Use Permit (Y/N)	N		\$	-
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID				\$ 33,282
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	3,328
	Subtotal Primary Construction Amount			\$	36,610
	Construction Sales Tax			\$	3,753
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	40,400
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	4,393
	Construction Management			\$	2,929
	Permitting & Support			\$	183
25	s.f. Land Area	Medium	Land Purchase/ROW Acquisition	\$	2,011
	WTD Staff Costs & Non-WTD Support			\$	1,831
	Subtotal Non-Construction Costs			\$	11,346
	Project Contingency			\$	7,762
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	19,100
	TOTAL PROJECT COST (2023 Dollars)			\$	59,500

Description: WQBE 07C - Deep UIC Well With Property Cost (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 59,500
Capital cost	\$ 59,500.00 \$/Unit
Total Direct O&M/Year	\$ 407.93
Direct O&M cost	\$ 407.93 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

Replacement Costs (N/A for UIC well)

Description: WQBE 07C - Deep UIC Well With Property Cost

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity.

2 Total for equipment \$360.

Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of 1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year.

Total Cost (NPV)	\$ 78,200	\$/unit
Annual O&M Cost	\$ 900	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

	2023 dollars	\$ -	\$/year
Annual Costs	2023 dollars	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$473	

Labor

Remove Trash from structure & roots from piping	3 hr
	0 hr
	0 hr
Activity	0 hr
Total hours per year	3
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 163
Labor cost, burdened	O/H 150.0% \$ 408
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 19,407	\$101,410	\$ 78,178			
0	1.000	\$ 59,500			\$59,500	\$ 59,500	\$ 59,500	\$ 59,500	\$ 78,178
1	0.950	\$473	\$ -	\$ 408	\$ 881	\$ 837	\$ 60,381	\$ 60,337	\$ 18,678
2	0.903	\$ 487	\$ -	\$ 420	\$ 907	\$ 819	\$ 61,288	\$ 61,156	\$ 17,841
3	0.858	\$ 502	\$ -	\$ 433	\$ 935	\$ 802	\$ 62,223	\$ 61,958	\$ 17,022
4	0.815	\$ 517	\$ -	\$ 446	\$ 963	\$ 784	\$ 63,185	\$ 62,742	\$ 16,223
5	0.774	\$ 532	\$ -	\$ 459	\$ 991	\$ 768	\$ 64,177	\$ 63,510	\$ 15,436
6	0.736	\$ 548	\$ -	\$ 473	\$ 1,021	\$ 751	\$ 65,199	\$ 64,261	\$ 14,668
7	0.699	\$ 565	\$ -	\$ 487	\$ 1,052	\$ 735	\$ 66,250	\$ 64,998	\$ 13,917
8	0.664	\$ 582	\$ -	\$ 502	\$ 1,083	\$ 719	\$ 67,333	\$ 65,716	\$ 13,182
9	0.631	\$ 599	\$ -	\$ 517	\$ 1,116	\$ 704	\$ 68,449	\$ 66,420	\$ 12,462
10	0.599	\$ 617	\$ -	\$ 532	\$ 1,149	\$ 689	\$ 69,599	\$ 67,109	\$ 11,758
11	0.570	\$ 636	\$ -	\$ 548	\$ 1,184	\$ 674	\$ 70,783	\$ 67,783	\$ 11,069
12	0.541	\$ 655	\$ -	\$ 565	\$ 1,219	\$ 660	\$ 72,002	\$ 68,443	\$ 10,395
13	0.514	\$ 674	\$ -	\$ 582	\$ 1,256	\$ 646	\$ 73,258	\$ 69,089	\$ 9,735
14	0.489	\$ 695	\$ -	\$ 599	\$ 1,294	\$ 632	\$ 74,552	\$ 69,721	\$ 9,098
15	0.464	\$ 715	\$ -	\$ 617	\$ 1,332	\$ 618	\$ 75,884	\$ 70,338	\$ 8,457
16	0.441	\$ 737	\$ -	\$ 636	\$ 1,372	\$ 605	\$ 77,257	\$ 70,945	\$ 7,838
17	0.419	\$ 759	\$ -	\$ 655	\$ 1,414	\$ 592	\$ 78,670	\$ 71,537	\$ 7,233
18	0.398	\$ 782	\$ -	\$ 674	\$ 1,456	\$ 580	\$ 80,126	\$ 72,117	\$ 6,641
19	0.378	\$ 805	\$ -	\$ 694	\$ 1,500	\$ 567	\$ 81,626	\$ 72,684	\$ 6,061
20	0.359	\$ 829	\$ -	\$ 715	\$ 1,545	\$ 555	\$ 83,171	\$ 73,239	\$ 5,494
21	0.341	\$ 854	\$ -	\$ 737	\$ 1,591	\$ 543	\$ 84,762	\$ 73,782	\$ 4,939
22	0.324	\$ 880	\$ -	\$ 759	\$ 1,639	\$ 532	\$ 86,401	\$ 74,314	\$ 4,396
23	0.308	\$ 906	\$ -	\$ 782	\$ 1,688	\$ 520	\$ 88,080	\$ 74,834	\$ 3,864
24	0.293	\$ 934	\$ -	\$ 805	\$ 1,739	\$ 509	\$ 89,827	\$ 75,343	\$ 3,344
25	0.278	\$ 962	\$ -	\$ 829	\$ 1,791	\$ 498	\$ 91,618	\$ 75,842	\$ 2,834
26	0.264	\$ 990	\$ -	\$ 854	\$ 1,844	\$ 488	\$ 93,462	\$ 76,329	\$ 2,336
27	0.251	\$ 1,020	\$ -	\$ 880	\$ 1,900	\$ 477	\$ 95,362	\$ 76,807	\$ 1,848
28	0.239	\$ 1,051	\$ -	\$ 906	\$ 1,957	\$ 467	\$ 97,319	\$ 77,274	\$ 1,371
29	0.227	\$ 1,082	\$ -	\$ 933	\$ 2,015	\$ 457	\$ 99,334	\$ 77,731	\$ 904
30	0.215	\$ 1,115	\$ -	\$ 961	\$ 2,076	\$ 447	\$ 101,410	\$ 78,178	\$ 447

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR)
Description:	WQBE_07C_Deep UIC Well With Property Cost			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	20 FT Deep UIC Well - On Property	20	LF	\$ -	\$ -
2	Well - Borehole Diameter (12")	1	FT	\$ -	\$ -
3	Well - Casing Diameter	0.7	FT	\$ -	\$ -
4	Drilling (12" Diameter Borehole)	20	VF	\$ 135	\$ 2,700
5	Well Casing (8-inch Diameter)	3	VF	\$ 59	\$ 177
6	Well Screen	20	VF	\$ 353	\$ 7,060
7	Maintenance Hole, Type 204A	1	EA	\$ 6,780	\$ 6,780
8	Misc Deep Well Costs	1	EA	\$ 3,710	\$ 3,710
9				\$ -	\$ -
10	Facility Removals and Restoration:			\$ -	\$ -
11	Clearing and Grubbing	69	SY	\$ 4	\$ 278
12	Landscaping and Restoration (25'WX25'L)	69	SY	\$ 59	\$ 4,097
13				\$ -	\$ -
14	Additional Costs			\$ -	\$ -
15	Removals @ 4% Construction Costs	4%	LS	\$ 24,802	\$ 992
16	TESC @2% Construction Costs	2%	LS	\$ 25,794	\$ 516
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 26,310
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 2,631
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 28,941
<i>Direct: Subtotal Construction Costs</i>					\$ 28,941

Description: WQBE 07_C - Deep UIC Well With Property Cost

Wells that extend below an upper confining layer and discharge into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below.

Cost Estimating Assumptions:

Facility design is per 2019 Ecology Stormwater Management Manual.

Assumed depth of facility is 20 feet with a 12" diameter borehole.

All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item
Cost is for Deep UIC well only, any inlet pipe will be accounted for in pretreatment BMP

The excavated material is unsuitable for use as backfill.

Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTS

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Installation is on property and does require easements or acquisition

The facility is located on Property and Traffic control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE_07D_Deep UIC Well with Filter in ROW (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 224,100
Capital cost	\$ 224,100.00 \$/Unit
Total Direct O&M/year	\$ 1,495.73
Direct O&M cost	\$ 1,495.73 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

Total Cost (NPV)	\$ 274,000	\$/unit
Annual O&M Cost	\$ 2,400	\$/year
Annualized Cost	\$1,360	\$/year

Materials, Supplies, Other Costs

Plant & Mulch Replacement	\$ -	\$ 383	\$/year
Misc Drainage parts	\$ -	\$ 113	
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$ 856	
Labor			
Remove Trash from structure & roots from piping		3 hr	
Plant Health (Filter)		4 hr	
Remediation of erosion		4 hr	
		0 hr	
Total hours per year		11	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 598	
Labor cost, burdened	O/H 150.0%	\$ 1,496	\$ 135.98
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 40,725		\$ 71,160	\$ 335,984	\$ 273,963			
0	1.000	\$ 224,100		\$ 1,496	\$ 224,100	\$ 224,100	\$ 224,100	\$ 224,100	\$ 273,963
1	0.950	\$ 856	\$ -	\$ 1,496	\$ 2,352	\$ 2,234	\$ 226,452	\$ 226,334	\$ 49,863
2	0.903	\$ 882	\$ -	\$ 1,541	\$ 2,422	\$ 2,187	\$ 228,874	\$ 226,521	\$ 47,628
3	0.858	\$ 908	\$ -	\$ 1,587	\$ 2,495	\$ 2,140	\$ 231,369	\$ 230,661	\$ 45,442
4	0.815	\$ 935	\$ -	\$ 1,634	\$ 2,570	\$ 2,094	\$ 233,939	\$ 232,755	\$ 43,302
5	0.774	\$ 963	\$ -	\$ 1,683	\$ 2,647	\$ 2,049	\$ 236,586	\$ 234,805	\$ 41,207
6	0.736	\$ 992	\$ -	\$ 1,734	\$ 2,726	\$ 2,006	\$ 239,312	\$ 236,810	\$ 39,158
7	0.699	\$ 1,022	\$ -	\$ 1,786	\$ 2,808	\$ 1,963	\$ 242,120	\$ 238,773	\$ 37,153
8	0.664	\$ 1,053	\$ -	\$ 1,840	\$ 2,892	\$ 1,921	\$ 245,012	\$ 240,694	\$ 35,190
9	0.631	\$ 1,084	\$ -	\$ 1,895	\$ 2,979	\$ 1,880	\$ 247,991	\$ 242,573	\$ 33,269
10	0.599	\$ 1,117	\$ -	\$ 1,952	\$ 3,068	\$ 1,840	\$ 251,060	\$ 244,413	\$ 31,389
11	0.570	\$ 1,150	\$ -	\$ 2,010	\$ 3,161	\$ 1,800	\$ 254,220	\$ 246,213	\$ 29,550
12	0.541	\$ 1,185	\$ -	\$ 2,070	\$ 3,255	\$ 1,762	\$ 257,476	\$ 247,975	\$ 27,750
13	0.514	\$ 1,220	\$ -	\$ 2,133	\$ 3,353	\$ 1,724	\$ 260,829	\$ 249,699	\$ 25,988
14	0.489	\$ 1,257	\$ -	\$ 2,197	\$ 3,454	\$ 1,687	\$ 264,282	\$ 251,386	\$ 24,264
15	0.464	\$ 1,295	\$ -	\$ 2,262	\$ 3,557	\$ 1,651	\$ 267,840	\$ 253,037	\$ 22,577
16	0.441	\$ 1,334	\$ -	\$ 2,330	\$ 3,664	\$ 1,616	\$ 271,503	\$ 254,653	\$ 20,926
17	0.419	\$ 1,374	\$ -	\$ 2,400	\$ 3,774	\$ 1,581	\$ 275,277	\$ 256,234	\$ 19,310
18	0.398	\$ 1,415	\$ -	\$ 2,472	\$ 3,887	\$ 1,547	\$ 279,164	\$ 257,781	\$ 17,729
19	0.378	\$ 1,457	\$ -	\$ 2,546	\$ 4,004	\$ 1,514	\$ 283,168	\$ 259,296	\$ 16,181
20	0.359	\$ 1,501	\$ -	\$ 2,623	\$ 4,124	\$ 1,482	\$ 287,292	\$ 260,778	\$ 14,667
21	0.341	\$ 1,546	\$ -	\$ 2,701	\$ 4,247	\$ 1,450	\$ 291,539	\$ 262,228	\$ 13,185
22	0.324	\$ 1,592	\$ -	\$ 2,782	\$ 4,375	\$ 1,419	\$ 295,914	\$ 263,648	\$ 11,734
23	0.308	\$ 1,640	\$ -	\$ 2,866	\$ 4,506	\$ 1,389	\$ 300,420	\$ 265,037	\$ 10,315
24	0.293	\$ 1,689	\$ -	\$ 2,952	\$ 4,641	\$ 1,359	\$ 305,062	\$ 266,396	\$ 8,926
25	0.278	\$ 1,740	\$ -	\$ 3,041	\$ 4,781	\$ 1,330	\$ 309,842	\$ 267,726	\$ 7,567
26	0.264	\$ 1,792	\$ -	\$ 3,132	\$ 4,924	\$ 1,302	\$ 314,766	\$ 269,028	\$ 6,237
27	0.251	\$ 1,846	\$ -	\$ 3,226	\$ 5,072	\$ 1,274	\$ 319,858	\$ 270,302	\$ 4,935
28	0.239	\$ 1,901	\$ -	\$ 3,322	\$ 5,224	\$ 1,247	\$ 325,062	\$ 271,549	\$ 3,661
29	0.227	\$ 1,958	\$ -	\$ 3,422	\$ 5,381	\$ 1,220	\$ 330,442	\$ 272,769	\$ 2,414
30	0.215	\$ 2,017	\$ -	\$ 3,525	\$ 5,542	\$ 1,194	\$ 335,984	\$ 273,963	\$ 1,194

Description: WQBE_07D_Deep UIC Well with Filter in ROW

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions (UIC):

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity. Total for equipment \$360.

Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of two by hand (2 visits per year, 0.5 hour per visit).

O&M Estimating Assumptions (Filter):

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. This task will be executed in the same hours as already set aside for UIC Well maintenance.

Twice a year the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed 4 annual cost of \$113 for mulch.

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed

4 biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit). Annual mulch and plan replacements 5 plants at \$54/Plant

Replacement Assumptions:

No capital replacement assumed in 30-year life for UIC well or Filter

Estimate - AACEI Class 10						
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024	
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jeff Price (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_07D_Deep UIC Well with Filter in ROW			Version:	`	
CONSTRUCTION COSTS						
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost	
1	Deep UIC Well - ROW (Urban Roadway)	20	LF	\$ -	\$ -	
2	Well - Borehole Diameter	12	IN	\$ -	\$ -	
3	Well - Casing Diameter	0.7	FT	\$ -	\$ -	
4	Drilling (12" Diameter Borehole)	20	VF	\$ 135	\$ 2,700	
5	Well Casing (8-inch Diameter)	3	VF	\$ 59	\$ 177	
6	Well Screen	20	VF	\$ 353	\$ 7,060	
7	Maintenance Hole, Type 204A	1	EA	\$ 6,780	\$ 6,780	
8	Misc Deep Well Costs	1	EA	\$ 3,710	\$ 3,710	
9				\$ -	\$ -	
10	Removal and Restoration UIC Well			\$ -	\$ -	
11	Remove Existing Pavement	69	SY	\$ 14	\$ 972	
12	Pavement Patch - Area of Disturbance (6"HMA/6"CSTC)	69	SY	\$ 110	\$ 7,639	
13				\$ -	\$ -	
14	High Rate Underground Filter			\$ -	\$ -	
15	Filterra Unit 4'X6' (complete)	1	EA	\$ 22,165	\$ 22,165	
16	Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D)	78	CY	\$ 79	\$ 6,144	
17	Imported Structural Fill	73	CY	\$ 44	\$ 3,227	
18	Crushed Base	1.0	CY	\$ 64	\$ 64	
19	Inlet Drain w/Energy Dissipating Rocks	1	EA	\$ 1,481	\$ 1,481	
20	Catch Basin	1	EA	\$ 3,900	\$ 3,900	
21	Pipe 8" PSD, DI CL 50	50	LF	\$ 160	\$ 8,000	
22	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900	
23				\$ -	\$ -	
24	Restoration High Rate Underground Filter			\$ -	\$ -	
25	Pavement Patching HMA 6" HMA/6"CSBC	36	SY	\$ 110	\$ 3,972	
26	Concrete Curb and Gutter	15	LF	\$ 111	\$ 1,665	
27	Sidewalk 6' Wide	10	SY	\$ 125	\$ 1,250	
28	Landscaping, planting, and restoration	10	SY	\$ 59	\$ 590	
29	Tree	1	EA	\$ 720	\$ 720	
30				\$ -	\$ -	
31	Additional Costs			\$ -	\$ -	
32	Removals @ 4% Construction Costs	4.0%	LS	\$ 86,116	\$ 3,445	
33	Traffic Control (Heavy)	0.5	MO	\$ 20,000	\$ 10,000	
34	TESC @2% Construction Costs	2%	LS	\$ 99,561	\$ 1,991	
				\$ -	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 101,552	
DIRECT: CONSTRUCTION COST MARK-UPS						
	General Conditions	0%		1	\$ -	
	Mobilization/Demobilization	10%		1.1	\$	10,155
	Overhead & Profit (OHP)	0%		1	\$	-
	Insurance	0.0%		1	\$	-
	Bonding	0.0%		1	\$	-
	Escalation Multiplier from ENR-CCI	0%		1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 111,708	
<i>Direct: Subtotal Construction Costs</i>					\$ 111,708	

Description: WQBE_07D_Deep UIC Well with Filter in ROW

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

General

The excavated material is unsuitable for use as backfill.

Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTM

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Installation is in ROW on the roadside and does not require easements or acquisition

The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

A street use permit is required.

Deep UIC Well

Facility design is per 2019 Ecology Stormwater Management Manual.

Assumed depth of facility is 20 feet with a 12" diameter borehole.

All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.

21" of proprietary Filterra treatment media is used.

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.

A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.

Trench Box shoring is used.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE_07E_Deep UIC Well with Bioretention Planter in ROW (2023 Dollars)

Unit	1	EA
Initial Capital Cost	\$ 1,336,800	
Capital cost	\$ 1,336,800.00	\$/Unit
Total Direct O&M/Year	\$ 3,127.43	
Direct O&M cost	\$ 3,127.43	\$/Unit
Capital Replacement Costs (10 Years)	\$ 5,030	\$/Unit
Discount rate (%)	5.25	\$/Unit

Description: WQBE_07E_Deep UIC Well with Bioretention Planter in ROW

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions (UIC):

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vector catch basin activity.

2 Total for equipment \$360.

Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of 1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year.

O&M Estimating Assumptions (Bioretention):

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using 8 hand tools (2 visits per year, 2 hours per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit). Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit). Annual

4 mulch/media layer replacement will cost \$680.

Annual plant replacement will cost \$1620. Comprised of (30) small plant replacements at \$54/each.

Total Cost (NPV)	\$ 1,466,700	\$/unit
Annual O&M Cost	\$ 5,900	\$/year
Annualized Cost	\$4,400	\$/year

Materials, Supplies, Other Costs			2023 dollars
Misc drainage parts	\$ -	\$ 113	\$/year
Annual costs (plant/mulch/media replacement, misc drainage parts)	\$ -	\$ 2,300	\$/year
Vactor Truck Equipment + Labor Cost		\$ 360	\$/year
Subtotal		\$ 2,773	

Labor	
Remove Trash, Inspect and Remove Roots, Remediate Holes and Breaks (UIC)	3 hr
Remove Trash, Sediment, Debris, Inspect Plant Health (bioretention)	16 hr
Remediate Erosion	4 hr
	0 hr
Total hours per year	23
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 1,251
Labor cost, burdened	O/H 150.0% \$ 3,127
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Replacement Assumptions:

Complete rebuild bioretention planter every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 131,927		\$ 148,789	\$ 1,627,575	\$ 1,466,727			
0	1.000	\$ 1,336,800		\$ 1,336,800	\$ 1,336,800	\$ 1,336,800	\$ 1,336,800	\$ 1,336,800	\$ 1,466,727
1	0.950	\$ 2,773	\$ -	\$ 3,127	\$ 5,900	\$ 5,906	\$ 1,342,700	\$ 1,342,406	\$ 129,927
2	0.903	\$ 2,856	\$ -	\$ 3,221	\$ 6,077	\$ 5,496	\$ 1,348,778	\$ 1,347,892	\$ 124,321
3	0.858	\$ 2,942	\$ -	\$ 3,318	\$ 6,260	\$ 5,369	\$ 1,355,038	\$ 1,353,261	\$ 118,835
4	0.815	\$ 3,030	\$ -	\$ 3,417	\$ 6,448	\$ 5,254	\$ 1,361,485	\$ 1,358,516	\$ 113,466
5	0.774	\$ 3,121	\$ -	\$ 3,520	\$ 6,641	\$ 5,142	\$ 1,368,126	\$ 1,363,657	\$ 108,212
6	0.736	\$ 3,215	\$ -	\$ 3,626	\$ 6,840	\$ 5,034	\$ 1,374,966	\$ 1,368,689	\$ 103,070
7	0.699	\$ 3,311	\$ -	\$ 3,734	\$ 7,045	\$ 4,924	\$ 1,382,012	\$ 1,373,614	\$ 98,038
8	0.664	\$ 3,410	\$ -	\$ 3,846	\$ 7,257	\$ 4,819	\$ 1,389,269	\$ 1,378,433	\$ 93,114
9	0.631	\$ 3,513	\$ -	\$ 3,962	\$ 7,474	\$ 4,716	\$ 1,396,743	\$ 1,383,149	\$ 88,294
10	0.599	\$ 3,618	\$ 5,030	\$ 4,081	\$ 12,729	\$ 7,631	\$ 1,409,472	\$ 1,390,780	\$ 83,578
11	0.570	\$ 3,727	\$ -	\$ 4,203	\$ 7,930	\$ 6,517	\$ 1,417,401	\$ 1,395,296	\$ 75,948
12	0.541	\$ 3,838	\$ -	\$ 4,329	\$ 8,168	\$ 4,420	\$ 1,425,569	\$ 1,399,716	\$ 71,431
13	0.514	\$ 3,954	\$ -	\$ 4,459	\$ 8,413	\$ 4,326	\$ 1,433,982	\$ 1,404,042	\$ 67,011
14	0.489	\$ 4,072	\$ -	\$ 4,593	\$ 8,665	\$ 4,233	\$ 1,442,647	\$ 1,408,275	\$ 62,685
15	0.464	\$ 4,194	\$ -	\$ 4,731	\$ 8,925	\$ 4,143	\$ 1,451,572	\$ 1,412,418	\$ 58,452
16	0.441	\$ 4,320	\$ -	\$ 4,872	\$ 9,193	\$ 4,054	\$ 1,460,764	\$ 1,416,472	\$ 54,310
17	0.419	\$ 4,450	\$ -	\$ 5,019	\$ 9,468	\$ 3,967	\$ 1,470,233	\$ 1,420,439	\$ 50,256
18	0.398	\$ 4,583	\$ -	\$ 5,169	\$ 9,753	\$ 3,883	\$ 1,479,985	\$ 1,424,322	\$ 46,288
19	0.378	\$ 4,721	\$ -	\$ 5,324	\$ 10,045	\$ 3,800	\$ 1,490,030	\$ 1,428,121	\$ 42,406
20	0.359	\$ 4,862	\$ 5,030	\$ 5,484	\$ 15,376	\$ 5,526	\$ 1,505,407	\$ 1,433,647	\$ 38,606
21	0.341	\$ 5,008	\$ -	\$ 5,648	\$ 10,657	\$ 3,639	\$ 1,516,064	\$ 1,437,286	\$ 33,080
22	0.324	\$ 5,159	\$ -	\$ 5,818	\$ 10,977	\$ 3,561	\$ 1,527,040	\$ 1,440,847	\$ 29,441
23	0.308	\$ 5,313	\$ -	\$ 5,992	\$ 11,306	\$ 3,485	\$ 1,538,346	\$ 1,444,332	\$ 25,880
24	0.293	\$ 5,473	\$ -	\$ 6,172	\$ 11,645	\$ 3,410	\$ 1,549,991	\$ 1,447,742	\$ 22,395
25	0.278	\$ 5,637	\$ -	\$ 6,357	\$ 11,994	\$ 3,336	\$ 1,561,985	\$ 1,451,080	\$ 18,985
26	0.264	\$ 5,806	\$ -	\$ 6,548	\$ 12,354	\$ 3,266	\$ 1,574,336	\$ 1,454,346	\$ 15,647
27	0.251	\$ 5,980	\$ -	\$ 6,745	\$ 12,725	\$ 3,196	\$ 1,587,064	\$ 1,457,542	\$ 12,381
28	0.239	\$ 6,160	\$ -	\$ 6,947	\$ 13,107	\$ 3,128	\$ 1,600,171	\$ 1,460,670	\$ 9,185
29	0.227	\$ 6,344	\$ -	\$ 7,155	\$ 13,500	\$ 3,061	\$ 1,613,671	\$ 1,463,732	\$ 6,057
30	0.215	\$ 6,535	\$ -	\$ 7,370	\$ 13,905	\$ 2,996	\$ 1,627,575	\$ 1,466,727	\$ 2,996

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jeff Price (HDR) Jess Dexheimer (HDR)
Description:	WQBE_07E_Deep UIC Well with Bioretentoin Planter in ROW			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Deep UIC Well - ROW (Urban Roadway)	20	LF	\$ -	\$ -
2	Well - Borehole Diameter	12	IN	\$ -	\$ -
3	Well - Casing Diameter	0.7	FT	\$ -	\$ -
4	Drilling (12" Diameter Borehole)	20	VF	\$ 135	\$ 2,700
5	Well Casing (8-inch Diameter)	3	VF	\$ 59	\$ 177
6	Well Screen	20	VF	\$ 353	\$ 7,060
7	Maintenance Hole, Type 204A	1	EA	\$ 6,780	\$ 6,780
8	Misc Deep Well Costs	1	EA	\$ 3,710	\$ 3,710
9			\$ -	\$ -	\$ -
10	Deep UIC Well Facility Removals and Restoration:			\$ -	\$ -
11	Remove Existing Pavement	69	SY	\$ 14	\$ 972
12	Pavement Patch - Area of Disturbance (6"HMA/6"CSTC)	69	SY	\$ 110	\$ 7,639
13			\$ -	\$ -	\$ -
14	Bioretention Planter - ROW	580	SF	\$ -	\$ -
15	Bioretention Planter Unit: 6 TOTAL Sized at 5ft x 19ft.	114	LF	\$ -	\$ -
16	Curbed, vertical sides - Top Area	580	SF	\$ -	\$ -
17	Structural Excavation to Waste (11'W X25'L X 6'D) x 6	367	CY	\$ 79	\$ 28,967
18	Imported Structural Fill (Bioretention Planter: 5'W X 19'L X 4.7'D) x 6	99	CY	\$ 44	\$ 4,366
19	Formed Concrete Walls (2'-6" walls: 48'L X 4.7'D) x 6	125	CY	\$ 1,560	\$ 195,520
20	Formed Concrete Base (2'-6" base: 10'W X 24'L) x 6	133	CY	\$ 590	\$ 78,667
21	Treatment Media (5'W X 19'L X 1.5'D) x 6 w/ biochar	32	CY	\$ 270	\$ 8,550
22	Mulch Compost (@ 0.3'D)	6	CY	\$ 86	\$ 554
23	Vegetated Entrance	63	SY	\$ 2	\$ 127
24	Trench Shoring Facility	1368	SF	\$ 10	\$ 13,680
25			\$ -	\$ -	\$ -
26	Underdrain Items:			\$ -	\$ -
27	Underdrain Aggregate (5'W X 19' LX 2.2'D)	7.7	CY	\$ 133	\$ 1,030
28	Overflow & Drain Pipe 8" Dia. (4' + 19')	115	LF	\$ 48	\$ 5,520
29			\$ -	\$ -	\$ -
30	Bioretention Planter Restoration:			\$ -	\$ -
31	Remove Existing Pavement	183	SY	\$ 14	\$ 2,567
32	Pavement Patch - Area of Disturbance (6"HMA/6"CSTC)	183	SY	\$ 110	\$ 20,167
33	Sidewalk 6' Wide	76	SY	\$ 125	\$ 9,500
34	Concrete Curb and Gutter	114	LF	\$ 111	\$ 12,654
35	Landscaping (Planter Only)	64	SY	\$ 59	\$ 3,802
36	Trees (Not in Design Basis)	0	EA	\$ 720	\$ -
37			\$ -	\$ -	\$ -
38	Outlet Pipe			\$ -	\$ -
39	Pipe 8" PSD, DI CL 50	300	LF	\$ 160	\$ 48,000
40	5' Wide Trench x 7'D to waste	389	CY	\$ 79	\$ 30,722
41	Trench Box Shoring (Shallow)	4,200	SF	\$ 10	\$ 42,000
42	Pavement Patch - Pipe@5'W (6"HMA/6"CSBC)	167	SY	\$ 110	\$ 18,333
43				\$ -	\$ -
44	Additional Costs				\$ -
45	Removals @ 4% Construction Costs	4.0%	LS	\$ 553,763	\$ 22,151
46	Traffic Control (Heavy)	1	MO	\$ 20,000	\$ 20,000
47	TESC @2% Construction Costs	2%	LS	\$ 595,913	\$ 11,918
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 607,832
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	
	Mobilization/Demobilization	10%	1.1	\$ 60,783	
	Overhead & Profit (OHP)	0%	1	\$ -	
	Insurance	0.0%	1	\$ -	
	Bonding	0.0%	1	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 668,615
Direct: Subtotal Construction Costs					\$ 668,615

Description: WQBE_07E_Deep UIC Well with Bioretention Planter

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Bioretention Planters include a designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

Cost Estimating Assumptions:

General

The excavated material is unsuitable for use as backfill.

Arterial Roadway restoration is assumed for facility footprint and area of disturbance and consists of 6" HMA/6" CSTC

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Installation is in ROW on the roadside and does not require easements or acquisition

The facility is located on Property and Traffic control is not required.

A street use permit is not required.

Deep UIC Well

Facility design is per 2019 Ecology Stormwater Management Manual.

Assumed depth of facility is 20 feet with a 12" diameter borehole.

All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

Bioretention Planter

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)

Installation is in ROW and does not require easements or acquisition

Filter fabrics not used between the subgrade and the Bioretention Soil Mix

Facility is sited in an open space with outlet pipe beneath a parking area

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 580 sf with curbed, vertical sides.

A maximum ponding depth of 6" and a 12" of freeboard depth are assumed.

Facilities have a closed bottom and include an underdrain.

A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure for each Bioretention Planter.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the box.

Trench Box shoring is used.

Roadway patching and restoration is assumed for the outlet pipe and consists of 6" HMA/6" CSTC

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

Restoration is required for the area of disturbance.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE_07F_Deep UIC Well with Bioretention Planter on Property (2023 Dollars)	Unit	1 EA
Initial Capital Cost	\$ 1,149,100	
Capital cost	\$ 1,149,100.00	/Unit
Total Direct O&M/Year	\$ 3,127.43	
Direct O&M cost	\$ 3,127.43	/Unit
Capital Replacement Costs (10 Years)	\$ 5,599	/unit
Discount rate (%)	5.25	/Unit

Total Cost (NPV)	\$ 1,279,600	/unit
Annual O&M Cost	\$ 5,900	/year
Annualized Cost	\$4,400	/year

Materials, Supplies, Other Costs		
Misc Drainage parts	\$ -	\$ 113 /year
Annual costs (plant/mulch/media replacement, misc drainage parts)		\$ 2,300 /year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360 /year

Subtotal \$ 2,773

Labor		
Remove Trash from structure & roots from piping	3 hr	
Remove trash debris and replace vegetation, sediment removal Bioretention.	8 hr	
Plant health (bioretention)	8 hr	
Remediation of erosion	4 hr	
Total hours per year	23	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded) \$ 1,251	
Labor cost, burdened	O/H 150.0% \$ 3,127	\$ 135.98
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 131,927		\$ 148,789	\$ 1,441,012	\$ 1,279,572			
0	1.000	\$ 1,149,100		\$ 1,149,100	\$ 1,149,100	\$ 1,149,100	\$ 1,149,100	\$ 1,149,100	\$ 1,279,572
1	0.950	\$ 2,773	\$ -	\$ 3,127	\$ 5,900	\$ 5,606	\$ 1,155,000	\$ 1,154,706	\$ 130,472
2	0.903	\$ 2,856	\$ -	\$ 3,221	\$ 6,077	\$ 5,486	\$ 1,161,078	\$ 1,160,192	\$ 124,866
3	0.858	\$ 2,942	\$ -	\$ 3,318	\$ 6,260	\$ 5,369	\$ 1,167,338	\$ 1,165,561	\$ 119,380
4	0.815	\$ 3,030	\$ -	\$ 3,417	\$ 6,448	\$ 5,254	\$ 1,173,785	\$ 1,170,816	\$ 114,011
5	0.774	\$ 3,121	\$ -	\$ 3,520	\$ 6,641	\$ 5,142	\$ 1,180,426	\$ 1,175,957	\$ 108,757
6	0.736	\$ 3,215	\$ -	\$ 3,626	\$ 6,840	\$ 5,032	\$ 1,187,266	\$ 1,180,989	\$ 103,615
7	0.699	\$ 3,311	\$ -	\$ 3,734	\$ 7,045	\$ 4,924	\$ 1,194,312	\$ 1,185,914	\$ 98,583
8	0.664	\$ 3,410	\$ -	\$ 3,846	\$ 7,257	\$ 4,819	\$ 1,201,569	\$ 1,190,733	\$ 93,659
9	0.631	\$ 3,513	\$ -	\$ 3,962	\$ 7,474	\$ 4,716	\$ 1,209,043	\$ 1,195,449	\$ 88,840
10	0.599	\$ 3,618	\$ 5,599	\$ 4,081	\$ 13,297	\$ 7,972	\$ 1,222,340	\$ 1,203,420	\$ 84,123
11	0.570	\$ 3,727	\$ -	\$ 4,203	\$ 7,930	\$ 4,517	\$ 1,230,270	\$ 1,207,937	\$ 76,152
12	0.541	\$ 3,838	\$ -	\$ 4,329	\$ 8,189	\$ 4,420	\$ 1,238,438	\$ 1,212,357	\$ 71,635
13	0.514	\$ 3,954	\$ -	\$ 4,459	\$ 8,413	\$ 4,326	\$ 1,246,450	\$ 1,216,683	\$ 67,215
14	0.489	\$ 4,072	\$ -	\$ 4,593	\$ 8,665	\$ 4,233	\$ 1,255,515	\$ 1,220,916	\$ 62,890
15	0.464	\$ 4,194	\$ -	\$ 4,731	\$ 8,925	\$ 4,143	\$ 1,264,440	\$ 1,225,058	\$ 58,657
16	0.441	\$ 4,320	\$ -	\$ 4,872	\$ 9,193	\$ 4,054	\$ 1,273,633	\$ 1,229,112	\$ 54,514
17	0.419	\$ 4,450	\$ -	\$ 5,019	\$ 9,468	\$ 3,967	\$ 1,283,101	\$ 1,233,080	\$ 50,460
18	0.398	\$ 4,583	\$ -	\$ 5,169	\$ 9,753	\$ 3,883	\$ 1,292,854	\$ 1,236,962	\$ 46,493
19	0.378	\$ 4,721	\$ -	\$ 5,324	\$ 10,045	\$ 3,808	\$ 1,302,899	\$ 1,240,762	\$ 42,610
20	0.359	\$ 4,862	\$ 5,599	\$ 5,484	\$ 15,945	\$ 5,730	\$ 1,318,844	\$ 1,246,492	\$ 38,811
21	0.341	\$ 5,008	\$ -	\$ 5,648	\$ 10,657	\$ 3,639	\$ 1,329,501	\$ 1,250,131	\$ 33,080
22	0.324	\$ 5,159	\$ -	\$ 5,818	\$ 10,977	\$ 3,561	\$ 1,340,477	\$ 1,253,692	\$ 29,441
23	0.308	\$ 5,313	\$ -	\$ 5,992	\$ 11,306	\$ 3,485	\$ 1,351,783	\$ 1,257,177	\$ 25,680
24	0.293	\$ 5,473	\$ -	\$ 6,172	\$ 11,645	\$ 3,410	\$ 1,363,428	\$ 1,260,588	\$ 22,395
25	0.278	\$ 5,637	\$ -	\$ 6,357	\$ 11,994	\$ 3,338	\$ 1,375,422	\$ 1,263,925	\$ 18,985
26	0.264	\$ 5,806	\$ -	\$ 6,548	\$ 12,354	\$ 3,266	\$ 1,387,776	\$ 1,267,191	\$ 15,647
27	0.251	\$ 5,980	\$ -	\$ 6,745	\$ 12,725	\$ 3,196	\$ 1,400,501	\$ 1,270,388	\$ 12,381
28	0.239	\$ 6,160	\$ -	\$ 6,947	\$ 13,107	\$ 3,128	\$ 1,413,608	\$ 1,273,516	\$ 9,185
29	0.227	\$ 6,344	\$ -	\$ 7,155	\$ 13,500	\$ 3,061	\$ 1,427,107	\$ 1,276,577	\$ 6,057
30	0.215	\$ 6,535	\$ -	\$ 7,370	\$ 13,905	\$ 2,996	\$ 1,441,012	\$ 1,279,572	\$ 2,996

Description: WQBE_07F_Deep UIC Well with Bioretention Planter on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

Q&M Estimating Assumptions (UIC):

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vactor catch basin activity. Total for equipment

2 \$360.

Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of two by 1 hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year.

Q&M Estimating Assumptions (Bioretention):

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. Work to be performed by a crew of two using hand tools 8 (2 visits per year, 2 hour per visit).

Inspection and remediation of plant health (pest, disease, poor vegetation growth, excessive vegetation growth, weed growth) to be performed quarterly and by a crew of two using hand tools (4 visits per year, 1 hour per visit).

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit). Annual mulch/media

4 layer replacement will cost \$680.

Annual plant replacement will cost \$1620. Comprised of (30) small plant replacements at \$54 each.

Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Royce Robertson (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jeff Price (HDR) Jess Dexheimer (HDR) Andrew Staples (HDR)
Description:	WQBE_07F_Deep UIC Well with Bioretention Planter on Property			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	20 FT Deep UIC Well - On Property	20	LF	\$ -	\$ -
2	Well - Borehole Diameter (12")	1	FT	\$ -	\$ -
3	Well - Casing Diameter	0.7	FT	\$ -	\$ -
4	Drilling (12" Diameter Borehole)	20	VF	\$ 135	\$ 2,700
5	Well Casing (8-inch Diameter)	3	VF	\$ 59	\$ 177
6	Well Screen	20	VF	\$ 353	\$ 7,060
7	Maintenance Hole, Type 204A	1	EA	\$ 6,780	\$ 6,780
8	Misc Deep Well Costs	1	EA	\$ 3,710	\$ 3,710
9				\$ -	\$ -
10	Facility Removals and Restoration:			\$ -	\$ -
11	Clearing and Grubbing	69	SY	\$ 4	\$ 278
12	Landscaping and Restoration (25'WX25'L)	69	SY	\$ 59	\$ 4,097
13				\$ -	\$ -
14	Bioretention Planter - On Property	580	SF	\$ -	\$ -
15	Bioretention Planter Unit: 6 TOTAL Sized at 5ft x 19ft.	114	LF	\$ -	\$ -
16	Curbed, vertical sides - Top Area	580	SF	\$ -	\$ -
17	Structural Excavation to Waste (11'W X 25'L X 6'D) x 6	367	CY	\$ 79	\$ 28,967
18	Imported Structural Fill (Bioretention Planter: 5'W X 19'L X 4.7'D) x 6	99	CY	\$ 44	\$ 4,366
19	Formed Concrete Walls (2'-6" walls: 48'L X 4.7'D) x 6	125	CY	\$ 1,560	\$ 195,520
20	Formed Concrete Base (2'-6" base: 10'W X 24'L) x 6	133	CY	\$ 590	\$ 78,667
21	Treatment Media (5'W X 19'L X 1.5'D) x 6 w/ biochar	32	CY	\$ 270	\$ 8,550
22	Mulch Compost (@ 0.3'D)	6	CY	\$ 86	\$ 554
23	Vegetated Entrance	63	SY	\$ 10	\$ 633
24	Trench Shoring Facility	1368	SF	\$ 10	\$ 13,680
25				\$ -	\$ -
26	Underdrain Items:		LF	\$ -	\$ -
27	Underdrain Aggregate (5'W X 19' LX 2.2'D)	7.7	CY	\$ 133	\$ 1,030
28	Overflow & Drain Pipe 8" Dia. (4' + 19')	115	LF	\$ 48	\$ 5,520
29				\$ -	\$ -
30	Bioretention Planter Restoration:			\$ -	\$ -
32	Landscaping (Planter Only)	64	SY	\$ 59	\$ 3,802
33	Trees (Not in Design Basis)	0	EA	\$ 720	\$ -
34				\$ -	\$ -
35	Outlet Pipe			\$ -	\$ -
36	Pipe 8" Diameter	300	LF	\$ 160	\$ 48,000
37	5' Wide Trench x 7'D to waste	389	CY	\$ 79	\$ 30,722
38	Trench Box Shoring (Shallow)	4,200	SF	\$ 10	\$ 42,000
39	Parking Lot Pavement Patch HMA 4" HM/4"CSBC	167	SY	\$ 71	\$ 11,833
40				\$ -	\$ -
41	Additional Costs			\$ -	\$ -
42	Removals @ 4% Construction Costs	4.0%	LS	\$ 498,646	\$ 19,946
43	TESC @2% Construction Costs	2%	LS	\$ 518,592	\$ 10,372
				\$ -	\$ -
Item Subtotal Construction Costs (Year 2023)					\$ 528,964
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 52,896
	Overhead & Profit (OHP)	0%	1	\$ -	
	Insurance	0.0%	1	\$ -	
	Bonding	0.0%	1	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	
Item Subtotal Construction Costs (Year 2023)					\$ 581,860
Direct: Subtotal Construction Costs					\$ 581,860

Description: WQBE_07F_Deep UIC Well with Bioretentoin Planter on Property

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Bioretention Planters include a designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. These designs are often used in ultra-urban settings. For this analysis, the Action is assumed to have an underdrain and closed bottom.

Cost Estimating Assumptions:

General

The excavated material is unsuitable for use as backfill.

It is assumed that these facilities are on property and part of a GSI rebate program. Property acquisition and easement costs are not included. Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and Traffic control is not required.

A street use permit is not required.

Deep UIC Well

Facility design is per 2019 Ecology Stormwater Management Manual.

Assumed depth of facility is 20 feet with a 12" diameter borehole.

All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

Bioretention Planter

Bioretention planter installation is per the Seattle Stormwater Manual, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2)

Filter fabrics not used between the subgrade and the Bioretention Soil Mix

Facility is sited in an open space with outlet pipe beneath a parking area

18" of treatment media with 70% sand, 20% coir, 10% high carbon wood ash (biochar) is used.

0.3' of composted media is included.

The facility treatment area is 580 sf with curbed, vertical sides.

A maximum ponding depth of 6" and a 12" of freeboard depth are assumed.

Facilities have a closed bottom and include an underdrain.

A total of 50 LF of 8" storm pipe is required to connect to the downstream main or structure for each Bioretention Planter.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the box.

Trench Box shoring is used.

Parking lot restoration is assumed for the outlet pipe and consists of 4" HMA/4" CSTC.

No concrete curb, gutter, and sidewalk removal or restoration will be required for the installation.

Restoration is required for the area of disturbance.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Jess Dexheimer (HDR) Tatiana Skadorkwa (HDR) Cindy Kinzer (HDR)
Description:	WQBE_07G_Deep UIC Well with High Rate Filter on Property			Version:	1
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Deep UIC Well (20 VF Depth) with High Rate Underground Filter (24 s.f. bottom area) on Property	1	EA	\$ 101,297	\$ 101,297
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				<i>Subtotal Construction Costs</i>	\$ 101,297
				Allowance for Indeterminates (Design Allowance)	\$ 15,195
				Street Use Permit (Y/N)	N \$ -
				<i>ESTIMATED PROBABLE COST OF CONSTRUCTION BID</i>	\$ 116,491
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$ 11,649	
	<i>Subtotal Primary Construction Amount</i>			\$ 128,141	
	Construction Sales Tax			\$ 13,134	
	Outside Agency Construction			\$ -	
	<i>TOTAL DIRECT CONSTRUCTION COSTS</i>			\$ 141,300	
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$ 15,377	
	Construction Management			\$ 10,251	
	Permitting & Support			\$ 641	
s.f. Land Area	None			Land Purchase/ROW Acquisition	\$ -
				WTD Staff Costs & Non-WTD Support	\$ 6,407
				<i>Subtotal Non-Construction Costs</i>	\$ 32,676
				Project Contingency	\$ 26,096
				<i>TOTAL INDIRECT NON-CONSTRUCTION COSTS</i>	\$ 58,800
				<i>TOTAL PROJECT COST (2023 Dollars)</i>	\$ 200,100

Description: WQBE_07G_Deep UIC Well with High Rate Filter on Property (2023 Dollars)

	Unit	1	EA
Initial Capital Cost	\$ 200,100		
Capital cost	\$ 200,100.00	\$/Unit	
Total Direct O&M/Year	\$ 1,495.73		
Direct O&M cost	\$ 1,495.73	\$/Unit	
Capital Replacement Costs (10 Years)	\$ -	\$/unit	
Discount rate (%)	5.25	\$/Unit	

Description: WQBE_07G_Deep UIC Well with High Rate Filter on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions (UIC):

Removal of trash, debris or obstructions limiting flow into drywell performed annually and after major storm events by a crew of two by hand (2 visits per year, 0.5 hour per visit). Combined w/vector catch basin activity.
2 Total for equipment \$360.

Inspection of vegetation and removal of roots that reduce free movement of water through pipes by a crew of 1 two by hand (2 visits per year, 0.5 hour per visit).

Miscellaneous drainage parts for maintenance and repair (pipe, rock, screen, fabric) \$113 per year.

Total Cost (NPV)	\$ 250,000	\$/unit
Annual O&M Cost	\$ 2,400	\$/year
Annualized Cost	\$1,360	\$/year

Materials, Supplies, Other Costs			2023 dollars
Misc drainage parts	\$ -	\$ 383	\$/year
Annual costs (plant/mulch/media replacement, misc drainage parts)	\$ -	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year

Subtotal Labor

Remove Trash, Inspect and Remove Roots, Remediate Holes and Breaks (UIC)	3 hr
Plant Health (Filter)	4 hr
Remediation of erosion	4 hr
	0 hr
Total hours per year	11
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 593
Labor cost, burdened	O/H 150.0% \$ 1,496
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

O&M Estimating Assumptions (Filter):

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal to occur annually and after major storm events. This task will be executed in the same hours as already set aside for UIC Well maintenance.

Twice a year the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual cost of \$113 for mulch.

Remediation of erosion of mulch/media layer around inlets, outlets and along slopes to be performed biannually and after major storm events by a crew of two using hand tools (2 visits per year, 1 hour per visit).

Annual mulch and plant replacements 5 plants at \$54/Plant

Replacement Assumptions:

No capital replacement assumed in 30-year life for UIC well or Filter

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 40,725			\$ 311,984	\$ 249,963			
0	1.000	\$ 200,100		\$ 71,160	\$ 200,100	\$ 200,100	\$ 200,100	\$ 200,100	\$ 249,963
1	0.950	\$ 856	\$ -	\$ 1,496	\$ 2,352	\$ 2,234	\$ 202,452	\$ 202,334	\$ 49,863
2	0.903	\$ 882	\$ -	\$ 1,541	\$ 2,422	\$ 2,187	\$ 204,874	\$ 204,521	\$ 47,628
3	0.858	\$ 908	\$ -	\$ 1,587	\$ 2,495	\$ 2,140	\$ 207,369	\$ 206,661	\$ 45,442
4	0.815	\$ 935	\$ -	\$ 1,634	\$ 2,570	\$ 2,094	\$ 209,939	\$ 208,755	\$ 43,302
5	0.774	\$ 963	\$ -	\$ 1,683	\$ 2,647	\$ 2,049	\$ 212,586	\$ 210,805	\$ 41,207
6	0.736	\$ 992	\$ -	\$ 1,734	\$ 2,726	\$ 2,006	\$ 215,312	\$ 212,810	\$ 39,158
7	0.699	\$ 1,022	\$ -	\$ 1,786	\$ 2,808	\$ 1,963	\$ 218,120	\$ 214,773	\$ 37,153
8	0.664	\$ 1,053	\$ -	\$ 1,840	\$ 2,892	\$ 1,921	\$ 221,012	\$ 216,694	\$ 35,190
9	0.631	\$ 1,084	\$ -	\$ 1,895	\$ 2,979	\$ 1,880	\$ 223,991	\$ 218,573	\$ 33,269
10	0.599	\$ 1,117	\$ -	\$ 1,952	\$ 3,068	\$ 1,840	\$ 227,060	\$ 220,413	\$ 31,389
11	0.570	\$ 1,150	\$ -	\$ 2,010	\$ 3,161	\$ 1,800	\$ 230,220	\$ 222,213	\$ 29,560
12	0.541	\$ 1,185	\$ -	\$ 2,070	\$ 3,255	\$ 1,762	\$ 233,476	\$ 223,975	\$ 27,750
13	0.514	\$ 1,220	\$ -	\$ 2,133	\$ 3,353	\$ 1,724	\$ 236,829	\$ 225,699	\$ 25,988
14	0.489	\$ 1,257	\$ -	\$ 2,197	\$ 3,454	\$ 1,687	\$ 240,282	\$ 227,386	\$ 24,264
15	0.464	\$ 1,295	\$ -	\$ 2,262	\$ 3,557	\$ 1,651	\$ 243,840	\$ 229,037	\$ 22,577
16	0.441	\$ 1,334	\$ -	\$ 2,330	\$ 3,664	\$ 1,616	\$ 247,503	\$ 230,653	\$ 20,926
17	0.419	\$ 1,374	\$ -	\$ 2,400	\$ 3,774	\$ 1,581	\$ 251,277	\$ 232,234	\$ 19,310
18	0.398	\$ 1,415	\$ -	\$ 2,472	\$ 3,887	\$ 1,547	\$ 255,164	\$ 233,781	\$ 17,729
19	0.378	\$ 1,457	\$ -	\$ 2,546	\$ 4,004	\$ 1,514	\$ 259,168	\$ 235,296	\$ 16,181
20	0.359	\$ 1,501	\$ -	\$ 2,623	\$ 4,124	\$ 1,482	\$ 263,292	\$ 236,778	\$ 14,667
21	0.341	\$ 1,546	\$ -	\$ 2,701	\$ 4,247	\$ 1,450	\$ 267,539	\$ 238,228	\$ 13,185
22	0.324	\$ 1,592	\$ -	\$ 2,782	\$ 4,375	\$ 1,419	\$ 271,914	\$ 239,648	\$ 11,734
23	0.308	\$ 1,640	\$ -	\$ 2,866	\$ 4,506	\$ 1,389	\$ 276,420	\$ 241,037	\$ 10,315
24	0.293	\$ 1,689	\$ -	\$ 2,952	\$ 4,641	\$ 1,359	\$ 281,062	\$ 242,396	\$ 8,926
25	0.278	\$ 1,740	\$ -	\$ 3,041	\$ 4,781	\$ 1,330	\$ 285,842	\$ 243,726	\$ 7,567
26	0.264	\$ 1,792	\$ -	\$ 3,132	\$ 4,924	\$ 1,302	\$ 290,766	\$ 245,028	\$ 6,237
27	0.251	\$ 1,846	\$ -	\$ 3,226	\$ 5,072	\$ 1,274	\$ 295,838	\$ 246,302	\$ 4,935
28	0.239	\$ 1,901	\$ -	\$ 3,322	\$ 5,224	\$ 1,247	\$ 301,062	\$ 247,549	\$ 3,661
29	0.227	\$ 1,958	\$ -	\$ 3,422	\$ 5,381	\$ 1,220	\$ 306,442	\$ 248,769	\$ 2,414
30	0.215	\$ 2,017	\$ -	\$ 3,525	\$ 5,542	\$ 1,194	\$ 311,984	\$ 249,963	\$ 1,194

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County Water Quality Benefits Evaluation - WO12			Estimator:	Jess Dexheimer (HDR) Tatiana Skadorwa (HDR) Cindy Kinzer (HDR)
Description:	King County, WA			Version:	1
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Deep UIC Well - ROW (Urban Roadway)	20	LF	\$ -	\$ -
2	Well - Borehole Diameter	12	IN	\$ -	\$ -
3	Well - Casing Diameter	0.7	FT	\$ -	\$ -
4	Drilling (12" Diameter Borehole)	20	VF	\$ 135	\$ 2,700
5	Well Casing (8-inch Diameter)	3	VF	\$ 59	\$ 177
6	Well Screen	20	VF	\$ 353	\$ 7,060
7	Maintenance Hole, Type 204A	1	EA	\$ 6,780	\$ 6,780
8	Misc Deep Well Costs	1	EA	\$ 3,710	\$ 3,710
9				\$ -	\$ -
10	Deep UIC Well Facility Removals and Restoration:			\$ -	\$ -
11	Clearing and Grubbing	69	SY	\$ 4	\$ 278
12	Grass seeding and Restoration	69	SY	\$ 10	\$ 683
13				\$ -	\$ -
14	High Rate Underground Filter			\$ -	\$ -
15	High Rate Underground Filter Length	6	FT		\$ -
16	High Rate Underground Filter Width	4	FT	\$ -	\$ -
17	Filterra Unit 4'X6' (complete)	1	EA	\$ 22,165	\$ 22,165
18	Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D)	78	CY	\$ 79	\$ 6,144
19	Imported Structural Fill	73	CY	\$ 44	\$ 3,227
20	Crushed Base	1	CY	\$ 64	\$ 64
21	Inlet Drain w/Energy Dissipating Rocks	1	EA	\$ 1,481	\$ 1,481
22	Catch Basin	1	EA	\$ 3,900	\$ 3,900
23	Pipe 8" dia.	50	LF	\$ 80	\$ 4,000
24	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900
25				\$ -	\$ -
26	Restoration High Rate Underground Filter			\$ -	\$ -
27	Landscaping, planting, and restoration	10	SY	\$ 59	\$ 590
28	Tree	1	EA	\$ 720	\$ 720
29					
30				\$ -	\$ -
31	Additional Costs			\$ -	\$ -
32	Removals @ 4% Construction Costs	4.0%	LS	\$ 67,579	\$ 2,703
33	Traffic Control (Heavy)	1	MO	\$ 20,000	\$ 20,000
34	TESC @2% Construction Costs	2%	LS	\$ 90,282	\$ 1,806
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 92,088
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%		1	\$ -
	Mobilization/Demobilization	10%		1.1	\$ 9,209
	Overhead & Profit (OHP)	0%		1	\$ -
	Insurance	0.0%		1	\$ -
	Bonding	0.0%		1	\$ -
	Escalation Multiplier from ENR-CCI	0%		1.0000	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 101,297
Direct: Subtotal Construction Costs					\$ 101,297

Description: WQBE_07G_Deep UIC Well with High Rate Filter on Property

A Deep UIC Well is a well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

General

The excavated material is unsuitable for use as backfill.
Restoration is seeded grass with mulch
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Installation is on property and does not require easements or acquisition
A street use permit is not required.

Deep UIC Well

Facility design is per 2019 Ecology Stormwater Management Manual.
Assumed depth of facility is 20 feet with a 12" diameter borehole.
All well backfill materials (gravel, bentonite clay, etc.) are assumed to be lumped in the "Misc. Deep Well Costs" bid item

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box.
Facility is sited on the property.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
Trench Box shoring is used.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Meaghan McGinn (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Description:	WQBE_08A_Pervious Concrete Sidewalk_no sand layer			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Pervious Concrete Sidewalk - No Treatment Sand Layer (200 SF Area)	200	SF	\$ 40	\$ 8,000
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 8,000
				Allowance for Indeterminates (Design Allowance)	\$ 1,200
				Street Use Permit (Y/N)	N
				ESTIMATED PROBABLE COST OF CONSTRUCTION BID	\$ 9,200
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	920
	Subtotal Primary Construction Amount			\$	10,120
	Construction Sales Tax			\$	1,037
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	11,200
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	1,214
	Construction Management			\$	810
	Permitting & Support			\$	51
	s.f. Land Area	None		Land Purchase/ROW Acquisition	\$ -
	WTD Staff Costs & Non-WTD Support			\$	506
	Subtotal Non-Construction Costs			\$	2,581
	Project Contingency			\$	2,067
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	4,600
	TOTAL PROJECT COST (2023 Dollars)			\$	15,800

Description: WQBE_08A - Pervious Concrete Sidewalk (no sand layer) (2023 Dollars)

Unit	200 ft ²
Initial Capital Cost	\$ 15,800
Capital cost	\$ 79.00 /Unit
Total Direct O&M/Year	\$ 1,631.70
Direct O&M cost	\$ 8.16 /Unit
Capital Replacement Costs	\$ 795 /Unit
Discount rate (%)	5.25 %/Unit

Replace 10% of total each year.

Total Cost (NPV)	\$ 75,700	\$/unit
Annual O&M Cost	\$ 2,300	\$/year
Annualized Cost	\$1,000	\$/year

Description: WQBE_08A - Pervious Concrete Sidewalk (no sand layer)

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

- ⁴ Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at \$518 annual total.
⁸ Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes annually with a crew of 2 at 4 hours per visit. Assumed \$113 annually for cement patching mix.

Replacement Assumptions:

Remediation of major cracks, trip hazards, or large areas of concrete spalling and raveling by cutting and replacing. Assume annual replacement of 10% of the total pavement area (20 square feet). Work would include sawcutting pavement, and excavating out and replacing the pavement and subbase. Items will include those highlighted in blue on the cost estimate sheet.

Materials, Supplies, Other Costs		2023 Costs
Miscellaneous Drainage Parts	\$ -	\$ 113 /\$/year
Equipment Rental-Regenerative Air Sweeper		\$ 518 /\$/year
		\$ - /\$/year
Subtotal		\$ 631
Labor		
Removal of Soil, Mulch, or Sediment	4	hr
Remediation of Cracks and Trip Hazards	8	hr
Activity	0	hr
Activity	0	hr
Total hours per year	12	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded)	\$ 653
Labor cost, burdened	O/H 150.0%	\$ 1,632
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30	years

\$ 135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 30,020		\$ 77,629	\$ 147,290	\$ 75,651			
0	1.000	\$ 15,800		\$ 15,800	\$ 15,800	\$ 15,800	\$ 15,800	\$ 15,800	\$ 75,651
1	0.950	\$ 631	\$ 795	\$ 1,632	\$ 3,057	\$ 2,905	\$ 18,857	\$ 18,705	\$ 59,851
2	0.903	\$ 650	\$ 795	\$ 1,681	\$ 3,125	\$ 2,821	\$ 21,983	\$ 21,526	\$ 56,946
3	0.858	\$ 669	\$ 795	\$ 1,731	\$ 3,195	\$ 2,741	\$ 25,178	\$ 24,267	\$ 54,125
4	0.815	\$ 690	\$ 795	\$ 1,783	\$ 3,267	\$ 2,662	\$ 28,445	\$ 26,929	\$ 51,384
5	0.774	\$ 710	\$ 795	\$ 1,836	\$ 3,341	\$ 2,587	\$ 31,786	\$ 29,516	\$ 48,722
6	0.736	\$ 732	\$ 795	\$ 1,892	\$ 3,418	\$ 2,514	\$ 35,204	\$ 32,031	\$ 46,135
7	0.699	\$ 753	\$ 795	\$ 1,948	\$ 3,496	\$ 2,444	\$ 38,701	\$ 34,474	\$ 43,620
8	0.664	\$ 776	\$ 795	\$ 2,007	\$ 3,578	\$ 2,376	\$ 42,278	\$ 36,850	\$ 41,177
9	0.631	\$ 799	\$ 795	\$ 2,067	\$ 3,661	\$ 2,310	\$ 45,939	\$ 39,160	\$ 38,801
10	0.599	\$ 823	\$ 795	\$ 2,129	\$ 3,747	\$ 2,246	\$ 49,686	\$ 41,406	\$ 36,491
11	0.570	\$ 848	\$ 795	\$ 2,193	\$ 3,836	\$ 2,188	\$ 53,522	\$ 43,591	\$ 34,245
12	0.541	\$ 873	\$ 795	\$ 2,259	\$ 3,927	\$ 2,125	\$ 57,449	\$ 45,716	\$ 32,060
13	0.514	\$ 900	\$ 795	\$ 2,326	\$ 4,021	\$ 2,067	\$ 61,470	\$ 47,784	\$ 29,935
14	0.489	\$ 927	\$ 795	\$ 2,396	\$ 4,118	\$ 2,012	\$ 65,587	\$ 49,795	\$ 27,867
15	0.464	\$ 954	\$ 795	\$ 2,468	\$ 4,217	\$ 1,957	\$ 69,804	\$ 51,763	\$ 25,866
16	0.441	\$ 983	\$ 795	\$ 2,542	\$ 4,320	\$ 1,905	\$ 74,124	\$ 53,658	\$ 23,898
17	0.419	\$ 1,013	\$ 795	\$ 2,618	\$ 4,426	\$ 1,854	\$ 78,550	\$ 55,512	\$ 21,993
18	0.398	\$ 1,043	\$ 795	\$ 2,697	\$ 4,535	\$ 1,808	\$ 83,084	\$ 57,317	\$ 20,139
19	0.378	\$ 1,074	\$ 795	\$ 2,778	\$ 4,647	\$ 1,758	\$ 87,731	\$ 59,075	\$ 18,334
20	0.359	\$ 1,106	\$ 795	\$ 2,861	\$ 4,762	\$ 1,712	\$ 92,494	\$ 60,787	\$ 16,576
21	0.341	\$ 1,140	\$ 795	\$ 2,947	\$ 4,881	\$ 1,667	\$ 97,375	\$ 62,453	\$ 14,864
22	0.324	\$ 1,174	\$ 795	\$ 3,035	\$ 5,004	\$ 1,623	\$ 102,379	\$ 64,077	\$ 13,198
23	0.308	\$ 1,209	\$ 795	\$ 3,127	\$ 5,130	\$ 1,581	\$ 107,509	\$ 65,658	\$ 11,574
24	0.293	\$ 1,245	\$ 795	\$ 3,220	\$ 5,260	\$ 1,541	\$ 112,770	\$ 67,199	\$ 9,993
25	0.278	\$ 1,283	\$ 795	\$ 3,317	\$ 5,394	\$ 1,501	\$ 118,164	\$ 68,700	\$ 8,452
26	0.264	\$ 1,321	\$ 795	\$ 3,416	\$ 5,532	\$ 1,463	\$ 123,698	\$ 70,162	\$ 6,951
27	0.251	\$ 1,361	\$ 795	\$ 3,519	\$ 5,674	\$ 1,425	\$ 129,371	\$ 71,588	\$ 5,489
28	0.239	\$ 1,402	\$ 795	\$ 3,624	\$ 5,821	\$ 1,389	\$ 135,191	\$ 72,977	\$ 4,063
29	0.227	\$ 1,444	\$ 795	\$ 3,733	\$ 5,972	\$ 1,354	\$ 141,163	\$ 74,331	\$ 2,674
30	0.215	\$ 1,487	\$ 795	\$ 3,845	\$ 6,127	\$ 1,320	\$ 147,290	\$ 75,651	\$ 1,320

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Meaghan McGinn (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Description:	WQBE_08A_Pervious Concrete Sidewalk_no sand layer			Version:	3
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Pervious Concrete Sidewalk (no sand layer)	200	SF	\$ -	\$ -
2	Excavation Incl. Haul (to waste)	9	CY	\$ 79	\$ 683
3	Pervious Concrete Sidewalk - 5" Thick	22	SY	\$ 267	\$ 5,933
4	Permeable Ballast Base Course, incl. haul - 3" Thick	2	CY	\$ 105	\$ 194
5				\$ -	\$ -
6	Additional Costs			\$ -	\$ -
7	Removals @ 4% Construction Costs	4.0%	LS	\$ 6,810	\$ 272
8	TESC @ 2% Construction Costs	2%	LS	\$ 7,083	\$ 142
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 7,225
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 722
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 7,947
<i>Direct: Subtotal Construction Costs (200 SF Area)</i>					\$ 7,947

Description: WQBE_08A - Pervious Concrete Sidewalk (no sand layer)

Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

Cost Assumptions

Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that the soils and drainage conditions are suitable for permeable pavement installation.

It is assumed that this facility is on cropland and part of a GSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 5-inches of porous concrete pavement and 3-inches of aggregate subbase. It is assumed to be non-PGIS and no treatment sand layer is provided.

The installation is assumed to be for residential and commercial installations and are not located within a vehicular traffic area.

The facility is 200 s.f. with a 1:1 Length:Width ratio.

It was assumed that there is less than 3-inches of grade loss across the facility, and that check dams - per Seattle SW Manual would not be required.

Concrete curb and gutter removal and restoration is not required for the installation.

Land acquisition and easements are not included.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on cropland and traffic control will not be required.

The facility is located outside of the ROW and a street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative pavement materials have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimates reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and chance order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low**, indirect project cost complexity factor was assigned: 12% Design Engineering, 8%, Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for unidentified risk (AFI) is applied to the total construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further developed as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE

International with an accuracy range of **±5% to ±10%** for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE_08B - Porous Asphalt Driveway (with sand layer) (2023 Dollars)

Unit	200 ft ²
Initial Capital Cost	\$ 8,300
Capital cost	\$ 41.50 /\$Unit
Total Direct O&M/Year	\$ 1,631.70
Direct O&M cost	\$ 8.16 /\$Unit
Capital Replacement Costs	\$ 423 /\$unit
Discount rate (%)	5.25 /\$Unit

Replace 10% of total each year.

Total Cost (NPV)	\$ 63,800	\$/unit
Annual O&M Cost	\$ 2,300	\$/year
Annualized Cost	\$1,090	\$/year

Materials, Supplies, Other Costs

Miscellaneous Drainage Parts	\$ -	\$ 169	\$/year
Equipment Rental- Regenerative Air Sweeper		\$ 518	
		\$ -	\$/year
Subtotal		\$ 687	
Labor			
Removal of Soil, Mulch, or Sediment		4 hr	
Remediation of Cracks and Trip Hazards		8 hr	
Activity		0 hr	
Activity		0 hr	
Total hours per year		12	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 653	
Labor cost, burdened	O/H 150.0%	\$ 1,632	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Description: WQBE_08B - Porous Asphalt Driveway (with sand layer)

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at \$518 annual total.
Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes. In this case, with pavers, it was assumed small repairs such as cracked pavers and minor localized settling and high spots would be repaired annually with a crew of 2 at 4 hours per visit. Assumed \$113 annually for replacement pavers and \$56 for sand leveling course; at this level of repair, the base course was assumed to not need repairs.

Replacement Assumptions:

Remediation of major cracks, trip hazards, or large areas of concrete spalling and raveling by cutting and replacing. Assume annual replacement of 10% of the total pavement area (20 square feet). Work would include sawcutting pavement, and excavating out and replacing the pavement and subbase. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 32,684		\$ 77,629	\$ 131,314	\$ 63,789				
0	1.000	\$ 8,300			\$ 8,300	\$ 8,300	\$ 8,300	\$ 8,300	\$ 63,789
1	0.950	\$ 687	\$ 423	\$ 1,632	\$ 2,742	\$ 2,605	\$ 11,042	\$ 10,905	\$ 55,489
2	0.903	\$ 708	\$ 423	\$ 1,681	\$ 2,812	\$ 2,538	\$ 13,854	\$ 13,443	\$ 52,884
3	0.858	\$ 729	\$ 423	\$ 1,731	\$ 2,883	\$ 2,473	\$ 16,737	\$ 15,916	\$ 50,346
4	0.815	\$ 751	\$ 423	\$ 1,783	\$ 2,957	\$ 2,410	\$ 19,694	\$ 18,326	\$ 47,873
5	0.774	\$ 773	\$ 423	\$ 1,836	\$ 3,033	\$ 2,348	\$ 22,727	\$ 20,675	\$ 45,463
6	0.736	\$ 796	\$ 423	\$ 1,892	\$ 3,111	\$ 2,289	\$ 25,839	\$ 22,963	\$ 43,115
7	0.699	\$ 820	\$ 423	\$ 1,948	\$ 3,192	\$ 2,231	\$ 29,031	\$ 25,195	\$ 40,826
8	0.664	\$ 845	\$ 423	\$ 2,007	\$ 3,275	\$ 2,175	\$ 32,306	\$ 27,369	\$ 38,593
9	0.631	\$ 870	\$ 423	\$ 2,067	\$ 3,361	\$ 2,120	\$ 35,666	\$ 29,490	\$ 36,420
10	0.599	\$ 896	\$ 423	\$ 2,129	\$ 3,449	\$ 2,067	\$ 39,115	\$ 31,557	\$ 34,299
11	0.570	\$ 923	\$ 423	\$ 2,193	\$ 3,540	\$ 2,016	\$ 42,655	\$ 33,573	\$ 32,232
12	0.541	\$ 951	\$ 423	\$ 2,259	\$ 3,633	\$ 1,966	\$ 46,288	\$ 35,539	\$ 30,216
13	0.514	\$ 979	\$ 423	\$ 2,326	\$ 3,729	\$ 1,918	\$ 50,017	\$ 37,457	\$ 28,250
14	0.489	\$ 1,009	\$ 423	\$ 2,396	\$ 3,828	\$ 1,870	\$ 53,845	\$ 39,327	\$ 26,332
15	0.464	\$ 1,039	\$ 423	\$ 2,468	\$ 3,931	\$ 1,824	\$ 57,776	\$ 41,152	\$ 24,462
16	0.441	\$ 1,070	\$ 423	\$ 2,542	\$ 4,036	\$ 1,780	\$ 61,812	\$ 42,932	\$ 22,638
17	0.419	\$ 1,102	\$ 423	\$ 2,618	\$ 4,144	\$ 1,736	\$ 65,956	\$ 44,668	\$ 20,858
18	0.398	\$ 1,136	\$ 423	\$ 2,697	\$ 4,256	\$ 1,694	\$ 70,212	\$ 46,362	\$ 19,121
19	0.378	\$ 1,170	\$ 423	\$ 2,778	\$ 4,371	\$ 1,653	\$ 74,583	\$ 48,016	\$ 17,427
20	0.359	\$ 1,205	\$ 423	\$ 2,861	\$ 4,489	\$ 1,613	\$ 79,072	\$ 49,629	\$ 15,774
21	0.341	\$ 1,241	\$ 423	\$ 2,947	\$ 4,611	\$ 1,575	\$ 83,683	\$ 51,203	\$ 14,160
22	0.324	\$ 1,278	\$ 423	\$ 3,035	\$ 4,737	\$ 1,537	\$ 88,420	\$ 52,740	\$ 12,586
23	0.308	\$ 1,316	\$ 423	\$ 3,127	\$ 4,866	\$ 1,500	\$ 93,286	\$ 54,240	\$ 11,049
24	0.293	\$ 1,356	\$ 423	\$ 3,220	\$ 5,000	\$ 1,464	\$ 98,286	\$ 55,704	\$ 9,549
25	0.278	\$ 1,397	\$ 423	\$ 3,317	\$ 5,137	\$ 1,429	\$ 103,422	\$ 57,134	\$ 8,085
26	0.264	\$ 1,438	\$ 423	\$ 3,416	\$ 5,278	\$ 1,395	\$ 108,701	\$ 58,529	\$ 6,656
27	0.251	\$ 1,482	\$ 423	\$ 3,519	\$ 5,424	\$ 1,362	\$ 114,125	\$ 59,892	\$ 5,260
28	0.239	\$ 1,526	\$ 423	\$ 3,624	\$ 5,574	\$ 1,330	\$ 119,698	\$ 61,222	\$ 3,898
29	0.227	\$ 1,572	\$ 423	\$ 3,733	\$ 5,728	\$ 1,299	\$ 125,427	\$ 62,521	\$ 2,567
30	0.215	\$ 1,619	\$ 423	\$ 3,845	\$ 5,888	\$ 1,268	\$ 131,314	\$ 63,789	\$ 1,268

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_08B_Porous Asphalt Driveway (with sand layer)		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
	Porous Asphalt Driveway (with sand layer) - On Property	200	SF	\$ -	\$ -
	Roadway Excavation Incl. Haul (to waste)	9	CY	\$ 79	\$ 683
	Permeable Pavement HMA Cl. 1/2" PG 70-22ER - 5" Thick (small quantity)	5.7	TN	\$ 360	\$ 2,040
	Permeable Ballast Base Course, incl. haul - 3" Thick	2	CY	\$ 105	\$ 194
	Sand (Water Quality Treatment Course) - 6" Thick	4	CY	\$ 168	\$ 622
	Geotextile	22	SY	\$ 4	\$ 89
				\$ -	\$ -
	Additional Costs			\$ -	\$ -
				\$ -	\$ -
	Removals @ 4% Construction Costs	4.0%	LS	\$ 3,628	\$ 145
	TESC @ 2% Construction Costs	2%	LS	\$ 3,773	\$ 75
				\$ -	\$ -
	<i>Item Subtotal Construction Costs (Year 2023)</i>				\$ 3,849
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 385
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
	<i>Item Subtotal Construction Costs (Year 2023)</i>				\$ 4,234
	Direct: Subtotal Construction Costs (200 SF Area)				\$ 4,234

Description: WQBE_08B - Porous Asphalt Driveway (with sand layer)

Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

Cost Assumptions

Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that the soils and drainage conditions are suitable for permeable pavement installation.

It is assumed that this facility is on property and part of a CSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 5-inches of permeable asphalt pavement, 3-inches of aggregate subbase, 6-inches of sand (treatment course), and a subgrade geotextile.

Permeable Pavement is Porous Hot Mix Asphalt Cl. 1/2 PG 70-22 ER

The installation is assume to be for residential and commercial installation and does not include industrial or heavily trafficked areas.

The facility is 200 s.f. with a 1:1 Length:Width ratio.

It was assumed that there is less than 3-inches of grade loss across the facility, and that check dams (per Seattle SW Manual) would not be required.

Dewatering is not required.

Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Landscape restoration is not included.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control will not be required.

The facility is located outside of the ROW and a street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **10%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE_08C - Permeable Paver Driveway (with sand layer) (2023 Dollars)

Unit	200	ft ²
Initial Capital Cost	\$ 11,000	
Capital cost	\$ 55.00	/Unit
Total Direct O&M/year	\$ 1,631.70	
Direct O&M cost	\$ 8.16	/Unit
Capital Replacement Costs	\$ 554	/Unit
Discount rate (%)	5.25	/Unit

Replace 10% of total each year.

Total Cost (NPV)	\$ 68,400	\$/unit
Annual O&M Cost	\$ 2,300	\$/year

Materials, Supplies, Other Costs

Miscellaneous Drainage Parts	\$ -	\$ 169	\$/year
Equipment Rental- Regenerative Air Sweeper		\$ 518	
		\$ -	\$/year

Subtotal \$ 687

Labor

Removal of soil, mulch and sediment	4 hr
Remediate small cracks and trip hazards	8 hr
Activity	0 hr
Activity	0 hr
Total hours per year	12
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 653
Labor cost, burdened	O/H 150.0% \$ 1,632
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Description: WQBE_08C - Permeable Paver Driveway (with sand layer)

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

4 Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at \$518 annual total.

8 Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes annually with a crew of 2 at 4 hours per visit. Assumed \$113 annually for replacement cement patching mix and \$56 for sand leveling course.

Replacement Assumptions:

Full replacement of 10% of the pavers every year.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 32,684		\$ 77,629	\$ 137,948	\$ 68,449			
0	1.000	\$ 11,000		\$ 11,000	\$ 11,000	\$ 11,000	\$ 11,000	\$ 11,000	\$ 68,449
1	0.950	\$ 687	\$ 554	\$ 1,632	\$ 2,873	\$ 2,730	\$ 13,873	\$ 13,730	\$ 57,449
2	0.903	\$ 708	\$ 554	\$ 1,681	\$ 2,943	\$ 2,656	\$ 16,816	\$ 16,386	\$ 54,719
3	0.858	\$ 729	\$ 554	\$ 1,731	\$ 3,014	\$ 2,585	\$ 19,830	\$ 18,972	\$ 52,062
4	0.815	\$ 751	\$ 554	\$ 1,783	\$ 3,088	\$ 2,517	\$ 22,919	\$ 21,488	\$ 49,477
5	0.774	\$ 773	\$ 554	\$ 1,836	\$ 3,164	\$ 2,450	\$ 26,083	\$ 23,938	\$ 46,960
6	0.736	\$ 796	\$ 554	\$ 1,892	\$ 3,242	\$ 2,385	\$ 29,325	\$ 26,324	\$ 44,510
7	0.699	\$ 820	\$ 554	\$ 1,948	\$ 3,323	\$ 2,323	\$ 32,648	\$ 28,646	\$ 42,125
8	0.664	\$ 845	\$ 554	\$ 2,007	\$ 3,406	\$ 2,262	\$ 36,055	\$ 30,908	\$ 39,802
9	0.631	\$ 870	\$ 554	\$ 2,067	\$ 3,492	\$ 2,203	\$ 39,546	\$ 33,111	\$ 37,540
10	0.599	\$ 896	\$ 554	\$ 2,129	\$ 3,580	\$ 2,146	\$ 43,126	\$ 35,258	\$ 35,337
11	0.570	\$ 923	\$ 554	\$ 2,193	\$ 3,671	\$ 2,091	\$ 46,797	\$ 37,348	\$ 33,191
12	0.541	\$ 951	\$ 554	\$ 2,259	\$ 3,764	\$ 2,037	\$ 50,561	\$ 39,385	\$ 31,100
13	0.514	\$ 979	\$ 554	\$ 2,326	\$ 3,860	\$ 1,985	\$ 54,421	\$ 41,370	\$ 29,063
14	0.489	\$ 1,009	\$ 554	\$ 2,396	\$ 3,960	\$ 1,934	\$ 58,381	\$ 43,305	\$ 27,078
15	0.464	\$ 1,039	\$ 554	\$ 2,468	\$ 4,062	\$ 1,885	\$ 62,443	\$ 45,190	\$ 25,144
16	0.441	\$ 1,070	\$ 554	\$ 2,542	\$ 4,167	\$ 1,838	\$ 66,610	\$ 47,028	\$ 23,259
17	0.419	\$ 1,102	\$ 554	\$ 2,618	\$ 4,275	\$ 1,791	\$ 70,885	\$ 48,819	\$ 21,421
18	0.398	\$ 1,136	\$ 554	\$ 2,697	\$ 4,387	\$ 1,746	\$ 75,272	\$ 50,565	\$ 19,630
19	0.378	\$ 1,170	\$ 554	\$ 2,778	\$ 4,502	\$ 1,703	\$ 79,774	\$ 52,268	\$ 17,883
20	0.359	\$ 1,205	\$ 554	\$ 2,861	\$ 4,620	\$ 1,660	\$ 84,394	\$ 53,929	\$ 16,180
21	0.341	\$ 1,241	\$ 554	\$ 2,947	\$ 4,742	\$ 1,619	\$ 89,136	\$ 55,548	\$ 14,520
22	0.324	\$ 1,278	\$ 554	\$ 3,035	\$ 4,868	\$ 1,579	\$ 94,004	\$ 57,127	\$ 12,900
23	0.308	\$ 1,316	\$ 554	\$ 3,127	\$ 4,997	\$ 1,540	\$ 99,002	\$ 58,668	\$ 11,321
24	0.293	\$ 1,356	\$ 554	\$ 3,220	\$ 5,131	\$ 1,503	\$ 104,132	\$ 60,170	\$ 9,781
25	0.278	\$ 1,397	\$ 554	\$ 3,317	\$ 5,268	\$ 1,466	\$ 109,400	\$ 61,636	\$ 8,278
26	0.264	\$ 1,438	\$ 554	\$ 3,416	\$ 5,409	\$ 1,430	\$ 114,810	\$ 63,066	\$ 6,812
27	0.251	\$ 1,482	\$ 554	\$ 3,519	\$ 5,555	\$ 1,395	\$ 120,364	\$ 64,462	\$ 5,382
28	0.239	\$ 1,526	\$ 554	\$ 3,624	\$ 5,705	\$ 1,362	\$ 126,069	\$ 65,823	\$ 3,987
29	0.227	\$ 1,572	\$ 554	\$ 3,733	\$ 5,860	\$ 1,329	\$ 131,929	\$ 67,152	\$ 2,625
30	0.215	\$ 1,619	\$ 554	\$ 3,845	\$ 6,019	\$ 1,297	\$ 137,948	\$ 68,449	\$ 1,297

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Meaghan McGinn (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_08C_Permeable Paver Driveway (with sand layer)		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Permeable Paver Driveway (with sand layer)	200	SF	\$ -	\$ -
2	Driveway Excavation Incl. Haul (to waste)	9	CY	\$ 79	\$ 683
3	Permeable Concrete Paver 8" Thick	200	SF	\$ 16	\$ 3,200
4	Sand (Leveling Course) - 1" Thick	1	CY	\$ 85	\$ 52
5	Permeable Ballast Base Course, incl. haul - 3" Thick	2	CY	\$ 105	\$ 194
6	Sand (Water Quality Treatment Course) - 6" Thick	4	CY	\$ 168	\$ 622
7					\$ -
8	Additional Costs				\$ -
9	Removals @ 4% Construction Costs	4.0%	LS	\$ 4,752	\$ 190
10	TESC @ 2% Construction Costs	2%	LS	\$ 4,942	\$ 99
					\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 5,041
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	
	Mobilization/Demobilization	10%	1.1	\$ -	504
	Overhead & Profit (OHP)	0%	1	\$ -	
	Insurance	0.0%	1	\$ -	
	Bonding	0.0%	1	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 5,545
<i>Direct: Subtotal Construction Costs (200 SF Area)</i>					\$ 5,545

Description: WQBE_08C - Permeable Paver Driveway (with sand layer)
Permeable concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

Cost Assumptions

Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that the soils and drainage conditions are suitable for permeable paver installation.

It is assumed that this facility is on crooked and out of a GSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 8-inches savers with 0.1' of leveling and filler sand. 3-inches of aggregate subbase. 6-inches of sand.

Permeable Concrete Pavers 8-inch thick and standard widths are used.

The installation is assume to be for residential and commercial installation and does not include industrial or heavily trafficked areas.

The permeable paver area is 200 s.f. with a 1:1 Length/Width ratio.

It is assumed that there is less than 3-inches of grade loss across the facility, and that check dams - per Seattle SW Manual is not required.

Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Landscape restoration is not included.

Removal and disposal of item construction costs, in conformance with LTCP.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control will not be required.

The facility is located outside of the ROW and a street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and type of allowances used in the estimates are as follows:

Salaries and wages included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential chance orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Low** indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a successful and safe project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mileage and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE

International with an accuracy range of **-50% to +10%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimation process.

Description: WQBE_08D_Permeable Paver Plaza (no sand layer) (2023 Dollars)

Unit	200 ft ²
Initial Capital Cost	\$ 9,500
Capital cost	\$ 47.50 \$/Unit
Total Direct O&M/year	\$ 1,631.70
Direct O&M cost	\$ 8.16 \$/Unit
Capital Replacement Costs	\$ 488 \$/unit
Discount rate (%)	5.25 \$/Unit

Replace 10% of total each year.

Total Cost (NPV)	\$ 64,800	\$/unit
Annual O&M Cost	\$ 2,300	\$/year

Annualized Cost \$1,000 \$/year

Materials, Supplies, Other Costs

Miscellaneous Drainage Parts	\$ -	\$ 113	\$/year
Equipment Rental- Regenerative Air Sweeper		\$ 518	

Subtotal \$ - \$ 631

Labor

Removal of Soil, Mulch, or Sediment	4 hr
Remediation of Cracks and Trip Hazards	8 hr
Remediation of erosion	0 hr
Activity	0 hr
Total hours per year	12
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 653
Labor cost, burdened	O/H 150.0% \$ 1,652
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Description: WQBE_08D_Permeable Paver Plaza (no sand layer)

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

- 4 Removal of soil, mulch or sediment on paving twice a year with a crew of two using a regenerative air sweeper at 1 hour per visit (4 hours per year total). Air sweeper rental costs at \$518 annual total.
8 Remediation of small cracks, trip hazards, or small areas of concrete spalling and raveling by filling with patching mixes annually with a crew of 2 at 4 hours per visit. Assumed \$113 annually for cement patching mix.

Replacement Assumptions:

Full replacement of 10% of the pavers every year.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 30,020		\$ 77,629	\$ 131,785	\$ 64,766				
0	1.000	\$ 9,500		\$ 9,500	\$ 9,500	\$ 9,500	\$ 9,500	\$ 9,500	\$ 64,766
1	0.950	\$ 631	\$ 488	\$ 1,632	\$ 2,751	\$ 2,613	\$ 12,251	\$ 12,113	\$ 55,266
2	0.903	\$ 650	\$ 488	\$ 1,681	\$ 2,818	\$ 2,544	\$ 15,069	\$ 14,658	\$ 52,652
3	0.858	\$ 669	\$ 488	\$ 1,731	\$ 2,888	\$ 2,477	\$ 17,957	\$ 17,135	\$ 50,108
4	0.815	\$ 690	\$ 488	\$ 1,783	\$ 2,960	\$ 2,412	\$ 20,918	\$ 19,547	\$ 47,631
5	0.774	\$ 710	\$ 488	\$ 1,836	\$ 3,035	\$ 2,350	\$ 23,952	\$ 21,897	\$ 45,218
6	0.736	\$ 732	\$ 488	\$ 1,892	\$ 3,111	\$ 2,289	\$ 27,063	\$ 24,185	\$ 42,869
7	0.699	\$ 753	\$ 488	\$ 1,948	\$ 3,190	\$ 2,229	\$ 30,253	\$ 26,415	\$ 40,580
8	0.664	\$ 776	\$ 488	\$ 2,007	\$ 3,271	\$ 2,172	\$ 33,524	\$ 28,587	\$ 38,351
9	0.631	\$ 799	\$ 488	\$ 2,067	\$ 3,354	\$ 2,116	\$ 36,878	\$ 30,703	\$ 36,179
10	0.599	\$ 823	\$ 488	\$ 2,129	\$ 3,440	\$ 2,062	\$ 40,318	\$ 32,766	\$ 34,062
11	0.570	\$ 848	\$ 488	\$ 2,193	\$ 3,529	\$ 2,010	\$ 43,847	\$ 34,775	\$ 32,000
12	0.541	\$ 873	\$ 488	\$ 2,259	\$ 3,620	\$ 1,959	\$ 47,467	\$ 36,735	\$ 29,990
13	0.514	\$ 900	\$ 488	\$ 2,326	\$ 3,714	\$ 1,910	\$ 51,181	\$ 38,644	\$ 28,031
14	0.489	\$ 927	\$ 488	\$ 2,396	\$ 3,811	\$ 1,862	\$ 54,991	\$ 40,506	\$ 26,121
15	0.464	\$ 954	\$ 488	\$ 2,468	\$ 3,910	\$ 1,815	\$ 58,902	\$ 42,321	\$ 24,260
16	0.441	\$ 983	\$ 488	\$ 2,542	\$ 4,013	\$ 1,770	\$ 62,915	\$ 44,091	\$ 22,445
17	0.419	\$ 1,013	\$ 488	\$ 2,618	\$ 4,119	\$ 1,726	\$ 67,034	\$ 45,816	\$ 20,675
18	0.398	\$ 1,043	\$ 488	\$ 2,697	\$ 4,228	\$ 1,683	\$ 71,261	\$ 47,500	\$ 18,949
19	0.378	\$ 1,074	\$ 488	\$ 2,778	\$ 4,340	\$ 1,642	\$ 75,601	\$ 49,141	\$ 17,266
20	0.359	\$ 1,106	\$ 488	\$ 2,861	\$ 4,456	\$ 1,601	\$ 80,057	\$ 50,742	\$ 15,624
21	0.341	\$ 1,140	\$ 488	\$ 2,947	\$ 4,575	\$ 1,562	\$ 84,631	\$ 52,304	\$ 14,023
22	0.324	\$ 1,174	\$ 488	\$ 3,035	\$ 4,697	\$ 1,524	\$ 89,328	\$ 53,828	\$ 12,461
23	0.308	\$ 1,209	\$ 488	\$ 3,127	\$ 4,823	\$ 1,487	\$ 94,152	\$ 55,315	\$ 10,937
24	0.293	\$ 1,245	\$ 488	\$ 3,220	\$ 4,953	\$ 1,451	\$ 99,105	\$ 56,766	\$ 9,451
25	0.278	\$ 1,283	\$ 488	\$ 3,317	\$ 5,087	\$ 1,416	\$ 104,193	\$ 58,181	\$ 8,000
26	0.264	\$ 1,321	\$ 488	\$ 3,416	\$ 5,225	\$ 1,381	\$ 109,418	\$ 59,563	\$ 6,584
27	0.251	\$ 1,361	\$ 488	\$ 3,519	\$ 5,368	\$ 1,348	\$ 114,786	\$ 60,911	\$ 5,203
28	0.239	\$ 1,402	\$ 488	\$ 3,624	\$ 5,514	\$ 1,316	\$ 120,300	\$ 62,227	\$ 3,854
29	0.227	\$ 1,444	\$ 488	\$ 3,733	\$ 5,665	\$ 1,285	\$ 125,965	\$ 63,512	\$ 2,538
30	0.215	\$ 1,487	\$ 488	\$ 3,845	\$ 5,820	\$ 1,254	\$ 131,785	\$ 64,766	\$ 1,254

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Meaghan McGinn (HDR) Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_08D_Permeable Paver Plaza (no sand layer)		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Permeable Paver Plaza (no sand layer)	200	SF	\$ -	\$ -
2	Driveway Excavation Incl. Haul (to waste)	9	CY	\$ 79	\$ 683
3	Permeable Concrete Paver 8" Thick	200	SF	\$ 16	\$ 3,200
4	Sand (Seating & Leveling Course) - 1" Thick	1	CY	\$ 168	\$ 104
5	Permeable Ballast Base Course, incl. haul - 3" Thick	2	CY	\$ 105	\$ 194
6					\$ -
7	Additional Costs				\$ -
8	Removals @ 4% Construction Costs	4.0%	LS	\$ 4,181	\$ 167
9	TESC @ 2% Construction Costs	2%	LS	\$ 4,348	\$ 87
					\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 4,435
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%		1	\$ -
	Mobilization/Demobilization	10%		1.1	\$ 444
	Overhead & Profit (OHP)	0%		1	\$ -
	Insurance	0.0%		1	\$ -
	Bonding	0.0%		1	\$ -
	Escalation Multiplier from ENR-CCI	0%		1.0000	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 4,879
Direct: Subtotal Construction Costs (200 SF Area)					\$ 4,879

Description: WQBE_08D - Permeable Paver Plaza (no sand layer)

Permeable concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through pavement.

Cost Assumptions

Permeable Pavement installation is per the King Co. SW Design Manual Appendix C, Section C.2.7.

It is assumed that site soils and drainage conditions are suitable for permeable paver installation.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

The permeable pavement section consists of 8-inches pavers with 0.1' of leveling and filler sand. 3-inches of aggregate subbase. 6-inches of sand.

Permeable Concrete Pavers 8-inch thick and standard widths are used.

The installation is assume to be for residential and commercial installation and does not include industrial or heavily trafficked areas.

The permeable paver area is 200 s.f. with a 1:1 Length:Width ratio.

It is assumed that there is less than 5-inches of grade loss across the facility, and that check dams - per Seattle SW Manual is not required.

Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Landscape restoration is not included.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control will not be required.

The facility is located outside of the ROW and a street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a one week per week with limited overtime.

No site specific environmental studies have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and type of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% added to the base construction cost including the design and change order contingencies.

Allowance for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD.

Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Utility Relocation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not included**.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** RCM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Description:	WQBE 09A_Removal of Impervious Surfaces on Property (wheel strips)			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Removal of Impervious Surfaces - On Property (Wheel Strips)	100	SF	\$ 13	\$ 1,300
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 1,300
				Allowance for Indeterminates (Design Allowance)	\$ 195
				Street Use Permit (Y/N) N	\$ -
				ESTIMATED PROBABLE COST OF CONSTRUCTION BID	\$ 1,495
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$ 150	
	Subtotal Primary Construction Amount			\$ 1,645	
	Construction Sales Tax			\$ 169	
	Outside Agency Construction			\$ -	
	TOTAL DIRECT CONSTRUCTION COSTS			\$ 1,800	
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$ 197	
	Construction Management			\$ 132	
	Permitting & Support			\$ 8	
s.f. Land Area	None			\$ -	
	Land Purchase/ROW Acquisition			\$ -	
	WTD Staff Costs & Non-WTD Support			\$ 82	
	Subtotal Non-Construction Costs			\$ 419	
	Project Contingency			\$ 333	
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$ 800	
	TOTAL PROJECT COST (2023 Dollars)			\$ 2,600	

Description: WQBE 9A_Removal of Impervious Surfaces on Property
(wheel strips) (2023 Dollars)

Unit	100 ft ²
Initial Capital Cost	\$ 2,600
Capital cost	\$ 26.00 /Unit
Total Direct O&M/year	\$ 543.90
Direct O&M cost	\$ 5.44 /Unit
Capital Replacement Costs (10 years)	\$ 244 /unit
Discount rate (%)	5.25 \$/Unit

Total Cost (NPV)	\$ 16,800	\$/unit
Annual O&M Cost	\$ 700	\$/year
Annualized Cost	\$180	\$/year

Materials, Supplies, Other Costs		\$ -	\$/year
Tilling and seeding	2023 Costs	\$ 113	\$/year
		\$ -	\$/year
Subtotal		\$ 113	
Labor			
Tilling and Overseeding	4 hr		
	0 hr		
	0 hr		
	0 hr		
Total hours per year	4		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 218	
Labor cost, burdened	O/H 150.0%	\$ 544	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 5,376		\$ 25,876	\$ 34,340	\$ 16,762			
0	1.000	\$ 2,600		\$ 544	\$ 2,600	\$ 2,600	\$ 2,600	\$ 2,600	\$ 16,762
1	0.950	\$ 113	\$ -	\$ 560	\$ 657	\$ 624	\$ 3,257	\$ 3,224	\$ 14,162
2	0.903	\$ 116	\$ -	\$ 577	\$ 697	\$ 598	\$ 4,630	\$ 3,835	\$ 13,538
3	0.858	\$ 120	\$ -	\$ 594	\$ 718	\$ 585	\$ 5,348	\$ 5,018	\$ 12,329
4	0.815	\$ 123	\$ -	\$ 612	\$ 739	\$ 572	\$ 6,088	\$ 5,590	\$ 11,744
5	0.774	\$ 127	\$ -	\$ 631	\$ 762	\$ 560	\$ 6,849	\$ 6,150	\$ 11,172
6	0.736	\$ 131	\$ -	\$ 649	\$ 784	\$ 548	\$ 7,633	\$ 6,699	\$ 10,611
7	0.699	\$ 135	\$ -	\$ 669	\$ 808	\$ 537	\$ 8,441	\$ 7,235	\$ 10,063
8	0.664	\$ 139	\$ -	\$ 689	\$ 832	\$ 525	\$ 9,274	\$ 7,760	\$ 9,527
9	0.631	\$ 143	\$ -	\$ 701	\$ 1,101	\$ 660	\$ 10,374	\$ 8,420	\$ 9,002
10	0.599	\$ 147	\$ 244	\$ 731	\$ 883	\$ 503	\$ 11,257	\$ 8,923	\$ 8,342
11	0.570	\$ 152	\$ -	\$ 753	\$ 909	\$ 492	\$ 12,167	\$ 9,415	\$ 7,839
12	0.541	\$ 156	\$ -	\$ 775	\$ 937	\$ 482	\$ 13,103	\$ 9,897	\$ 7,347
13	0.514	\$ 161	\$ -	\$ 799	\$ 965	\$ 471	\$ 14,068	\$ 10,368	\$ 6,865
14	0.489	\$ 166	\$ -	\$ 823	\$ 994	\$ 461	\$ 15,061	\$ 10,829	\$ 6,394
15	0.464	\$ 171	\$ -	\$ 847	\$ 1,023	\$ 451	\$ 16,085	\$ 11,280	\$ 5,933
16	0.441	\$ 176	\$ -	\$ 873	\$ 1,054	\$ 442	\$ 17,139	\$ 11,722	\$ 5,481
17	0.419	\$ 181	\$ -	\$ 899	\$ 1,086	\$ 432	\$ 18,225	\$ 12,154	\$ 5,040
18	0.398	\$ 187	\$ -	\$ 926	\$ 1,118	\$ 423	\$ 19,343	\$ 12,577	\$ 4,607
19	0.378	\$ 192	\$ -	\$ 954	\$ 1,136	\$ 502	\$ 20,739	\$ 13,079	\$ 4,184
20	0.359	\$ 198	\$ 244	\$ 1,106	\$ 1,335	\$ 372	\$ 27,038	\$ 15,020	\$ 2,114
21	0.341	\$ 204	\$ -	\$ 982	\$ 1,186	\$ 405	\$ 21,925	\$ 13,484	\$ 3,683
22	0.324	\$ 210	\$ -	\$ 1,012	\$ 1,222	\$ 396	\$ 23,147	\$ 13,880	\$ 3,278
23	0.308	\$ 217	\$ -	\$ 1,042	\$ 1,259	\$ 388	\$ 24,406	\$ 14,268	\$ 2,881
24	0.293	\$ 223	\$ -	\$ 1,073	\$ 1,296	\$ 380	\$ 25,702	\$ 14,648	\$ 2,493
25	0.278	\$ 230	\$ -	\$ 1,106	\$ 1,335	\$ 372	\$ 27,038	\$ 15,020	\$ 2,114
26	0.264	\$ 237	\$ -	\$ 1,139	\$ 1,375	\$ 364	\$ 28,413	\$ 15,383	\$ 1,742
27	0.251	\$ 244	\$ -	\$ 1,173	\$ 1,417	\$ 356	\$ 29,830	\$ 15,739	\$ 1,378
28	0.239	\$ 251	\$ -	\$ 1,208	\$ 1,459	\$ 348	\$ 31,289	\$ 16,087	\$ 1,023
29	0.227	\$ 259	\$ -	\$ 1,244	\$ 1,503	\$ 341	\$ 32,792	\$ 16,428	\$ 674
30	0.215	\$ 266	\$ -	\$ 1,282	\$ 1,548	\$ 334	\$ 34,340	\$ 16,762	\$ 334

Description: WQBE 9A_Removal of Impervious Surfaces on Property (wheel strips)

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Tilling and overseeding as needed by crew of two (two visits per year, 1 hour per visit). Assume annual cost of 4 grass seed mix is \$113.

Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 09A_Removal of Impervious Surfaces on Property (wheel strips)		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Removal of Impervious Surfaces	100	SF	\$ -	\$ -
2	Remove Existing Pavement	11	SY	\$ 14	\$ 156
3	Unsuitable Roadway Foundation Excavation Incl. Haul @18" D	6	CY	\$ 79	\$ 439
4				\$ -	\$ -
5	Wheel Strips (2 strips @ 2'W X 10'L X 0.5' Thick)	40	SF	\$ -	\$ -
6	Concrete Wheel Strips	1	CY	\$ 182	\$ 135
7	Subgrade Preparation and Compaction	4	SY	\$ 22	\$ 98
8	Sand Subbase Layer (2 Strips @ 3'WX10'L)	1	CY	\$ 85	\$ 94
9				\$ -	\$ -
10	Restoration			\$ -	\$ -
11	Mulch Compost @ 4"D	1	CY	\$ 86	\$ 106
12	Disking or Tilling Soil	11	SY	\$ 4	\$ 44
13	Grass Seeding and Restoration	7	SY	\$ 10	\$ 67
14	Trees (None listed in design description)	0	EA	\$ 720	\$ -
15				\$ -	\$ -
16	Additional Costs			\$ -	\$ -
17	Removals @ 4% Construction Costs	4.0%	LS	\$ 1,139	\$ 46
18	TESC @ 2% Construction Costs	2%	LS	\$ 1,184	\$ 24
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 1,208
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%		1	\$ -
	Mobilization/Demobilization	10%		1.1	\$ 121
	Overhead & Profit (OHP)	0%		1	\$ -
	Insurance	0.0%		1	\$ -
	Bonding	0.0%		1	\$ -
	Escalation Multiplier from ENR-CCI	0%		1.0000	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 1,329
Direct: Subtotal Construction Costs (100 SF Area)					\$ 1,329

Description: WOBE 09A_Removal of Impervious Surfaces on Property (wheel strips)

Remove impervious surface down to bare soil. Area is amended with soil and planted with grass. To allow continued site use, area is retrofitted with an alternative treatment (e.g., wheel strip driveways) per KCSWDM, "Reduced Impervious Surface Credit".

Cost Estimating Assumptions:

Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

The pavement removal footprint = 100 sq. ft. with a 1:1 length to width ratio.

The cost model assumes a residential driveway two application. The driveway is assumed to be 10 feet wide by 10 feet long.

No removals are assumed beyond the existing pavement and base foundation sections.

Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Existing impervious surface and any underlying base course (e.g., crushed rock, gravel, etc.) must be completely removed from the conversion area(s).

Assumed underlying soils are scarified to a depth of 18 inches.

Concrete wheel strips are installed at 2 feet wide by 10 feet long by 6-inches deep.

A 3 feet wide by 10 feet long area beneath the wheel strips will be prepared and compacted prior to installation. A 6 inch sand base will be installed to support the concrete wheel strips.

A minimum of 4 inches of compost are added and mixed into the remaining exposed soils.

All exposed disturbed areas will be seeded with a grass mixture.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Tree plantings are not included with this design.

Removals are estimated at 4% of the item construction costs.

The facility is located on property and traffic control will not be required.

The facility is located outside of the ROW and a street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was considered as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further developed during the design and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mission and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Description:	WQBE 9B_Removal of Impervious Surfaces_On Property (no wheel strips)			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Removal of Impervious Surfaces - On Property (no wheel strips)	100	SF	\$ 10	\$ 1,000
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 1,000
				Allowance for Indeterminates (Design Allowance)	\$ 150
				Street Use Permit (Y/N)	N
				ESTIMATED PROBABLE COST OF CONSTRUCTION BID	\$ 1,150
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	115
	Subtotal Primary Construction Amount			\$	1,265
	Construction Sales Tax			\$	130
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	1,400
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	152
	Construction Management			\$	101
	Permitting & Support			\$	6
	s.f. Land Area	None		Land Purchase/ROW Acquisition	\$ -
				WTD Staff Costs & Non-WTD Support	\$ 63
				Subtotal Non-Construction Costs	\$ 323
				Project Contingency	\$ 258
				TOTAL INDIRECT NON-CONSTRUCTION COSTS	\$ 600
				TOTAL PROJECT COST (2023 Dollars)	\$ 2,000

Description: WQBE 9B_Removal of Impervious Surfaces_Property (2023 Dollars)

Unit	100 ft ²
Initial Capital Cost	\$ 2,000
Capital cost	\$ 20.00 \$/Unit
Total Direct O&M/Year	\$ 543.90
Direct O&M cost	\$ 5.44 \$/Unit
Capital Replacement Costs (10 years)	\$ 294 \$/unit
Discount rate (%)	5.25 \$/Unit

Total Cost (NPV)	\$ 16,200	\$/unit
Annual O&M Cost	\$ 700	\$/year
Annualized Cost	\$180	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Tilling and seeding	2023 Costs	\$ 113	\$/year
		\$ -	\$/year
Subtotal		\$ 113	
Labor			
Tilling and Overseeding		4 hr	
		0 hr	
		0 hr	
		0 hr	
Total hours per year		4	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 218	
Labor cost, burdened	O/H 150.0%	\$ 544	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 5,376		\$ 25,876	\$ 33,840	\$ 16,210			
0	1.000	\$ 2,000		\$ 2,000	\$ 2,000	\$ 2,000	\$ 2,000	\$ 2,000	\$ 16,210
1	0.950	\$ 113	\$ -	\$ 544	\$ 657	\$ 624	\$ 2,657	\$ 2,624	\$ 14,210
2	0.903	\$ 116	\$ -	\$ 560	\$ 677	\$ 611	\$ 3,334	\$ 3,235	\$ 13,585
3	0.858	\$ 120	\$ -	\$ 577	\$ 697	\$ 598	\$ 4,030	\$ 3,833	\$ 12,975
4	0.815	\$ 123	\$ -	\$ 594	\$ 718	\$ 585	\$ 4,748	\$ 4,418	\$ 12,377
5	0.774	\$ 127	\$ -	\$ 612	\$ 739	\$ 572	\$ 5,488	\$ 4,990	\$ 11,792
6	0.736	\$ 131	\$ -	\$ 631	\$ 762	\$ 560	\$ 6,249	\$ 5,550	\$ 11,219
7	0.699	\$ 135	\$ -	\$ 649	\$ 784	\$ 548	\$ 7,033	\$ 6,099	\$ 10,659
8	0.664	\$ 139	\$ -	\$ 669	\$ 808	\$ 537	\$ 7,841	\$ 6,635	\$ 10,111
9	0.631	\$ 143	\$ -	\$ 689	\$ 832	\$ 525	\$ 8,674	\$ 7,160	\$ 9,575
10	0.599	\$ 147	\$ 294	\$ 710	\$ 1,151	\$ 690	\$ 9,824	\$ 7,850	\$ 9,049
11	0.570	\$ 152	\$ -	\$ 731	\$ 883	\$ 503	\$ 10,707	\$ 8,353	\$ 8,360
12	0.541	\$ 156	\$ -	\$ 753	\$ 909	\$ 492	\$ 11,616	\$ 8,845	\$ 7,857
13	0.514	\$ 161	\$ -	\$ 775	\$ 937	\$ 482	\$ 12,553	\$ 9,326	\$ 7,365
14	0.489	\$ 166	\$ -	\$ 799	\$ 965	\$ 471	\$ 13,518	\$ 7,979	\$ 6,883
15	0.464	\$ 171	\$ -	\$ 823	\$ 994	\$ 461	\$ 14,511	\$ 10,259	\$ 6,412
16	0.441	\$ 176	\$ -	\$ 847	\$ 1,023	\$ 451	\$ 15,535	\$ 10,710	\$ 5,951
17	0.419	\$ 181	\$ -	\$ 873	\$ 1,054	\$ 442	\$ 16,589	\$ 11,152	\$ 5,499
18	0.398	\$ 187	\$ -	\$ 899	\$ 1,086	\$ 432	\$ 17,675	\$ 11,584	\$ 5,058
19	0.378	\$ 192	\$ -	\$ 926	\$ 1,118	\$ 423	\$ 18,793	\$ 12,007	\$ 4,625
20	0.359	\$ 198	\$ 294	\$ 954	\$ 1,446	\$ 520	\$ 20,238	\$ 12,527	\$ 4,202
21	0.341	\$ 204	\$ -	\$ 982	\$ 1,186	\$ 405	\$ 21,425	\$ 12,932	\$ 3,683
22	0.324	\$ 210	\$ -	\$ 1,012	\$ 1,222	\$ 396	\$ 22,647	\$ 13,326	\$ 3,278
23	0.308	\$ 217	\$ -	\$ 1,042	\$ 1,259	\$ 388	\$ 23,906	\$ 13,716	\$ 2,881
24	0.293	\$ 223	\$ -	\$ 1,073	\$ 1,296	\$ 380	\$ 25,202	\$ 14,096	\$ 2,493
25	0.278	\$ 230	\$ -	\$ 1,106	\$ 1,335	\$ 372	\$ 26,537	\$ 14,466	\$ 2,114
26	0.264	\$ 237	\$ -	\$ 1,139	\$ 1,375	\$ 364	\$ 27,913	\$ 14,831	\$ 1,742
27	0.251	\$ 244	\$ -	\$ 1,173	\$ 1,417	\$ 356	\$ 29,329	\$ 15,187	\$ 1,378
28	0.239	\$ 251	\$ -	\$ 1,208	\$ 1,459	\$ 348	\$ 30,789	\$ 15,535	\$ 1,023
29	0.227	\$ 259	\$ -	\$ 1,244	\$ 1,503	\$ 341	\$ 32,292	\$ 15,876	\$ 674
30	0.215	\$ 266	\$ -	\$ 1,282	\$ 1,548	\$ 334	\$ 33,840	\$ 16,210	\$ 334

Description: WQBE 9B_Removal of Impervious Surfaces_Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost.
Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Tilling and overseeding as needed by crew of two (two visits per year, 1 hour per visit). Assume annual cost of 4 grass seed mix is \$113.

Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Items will include those highlighted in blue on the cost estimate sheet.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 9B_Removal of Impervious Surfaces_On Property (no wheel strips)		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Removal of Impervious Surfaces	100	SF	\$ -	\$ -
2	Remove Existing Pavement	11	SY	\$ 14	\$ 156
3	Unsuitable Roadway Foundation Excavation Incl. Haul @18" D	6	CY	\$ 79	\$ 439
4				\$ -	\$ -
5	Restoration			\$ -	\$ -
6	Mulch Compost @ 4"D	1	CY	\$ 86	\$ 106
7	Disking or Tilling Soil	11	SY	\$ 4	\$ 44
8	Grass Seeding and Restoration	11	SY	\$ 10	\$ 111
9	Trees (None listed in design description)	0	EA	\$ 720	\$ -
10				\$ -	\$ -
11	Additional Costs			\$ -	\$ -
12	Removals @4% Construction Costs	4%	LS	\$ 856	\$ 34
13	TESC @ 2% Construction Costs	2%	LS	\$ 890	\$ 18
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 908
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 91
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 999
Direct: Subtotal Construction Costs (100 SF Area)					\$ 999

Description: WQBE 9B_Removal of Impervious Surfaces_On Property (no wheel strips)

Remove impervious surface down to bare soil. Area is amended with soil and planted with grass.

Cost Estimating Assumptions:

Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9.

It is assumed that this facility is on property and part of a GSI rebate program. Property acquisition and easement costs are not included.

The pavement removal footprint = 100 sq. ft. with a 1:1 length to width ratio.

The cost model assumes a residential driveway type application. The driveway is assumed to be 10 feet wide by 10 feet long.

No removals are assumed beyond the existing pavement and base foundation sections.

Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Existing impervious surface and any underlying base course (e.g., crushed rock, gravel, etc.) must be completely removed from the conversion area(s).

Assumed underlying soils are scarified to a depth of 18 inches.

A minimum of 4 inches of compost are added and mixed into the remaining exposed soils.

All exposed disturbed areas will be seeded with a grass mixture.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Tree plantings are not included with this design.

Removals are estimated at 4% of the item construction costs.

The facility is located on property and traffic control will not be required.

The facility is located outside of the ROW and a street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level of allowances used in the estimate are as follows:

Sales Tax was included at 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor.

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)
Description:	WQBE 21A_High Rate Underground Filter in Urban ROW PCCP			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	High Rate Underground Filter (16 s.f. bottom area)	1	EA	\$ 103,737	\$ 103,737
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 103,737
	Allowance for Indeterminates (Design Allowance)			\$	15,561
	Street Use Permit (Y/N)		Y	\$	700
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID			\$	119,998
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	11,930
	Subtotal Primary Construction Amount			\$	131,928
	Construction Sales Tax			\$	13,451
	Outside Agency Construction			\$	2,075
	TOTAL DIRECT CONSTRUCTION COSTS			\$	147,500
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	15,831
	Construction Management			\$	10,554
	Permitting & Support			\$	660
s.f. Land Area	None			\$	-
	WTD Staff Costs & Non-WTD Support			\$	6,596
	Subtotal Non-Construction Costs			\$	33,642
	Project Contingency			\$	27,171
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	60,800
	TOTAL PROJECT COST (2023 Dollars)			\$	208,300

Description: WQBE 21A_High Rate Underground Filter in Urban ROW
PCCP (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 208,300
Capital cost	\$ 208,300.00 \$/Unit
Total Direct O&M/year	\$ 1,903.65
Direct O&M cost	\$ 1,903.65 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

No replacement costs

Total Cost (NPV)	\$ 262,000	\$/unit
Annual O&M Cost	\$ 2,500	\$/year
Annualized Cost	\$1,000	\$/year

Materials, Supplies, Other Costs

Mulch Replacement	\$ -	\$ 113 \$/year
Plant Material	\$ -	\$ 270 \$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360 \$/year

Subtotal \$ 630

Labor

Remove Trash	6 hr
Plant Health	4 hr
Mulch Replacement	4 hr
Activity	0 hr
Total hours per year	14
Raw Labor Rate/Hr	\$ 54
Raw labor cost	(embedded) \$ 761
Labor cost, burdened	O/H 150.0% \$ 1,904
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Description: WQBE 21A_High Rate Underground Filter in Urban ROW PCCP

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost. Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed 4 annual cost of \$113 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours. Annual mulch and plan replacements 5 plants at \$54/Plant Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 29,973		\$ 90,567	\$ 328,839	\$ 262,020				
0	1.000	\$ 208,300		\$ 208,300	\$ 208,300	\$ 208,300	\$ 208,300	\$ 208,300	\$ 262,020
1	0.950	\$ 630	\$ -	\$ 1,904	\$ 2,534	\$ 2,407	\$ 210,634	\$ 210,707	\$ 53,720
2	0.903	\$ 649	\$ -	\$ 1,961	\$ 2,610	\$ 2,356	\$ 213,443	\$ 213,063	\$ 51,313
3	0.858	\$ 668	\$ -	\$ 2,020	\$ 2,688	\$ 2,305	\$ 216,131	\$ 215,369	\$ 48,957
4	0.815	\$ 688	\$ -	\$ 2,080	\$ 2,769	\$ 2,256	\$ 219,900	\$ 217,625	\$ 46,651
5	0.774	\$ 709	\$ -	\$ 2,143	\$ 2,852	\$ 2,208	\$ 221,751	\$ 219,833	\$ 44,395
6	0.736	\$ 730	\$ -	\$ 2,207	\$ 2,937	\$ 2,161	\$ 224,689	\$ 221,993	\$ 42,187
7	0.699	\$ 752	\$ -	\$ 2,273	\$ 3,025	\$ 2,115	\$ 227,714	\$ 224,108	\$ 40,027
8	0.664	\$ 775	\$ -	\$ 2,341	\$ 3,116	\$ 2,069	\$ 230,830	\$ 226,177	\$ 37,912
9	0.631	\$ 798	\$ -	\$ 2,411	\$ 3,210	\$ 2,025	\$ 234,040	\$ 228,205	\$ 35,843
10	0.599	\$ 822	\$ -	\$ 2,484	\$ 3,306	\$ 1,982	\$ 237,345	\$ 230,184	\$ 33,818
11	0.570	\$ 847	\$ -	\$ 2,558	\$ 3,405	\$ 1,939	\$ 240,750	\$ 232,124	\$ 31,836
12	0.541	\$ 872	\$ -	\$ 2,635	\$ 3,507	\$ 1,898	\$ 244,258	\$ 234,022	\$ 29,896
13	0.514	\$ 898	\$ -	\$ 2,714	\$ 3,612	\$ 1,857	\$ 247,870	\$ 235,879	\$ 27,998
14	0.489	\$ 925	\$ -	\$ 2,796	\$ 3,721	\$ 1,818	\$ 251,591	\$ 237,697	\$ 26,141
15	0.464	\$ 953	\$ -	\$ 2,879	\$ 3,832	\$ 1,779	\$ 255,423	\$ 239,475	\$ 24,323
16	0.441	\$ 982	\$ -	\$ 2,966	\$ 3,947	\$ 1,741	\$ 259,370	\$ 241,216	\$ 22,544
17	0.419	\$ 1,011	\$ -	\$ 3,055	\$ 4,066	\$ 1,704	\$ 263,436	\$ 242,920	\$ 20,804
18	0.398	\$ 1,041	\$ -	\$ 3,146	\$ 4,188	\$ 1,667	\$ 267,624	\$ 244,587	\$ 19,100
19	0.378	\$ 1,073	\$ -	\$ 3,241	\$ 4,313	\$ 1,632	\$ 271,937	\$ 246,219	\$ 17,433
20	0.359	\$ 1,105	\$ -	\$ 3,338	\$ 4,443	\$ 1,597	\$ 276,380	\$ 247,815	\$ 15,801
21	0.341	\$ 1,138	\$ -	\$ 3,438	\$ 4,576	\$ 1,563	\$ 280,956	\$ 249,378	\$ 14,205
22	0.324	\$ 1,172	\$ -	\$ 3,541	\$ 4,713	\$ 1,529	\$ 285,670	\$ 250,907	\$ 12,642
23	0.308	\$ 1,207	\$ -	\$ 3,648	\$ 4,855	\$ 1,496	\$ 290,524	\$ 252,403	\$ 11,113
24	0.293	\$ 1,243	\$ -	\$ 3,757	\$ 5,000	\$ 1,464	\$ 295,525	\$ 253,868	\$ 9,617
25	0.278	\$ 1,281	\$ -	\$ 3,870	\$ 5,150	\$ 1,433	\$ 300,675	\$ 255,301	\$ 8,152
26	0.264	\$ 1,319	\$ -	\$ 3,986	\$ 5,305	\$ 1,402	\$ 305,980	\$ 256,703	\$ 6,719
27	0.251	\$ 1,359	\$ -	\$ 4,105	\$ 5,464	\$ 1,373	\$ 311,444	\$ 258,076	\$ 5,317
28	0.239	\$ 1,399	\$ -	\$ 4,229	\$ 5,628	\$ 1,343	\$ 317,072	\$ 259,419	\$ 3,944
29	0.227	\$ 1,441	\$ -	\$ 4,355	\$ 5,797	\$ 1,314	\$ 322,869	\$ 260,734	\$ 2,601
30	0.215	\$ 1,485	\$ -	\$ 4,486	\$ 5,971	\$ 1,286	\$ 328,839	\$ 262,020	\$ 1,286

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 21A_High Rate Underground Filter in Urban ROW PCCP		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Treatment BMP			\$ -	\$ -
2	Filterra Unit 4'X4' (complete)	1	EA	\$ 19,680	\$ 19,680
3	Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D)	74	CY	\$ 79	\$ 5,852
4	Imported Structural Fill	71	CY	\$ 44	\$ 3,129
5	Crushed Base	1	CY	\$ 64	\$ 64
6	Inlet Drain w/Energy Dissipating Rocks	1	EA	\$ 1,481	\$ 1,481
7	Catch Basin	1	EA	\$ 3,900	\$ 3,900
8	Pipe 8" PSD, DI CL 50	50	LF	\$ 160	\$ 8,000
9	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900
10	Restoration			\$ -	\$ -
11	Road Restoration (patching) 10" PCCP/6" CSTC	48	SY	\$ 405	\$ 19,440
12	Concrete Curb and Gutter	15	LF	\$ 111	\$ 1,665
13	Sidewalk 6' Wide	10	SY	\$ 125	\$ 1,250
14	Landscaping, planting, and restoration	10	SY	\$ 59	\$ 590
15	Street Tree	1	EA	\$ 720	\$ 720
16	Additional Costs			\$ -	\$ -
17	Removals @ 4% Construction Costs	4.0%	LS	\$ 69,671	\$ 2,787
18	Traffic Control (Heavy)	1	MO	\$ 20,000	\$ 20,000
19	TESC @2% Construction Costs	2%	LS	\$ 92,458	\$ 1,849
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 94,307
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ 9,431	\$ 9,431
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 103,737
<i>Direct: Subtotal Construction Costs</i>					\$ 103,737

Description: WQBE 21A_High Rate Underground Filter in Urban ROW PCCP

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.

Installation is within a roadside right-of-way and does not require easements or acquisition

An excavation width of 3 feet is assumed on each side of the precast box.

The excavated material is unsuitable for use as backfill.

Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.

A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.

Trench box shoring is used.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

Urban roadway restoration is assumed consisting of 10" PCCP/6"CSTC. Full panel replacement is required.

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A **15%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 21B_High Rate Underground Filter In Highway ROW
PCCP (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 153,300
Capital cost	\$ 153,300.00 \$/Unit
Total Direct O&M/year	\$ 1,903.65
Direct O&M cost	\$ 1,903.65 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

No replacement costs

Total Cost (NPV)	\$ 207,000	\$/unit
Annual O&M Cost	\$ 2,500	\$/year
Annualized Cost	\$1,000	\$/year

Materials, Supplies, Other Costs

Mulch Replacement	\$ -	\$ 113	\$/year
Plant Material	\$ -	\$ 270	\$/year
Vacuum Truck Equipment + Labor	2023 dollars	\$ 360	\$/year
Subtotal		\$ 630	
Labor			
Remove Trash	6 hr		
Plant Health	4 hr		
Mulch Replacement	4 hr		
Activity	0 hr		
Total hours per year	14		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 761	
Labor cost, burdened	O/H 150.0%	\$ 1,904	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Description: WQBE 21B_High Rate Underground Filter In Highway ROW PCCP

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings.

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost. Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm 6 event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed

4 annual cost of \$113 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4

4 man hours.

Annual mulch and plan replacements 5 plants at \$54/Plant

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 29,973		\$ 90,567	\$ 273,839	\$ 207,020				
0	1.000	\$ 153,300		\$ 153,300	\$ 153,300	\$ 153,300	\$ 153,300	\$ 153,300	\$ 207,020
1	0.950	\$ 630	\$ -	\$ 1,904	\$ 2,534	\$ 2,407	\$ 155,834	\$ 155,707	\$ 53,720
2	0.903	\$ 649	\$ -	\$ 1,961	\$ 2,610	\$ 2,356	\$ 158,443	\$ 158,063	\$ 51,313
3	0.858	\$ 668	\$ -	\$ 2,020	\$ 2,688	\$ 2,305	\$ 161,131	\$ 160,369	\$ 48,957
4	0.815	\$ 688	\$ -	\$ 2,080	\$ 2,769	\$ 2,256	\$ 163,900	\$ 162,625	\$ 46,651
5	0.774	\$ 709	\$ -	\$ 2,143	\$ 2,852	\$ 2,208	\$ 166,751	\$ 164,833	\$ 44,395
6	0.736	\$ 730	\$ -	\$ 2,207	\$ 2,937	\$ 2,161	\$ 169,689	\$ 166,993	\$ 42,187
7	0.699	\$ 752	\$ -	\$ 2,273	\$ 3,025	\$ 2,115	\$ 172,714	\$ 169,108	\$ 40,027
8	0.664	\$ 775	\$ -	\$ 2,341	\$ 3,116	\$ 2,069	\$ 175,830	\$ 171,177	\$ 37,912
9	0.631	\$ 798	\$ -	\$ 2,411	\$ 3,210	\$ 2,025	\$ 179,040	\$ 173,202	\$ 35,843
10	0.599	\$ 822	\$ -	\$ 2,484	\$ 3,306	\$ 1,982	\$ 182,345	\$ 175,184	\$ 33,818
11	0.570	\$ 847	\$ -	\$ 2,558	\$ 3,405	\$ 1,939	\$ 185,750	\$ 177,124	\$ 31,836
12	0.541	\$ 872	\$ -	\$ 2,635	\$ 3,507	\$ 1,898	\$ 189,258	\$ 179,022	\$ 29,896
13	0.514	\$ 898	\$ -	\$ 2,714	\$ 3,612	\$ 1,857	\$ 192,870	\$ 180,879	\$ 27,998
14	0.489	\$ 925	\$ -	\$ 2,796	\$ 3,721	\$ 1,818	\$ 196,591	\$ 182,697	\$ 26,141
15	0.464	\$ 953	\$ -	\$ 2,879	\$ 3,832	\$ 1,779	\$ 200,423	\$ 184,475	\$ 24,323
16	0.441	\$ 982	\$ -	\$ 2,966	\$ 3,947	\$ 1,741	\$ 204,370	\$ 186,216	\$ 22,544
17	0.419	\$ 1,011	\$ -	\$ 3,055	\$ 4,066	\$ 1,704	\$ 208,436	\$ 187,920	\$ 20,804
18	0.398	\$ 1,041	\$ -	\$ 3,146	\$ 4,188	\$ 1,667	\$ 212,624	\$ 189,587	\$ 19,100
19	0.378	\$ 1,073	\$ -	\$ 3,241	\$ 4,313	\$ 1,632	\$ 216,937	\$ 191,219	\$ 17,433
20	0.359	\$ 1,105	\$ -	\$ 3,338	\$ 4,443	\$ 1,597	\$ 221,380	\$ 192,815	\$ 15,801
21	0.341	\$ 1,138	\$ -	\$ 3,438	\$ 4,576	\$ 1,563	\$ 225,956	\$ 194,378	\$ 14,205
22	0.324	\$ 1,172	\$ -	\$ 3,541	\$ 4,713	\$ 1,529	\$ 230,670	\$ 195,907	\$ 12,642
23	0.308	\$ 1,207	\$ -	\$ 3,648	\$ 4,855	\$ 1,496	\$ 235,524	\$ 197,403	\$ 11,113
24	0.293	\$ 1,243	\$ -	\$ 3,757	\$ 5,000	\$ 1,464	\$ 240,525	\$ 198,868	\$ 9,617
25	0.278	\$ 1,281	\$ -	\$ 3,870	\$ 5,150	\$ 1,433	\$ 245,675	\$ 200,301	\$ 8,152
26	0.264	\$ 1,319	\$ -	\$ 3,986	\$ 5,305	\$ 1,402	\$ 250,980	\$ 201,703	\$ 6,719
27	0.251	\$ 1,359	\$ -	\$ 4,105	\$ 5,464	\$ 1,373	\$ 256,444	\$ 203,076	\$ 5,317
28	0.239	\$ 1,399	\$ -	\$ 4,229	\$ 5,628	\$ 1,343	\$ 262,072	\$ 204,419	\$ 3,944
29	0.227	\$ 1,441	\$ -	\$ 4,355	\$ 5,797	\$ 1,314	\$ 267,869	\$ 205,734	\$ 2,601
30	0.215	\$ 1,485	\$ -	\$ 4,486	\$ 5,971	\$ 1,286	\$ 273,839	\$ 207,020	\$ 1,286

Estimate - AACEI Class 10						
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024	
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 21B_High Rate Underground Filter In Highway ROW PCCP			Version:	3	
CONSTRUCTION COSTS						
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost	
1	Treatment BMP			\$ -	\$ -	
2	Filterra Unit 4'X4' (complete)	1	EA	\$ 19,680	\$ 19,680	
3	Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D)	74	CY	\$ 79	\$ 5,852	
4	Imported Structural Fill	71	CY	\$ 44	\$ 3,129	
5	Crushed Base	1	CY	\$ 64	\$ 64	
6	Inlets with energy dissipating rocks	1	EA	\$ 1,481	\$ 1,481	
7	Catch Basin	1	EA	\$ 3,900	\$ 3,900	
8	Pipe 8" PSD, DI CL 50	50	LF	\$ 160	\$ 8,000	
9	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900	
10	Restoration			\$ -	\$ -	
11	Road Restoration (Patching) 6" PCCP/6" CSTC	48	SY	\$ 110	\$ 5,280	
12	Concrete Curb and Gutter	15	LF	\$ 111	\$ 1,665	
13	Sidewalk 5' Wide	8	SY	\$ 125	\$ 1,042	
14	Landscaping, planting, and restoration	10	SY	\$ 59	\$ 590	
15	Street Tree	1	EA	\$ 720	\$ 720	
16	Additional Costs			\$ -	\$ -	
17	Removals @ 4% Construction Costs	4.0%	LS	\$ 55,302	\$ 2,212	
18	Traffic Control (Light)	1	MO	\$ 10,430	\$ 10,430	
19	TESC @2% Construction Costs	2%	LS	\$ 67,945	\$ 1,359	
				\$ -	\$ -	
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 69,303	
DIRECT: CONSTRUCTION COST MARK-UPS						
General Conditions					0%	1 \$ -
Mobilization/Demobilization					10%	1.1 \$ 6,930
Overhead & Profit (OHP)					0%	1 \$ -
Insurance					0.0%	1 \$ -
Bonding					0.0%	1 \$ -
Escalation Multiplier from ENR-CCI					0%	1.0000 \$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 76,234	
<i>Direct: Subtotal Construction Costs</i>					\$ 76,234	

Description: WQBE 21B_High Rate Underground Filter In Highway ROW PCCP

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings.

Cost Estimating Assumptions:

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.

21" of proprietary Filterra treatment media is used.

Installation is within a roadside right-of-way and does not require easements or acquisition

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

The excavated material is unsuitable for use as backfill.

Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.

A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.

Trench Box shoring is used.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

Rural roadway restoration is assumed consisting of 6" PCCP/6"CSTC. Full panel replacement is required.

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)
Description:	WQBE 21C_High Rate Underground Filter In Urban ROW HMA			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	High Rate Underground Filter (16 s.f.)	1	EA	\$ 74,468	\$ 74,468
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 74,468
	Allowance for Indeterminates (Design Allowance)			\$	11,170
	Street Use Permit (Y/N)		Y	\$	700
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID			\$	86,339
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	8,564
	Subtotal Primary Construction Amount			\$	94,902
	Construction Sales Tax			\$	9,656
	Outside Agency Construction			\$	1,489
	TOTAL DIRECT CONSTRUCTION COSTS			\$	106,000
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	11,388
	Construction Management			\$	7,592
	Permitting & Support			\$	475
s.f. Land Area	None			\$	-
	WTD Staff Costs & Non-WTD Support			\$	4,745
	Subtotal Non-Construction Costs			\$	24,200
	Project Contingency			\$	19,530
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	43,700
	TOTAL PROJECT COST (2023 Dollars)			\$	149,700

Description: WQBE 21C_High Rate Underground Filter In Urban ROW
HMA (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 149,700
Capital cost	\$ 149,700.00 \$/Unit
Total Direct O&M/Year	\$ 1,903.65
Direct O&M cost	\$ 1,903.65 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

No replacement costs

Total Cost (NPV)	\$ 203,400	\$/unit
Annual O&M Cost	\$ 2,500	\$/year
Annualized Cost	\$1,000	\$/year

Materials, Supplies, Other Costs

Mulch Replacement	\$ -	\$ 113	\$/year
Plant Material	\$ -	\$ 270	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$ 630	
Labor			
Remove Trash	6	hr	
Plant Health	4	hr	
Mulch Replacement	4	hr	
Activity	0	hr	
Total hours per year	14		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 761	
Labor cost, burdened	O/H 150.0%	\$ 1,904	\$
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30	years	

\$ 135.98

Description: WQBE 21C_High Rate Underground Filter In Urban ROW HMA

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into WTD LCC Model as total project cost and not construction cost. Capital replacement is input into WTD LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm 6 event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed 4 annual cost of \$113 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours.

Annual mulch and plan replacements 5 plants at \$54/Plant Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 29,973			\$ 90,567	\$ 270,239	\$ 203,420			
0	1.000	\$ 149,700			\$ 149,700	\$ 149,700	\$ 149,700	\$ 149,700	\$ 203,420
1	0.950	\$ 630	\$ -	\$ 1,904	\$ 2,534	\$ 2,407	\$ 152,234	\$ 152,107	\$ 53,720
2	0.903	\$ 649	\$ -	\$ 1,961	\$ 2,610	\$ 2,356	\$ 154,843	\$ 154,463	\$ 51,313
3	0.858	\$ 668	\$ -	\$ 2,020	\$ 2,688	\$ 2,305	\$ 157,531	\$ 156,769	\$ 48,957
4	0.815	\$ 688	\$ -	\$ 2,080	\$ 2,769	\$ 2,256	\$ 160,300	\$ 159,026	\$ 46,651
5	0.774	\$ 709	\$ -	\$ 2,143	\$ 2,852	\$ 2,208	\$ 163,151	\$ 161,233	\$ 44,395
6	0.736	\$ 730	\$ -	\$ 2,207	\$ 2,937	\$ 2,161	\$ 166,089	\$ 163,393	\$ 42,187
7	0.699	\$ 752	\$ -	\$ 2,273	\$ 3,025	\$ 2,115	\$ 169,114	\$ 165,508	\$ 40,027
8	0.664	\$ 775	\$ -	\$ 2,341	\$ 3,116	\$ 2,069	\$ 172,230	\$ 167,577	\$ 37,912
9	0.631	\$ 798	\$ -	\$ 2,411	\$ 3,210	\$ 2,025	\$ 175,440	\$ 169,602	\$ 35,843
10	0.599	\$ 822	\$ -	\$ 2,484	\$ 3,306	\$ 1,982	\$ 178,745	\$ 171,584	\$ 33,818
11	0.570	\$ 847	\$ -	\$ 2,558	\$ 3,405	\$ 1,939	\$ 182,150	\$ 173,524	\$ 31,836
12	0.541	\$ 872	\$ -	\$ 2,635	\$ 3,507	\$ 1,888	\$ 185,658	\$ 175,422	\$ 29,896
13	0.514	\$ 898	\$ -	\$ 2,714	\$ 3,612	\$ 1,857	\$ 189,270	\$ 177,279	\$ 27,998
14	0.489	\$ 925	\$ -	\$ 2,796	\$ 3,721	\$ 1,818	\$ 192,991	\$ 179,097	\$ 26,141
15	0.464	\$ 953	\$ -	\$ 2,879	\$ 3,832	\$ 1,779	\$ 196,823	\$ 180,875	\$ 24,323
16	0.441	\$ 982	\$ -	\$ 2,966	\$ 3,947	\$ 1,741	\$ 200,770	\$ 182,616	\$ 22,544
17	0.419	\$ 1,011	\$ -	\$ 3,055	\$ 4,066	\$ 1,704	\$ 204,836	\$ 184,320	\$ 20,804
18	0.398	\$ 1,041	\$ -	\$ 3,146	\$ 4,188	\$ 1,667	\$ 209,024	\$ 185,987	\$ 19,100
19	0.378	\$ 1,073	\$ -	\$ 3,241	\$ 4,313	\$ 1,632	\$ 213,337	\$ 187,619	\$ 17,433
20	0.359	\$ 1,105	\$ -	\$ 3,338	\$ 4,443	\$ 1,597	\$ 217,780	\$ 189,215	\$ 15,801
21	0.341	\$ 1,138	\$ -	\$ 3,438	\$ 4,576	\$ 1,563	\$ 222,356	\$ 190,778	\$ 14,205
22	0.324	\$ 1,172	\$ -	\$ 3,541	\$ 4,713	\$ 1,529	\$ 227,070	\$ 192,307	\$ 12,642
23	0.308	\$ 1,207	\$ -	\$ 3,648	\$ 4,855	\$ 1,496	\$ 231,924	\$ 193,803	\$ 11,113
24	0.293	\$ 1,243	\$ -	\$ 3,757	\$ 5,000	\$ 1,464	\$ 236,925	\$ 195,268	\$ 9,617
25	0.278	\$ 1,281	\$ -	\$ 3,870	\$ 5,150	\$ 1,433	\$ 242,075	\$ 196,701	\$ 8,152
26	0.264	\$ 1,319	\$ -	\$ 3,986	\$ 5,305	\$ 1,402	\$ 247,380	\$ 198,103	\$ 6,719
27	0.251	\$ 1,359	\$ -	\$ 4,105	\$ 5,464	\$ 1,373	\$ 252,844	\$ 199,476	\$ 5,317
28	0.239	\$ 1,399	\$ -	\$ 4,229	\$ 5,628	\$ 1,343	\$ 258,472	\$ 200,819	\$ 3,944
29	0.227	\$ 1,441	\$ -	\$ 4,355	\$ 5,797	\$ 1,314	\$ 264,269	\$ 202,134	\$ 2,601
30	0.215	\$ 1,485	\$ -	\$ 4,486	\$ 5,971	\$ 1,286	\$ 270,239	\$ 203,420	\$ 1,286

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024 Cinny Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Location:	King County, WA		Estimator:		
Description:	WQBE 21C_High Rate Underground Filter In Urban ROW HMA		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Treatment BMP			\$ -	\$ -
2	Filterra Unit 4'X4' (complete)	1	EA	\$ 19,680	\$ 19,680
3	Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D)	74	CY	\$ 79	\$ 5,852
4	Imported Structural Fill	71	CY	\$ 44	\$ 3,129
5	Crushed Base	1	CY	\$ 64	\$ 64
6	Inlets with energy dissipating rocks	1	EA	\$ 1,481	\$ 1,481
7	Catch Basin	1	EA	\$ 3,900	\$ 3,900
8	Pipe 8" PSD, DI CL 50	50	LF	\$ 160	\$ 8,000
9	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900
10	Restoration			\$ -	\$ -
11	Pavement Patching HMA 6" HMA/6"CSBC	36	SY	\$ 110	\$ 3,972
12	Concrete Curb and Gutter	15	LF	\$ 111	\$ 1,665
13	Sidewalk 6' Wide	10	SY	\$ 125	\$ 1,250
14	Landscaping, planting, and restoration	10	SY	\$ 59	\$ 590
15	Street Tree	1	EA	\$ 720	\$ 720
16	Additional Costs			\$ -	\$ -
17	Removals @ 4% Construction Costs	4.0%	LS	\$ 54,203	\$ 2,168
18	Traffic Control (Heavy)	0.5	MO	\$ 20,000	\$ 10,000
19	TESC @2% Construction Costs	2%	LS	\$ 66,371	\$ 1,327
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 67,699
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 6,770
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 74,468
<i>Direct: Subtotal Construction Costs</i>					\$ 74,468

Description: WQBE 21C_High Rate Underground Filter In Urban ROW HMA

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.

21" of proprietary Filterra treatment media is used.

Installation is within a roadside right-of-way and does not require easements or acquisition

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

The excavated material is unsuitable for use as backfill.

Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.

A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.

Trench Box shoring is used.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

Urban roadway restoration is assumed consisting of 6"HMA/6"CSTC.

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:				Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)
Description:	WQBE_21D_High Rate Underground Filter In Highway ROW HMA			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	High Rate Underground Filter (16 s.f.)	1	EA	\$ 67,456	\$ 67,456
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
Subtotal Construction Costs					\$ 67,456
Allowance for Indeterminates (Design Allowance)					\$ 10,118
Street Use Permit (Y/N) Y					\$ 700
ESTIMATED PROBABLE COST OF CONSTRUCTION BID					
					\$ 78,275
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
Construction Change Order Allowance					\$ 7,757
Subtotal Primary Construction Amount					\$ 86,032
Construction Sales Tax					\$ 8,747
Outside Agency Construction					\$ 1,349
TOTAL DIRECT CONSTRUCTION COSTS					\$ 96,100
INDIRECT: NON-CONSTRUCTION COSTS					
Design Engineering					\$ 10,324
Construction Management					\$ 6,883
Permitting & Support					\$ 430
s.f. Land Area		None	Land Purchase/ROW Acquisition		
WTD Staff Costs & Non-WTD Support					\$ 4,302
Subtotal Non-Construction Costs					\$ 21,938
Project Contingency					\$ 17,706
TOTAL INDIRECT NON-CONSTRUCTION COSTS					\$ 39,600
TOTAL PROJECT COST (2023 Dollars)					\$ 135,700

Description: WQBE_21D_High Rate Underground Filter In Highway ROW HMA (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 135,700
Capital cost	\$ 135,700.00 \$/Unit
Total Direct O&M/Year	\$ 1,903.65
Direct O&M cost	\$ 1,903.65 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

No replacement costs

Total Cost (NPV)	\$ 189,400	\$/unit
Annual O&M Cost	\$ 2,500	\$/year
Annualized Cost	\$1,000	\$/year

Materials, Supplies, Other Costs

Mulch Replacement	\$ -	\$ 113	\$/year
Plant Material	\$ -	\$ 270	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$ 630	
Labor			
Remove Trash	6	hr	
Plant Health	4	hr	
Mulch Replacement	4	hr	
Activity	0	hr	
Total hours per year	14		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 761	
Labor cost, burdened	O/H 150.0%	\$ 1,904	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30	years	

\$ 135.98

Description: WQBE_21D_High Rate Underground Filter In Highway ROW HMA

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.
Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual cost of \$113 for mulch.
Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man hours.
Annual mulch and plan replacements 5 plants at \$54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 29,973	\$ 90,567	\$ 256,239	\$ 189,420					
0	1.000	\$ 135,700		\$ 135,700	\$ 135,700	\$ 135,700	\$ 135,700	\$ 135,700	\$ 189,420
1	0.950	\$ 630	\$ -	\$ 1,904	\$ 2,534	\$ 2,407	\$ 138,234	\$ 138,107	\$ 53,720
2	0.903	\$ 649	\$ -	\$ 1,961	\$ 2,610	\$ 2,356	\$ 140,843	\$ 140,463	\$ 51,313
3	0.858	\$ 668	\$ -	\$ 2,020	\$ 2,688	\$ 2,305	\$ 143,531	\$ 142,769	\$ 48,957
4	0.815	\$ 688	\$ -	\$ 2,080	\$ 2,769	\$ 2,256	\$ 146,300	\$ 145,025	\$ 46,651
5	0.774	\$ 709	\$ -	\$ 2,143	\$ 2,852	\$ 2,208	\$ 149,151	\$ 147,233	\$ 44,395
6	0.736	\$ 730	\$ -	\$ 2,207	\$ 2,937	\$ 2,161	\$ 152,084	\$ 149,393	\$ 42,187
7	0.699	\$ 752	\$ -	\$ 2,273	\$ 3,025	\$ 2,115	\$ 155,114	\$ 151,508	\$ 40,027
8	0.664	\$ 775	\$ -	\$ 2,341	\$ 3,116	\$ 2,069	\$ 158,230	\$ 153,577	\$ 37,912
9	0.631	\$ 798	\$ -	\$ 2,411	\$ 3,210	\$ 2,025	\$ 161,440	\$ 155,602	\$ 35,843
10	0.599	\$ 822	\$ -	\$ 2,484	\$ 3,306	\$ 1,982	\$ 164,745	\$ 157,584	\$ 33,818
11	0.570	\$ 847	\$ -	\$ 2,558	\$ 3,405	\$ 1,939	\$ 168,150	\$ 159,524	\$ 31,836
12	0.541	\$ 872	\$ -	\$ 2,635	\$ 3,507	\$ 1,898	\$ 171,658	\$ 161,422	\$ 29,896
13	0.514	\$ 898	\$ -	\$ 2,714	\$ 3,612	\$ 1,857	\$ 175,270	\$ 163,279	\$ 27,998
14	0.489	\$ 925	\$ -	\$ 2,796	\$ 3,721	\$ 1,818	\$ 178,991	\$ 165,097	\$ 26,141
15	0.464	\$ 953	\$ -	\$ 2,879	\$ 3,832	\$ 1,779	\$ 182,823	\$ 166,875	\$ 24,323
16	0.441	\$ 982	\$ -	\$ 2,966	\$ 3,947	\$ 1,741	\$ 186,770	\$ 168,616	\$ 22,544
17	0.419	\$ 1,011	\$ -	\$ 3,055	\$ 4,066	\$ 1,704	\$ 190,836	\$ 170,320	\$ 20,804
18	0.398	\$ 1,041	\$ -	\$ 3,146	\$ 4,188	\$ 1,667	\$ 195,024	\$ 171,987	\$ 19,100
19	0.378	\$ 1,073	\$ -	\$ 3,241	\$ 4,313	\$ 1,632	\$ 199,337	\$ 173,619	\$ 17,433
20	0.359	\$ 1,105	\$ -	\$ 3,338	\$ 4,443	\$ 1,597	\$ 203,781	\$ 175,215	\$ 15,801
21	0.341	\$ 1,138	\$ -	\$ 3,438	\$ 4,576	\$ 1,563	\$ 208,356	\$ 176,778	\$ 14,205
22	0.324	\$ 1,172	\$ -	\$ 3,541	\$ 4,713	\$ 1,529	\$ 213,070	\$ 178,307	\$ 12,642
23	0.308	\$ 1,207	\$ -	\$ 3,648	\$ 4,855	\$ 1,496	\$ 217,924	\$ 179,803	\$ 11,113
24	0.293	\$ 1,243	\$ -	\$ 3,757	\$ 5,000	\$ 1,464	\$ 222,925	\$ 181,268	\$ 9,617
25	0.278	\$ 1,281	\$ -	\$ 3,870	\$ 5,150	\$ 1,433	\$ 228,075	\$ 182,701	\$ 8,152
26	0.264	\$ 1,319	\$ -	\$ 3,986	\$ 5,305	\$ 1,402	\$ 233,380	\$ 184,103	\$ 6,719
27	0.251	\$ 1,359	\$ -	\$ 4,105	\$ 5,464	\$ 1,373	\$ 238,844	\$ 185,476	\$ 5,317
28	0.239	\$ 1,399	\$ -	\$ 4,229	\$ 5,628	\$ 1,343	\$ 244,472	\$ 186,819	\$ 3,944
29	0.227	\$ 1,441	\$ -	\$ 4,355	\$ 5,797	\$ 1,314	\$ 250,269	\$ 188,134	\$ 2,601
30	0.215	\$ 1,485	\$ -	\$ 4,486	\$ 5,971	\$ 1,286	\$ 256,239	\$ 189,420	\$ 1,286

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_21D_High Rate Underground Filter In Highway ROW HMA		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Treatment BMP			\$ -	\$ -
2	Filterra Unit 4'X4' (complete)	1	EA	\$ 19,680	\$ 19,680
3	Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D)	74	CY	\$ 79	\$ 5,852
4	Imported Structural Fill	71	CY	\$ 44	\$ 3,129
5	Crushed Base	1	CY	\$ 64	\$ 64
6	Inlets with energy dissipating rocks	1	EA	\$ 1,481	\$ 1,481
7	Catch Basin	1	EA	\$ 3,900	\$ 3,900
8	Pipe 8" PSD, DI CL 50	50	LF	\$ 160	\$ 8,000
9	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900
10	Restoration			\$ -	\$ -
11	Pavement Patching HMA 4" HMA/4"CSBC	36	SY	\$ 71	\$ 2,564
12	Concrete Curb and Gutter	15	LF	\$ 111	\$ 1,665
13	Sidewalk 6' Wide	10	SY	\$ 125	\$ 1,250
14	Landscaping, planting, and restoration	10	SY	\$ 59	\$ 590
15	Street Tree	1	EA	\$ 720	\$ 720
16	Additional Costs			\$ -	\$ -
17	Removals @ 4% Construction Costs	4.0%	LS	\$ 52,795	\$ 2,112
18	Traffic Control (Light)	0.5	MO	\$ 10,430	\$ 5,215
19	TESC @2% Construction Costs	2%	LS	\$ 60,122	\$ 1,202
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 61,324
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 6,132
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 67,456
<i>Direct: Subtotal Construction Costs (SF Area)</i>					\$ 67,456

Description: WQBE_21D_High Rate Underground Filter In Highway ROW HMA

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.

21" of proprietary Filterra treatment media is used.

Installation is within a roadside right-of-way and does not require easements or acquisition

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

The excavated material is unsuitable for use as backfill.

Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.

A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.

Trench Box shoring is used.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

Rural roadway restoration is assumed consisting of 4"HMA/4"CSTC.

Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included. It is assumed that utility work will be required. Utility relocation work is estimated at 2% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12			Date:	6/7/2024
Location:	King County, WA			Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR)
Description:	WQBE 21E_High Rate Underground Filter On Public Property			Version:	3
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	High Rate Underground Filter (16 s.f.)	1	EA	\$ 52,533	\$ 52,533
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 52,533
				Allowance for Indeterminates (Design Allowance)	\$ 7,880
				Street Use Permit (Y/N)	N
				ESTIMATED PROBABLE COST OF CONSTRUCTION BID	\$ 60,413
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
				Construction Change Order Allowance	\$ 6,041
				Subtotal Primary Construction Amount	\$ 66,454
				Construction Sales Tax	\$ 6,812
				Outside Agency Construction	\$ -
				TOTAL DIRECT CONSTRUCTION COSTS	\$ 73,300
INDIRECT: NON-CONSTRUCTION COSTS					
				Design Engineering	\$ 7,975
				Construction Management	\$ 5,316
				Permitting & Support	\$ 332
	s.f. Land Area			Land Purchase/ROW Acquisition	\$ -
				WTD Staff Costs & Non-WTD Support	\$ 3,323
				Subtotal Non-Construction Costs	\$ 16,946
				Project Contingency	\$ 13,537
				TOTAL INDIRECT NON-CONSTRUCTION COSTS	\$ 30,500
				TOTAL PROJECT COST (2023 Dollars)	\$ 103,800

Description: WQBE 21E_High Rate Underground Filter On Public Property
(2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 103,800
Capital cost	\$ 103,800.00 \$/Unit
Total Direct O&M/Year	\$ 1,903.65
Direct O&M cost	\$ 1,903.65 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

No replacement costs

Total Cost (NPV)	\$ 157,500	\$/unit
Annual O&M Cost	\$ 2,500	\$/year
Annualized Cost	\$1,000	\$/year

Materials, Supplies, Other Costs

Mulch Replacement	\$ -	\$ 113	\$/year
Plant Material	\$ -	\$ 270	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$ 630	
Labor			
Remove Trash	6 hr		
Plant Health	4 hr		
Mulch Replacement	4 hr		
Activity	0 hr		
Total hours per year	14		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 761	
Labor cost, burdened	O/H 150.0%	\$ 1,904	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 29,973		\$ 90,567	\$ 224,339	\$ 157,520			
0	1.000	\$ 103,800			\$ 103,800	\$ 103,800	\$ 103,800	\$ 103,800	\$ 157,520
1	0.950	\$ 630	\$ -	\$ 1,904	\$ 2,534	\$ 2,407	\$ 106,334	\$ 106,207	\$ 53,720
2	0.903	\$ 649	\$ -	\$ 1,961	\$ 2,610	\$ 2,356	\$ 108,943	\$ 108,563	\$ 51,313
3	0.858	\$ 668	\$ -	\$ 2,020	\$ 2,688	\$ 2,305	\$ 111,631	\$ 110,869	\$ 48,957
4	0.815	\$ 688	\$ -	\$ 2,080	\$ 2,769	\$ 2,256	\$ 114,400	\$ 113,125	\$ 46,651
5	0.774	\$ 709	\$ -	\$ 2,143	\$ 2,852	\$ 2,208	\$ 117,251	\$ 115,333	\$ 44,395
6	0.736	\$ 730	\$ -	\$ 2,207	\$ 2,937	\$ 2,161	\$ 120,189	\$ 117,493	\$ 42,187
7	0.699	\$ 752	\$ -	\$ 2,273	\$ 3,025	\$ 2,115	\$ 123,214	\$ 119,608	\$ 40,027
8	0.664	\$ 775	\$ -	\$ 2,341	\$ 3,116	\$ 2,069	\$ 126,330	\$ 121,677	\$ 37,912
9	0.631	\$ 798	\$ -	\$ 2,411	\$ 3,210	\$ 2,025	\$ 129,540	\$ 123,702	\$ 35,843
10	0.599	\$ 822	\$ -	\$ 2,484	\$ 3,306	\$ 1,982	\$ 132,845	\$ 125,684	\$ 33,818
11	0.570	\$ 847	\$ -	\$ 2,558	\$ 3,405	\$ 1,939	\$ 136,250	\$ 127,624	\$ 31,836
12	0.541	\$ 872	\$ -	\$ 2,635	\$ 3,507	\$ 1,898	\$ 139,758	\$ 129,522	\$ 29,896
13	0.514	\$ 898	\$ -	\$ 2,714	\$ 3,612	\$ 1,857	\$ 143,370	\$ 131,379	\$ 27,998
14	0.489	\$ 925	\$ -	\$ 2,796	\$ 3,721	\$ 1,818	\$ 147,091	\$ 133,197	\$ 26,141
15	0.464	\$ 953	\$ -	\$ 2,879	\$ 3,832	\$ 1,779	\$ 150,923	\$ 134,975	\$ 24,323
16	0.441	\$ 982	\$ -	\$ 2,966	\$ 3,947	\$ 1,741	\$ 154,870	\$ 136,716	\$ 22,544
17	0.419	\$ 1,011	\$ -	\$ 3,055	\$ 4,066	\$ 1,704	\$ 158,936	\$ 138,420	\$ 20,804
18	0.398	\$ 1,041	\$ -	\$ 3,146	\$ 4,188	\$ 1,667	\$ 163,124	\$ 140,087	\$ 19,100
19	0.378	\$ 1,073	\$ -	\$ 3,241	\$ 4,313	\$ 1,632	\$ 167,437	\$ 141,719	\$ 17,433
20	0.359	\$ 1,105	\$ -	\$ 3,338	\$ 4,443	\$ 1,597	\$ 171,880	\$ 143,315	\$ 15,801
21	0.341	\$ 1,138	\$ -	\$ 3,438	\$ 4,576	\$ 1,563	\$ 176,456	\$ 144,878	\$ 14,205
22	0.324	\$ 1,172	\$ -	\$ 3,541	\$ 4,713	\$ 1,529	\$ 181,170	\$ 146,407	\$ 12,642
23	0.308	\$ 1,207	\$ -	\$ 3,648	\$ 4,855	\$ 1,496	\$ 186,024	\$ 147,903	\$ 11,113
24	0.293	\$ 1,243	\$ -	\$ 3,757	\$ 5,000	\$ 1,464	\$ 191,025	\$ 149,368	\$ 9,617
25	0.278	\$ 1,281	\$ -	\$ 3,870	\$ 5,150	\$ 1,433	\$ 196,175	\$ 150,801	\$ 8,152
26	0.264	\$ 1,319	\$ -	\$ 3,986	\$ 5,305	\$ 1,402	\$ 201,480	\$ 152,203	\$ 6,719
27	0.251	\$ 1,359	\$ -	\$ 4,105	\$ 5,464	\$ 1,373	\$ 206,944	\$ 153,576	\$ 5,317
28	0.239	\$ 1,399	\$ -	\$ 4,229	\$ 5,628	\$ 1,343	\$ 212,572	\$ 154,919	\$ 3,944
29	0.227	\$ 1,441	\$ -	\$ 4,355	\$ 5,797	\$ 1,314	\$ 218,369	\$ 156,234	\$ 2,601
30	0.215	\$ 1,485	\$ -	\$ 4,486	\$ 5,971	\$ 1,286	\$ 224,339	\$ 157,520	\$ 1,286

Description: WQBE 21E_High Rate Underground Filter On Public Property

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.

Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual

4 cost of \$113 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man 4 hours.

Annual mulch and plan replacements 5 plants at \$54/Plant

Vector Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR)	
Description:	WQBE 21E_High Rate Underground Filter On Public Property		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Treatment BMP			\$	-
2	Filterra Unit 4'X4' (complete)	1	EA	\$ 19,680	\$ 19,680
3	Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D)	74	CY	\$ 79	\$ 5,852
4	Imported Structural Fill	71	CY	\$ 44	\$ 3,129
5	Crushed Base	1	CY	\$ 64	\$ 64
6	Inlet Drain w/Energy Dissipating Rocks	1	EA	\$ 1,481	\$ 1,481
7	Catch Basin	1	EA	\$ 3,900	\$ 3,900
8	Pipe 8" dia.	50	LF	\$ 80	\$ 4,000
9	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900
10	Restoration			\$	-
11	Landscaping, planting, and restoration	39	SY	\$ 59	\$ 2,294
12	Street Tree	1	EA	\$ 720	\$ 720
13	Additional Costs			\$	-
14	Removals @ 4% Construction Costs	4.0%	LS	\$ 45,020	\$ 1,801
15	TESC @2% Construction Costs	2%	LS	\$ 46,821	\$ 936
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 47,757
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	4,776
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 52,533
<i>Direct: Subtotal Construction Costs</i>					\$ 52,533

Description: WQBE 21E_High Rate Underground Filter On Public Property

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

Facility design is per Filtera Design Recommendations. Prototypical sizing based on Filtera Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 16 sf (4'X4') with dimensions per Filtera Detail Sheets.

21" of proprietary Filtera treatment media is used.

Installation is on public property and does not require easements or acquisition

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

The excavated material is unsuitable for use as backfill.

Facility is not sited on the roadside and assumes no restoration of curb, gutter or roadway to accommodate the facility.

A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.

Trench Box shoring is used.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

No roadway restoration is assumed.

No Concrete curb, gutter, sidewalk restoration will be required for the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and Traffic Control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included.

Costs were not included for utility relocation work.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE 21F_High Rate Underground Filter with Property Cost
(2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 105,300
Capital cost	\$ 105,300 \$/Unit
Total Direct O&M/Year	\$ 1,904
Direct O&M cost	\$ 1,904 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Discount rate (%)	5.25 \$/Unit

No replacement costs

Total Cost (NPV)	\$ 159,000	\$/unit
Annual O&M Cost	\$ 2,500	\$/year
Annualized Cost	\$1,000	\$/year

Materials, Supplies, Other Costs

Mulch Replacement	\$ -	\$ 113	\$/year
Plant Material	\$ -	\$ 270	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$ 630	
Labor			
Remove Trash		6 hr	
Plant Health		4 hr	
Mulch Replacement		4 hr	
Activity		0 hr	
Total hours per year		14	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 761	
Labor cost, burdened	O/H 150.0%	\$ 1,904	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:		30 years	

\$ 135.98

Description: WQBE 21F_High Rate Underground Filter with Property Cost

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm 6 event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.
Biannually the 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man hours. Assumed annual 4 cost of \$113 for mulch.
Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit. Total of 4 man 4 hours.
Annual mulch and plan replacements 5 plants at \$54/Plant
Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Replacement Assumptions:

No capital replacement assumed in 30-year life.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 29,973	\$ 90,567	\$ 225,839	\$ 159,020					
0	1.000	\$ 105,300		\$ 105,300	\$ 105,300	\$ 105,300	\$ 105,300	\$ 105,300	\$ 159,020
1	0.950	\$ 630	\$ -	\$ 1,904	\$ 2,534	\$ 2,407	\$ 107,834	\$ 107,707	\$ 53,720
2	0.903	\$ 649	\$ -	\$ 1,961	\$ 2,610	\$ 2,356	\$ 110,443	\$ 110,063	\$ 51,313
3	0.858	\$ 668	\$ -	\$ 2,020	\$ 2,688	\$ 2,305	\$ 113,131	\$ 112,369	\$ 48,957
4	0.815	\$ 688	\$ -	\$ 2,080	\$ 2,769	\$ 2,256	\$ 115,900	\$ 114,625	\$ 46,651
5	0.774	\$ 709	\$ -	\$ 2,143	\$ 2,852	\$ 2,208	\$ 118,751	\$ 116,833	\$ 44,395
6	0.736	\$ 730	\$ -	\$ 2,207	\$ 2,937	\$ 2,161	\$ 121,689	\$ 118,993	\$ 42,187
7	0.699	\$ 752	\$ -	\$ 2,273	\$ 3,025	\$ 2,115	\$ 124,714	\$ 121,108	\$ 40,027
8	0.664	\$ 775	\$ -	\$ 2,341	\$ 3,116	\$ 2,069	\$ 127,830	\$ 123,177	\$ 37,912
9	0.631	\$ 798	\$ -	\$ 2,411	\$ 3,210	\$ 2,025	\$ 131,040	\$ 125,202	\$ 35,843
10	0.599	\$ 822	\$ -	\$ 2,484	\$ 3,306	\$ 1,982	\$ 134,345	\$ 127,184	\$ 33,818
11	0.570	\$ 847	\$ -	\$ 2,558	\$ 3,405	\$ 1,939	\$ 137,750	\$ 129,124	\$ 31,836
12	0.541	\$ 872	\$ -	\$ 2,635	\$ 3,507	\$ 1,898	\$ 141,258	\$ 131,022	\$ 29,896
13	0.514	\$ 898	\$ -	\$ 2,714	\$ 3,612	\$ 1,857	\$ 144,870	\$ 132,879	\$ 27,998
14	0.489	\$ 925	\$ -	\$ 2,796	\$ 3,721	\$ 1,818	\$ 148,591	\$ 134,697	\$ 26,141
15	0.464	\$ 953	\$ -	\$ 2,879	\$ 3,832	\$ 1,779	\$ 152,423	\$ 136,475	\$ 24,323
16	0.441	\$ 982	\$ -	\$ 2,966	\$ 3,947	\$ 1,741	\$ 156,370	\$ 138,216	\$ 22,544
17	0.419	\$ 1,011	\$ -	\$ 3,055	\$ 4,066	\$ 1,704	\$ 160,430	\$ 139,920	\$ 20,804
18	0.398	\$ 1,041	\$ -	\$ 3,146	\$ 4,188	\$ 1,667	\$ 164,624	\$ 141,587	\$ 19,100
19	0.378	\$ 1,073	\$ -	\$ 3,241	\$ 4,313	\$ 1,632	\$ 168,937	\$ 143,219	\$ 17,433
20	0.359	\$ 1,105	\$ -	\$ 3,338	\$ 4,443	\$ 1,597	\$ 173,380	\$ 144,815	\$ 15,801
21	0.341	\$ 1,138	\$ -	\$ 3,438	\$ 4,576	\$ 1,563	\$ 177,956	\$ 146,378	\$ 14,205
22	0.324	\$ 1,172	\$ -	\$ 3,541	\$ 4,713	\$ 1,529	\$ 182,670	\$ 147,907	\$ 12,642
23	0.308	\$ 1,207	\$ -	\$ 3,648	\$ 4,855	\$ 1,496	\$ 187,524	\$ 149,403	\$ 11,113
24	0.293	\$ 1,243	\$ -	\$ 3,757	\$ 5,000	\$ 1,464	\$ 192,525	\$ 150,868	\$ 9,617
25	0.278	\$ 1,281	\$ -	\$ 3,870	\$ 5,150	\$ 1,433	\$ 197,675	\$ 152,301	\$ 8,152
26	0.264	\$ 1,319	\$ -	\$ 3,986	\$ 5,305	\$ 1,402	\$ 202,980	\$ 153,703	\$ 6,719
27	0.251	\$ 1,359	\$ -	\$ 4,105	\$ 5,464	\$ 1,373	\$ 208,444	\$ 155,076	\$ 5,317
28	0.239	\$ 1,399	\$ -	\$ 4,229	\$ 5,628	\$ 1,343	\$ 214,072	\$ 156,419	\$ 3,944
29	0.227	\$ 1,441	\$ -	\$ 4,355	\$ 5,797	\$ 1,314	\$ 219,869	\$ 157,734	\$ 2,601
30	0.215	\$ 1,485	\$ -	\$ 4,486	\$ 5,971	\$ 1,286	\$ 225,839	\$ 159,020	\$ 1,286

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation - WO12		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Troy Gibbs (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 21F_High Rate Underground Filter with Property Cost		Version:	3	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Treatment BMP			\$ -	\$ -
2	Filterra Unit 4'X4' (complete)	1	EA	\$ 19,680	\$ 19,680
3	Structural Excavation to Waste (10'W X10'L X 5'D) + (50'LX5'WX6'D)	74	CY	\$ 79	\$ 5,852
4	Imported Structural Fill	71	CY	\$ 44	\$ 3,129
5	Crushed Base	1	CY	\$ 64	\$ 64
6	Inlet Drain w/Energy Dissipating Rocks	1	EA	\$ 1,481	\$ 1,481
7	Catch Basin	1	EA	\$ 3,900	\$ 3,900
8	Pipe 8" dia.	50	LF	\$ 80	\$ 4,000
9	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,900
10	Restoration			\$ -	\$ -
11	Landscaping, planting, and restoration	39	SY	\$ 59	\$ 2,294
12	Street Tree	1	EA	\$ 720	\$ 720
13	Additional Costs			\$ -	\$ -
14	Removals @ 4% Construction Costs	4.0%	LS	\$ 45,020	\$ 1,801
15	TESC @2% Construction Costs	2%	LS	\$ 46,821	\$ 936
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 47,757
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ 4,776	\$ 4,776
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 52,533
<i>Direct: Subtotal Construction Costs)</i>					\$ 52,533

Description: WQBE 21F_High Rate Underground Filter with Property Cost

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 16 sf (4'X4') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.

It is assumed that this facility is on property. Property acquisition and easement costs are included.

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

The excavated material is unsuitable for use as backfill.

Facility is not sited on the roadside and assumes no restoration of curb, gutter or roadway to accommodate the facility.

A total of 50 LF of 8" storm pipe is required to connect to a downstream main or facility.

Trench Box shoring is used.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

No roadway restoration is assumed.

No Concrete curb, gutter, sidewalk restoration will be required for the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP University GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and Traffic Control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor

A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Updated on: 06/07/24

Phase 2 Updated on: 5/6/21

Item No.	Action	Class	Complexity	Description	Sub-Action Number	Subcategory	Action Unit	Design Drainage Area	PHASE 3 COSTS (2023 Dollars)					PHASE 2 COSTS (2019 Dollars)							
									Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)	Action Unit	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)
11	Detention Vault	Class 10	Routine	WQBE_11A_Detention Vault on Public Property	11A	On property without Acquisition	1 Each	28,658 SF	\$3,281,800	\$0	\$2,493,700	\$5,775,500	\$5,200	\$5,905,200	1 Each	\$3,519,000	\$0	\$2,710,000	\$6,229,000	\$4,900	\$6,352,000
				WQBE_11B_Detention Vault in ROW	11B	In ROW/Highway	1 Each	28,658 SF	\$3,638,400	\$0	\$2,664,000	\$6,302,400	\$5,200	\$6,432,100	1 Each	\$4,473,000	\$0	\$3,130,500	\$7,603,000	\$4,900	\$7,727,000
				WQBE_11C_Detention Vault With Property Cost	11C	On Property with Acquisition	1 Each	28,658 SF	\$3,281,800	\$422,603	\$3,043,100	\$6,324,900	\$5,200	\$6,454,600	1 Each	\$3,519,000	\$589,000	\$3,446,000	\$6,965,000	\$4,900	\$7,085,000
12	Detention Pond	Class 10	Routine	WQBE_12A_Detention Pond on Public Property	12A	On Property/Highway without Acquisition	1 Each	36,569 SF	\$694,600	\$0	\$527,800	\$1,222,400	\$10,000	\$1,444,200	1 Each	\$617,000	\$0	\$484,000	\$1,102,000	\$9,400	\$1,473,000
				WQBE_12B_Detention Pond With Property Cost	12B	On property with Acquisition	1 Each	36,569 SF	\$694,200	\$1,144,543	\$2,015,400	\$2,709,600	\$10,000	\$2,931,400	1 Each	\$617,000	\$1,073,000	\$1,826,000	\$2,443,000	\$9,400	\$2,807,000
13	Infiltration Pond	Class 10	Routine	WQBE_13A_Infiltration Pond Till Soil on Public Property	13A	On Property/Highway without Acquisition - In Till Soil	1 Each	36,595 SF	\$500,500	\$0	\$380,300	\$880,800	\$5,900	\$1,016,100	1 Each	\$395,000	\$0	\$310,000	\$705,000	\$5,500	\$971,000
				WQBE_13B_Infiltration Pond Outwash Soil on Public Property	13B	On Property/Highway without Acquisition - In Outwash Soil	1 Each	46,396 SF	\$448,200	\$0	\$340,600	\$788,800	\$3,700	\$878,000	1 Each	\$352,000	\$0	\$276,000	\$629,000	\$3,500	\$836,000
				WQBE_13C_Infiltration Pond Till Soil with Property Cost	13C	On property with Acquisition - Till Soil	1 Each	36,595 SF	\$500,500	\$891,189	\$1,538,800	\$2,039,300	\$5,900	\$2,174,600	1 Each	\$395,000	\$903,000	\$1,439,000	\$1,834,000	\$5,500	\$2,094,000
				WQBE_13D_Infiltration Pond Outwash Soil with Property Cost	13D	On property with Acquisition - Outwash Soil	1 Each	46,396 SF	\$448,200	\$891,189	\$1,499,100	\$1,947,300	\$3,700	\$2,036,500	1 Each	\$352,000	\$903,000	\$1,405,000	\$1,758,000	\$3,500	\$1,959,000
				WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property	13E	On Property without Acquisition - In Outwash Soil with High Rate Underground Filter System	1 Each	52,164 SF	\$529,400	\$0	\$402,300	\$931,700	\$6,600	\$1,082,700	1 Each	\$424,000	\$0	\$332,000	\$756,000	\$6,400	\$1,033,000
				WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost	13F	On Property with Acquisition - In Outwash Soil with High Rate Underground Filter System	1 Each	52,164 SF	\$529,400	\$893,119	\$1,563,300	\$2,092,700	\$6,600	\$2,243,700							
14	Infiltration Vault	Class 10	Routine	WQBE_14A_Infiltration Vault Till Soil on Public Property	14A	On Property/Highway without Acquisition - In Till Soil	1 Each	28,719 SF	\$2,262,300	\$0	\$1,719,000	\$3,981,300	\$4,800	\$4,104,000	1 Each	\$2,577,000	\$0	\$2,012,000	\$4,589,000	\$4,900	\$4,721,000
				WQBE_14B_Infiltration Vault Outwash Soil on Public Property	14B	On Property/Highway without Acquisition - In Outwash Soil	1 Each	39,365 SF	\$1,870,200	\$0	\$1,421,100	\$3,291,300	\$4,800	\$3,414,000	1 Each	\$2,009,000	\$0	\$1,562,000	\$3,572,000	\$4,900	\$3,709,000
				WQBE_14C_Infiltration Vault Till Soil in ROW	14C	In ROW/Highway - In Till Soil	1 Each	28,719 SF	\$2,782,300	\$0	\$2,038,800	\$4,821,100	\$4,800	\$4,943,800	1 Each	\$3,008,000	\$0	\$2,245,000	\$5,253,000	\$4,900	\$5,384,000
				WQBE_14D_Infiltration Vault Outwash Soil in ROW	14D	In ROW/Highway - In Outwash Soil	1 Each	39,365 SF	\$2,282,500	\$0	\$1,673,800	\$3,956,300	\$4,800	\$4,079,000	1 Each	\$2,351,000	\$0	\$1,769,000	\$4,120,000	\$4,900	\$4,257,000
				WQBE_14E_Infiltration Vault Till Soil With Property Cost	14E	On property with Acquisition - Till Soil	1 Each	28,719 SF	\$2,262,300	\$340,082	\$2,161,200	\$4,423,500	\$4,800	\$4,546,200	1 Each	\$2,577,000	\$533,000	\$2,679,000	\$5,256,000	\$4,900	\$5,385,000
				WQBE_14F_Infiltration Vault Outwash Soil with Property Cost	14F	On property with Acquisition - Outwash Soil	1 Each	39,365 SF	\$1,870,200	\$340,082	\$1,863,200	\$3,733,400	\$4,800	\$3,856,100	1 Each	\$2,009,000	\$533,000	\$2,229,000	\$4,238,000	\$4,900	\$4,372,000
				WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW	14G	In ROW/Highway - In Outwash Soil With High Rate Underground Filter System	1 Each	52,164 SF	\$2,211,100	\$0	\$1,621,700	\$3,832,800	\$6,600	\$3,992,400	1 Each	\$2,368,000	\$0	\$1,795,000	\$4,163,000	\$7,800	\$4,376,000
				WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost	14H	On Property with Acquisition - In Outwash Soil With High Rate Underground Filter System	1 Each	52,164 SF	\$2,175,500	\$342,013	\$2,040,300	\$4,215,800	\$6,600	\$4,375,400							
				WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter System without Property Cost	14I	On Property without Acquisition - In Outwash Soil With High Rate Underground Filter System	1 Each	52,164 SF	\$2,175,500	\$0	\$1,595,700	\$3,771,200	\$6,600	\$3,930,800							
18	WetPond	Class 10	Routine	WQBE_18A_Wetpond On Public Property	18A	On Property/Highway without Acquisition	553 SF	63,075 SF	\$493,900	\$0	\$375,300	\$869,200	\$2,200	\$929,200	553 SF	\$383,000	\$0	\$300,000	\$683,000	\$2,000	\$852,000
				WQBE_18B_Wetpond with Property Cost	18B	On Property with Acquisition	553 SF	63,075 SF	\$493,900	\$615,475	\$1,175,400	\$1,669,300	\$2,200	\$1,729,300	553 SF	\$383,000	\$718,000	\$1,198,000	\$1,581,000	\$2,000	\$1,745,000
19	WetVault	Class 10	Routine	WQBE_19A_WetVault On Public Property	19A	On property without Acquisition	1 Each	63,010 SF	\$2,981,300	\$0	\$2,265,400	\$5,246,700	\$3,100	\$5,333,600	1 Each	\$2,852,000	\$0	\$2,203,000	\$5,055,000	\$2,900	\$5,125,000
				WQBE_19B_WetVault In ROW	19B	On Property/Highway without Acquisition	1 Each	63,010 SF	\$3,342,400	\$0	\$2,447,900	\$5,790,300	\$3,100	\$5,877,200	1 Each	\$3,314,000	\$0	\$2,493,000	\$5,806,000	\$2,900	\$5,874,000
				WQBE_19C_WetVault with Property Cost	19C	On Property with Acquisition	1 Each	63,010 SF	\$2,981,300	\$347,803	\$2,717,500	\$5,698,800	\$3,100	\$5,785,700	1 Each	\$2,852,000	\$538,000	\$2,876,000	\$5,728,000	\$2,900	\$5,795,000
20	SW Treatment Wetland	Class 10	Routine	WQBE_20A_Stormwater Treatment Wetland on Public Property	20A	On Property/Highway without Acquisition	503 SF	62,988 SF	\$463,100	\$0	\$351,900	\$815,000	\$2,500	\$880,800	503 SF	\$360,000	\$0	\$282,000	\$642,000	\$2,300	\$817,000
				WQBE_20B_Stormwater Treatment Wetland with Property Cost	20B	On property with Acquisition	503 SF	62,988 SF	\$463,100	\$555,554	\$1,074,100	\$1,537,200	\$2,500								

MANDATORY INPUTS		
Input Category	Inputs	Comments
Retail Sales Tax Rate	10.25%	Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle
Allowance for Indeterminates (AFI), Dependent Upon Project Phase	20%	Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%)
Construction Change Order Allowance	10%	
Project Contingency	30%	Complexity Inputs (Moderate, & Routine = 30%; Override for Low = 15%)

SECONDARY INPUTS		
Input Category	Inputs	Comments
Street Use Permit	\$ 90,000	In ROW only - Arterial @ \$90,000/Unit; Non-Arterial @use \$30000/unit
Outside Agency Construction	10%	For Projects in ROW Utility Outside Agency Construction estimated at 10% construction cost.

PROJECT CATEGORY AND INDIRECT PROJECT INPUTS		
Input Category	Inputs	Comments

PROPERTY COST

Cost Category	\$/sf
Low	\$ 10.10
Medium	\$ 80.43
High	\$ 284.37
None	\$ -

Description: WQBE_11A_Detention Vault on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 5,775,500
Capital cost	\$ 5,775,500 \$/Unit
Total Direct O&M/Year	4,351
Direct O&M cost	4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	55,700 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 5,905,200	\$/unit
Annual O&M Cost	\$ 5,200	\$/year
Annualized Cost	\$1,310	\$/year

Description: WQBE_11A_Detention Vault on Public Property

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day using a vactor truck at \$711 total cost for equipment.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Materials, Supplies, Other Costs

		\$ -	\$/year
Cement Patching	2023 dollars	\$ 113	\$/year
Vacuum Truck Equipment + Labor	2023 dollars	\$ 711	\$/year
Subtotal		\$824	
Labor			
Vactor to remove sediment and debris	16	hr	
Inspection and joint repair, crack repair	16	hr	
	0	hr	
	0	hr	
Total hours per year	32		
Raw Labor Rate/hr		\$ 54	
Raw labor cost	(embedded)	\$ 1,740	
Labor cost, burdened	O/H 150.0%	\$ 4,351	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 39,202		\$ 207,010	\$ 6,077,412	\$ 5,905,245			
0	1.000	\$ 5,775,500		\$ 5,775,500	\$ 5,775,500	\$ 5,775,500	\$ 5,775,500	\$ 5,775,500	\$ 5,905,245
1	0.950	\$824	\$ -	\$ 4,351	\$ 5,175	\$ 4,917	\$ 5,780,675	\$ 5,780,417	\$ 129,745
2	0.903	\$ 849	\$ -	\$ 4,482	\$ 5,330	\$ 4,812	\$ 5,786,006	\$ 5,785,229	\$ 124,828
3	0.858	\$ 874	\$ -	\$ 4,616	\$ 5,490	\$ 4,709	\$ 5,791,496	\$ 5,789,938	\$ 120,016
4	0.815	\$ 900	\$ -	\$ 4,755	\$ 5,655	\$ 4,608	\$ 5,797,151	\$ 5,794,546	\$ 115,307
5	0.774	\$ 927	\$ -	\$ 4,897	\$ 5,825	\$ 4,510	\$ 5,802,976	\$ 5,799,056	\$ 110,699
6	0.736	\$ 955	\$ -	\$ 5,044	\$ 5,999	\$ 4,413	\$ 5,808,975	\$ 5,803,470	\$ 106,189
7	0.699	\$ 984	\$ -	\$ 5,196	\$ 6,179	\$ 4,319	\$ 5,815,155	\$ 5,807,789	\$ 101,775
8	0.664	\$ 1,013	\$ -	\$ 5,351	\$ 6,365	\$ 4,227	\$ 5,821,520	\$ 5,812,016	\$ 97,456
9	0.631	\$ 1,044	\$ -	\$ 5,512	\$ 6,556	\$ 4,136	\$ 5,828,075	\$ 5,816,152	\$ 93,229
10	0.599	\$ 1,075	\$ -	\$ 5,677	\$ 6,752	\$ 4,048	\$ 5,834,828	\$ 5,820,200	\$ 89,993
11	0.570	\$ 1,107	\$ -	\$ 5,848	\$ 6,955	\$ 3,961	\$ 5,841,783	\$ 5,824,162	\$ 85,045
12	0.541	\$ 1,141	\$ -	\$ 6,023	\$ 7,164	\$ 3,877	\$ 5,848,947	\$ 5,828,038	\$ 81,084
13	0.514	\$ 1,175	\$ -	\$ 6,204	\$ 7,379	\$ 3,794	\$ 5,856,325	\$ 5,831,832	\$ 77,207
14	0.489	\$ 1,210	\$ -	\$ 6,390	\$ 7,600	\$ 3,713	\$ 5,863,925	\$ 5,835,545	\$ 73,413
15	0.464	\$ 1,246	\$ -	\$ 6,582	\$ 7,828	\$ 3,633	\$ 5,871,753	\$ 5,839,179	\$ 69,700
16	0.441	\$ 1,284	\$ -	\$ 6,779	\$ 8,063	\$ 3,556	\$ 5,879,816	\$ 5,842,734	\$ 66,067
17	0.419	\$ 1,322	\$ -	\$ 6,982	\$ 8,305	\$ 3,480	\$ 5,888,121	\$ 5,846,214	\$ 62,511
18	0.398	\$ 1,362	\$ -	\$ 7,192	\$ 8,554	\$ 3,405	\$ 5,896,674	\$ 5,849,619	\$ 59,031
19	0.378	\$ 1,403	\$ -	\$ 7,408	\$ 8,810	\$ 3,333	\$ 5,905,485	\$ 5,852,952	\$ 56,262
20	0.359	\$ 1,445	\$ 55,700	\$ 7,630	\$ 64,775	\$ 23,279	\$ 5,970,260	\$ 5,876,231	\$ 52,293
21	0.341	\$ 1,488	\$ -	\$ 7,859	\$ 9,347	\$ 3,192	\$ 5,979,607	\$ 5,879,423	\$ 29,014
22	0.324	\$ 1,533	\$ -	\$ 8,095	\$ 9,627	\$ 3,123	\$ 5,989,234	\$ 5,882,546	\$ 25,823
23	0.308	\$ 1,579	\$ -	\$ 8,337	\$ 9,916	\$ 3,057	\$ 5,999,150	\$ 5,885,602	\$ 22,699
24	0.293	\$ 1,626	\$ -	\$ 8,587	\$ 10,214	\$ 2,991	\$ 6,009,364	\$ 5,888,594	\$ 19,643
25	0.278	\$ 1,675	\$ -	\$ 8,845	\$ 10,520	\$ 2,927	\$ 6,019,884	\$ 5,891,521	\$ 16,651
26	0.264	\$ 1,725	\$ -	\$ 9,110	\$ 10,836	\$ 2,865	\$ 6,030,720	\$ 5,894,386	\$ 13,724
27	0.251	\$ 1,777	\$ -	\$ 9,384	\$ 11,161	\$ 2,803	\$ 6,041,880	\$ 5,897,189	\$ 10,859
28	0.239	\$ 1,830	\$ -	\$ 9,665	\$ 11,496	\$ 2,744	\$ 6,053,376	\$ 5,899,933	\$ 8,056
29	0.227	\$ 1,885	\$ -	\$ 9,955	\$ 11,840	\$ 2,685	\$ 6,065,217	\$ 5,902,618	\$ 5,312
30	0.215	\$ 1,942	\$ -	\$ 10,254	\$ 12,196	\$ 2,628	\$ 6,077,412	\$ 5,905,245	\$ 2,628

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Tataina Skadovra (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_11A_Detention Vault on Public Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Detention Vault on Public Property			\$	-
2	Detention Vault Assumptions			\$	-
3	Exterior Length	73	FT	\$	-
4	Interior Length	70	FT	\$	-
5	Sump Length	4	FT	\$	-
6	Sump Wall Width	25	FT	\$	-
	Sump Interior Depth	4	FT	\$	-
	Sump Wall Total Length	64	FT	\$	-
	Exterior Width	28	FT	\$	-
	Interior Width	25	FT	\$	-
	Interior Structure Height (Ave.)	10.5	FT	\$	-
	Storage Depth (Ave.)	9	FT	\$	-
	Sediment Storage Depth	0.5	FT	\$	-
	Freeboard (Ave.)	1	FT	\$	-
	Storage Facility Exterior Footprint Area	2,044	SF	\$	-
				\$	-
	Storage Volume			\$	-
	Storage Facility Interior Area	1,750	SF	\$	-
	Effective Storage Volume (15,500 cf target)	15,575	CF	\$	-
	Vault Storage Volume	0.12	MG	\$	-
				\$	-
	Structure Concrete Assumptions			\$	-
	Exterior Wall thickness	1.5	FT	\$	-
	Sump Wall Thickness	1.5	FT	\$	-
	Top Slab Thickness	2	FT	\$	-
	Foundation Slab thickness	3	FT	\$	-
	Concrete Reinforcing Rebar	225	LB/CY	\$	-
	Crushed Base Thickness	1	FT	\$	-
				\$	-
	Concrete Structure			\$	-
	Vault Interior Walls Concrete @2' Thick (partial for supports)	5	CY	\$ 650	\$ 3,250
	Sump Wall Concrete	14	CY	\$ 1,250	\$ 17,778
	Exterior Wall Concrete	118	CY	\$ 1,250	\$ 147,292
	Top Slab Concrete	151	CY	\$ 1,250	\$ 189,359
	Foundation Slab Concrete	227	CY	\$ 950	\$ 215,756
	Stormwater Treatment Rebar @ 225 lbs/cy	116,004	LBS	\$ 1.38	\$ 160,866
	Crushed Base	76	CY	\$ 64	\$ 4,845
				\$	-
	Shoring and Excavation Assumptions			\$	-
	Construction Room	3	FT	\$	-
	Tank Bury Depth	2	FT	\$	-
	Total Excavation Depth	19	FT	\$	-
	Excavation Length	83	FT	\$	-
	Excavation Width	38	FT	\$	-
				\$	-
	Soil Excavation and Disposal			\$	-
	Excavation to waste	2,161	CY	\$ 79	\$ 170,725
	Imported Structure Backfill	912	CY	\$ 44	\$ 40,126
				\$	-
	Solder Pile Shoring			\$	-
	Solder Pile Shaft Depth (3 x Exc. Depth)	56	FT	\$	-
	Solder Pile Shaft Thickness	2	FT	\$	-
	Center to Center Shaft Spacing	6	FT	\$	-
	Rebar in Shaft	114	LB/CY	\$	-
	Shoring Wall Perimeter	234	FT	\$	-
	Number of Shafts	39	EA	\$	-
	Drill Solder Pile Shafts	252	CY	\$ 262	\$ 65,985
	Set Solder Pile and CDF	252	CY	\$ 391	\$ 98,474
	Purchase and Salvage Solder Piles	246,753	LB	\$ 0.7	\$ 172,727
	Tie Backs - one per soldier pile except corners	35	EA	\$ 2,477	\$ 86,695
	Timber Lagging	14,883	BF	\$ 9	\$ 133,947
				\$	-
	Gates and Access			\$	-
	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
	Access Hatches	2	EA	\$ 13,038	\$ 26,076
				\$	-
	Conveyance Pipe			\$	-
	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
	Imported Backfill	883	CY	\$ 44	\$ 38,855
	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100')	444	SY	\$ 71	\$ 31,556
				\$	-
	Site Removals and Restoration			\$	-
	Disking or tilling of compacted soil (assumed 100'X100')	526	SY	\$ 4	\$ 2,103
	Seeding, mulching and compost	526	SY	\$ 10	\$ 5,257
	Demolish Existing Surface	350	SY	\$ 14	\$ 4,906
	Pavement Restoration (Vault) - 4" HMA/4"CSBC	350	SY	\$ 71	\$ 24,882
				\$	-
	Removals at 4% Construction Costs	4.0%	LS	\$ 1,932,577	\$ 77,303
	TESC at 2% of Construction	2%	LS	\$ 2,009,880	\$ 40,198
				\$	-
				\$	-
	Item Subtotal Construction Costs (Year 2023)			\$	2,050,078
	DIRECT: CONSTRUCTION COST MARK-UPS				
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	205,008
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
	Item Subtotal Construction Costs (Year 2023)			\$	2,255,086
	Direct: Subtotal Construction Costs			\$	2,255,100

	<p>Description: WQBE 11A - Detention Vault on Public Property</p> <p>Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.</p>
	<p>Cost Estimating Assumptions:</p> <p>The Detention Vault installation is per the King Co. SW Design Manual Chapter 5, Section 5.1.3.</p> <p>The vault is an online storage facility with a flow restricting device.</p> <p>The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.</p> <p>The vault is an underground cast in place concrete structure with an interior storage volume of +/-15,500 cf.</p> <p>The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.12 MG.</p> <p>Sump interior dimensions 4'W x 4'H.</p> <p>The minimum vault height is 7 feet deep at the shallowest end.</p> <p>The vault side slopes are a minimum of 5% towards the center of the vault.</p> <p>The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.</p> <p>An average of 0.5' of additional storage depth is provided for sediment storage.</p> <p>Exterior and interior wall thickness is 1.5 feet.</p> <p>Top slab thickness is 2 feet</p> <p>Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)</p> <p>There is a 1' layer of crushed base beneath the base/ballast slab.</p> <p>The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.</p> <p>No contaminated soil or groundwater is assumed to exist at the proposed vault location.</p> <p>Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.</p> <p>The shafts are 3 times the excavation depth.</p> <p>The vault is positively anchored to the shoring piles.</p> <p>Vault is designed to accommodate traffic loading.</p> <p>All metal is galvanized or stainless steel per SW Manual.</p> <p>Access hatches are provided as shown on the WTD detail.</p> <p>Two maintenance hole access with ladder rungs.</p> <p>The excavated material is unsuitable for use as backfill.</p> <p>An excavation width of 3 feet is assumed on each side of the structure.</p> <p>Shoring and Lagging is required for construction of the structure.</p> <p>Pipe length is 200' of 12" Diameter Pipe for both influent and effluent combined.</p> <p>The storage vault, facility inlet and outlet pipes are sited beneath a parking area.</p> <p>It is assumed that the tank restoration will consist of parking lot restoration with 4" HMA/4" CSTM.</p> <p>It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.</p> <p>Allowance for removals estimated at 4% of the construction cost.</p> <p>Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.</p> <p>Construction occurs outside of the right-of-way and no traffic control or street use permits are required.</p> <p>The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.</p>
	<p>Planning Basis Assumptions:</p> <p>No project construction plan is in place at this time.</p> <p>The assumed execution strategy is a standard work week with limited overtime.</p> <p>No alternative procurement methods have been considered as part of delivery of this concept.</p> <p>No unusual site conditions have been considered as part of this estimate.</p> <p>Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.</p>
	<p>Cost Basis Assumptions:</p> <p>All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.</p> <p>Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.</p>
	<p>Allowances:</p> <p>The level and types of allowances used in the estimate are as follows:</p> <p>Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.</p> <p>Allowance of 10% for potential change orders.</p> <p>This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor</p> <p>A 20% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.</p> <p>Costs were not included for Local Agency Mitigation and Indirect Burden.</p> <p>The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included.</p> <p>Costs were not included for utility relocation work.</p>
	<p>Estimating Assumptions:</p> <p>This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100%, for the scope as known at the time of the estimate preparation.</p> <p>It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.</p> <p>It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.</p> <p>It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.</p> <p>It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.</p> <p>A 30% Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.</p>

Description: WQBE_11B_Detention_Vault in ROW (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 6,302,400
Capital cost	\$ 6,302,400 \$/Unit
Total Direct O&M/Year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 55,700 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 6,432,100	\$/unit
Annual O&M Cost	\$ 5,200	\$/year
Annualized Cost	\$ 1,310	\$/year

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ -	\$/year
Vacuum Truck Equipment + Labor	2023 dollars	\$ 113	\$/year
Subtotal		\$ 711	\$/year
Labor		\$ 824	
Vactor to remove sediment and debris	16 hr		
Inspection and joint repair, crack repair	16 hr		
	0 hr		
	0 hr		
Total hours per year	32		
Raw Labor Rate/hr		\$ 54	
Raw labor cost	(embedded)	\$ 1,740	
Labor cost, burdened	O/H 150.0%	\$ 4,351	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Description: WQBE_11B_Detention_Vault in ROW

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day using a vactor truck at \$711 total cost for equipment.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 39,202		\$ 207,010	\$ 6,604,312	\$ 6,432,145			
0	1.000	\$ 6,302,400		\$ 6,302,400	\$ 6,302,400	\$ 6,302,400	\$ 6,302,400	\$ 6,302,400	\$ 6,432,145
1	0.950	\$ 824	\$ -	\$ 4,351	\$ 5,175	\$ 4,917	\$ 6,307,575	\$ 6,307,517	\$ 129,745
2	0.903	\$ 849	\$ -	\$ 4,482	\$ 5,330	\$ 4,812	\$ 6,312,906	\$ 6,312,129	\$ 124,828
3	0.858	\$ 874	\$ -	\$ 4,616	\$ 5,490	\$ 4,709	\$ 6,318,396	\$ 6,316,838	\$ 120,016
4	0.815	\$ 900	\$ -	\$ 4,755	\$ 5,655	\$ 4,608	\$ 6,324,051	\$ 6,321,446	\$ 115,307
5	0.774	\$ 927	\$ -	\$ 4,897	\$ 5,825	\$ 4,510	\$ 6,329,876	\$ 6,325,956	\$ 110,699
6	0.736	\$ 955	\$ -	\$ 5,044	\$ 5,999	\$ 4,413	\$ 6,335,875	\$ 6,330,370	\$ 106,189
7	0.699	\$ 984	\$ -	\$ 5,196	\$ 6,179	\$ 4,319	\$ 6,342,055	\$ 6,334,689	\$ 101,775
8	0.664	\$ 1,013	\$ -	\$ 5,351	\$ 6,365	\$ 4,227	\$ 6,348,420	\$ 6,338,816	\$ 97,456
9	0.631	\$ 1,044	\$ -	\$ 5,512	\$ 6,556	\$ 4,136	\$ 6,354,975	\$ 6,343,052	\$ 93,229
10	0.599	\$ 1,075	\$ -	\$ 5,677	\$ 6,752	\$ 4,048	\$ 6,361,728	\$ 6,347,100	\$ 89,993
11	0.570	\$ 1,107	\$ -	\$ 5,848	\$ 6,955	\$ 3,961	\$ 6,368,683	\$ 6,351,062	\$ 85,045
12	0.541	\$ 1,141	\$ -	\$ 6,023	\$ 7,164	\$ 3,877	\$ 6,375,847	\$ 6,354,938	\$ 81,084
13	0.514	\$ 1,175	\$ -	\$ 6,204	\$ 7,379	\$ 3,794	\$ 6,383,225	\$ 6,358,732	\$ 77,207
14	0.489	\$ 1,210	\$ -	\$ 6,390	\$ 7,600	\$ 3,713	\$ 6,390,825	\$ 6,362,445	\$ 73,413
15	0.464	\$ 1,246	\$ -	\$ 6,582	\$ 7,828	\$ 3,633	\$ 6,398,653	\$ 6,366,079	\$ 69,700
16	0.441	\$ 1,284	\$ -	\$ 6,779	\$ 8,063	\$ 3,556	\$ 6,406,716	\$ 6,369,634	\$ 66,067
17	0.419	\$ 1,322	\$ -	\$ 6,982	\$ 8,305	\$ 3,480	\$ 6,415,021	\$ 6,373,114	\$ 62,511
18	0.398	\$ 1,362	\$ -	\$ 7,192	\$ 8,554	\$ 3,405	\$ 6,423,574	\$ 6,376,519	\$ 59,031
19	0.378	\$ 1,403	\$ -	\$ 7,408	\$ 8,810	\$ 3,333	\$ 6,432,385	\$ 6,379,852	\$ 55,262
20	0.359	\$ 1,445	\$ 55,700	\$ 7,630	\$ 64,775	\$ 23,279	\$ 6,497,160	\$ 6,403,131	\$ 52,293
21	0.341	\$ 1,488	\$ -	\$ 7,859	\$ 9,347	\$ 3,192	\$ 6,506,507	\$ 6,406,323	\$ 29,014
22	0.324	\$ 1,533	\$ -	\$ 8,095	\$ 9,627	\$ 3,123	\$ 6,516,134	\$ 6,409,446	\$ 25,823
23	0.308	\$ 1,579	\$ -	\$ 8,337	\$ 9,916	\$ 3,057	\$ 6,526,050	\$ 6,412,502	\$ 22,699
24	0.293	\$ 1,626	\$ -	\$ 8,587	\$ 10,214	\$ 2,991	\$ 6,536,264	\$ 6,415,494	\$ 19,643
25	0.278	\$ 1,675	\$ -	\$ 8,845	\$ 10,520	\$ 2,927	\$ 6,546,784	\$ 6,418,421	\$ 16,651
26	0.264	\$ 1,725	\$ -	\$ 9,110	\$ 10,836	\$ 2,865	\$ 6,557,620	\$ 6,421,286	\$ 13,724
27	0.251	\$ 1,777	\$ -	\$ 9,384	\$ 11,161	\$ 2,803	\$ 6,568,780	\$ 6,424,089	\$ 10,859
28	0.239	\$ 1,830	\$ -	\$ 9,665	\$ 11,496	\$ 2,744	\$ 6,580,276	\$ 6,426,833	\$ 8,056
29	0.227	\$ 1,885	\$ -	\$ 9,955	\$ 11,840	\$ 2,685	\$ 6,592,117	\$ 6,429,518	\$ 5,312
30	0.215	\$ 1,942	\$ -	\$ 10,254	\$ 12,196	\$ 2,628	\$ 6,604,312	\$ 6,432,145	\$ 2,628

Description: WQBE 11B - Detention Vault in Highway ROW

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Cost Estimating Assumptions:

The Detention Vault installation is per the King Co. SW Design Manual Chapter 5, Section 5.1.3.
The vault is an online storage facility with a flow restricting device.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The vault is an underground cast in place concrete structure with an interior storage volume of +/-15,500 cf.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.12 MG.
Sump interior dimensions 4'W x 4'H.
The minimum vault height is 7 feet deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.
An average of 0.5' of additional storage depth is provided for sediment storage.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet
Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)
There is a 1' layer of crushed base beneath the base/ballast slab.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.
Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth.
The vault is positively anchored to the shoring piles.
Vault is designed for heavy traffic loads.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
Two maintenance hole access with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and Lagging is required for construction of the structure.
Pipe length is 200' of 12" Diameter Pipe for both influent and effluent.
Full width arterial roadway restoration is assumed, including the sidewalks and landscape areas on both sides of the roadway.
Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_11C_Detention_Vault with Property Costs (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 6,324,900 Does not include property costs
Capital cost	\$ 6,324,900 \$/Unit
Total Direct O&M/Year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 55,700 \$/unit
Discount rate (%)	5.25 \$/Unit
Total Cost (NPV)	\$ 6,454,600 \$/unit
Annual O&M Cost	\$ 5,200 \$/year
Annualized Cost	\$ 1,310 \$/year

Description: WQBE_11C_Detention_Vault with Property Costs

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day using 16 a vector truck at \$711 total cost for equipment.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour 16 work day. Assume annual cost of \$113 for cement patching mix.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ 113	\$/year
Vactor Truck Equipment	2023 dollars	\$ 711	\$/year
Subtotal		\$824	
Labor			
Vactor to remove sediment and debris	16	hr	
Inspection and joint repair, crack repair	16	hr	
	0	hr	
	0	hr	
Total hours per year	32		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 1,740	
Labor cost, burdened	O/H 150.0%	\$ 4,351	\$
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30	years	

135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 39,202		\$ 207,010	\$ 6,626,812	\$ 6,454,645			
0	1.000	\$ 6,324,900		\$ -	\$ 6,324,900	\$ 6,324,900	\$ 6,324,900	\$ 6,324,900	\$ 6,454,645
1	0.950	\$ 824	\$ -	\$ 4,351	\$ 5,175	\$ 4,917	\$ 6,330,075	\$ 6,328,817	\$ 129,745
2	0.903	\$ 849	\$ -	\$ 4,482	\$ 5,330	\$ 4,812	\$ 6,335,406	\$ 6,334,629	\$ 124,828
3	0.858	\$ 874	\$ -	\$ 4,616	\$ 5,490	\$ 4,709	\$ 6,340,896	\$ 6,339,338	\$ 120,016
4	0.815	\$ 900	\$ -	\$ 4,755	\$ 5,655	\$ 4,608	\$ 6,346,551	\$ 6,343,946	\$ 115,307
5	0.774	\$ 927	\$ -	\$ 4,897	\$ 5,825	\$ 4,510	\$ 6,352,376	\$ 6,348,456	\$ 110,699
6	0.736	\$ 955	\$ -	\$ 5,044	\$ 5,999	\$ 4,413	\$ 6,358,375	\$ 6,352,870	\$ 106,189
7	0.699	\$ 984	\$ -	\$ 5,196	\$ 6,179	\$ 4,319	\$ 6,364,555	\$ 6,357,189	\$ 101,775
8	0.664	\$ 1,013	\$ -	\$ 5,351	\$ 6,365	\$ 4,227	\$ 6,370,920	\$ 6,361,416	\$ 97,456
9	0.631	\$ 1,044	\$ -	\$ 5,512	\$ 6,556	\$ 4,136	\$ 6,377,475	\$ 6,365,552	\$ 93,229
10	0.599	\$ 1,075	\$ -	\$ 5,677	\$ 6,752	\$ 4,048	\$ 6,384,228	\$ 6,369,600	\$ 89,093
11	0.570	\$ 1,107	\$ -	\$ 5,848	\$ 6,955	\$ 3,961	\$ 6,391,183	\$ 6,373,562	\$ 85,045
12	0.541	\$ 1,141	\$ -	\$ 6,023	\$ 7,164	\$ 3,877	\$ 6,398,347	\$ 6,377,438	\$ 81,084
13	0.514	\$ 1,175	\$ -	\$ 6,204	\$ 7,379	\$ 3,794	\$ 6,405,725	\$ 6,381,232	\$ 77,207
14	0.489	\$ 1,210	\$ -	\$ 6,390	\$ 7,600	\$ 3,713	\$ 6,413,325	\$ 6,384,945	\$ 73,413
15	0.464	\$ 1,246	\$ -	\$ 6,582	\$ 7,828	\$ 3,633	\$ 6,421,153	\$ 6,388,579	\$ 69,700
16	0.441	\$ 1,284	\$ -	\$ 6,779	\$ 8,063	\$ 3,556	\$ 6,429,216	\$ 6,392,134	\$ 66,067
17	0.419	\$ 1,322	\$ -	\$ 6,982	\$ 8,305	\$ 3,480	\$ 6,437,521	\$ 6,395,614	\$ 62,511
18	0.398	\$ 1,362	\$ -	\$ 7,192	\$ 8,554	\$ 3,405	\$ 6,446,074	\$ 6,399,019	\$ 59,031
19	0.378	\$ 1,403	\$ -	\$ 7,408	\$ 8,810	\$ 3,333	\$ 6,454,885	\$ 6,402,352	\$ 56,626
20	0.359	\$ 1,445	\$ 55,700	\$ 7,630	\$ 64,775	\$ 23,279	\$ 6,519,660	\$ 6,425,631	\$ 52,293
21	0.341	\$ 1,488	\$ -	\$ 7,859	\$ 9,347	\$ 3,192	\$ 6,529,007	\$ 6,428,823	\$ 29,014
22	0.324	\$ 1,533	\$ -	\$ 8,095	\$ 9,627	\$ 3,123	\$ 6,538,634	\$ 6,431,946	\$ 25,823
23	0.308	\$ 1,579	\$ -	\$ 8,337	\$ 9,916	\$ 3,057	\$ 6,548,550	\$ 6,435,002	\$ 22,699
24	0.293	\$ 1,626	\$ -	\$ 8,587	\$ 10,214	\$ 2,991	\$ 6,558,764	\$ 6,437,994	\$ 19,643
25	0.278	\$ 1,675	\$ -	\$ 8,845	\$ 10,520	\$ 2,927	\$ 6,569,294	\$ 6,440,921	\$ 16,651
26	0.264	\$ 1,725	\$ -	\$ 9,110	\$ 10,836	\$ 2,865	\$ 6,580,120	\$ 6,443,786	\$ 13,724
27	0.251	\$ 1,777	\$ -	\$ 9,384	\$ 11,161	\$ 2,803	\$ 6,591,280	\$ 6,446,589	\$ 10,859
28	0.239	\$ 1,830	\$ -	\$ 9,665	\$ 11,496	\$ 2,744	\$ 6,602,776	\$ 6,449,333	\$ 8,056
29	0.227	\$ 1,885	\$ -	\$ 9,955	\$ 11,840	\$ 2,685	\$ 6,614,617	\$ 6,452,018	\$ 5,312
30	0.215	\$ 1,942	\$ -	\$ 10,254	\$ 12,196	\$ 2,628	\$ 6,626,812	\$ 6,454,645	\$ 2,628

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer (HDR) Tataina Skadovwa (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_11C_Detention Vault With Property Costs		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Detention Vault on Public Property			\$	-
2	Detention Vault Assumptions			\$	-
3	Exterior Length	73	FT	\$	-
4	Interior Length	70	FT	\$	-
5	Sump Length	4	FT	\$	-
6	Sump Wall Width	25	FT	\$	-
7	Sump Interior Depth	4	FT	\$	-
8	Sump Wall Total Length	64	FT	\$	-
9	Exterior Width	28	FT	\$	-
10	Interior Width	25	FT	\$	-
11	Interior Structure Height (Ave.)	10.5	FT	\$	-
12	Storage Depth (Ave.)	9	FT	\$	-
13	Sediment Storage Depth	0.5	FT	\$	-
14	Freeboard (Ave.)	1	FT	\$	-
15	Storage Facility Exterior Footprint Area	2,044	SF	\$	-
16				\$	-
17	Storage Volume			\$	-
18	Storage Facility interior Area	1,750	SF	\$	-
19	Effective Storage Volume (15.500 cf target)	15,575	CF	\$	-
20	Vault Storage Volume	0.12	MG	\$	-
21				\$	-
22	Structure Concrete Assumptions			\$	-
23	Exterior Wall thickness	1.5	FT	\$	-
24	Sump Wall Thickness	1.5	FT	\$	-
25	Top Slab Thickness	2	FT	\$	-
26	Foundation Slab thickness	3	FT	\$	-
27	Concrete Reinforcing Rebar	225	LB/CY	\$	-
28	Crushed Base Thickness	1	FT	\$	-
29				\$	-
30	Concrete Structure			\$	-
31	Vault Interior Walls Concrete @2" Thick (partial for supports)	5	CY	\$ 650	\$ 3,250
32	Sump Wall Concrete	14	CY	\$ 1,250	\$ 17,778
33	Exterior Wall Concrete	118	CY	\$ 1,250	\$ 147,292
34	Top Slab Concrete	151	CY	\$ 1,250	\$ 189,359
35	Foundation Slab Concrete	227	CY	\$ 950	\$ 215,756
36	Stormwater Treatment Rebar @ 225 lbs/cy	116,004	LBS	\$ 1.38	\$ 160,866
37	Crushed Base	76	CY	\$ 64	\$ 4,845
38				\$	-
39	Shoring and Excavation Assumptions			\$	-
40	Construction Room	3	FT	\$	-
41	Tank Burry Depth	2	FT	\$	-
42	Total Excavation Depth	19	FT	\$	-
43	Excavation Length	83	FT	\$	-
44	Excavation Width	38	FT	\$	-
45				\$	-
46	Soil Excavation and Disposal			\$	-
47	Excavation	2,161	CY	\$ 79	\$ 170,725
51	Imported Structure Backfill	912	CY	\$ 44	\$ 40,126
52				\$	-
53	Solder Pile Shoring			\$	-
54	Solder Pile Shaft Depth (3 x Exc. Depth)	56	FT	\$	-
55	Solder Pile Shaft Thickness	2	FT	\$	-
56	Center to Center Shaft Spacing	6	FT	\$	-
57	Rebar in Shaft	114	LB/CY	\$	-
58	Shoring Wall Perimeter	234	FT	\$	-
59	Number of Shafts	39	EA	\$	-
60	Drill Solder Pile Shafts	252	CY	\$ 262	\$ 65,985
61	Set Solder Pile and CDF	252	CY	\$ 391	\$ 98,474
62	Purchase and Salvage Solder Piles	246,753	LB	\$ 0.7	\$ 172,727
63	Tie Backs - one per soldier pile except corners	35	EA	\$ 2,477	\$ 86,695
64	Timber Lagging	14,883	BF	\$ 9	\$ 133,947
65				\$	-
66	Gates and Access			\$	-
67	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
68	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
69	Access Hatches	2	EA	\$ 13,038	\$ 26,076
70				\$	-
71	Conveyance Pipe			\$	-
72	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
73	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
74	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
75	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
76	Imported Backfill	883	CY	\$ 44	\$ 38,855
77	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
78	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
79	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100')	444	SY	\$ 71	\$ 31,556
80				\$	-
81	Site Removals and Restoration			\$	-
82	Disking or tilling of compacted soil (assumed 100'X100')	526	SY	\$ 4	\$ 2,103
83	Seeding, mulching and compost	526	SY	\$ 10	\$ 5,257
84	Demolish Existing Surface	350	SY	\$ 14	\$ 4,906
85	Pavement Restoration (Vault) - 4" HMA/4"CSBC	350	SY	\$ 71	\$ 24,882
86				\$	-
87	Removals at 4% Construction Costs	4.0%	LS	\$ 1,932,577	\$ 77,303
88	TESC at 2% of Construction	2%	LS	\$ 2,009,880	\$ 40,198
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)				\$	2,050,078
DIRECT: CONSTRUCTION COST MARK-UPS					
General Conditions 0%					
Mobilization/Demobilization 10%					
Overhead & Profit (OHP) 0%					
Insurance 0.0%					
Bonding 0.0%					
Escalation Multiplier from ENR-CCI 0%					
Item Subtotal Construction Costs (Year 2023)				\$	2,255,086
Direct: Subtotal Construction Costs				\$	2,255,100

Description: WQBE 11C - Detention Vault With Property Cost

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Cost Estimating Assumptions:

The Detention Vault installation is per the King Co. SW Design Manual Chapter 5, Section 5.1.3.

It is assumed that no agency mitigation costs will be required.

The vault is an online storage facility with a flow restricting device.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The vault is an underground cast in place concrete structure with an interior storage volume of +/-15,500 cf.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.12 MG.

Sump interior dimensions 4'W x 4'H.

The minimum vault height is 7 feet deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.

An average of 0.5' of additional storage depth is provided for sediment storage.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet

Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)

There is a 1' layer of crushed base beneath the base/ballast slab.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth.

The vault is positively anchored to the shoring piles.

Vault is designed to accommodate traffic loading.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

Two maintenance hole access with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and Lagging is required for construction of the structure.

Pipe length is 200' of 12" Diameter Pipe for both influent and effluent combined.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

It is assumed that the tank restoration will consist of parking lot restoration with 4" HMA/4" CSTC.

It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

Allowance for removals estimated at 4% of the construction cost.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control is not required.

A street use permit is not required.

The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jeff Price (HDR) Jess Dexheimer (HDR)
Description:	WQBE_12A_Detention Pond On Public Property			Version:	2
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Detention Pond Installation (4,500 s.f. bottom area @ 4 ft. Storage Depth)	1	EA	\$ 477,300	\$ 477,300
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 477,300
	Allowance for Indeterminates (Design Allowance)			\$	95,460
	Street Use Permit (Y/N)	N		\$	-
ESTIMATED PROBABLE COST OF CONSTRUCTION BID					
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	57,276
	Subtotal Primary Construction Amount			\$	630,036
	Construction Sales Tax			\$	64,579
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	694,600
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	138,608
	Construction Management			\$	63,004
	Permitting & Support			\$	6,300
	s.f. Land Area	None		\$	-
	s.f. Land Area	None		\$	-
	WTD Staff Costs & Non-WTD Support			\$	37,802
	Subtotal Non-Construction Costs			\$	245,714
	Project Contingency			\$	282,094
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	527,800
	TOTAL PROJECT COST			\$	1,222,400

WQBE_12A_Detention Pond On Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 1,222,400
Capital cost	\$ 1,222,400 \$/Unit
Total Direct O&M/Year	\$ 9,790
Direct O&M cost	\$ 9,790 \$/Unit
Capital Replacement Costs (10 Years)	\$ 11,100 \$/Unit
Discount rate (%)	5.25 \$/Unit

Total Cost (NPV)	\$ 1,444,200	\$/unit
Annual O&M Cost	\$ 10,000	\$/year
Annualized Cost	\$270	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Grass seeding	2023 dollars	\$ 113	\$/year
Chain Saw Rental	2023 dollars	\$ 56	\$/year
Subtotal		\$169	
Labor			
Remove trash, sediment, debris and replace vegetation	16 hr		
Remove dead trees	32 hr		
stabilize eroded berms and embankments	24 hr		
	0 hr		
Total hours per year	72		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 3,916	
Labor cost, burdened	O/H 150.0%	\$ 9,790	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

WQBE_12A_Detention Pond On Public Property

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, 16 sediment and debris removal performed annually by a crew of two over a 8 hour workday.

Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as 32 needed (8 hour work day). Assume annual cost of chainsaw rental as \$56.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Biannual site visits by 2 crew 24 members, 6 hour work day. Grass seed mix as needed to stabilize at an estimated cost of \$113 per year.

Capital Replacement Assumptions:

Replacement of items highlighted in blue on estimate sheet every 10 years (i.e. riprap pads, gates, etc.)

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 8,040		\$ 465,773	\$ 1,718,413	\$ 1,444,204			
0	1.000	\$ 1,222,400		\$ 9,790	\$ 9,869	\$ 9,462	\$ 1,222,400	\$ 1,222,400	\$ 1,444,204
1	0.950	\$ 169		\$ 10,084	\$ 10,258	\$ 9,260	\$ 1,232,593	\$ 1,231,862	\$ 221,804
2	0.903	\$ 174		\$ 10,386	\$ 10,566	\$ 9,062	\$ 1,242,617	\$ 1,241,123	\$ 212,342
3	0.858	\$ 179		\$ 10,688	\$ 10,883	\$ 8,868	\$ 1,253,183	\$ 1,250,165	\$ 203,082
4	0.815	\$ 185		\$ 11,091	\$ 11,209	\$ 8,679	\$ 1,263,750	\$ 1,259,053	\$ 194,019
5	0.774	\$ 190		\$ 11,494	\$ 11,417	\$ 8,489	\$ 1,275,279	\$ 1,267,732	\$ 185,151
6	0.736	\$ 196		\$ 11,897	\$ 11,645	\$ 8,299	\$ 1,286,820	\$ 1,276,225	\$ 176,472
7	0.699	\$ 202		\$ 12,290	\$ 11,892	\$ 8,112	\$ 1,298,712	\$ 1,284,537	\$ 167,979
8	0.664	\$ 208		\$ 12,683	\$ 12,249	\$ 7,934	\$ 1,310,967	\$ 1,292,671	\$ 159,667
9	0.631	\$ 214		\$ 13,076	\$ 12,616	\$ 7,760	\$ 1,323,577	\$ 1,300,631	\$ 151,533
10	0.599	\$ 221		\$ 13,469	\$ 12,774	\$ 7,584	\$ 1,347,671	\$ 1,315,076	\$ 143,573
11	0.570	\$ 227		\$ 13,862	\$ 13,157	\$ 7,411	\$ 1,361,055	\$ 1,322,699	\$ 129,128
12	0.541	\$ 234		\$ 14,255	\$ 13,552	\$ 7,238	\$ 1,374,841	\$ 1,330,160	\$ 121,505
13	0.514	\$ 241		\$ 14,648	\$ 13,955	\$ 7,065	\$ 1,389,041	\$ 1,337,461	\$ 114,044
14	0.489	\$ 248		\$ 15,041	\$ 14,377	\$ 6,892	\$ 1,403,666	\$ 1,344,606	\$ 106,743
15	0.464	\$ 256		\$ 15,434	\$ 14,809	\$ 6,719	\$ 1,418,730	\$ 1,351,598	\$ 99,598
16	0.441	\$ 263		\$ 15,827	\$ 15,253	\$ 6,545	\$ 1,434,246	\$ 1,358,441	\$ 92,606
17	0.419	\$ 271		\$ 16,220	\$ 15,710	\$ 6,372	\$ 1,450,228	\$ 1,365,137	\$ 85,764
18	0.398	\$ 279		\$ 16,613	\$ 16,182	\$ 6,200	\$ 1,466,689	\$ 1,371,690	\$ 79,067
19	0.378	\$ 286		\$ 16,996	\$ 16,667	\$ 6,027	\$ 1,483,644	\$ 1,378,104	\$ 72,514
20	0.359	\$ 296		\$ 17,389	\$ 17,167	\$ 5,854	\$ 1,500,198	\$ 1,388,369	\$ 66,101
21	0.341	\$ 305		\$ 17,782	\$ 17,682	\$ 5,681	\$ 1,513,195	\$ 1,394,511	\$ 55,835
22	0.324	\$ 314		\$ 18,175	\$ 18,213	\$ 5,508	\$ 1,527,207	\$ 1,400,521	\$ 49,693
23	0.308	\$ 324		\$ 18,568	\$ 18,759	\$ 5,335	\$ 1,542,722	\$ 1,406,403	\$ 43,683
24	0.293	\$ 334		\$ 18,961	\$ 19,322	\$ 5,162	\$ 1,557,460	\$ 1,412,160	\$ 37,801
25	0.278	\$ 344		\$ 19,354	\$ 19,901	\$ 4,989	\$ 1,572,108	\$ 1,417,793	\$ 32,044
26	0.264	\$ 354		\$ 19,747	\$ 20,499	\$ 4,816	\$ 1,587,457	\$ 1,423,306	\$ 26,411
27	0.251	\$ 364		\$ 20,140	\$ 21,113	\$ 4,643	\$ 1,602,095	\$ 1,428,701	\$ 20,896
28	0.239	\$ 375		\$ 20,533	\$ 21,747	\$ 4,469	\$ 1,617,158	\$ 1,433,981	\$ 15,503
29	0.227	\$ 387		\$ 20,926	\$ 22,399	\$ 4,296	\$ 1,632,221	\$ 1,439,148	\$ 10,223
30	0.215	\$ 398		\$ 21,319	\$ 23,071	\$ 4,123	\$ 1,647,284	\$ 1,444,204	\$ 5,056

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jeff Price (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_12A_Detention Pond On Public Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Detention Pond on Public Property			\$	-
2	Pond Assumptions			\$	-
3	<i>Pond Bottom Area</i>	4,500	SF	\$	-
4	<i>Pond Top Area</i>	8,493	SF	\$	-
5	<i>Pond Top Area</i>			\$	-
6	<i>Pond Bottom Length</i>	95	FT	\$	-
7	<i>Pond Top Length</i>	119	FT	\$	-
8	<i>Pond Bottom Width</i>	47	FT	\$	-
9	<i>Pond Top Width</i>	71	FT	\$	-
10	<i>Pond Exc. Depth</i>	4	FT	\$	-
11	<i>Slope Run/Rise</i>	3:1		\$	-
12	<i>Slope Length</i>	12	FT	\$	-
13	<i>Freeboard (Ave.)</i>	1	FT	\$	-
14	<i>Imported Treatment Liner depth</i>	2	FT	\$	-
15				\$	-
16	Storage Volume			\$	-
17	<i>Pond Effective Storage Depth (Ave.)</i>	3	FT	\$	-
18	<i>Pond Storage Top Area</i>	7,387	SF	\$	-
19	<i>Storage Facility Interior Area (Ave.)</i>	5,943	SF	\$	-
20	<i>Effective Storage Volume</i>	23,773	CF	\$	-
21	<i>Storage Volume</i>	0.18	MG	\$	-
22				\$	-
23	Compacted Berm Assumptions (per KC Manual)			\$	-
24	<i>Berm Height (Average)</i>	3.5	FT	\$	-
25	<i>Berm slope Length@2:1 Slopes</i>	7	FT	\$	-
26	<i>Berm flat top Width</i>	6	FT	\$	-
27	<i>Berm Bottom Width</i>	20	FT	\$	-
28	<i>Distance to CL Berm - Width</i>	10	FT	\$	-
29	<i>Berm Centerline Length (for perimeter calcs)</i>	129	FT	\$	-
30	<i>Berm Centerline Width (for perimeter calcs)</i>	81	FT	\$	-
31	<i>Berm perimeter (at CL Length)</i>	420	FT	\$	-
32	<i>Berm Area/LF</i>	46	SF/FT	\$	-
33	<i>Imported Fill for Berm</i>	708	CY	\$ 44	\$ 31,142
34	<i>Embankment Compaction</i>	708	CY	\$ 22	\$ 15,571
35				\$	-
36	Spillway Assumptions KCSWDM Table 4.2.2A			\$	-
37	<i>RipRap Lining for Overflow</i>	5	CY	\$ 346	\$ 1,845
38	<i>Width</i>	6	FT	\$	-
39	<i>Length</i>	12	FT	\$	-
40	<i>RipRap Depth</i>	2	FT	\$	-
41	<i>Slope Run:Rise</i>	3:1		\$	-
42				\$	-
43	Wetpond Excavation and Liner			\$	-
44	<i>Facility Excavation to Berm and Waste</i>	962	CY	\$ 79	\$ 76,032
45	<i>Imported Treatment Liner @ 2' thick</i>	629	CY	\$ 105	\$ 66,055
46				\$	-
47	Outlet Pipe			\$	-
48	<i>Pipe - 12" Diameter</i>	100	LF	\$ 140	\$ 14,000
49	<i>5' Wide Trench x 6'D to waste</i>	111	CY	\$ 79	\$ 8,778
50	<i>Trench Box Shoring (Shallow)</i>	1,200	SF	\$ 10	\$ 12,000
51	<i>48" Maintenance hole</i>	1	EA	\$ 10,640	\$ 10,640
52	<i>Control Structure</i>	1	EA	\$ 24,860	\$ 24,860
53	<i>Imported Backfill</i>	108	CY	\$ 44	\$ 4,761
54	<i>Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick)</i>	7	CY	\$ 346	\$ 2,460
55	<i>Debris Barrier</i>	1	EA	\$ 14,808	\$ 14,808
56				\$	-
57	Conveyance Pipe			\$	-
58	<i>Pipe - 12" Diameter</i>	100	LF	\$ 140	\$ 14,000
59	<i>5' Wide Trench x 6'D to waste</i>	111	CY	\$ 79	\$ 8,778
60	<i>Trench Box Shoring (Shallow)</i>	1,200	SF	\$ 10	\$ 12,000
61	<i>Imported Backfill</i>	108	CY	\$ 44	\$ 4,761
62	<i>Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)</i>	7	CY	\$ 346	\$ 2,460
63	<i>48" Maintenance hole</i>	1	EA	\$ 10,640	\$ 10,640
64				\$	-
65	Site Removals and Restoration			\$	-
66	<i>Access Gate (16 ft wide gate)</i>	1	EA	\$ 3,085	\$ 3,085
67	<i>Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate</i>	267	SY	\$ 72	\$ 19,200
68	<i>Disking or tilling of compacted soil (180'W X 140'L est. disturbance)</i>	2,800	SY	\$ 4	\$ 10,320
69	<i>Seeding, mulching and compost (Emergent, Riparian & Upland)</i>	2,800	SY	\$ 10	\$ 27,552
70	<i>Plantings (Emergent & Riparian) est. @ 25% of the seeded area</i>	700	SY	\$ 19	\$ 13,300
71				\$	-
72	Additional Costs			\$	-
73	<i>Removals at 4 % Construction Costs</i>	4.0%	LS	\$ 409,061	\$ 16,362
74	<i>TESC at 2% of Construction</i>	2%	LS	\$ 425,423	\$ 8,508
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 433,931
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	43,393
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 477,325
Direct: Subtotal Construction Costs					\$ 477,300

Description: WQBE 12A Detention Pond On Public Property

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Cost Estimating Assumptions:

The detention pond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 5.1.1 and is generally as described below:

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside ,right-of way. No property easements or acquisition are required.

It is assumed that no agency mitigation costs will be required.

The detention pond has a bottom area of 4,500 s.f. and has a storage depth of 4' deep (48-inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 47 ft. width and is 95 ft. in length.

The pond is constructed with 3:1 side slopes.

The design includes 6 inches for freeboard and 6 inches for sediment storage.

The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.

An emergency overflow spillway is included.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.

The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content

A flow restrictor (weir) is included in accordance with Figure 4.1.4C from the KC SWDM.

A pre-settling pond is not included.

Pipe length is 200' of 12" diameter pipe for both influent and effluent combined.

Dewatering is not required.

Trench Box shoring for pipe installation.

A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.

Property is assumed to be existing open space without building or pavement removal.

Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

WQBE_12B_Detention Pond With Property Cost (2023 Dollars)

Unit	1	EA
Initial Capital Cost	\$ 2,709,600	
Capital cost	\$ 2,709,600	\$/Unit
Total Direct O&M/year	\$ 9,790	
Direct O&M cost	\$ 9,790	\$/Unit
Capital Replacement Costs (10 Years)	\$ 11,100	\$/unit
Discount rate (%)	5.25	\$/Unit

WQBE_12B_Detention Pond With Property Cost

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, 16 sediment and debris removal performed annually by a crew of two over a 8 hour workday.

Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as 32 needed (8 hour work day). Assume annual cost of chainsaw rental as \$56.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Biannual site visits by 2 crew 24 members, 6 hour work day. Grass seed mix as needed to stabilize at an estimated cost of \$113 per year.

Capital Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

Total Cost (NPV)	\$ 2,931,400	\$/unit
Annual O&M Cost	\$ 10,000	\$/year
Annualized Cost	\$270	\$/year

Materials, Supplies, Other Costs

Grass seeding	2023 dollars	\$ 113	\$/year
Chain Saw Rental	2023 dollars	\$ 56	\$/year
Subtotal			\$169
Labor			
Remove trash, sediment, debris and replace vegetation		16	hr
Remove dead trees		32	hr
stabilize eroded berms and embankments		24	hr
0		0	hr
Total hours per year		72	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 3,816	
Labor cost, burdened	O/H 150.0%	\$ 9,790	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30	years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 8,040	\$ 465,773	\$3,205,613	\$ 2,931,404				
0	1.000	\$ 2,709,600	\$ 2,709,600	\$ 2,709,600	\$ 2,709,600	\$ 2,709,600	\$ 2,709,600	\$ 2,709,600	\$ 2,709,600
1	0.950	\$169	\$ -	\$ 9,790	\$ 9,959	\$ 9,462	\$ 2,719,595	\$ 2,719,062	\$ 221,804
2	0.903	\$ 174	\$ -	\$ 10,084	\$ 10,258	\$ 9,260	\$ 2,729,817	\$ 2,728,323	\$ 212,342
3	0.858	\$ 179	\$ -	\$ 10,386	\$ 10,566	\$ 9,062	\$ 2,740,383	\$ 2,737,385	\$ 203,082
4	0.815	\$ 185	\$ -	\$ 10,689	\$ 10,883	\$ 8,868	\$ 2,751,266	\$ 2,746,253	\$ 194,019
5	0.774	\$ 190	\$ -	\$ 11,019	\$ 11,209	\$ 8,679	\$ 2,762,475	\$ 2,754,933	\$ 185,151
6	0.736	\$ 196	\$ -	\$ 11,350	\$ 11,545	\$ 8,493	\$ 2,774,020	\$ 2,763,425	\$ 176,472
7	0.699	\$ 202	\$ -	\$ 11,691	\$ 11,892	\$ 8,312	\$ 2,785,912	\$ 2,771,737	\$ 167,979
8	0.664	\$ 208	\$ -	\$ 12,041	\$ 12,249	\$ 8,134	\$ 2,798,161	\$ 2,779,871	\$ 159,667
9	0.631	\$ 214	\$ -	\$ 12,402	\$ 12,616	\$ 7,960	\$ 2,810,777	\$ 2,787,831	\$ 151,533
10	0.599	\$ 221	\$ 11,100	\$ 12,774	\$ 12,949	\$ 7,784	\$ 2,824,444	\$ 2,802,276	\$ 143,573
11	0.570	\$ 227	\$ -	\$ 13,157	\$ 13,384	\$ 7,623	\$ 2,848,255	\$ 2,809,895	\$ 129,128
12	0.541	\$ 234	\$ -	\$ 13,562	\$ 13,788	\$ 7,461	\$ 2,863,041	\$ 2,817,360	\$ 121,505
13	0.514	\$ 241	\$ -	\$ 13,958	\$ 14,199	\$ 7,301	\$ 2,876,241	\$ 2,824,661	\$ 114,044
14	0.489	\$ 248	\$ -	\$ 14,377	\$ 14,625	\$ 7,145	\$ 2,890,666	\$ 2,831,806	\$ 106,743
15	0.464	\$ 256	\$ -	\$ 14,809	\$ 15,064	\$ 6,992	\$ 2,905,930	\$ 2,838,798	\$ 99,598
16	0.441	\$ 263	\$ -	\$ 15,253	\$ 15,516	\$ 6,843	\$ 2,921,446	\$ 2,845,641	\$ 92,606
17	0.419	\$ 271	\$ -	\$ 15,710	\$ 15,982	\$ 6,696	\$ 2,937,428	\$ 2,852,337	\$ 85,764
18	0.398	\$ 279	\$ -	\$ 16,182	\$ 16,461	\$ 6,553	\$ 2,953,889	\$ 2,858,890	\$ 79,067
19	0.378	\$ 288	\$ -	\$ 16,667	\$ 16,955	\$ 6,413	\$ 2,970,844	\$ 2,865,303	\$ 72,514
20	0.359	\$ 296	\$ 11,100	\$ 17,167	\$ 28,564	\$ 10,265	\$ 2,999,407	\$ 2,875,565	\$ 66,101
21	0.341	\$ 305	\$ -	\$ 17,682	\$ 17,987	\$ 6,142	\$ 3,017,395	\$ 2,881,711	\$ 55,835
22	0.324	\$ 314	\$ -	\$ 18,213	\$ 18,527	\$ 6,011	\$ 3,036,922	\$ 2,887,721	\$ 49,693
23	0.308	\$ 324	\$ -	\$ 18,759	\$ 19,083	\$ 5,882	\$ 3,055,005	\$ 2,893,603	\$ 43,683
24	0.293	\$ 334	\$ -	\$ 19,322	\$ 19,655	\$ 5,756	\$ 3,074,660	\$ 2,899,360	\$ 37,801
25	0.278	\$ 344	\$ -	\$ 19,901	\$ 20,245	\$ 5,633	\$ 3,094,905	\$ 2,904,993	\$ 32,044
26	0.264	\$ 354	\$ -	\$ 20,499	\$ 20,852	\$ 5,513	\$ 3,115,757	\$ 2,910,506	\$ 26,411
27	0.251	\$ 364	\$ -	\$ 21,113	\$ 21,479	\$ 5,396	\$ 3,137,236	\$ 2,916,901	\$ 20,898
28	0.239	\$ 375	\$ -	\$ 21,747	\$ 22,122	\$ 5,280	\$ 3,159,358	\$ 2,921,181	\$ 15,503
29	0.227	\$ 387	\$ -	\$ 22,399	\$ 22,786	\$ 5,167	\$ 3,182,144	\$ 2,926,348	\$ 10,223
30	0.215	\$ 398	\$ -	\$ 23,071	\$ 23,470	\$ 5,056	\$ 3,205,613	\$ 2,931,404	\$ 5,056

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Cindy Kinzer (HDR) Jeff Price (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_12B_Detention Pond With Property Cost		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Detention Pond on Public Property			\$	-
2	Pond Assumptions			\$	-
3	<i>Pond Bottom Area</i>	4,500	SF	\$	-
4	<i>Pond Top Area</i>	8,493	SF	\$	-
5	<i>Pond Top Area</i>			\$	-
6	<i>Pond Bottom Length</i>	95	FT	\$	-
7	<i>Pond Top Length</i>	119	FT	\$	-
8	<i>Pond Bottom Width</i>	47	FT	\$	-
9	<i>Pond Top Width</i>	71	FT	\$	-
10	<i>Pond Exc. Depth</i>	4	FT	\$	-
11	<i>Slope Run/Rise</i>	3:1		\$	-
12	<i>Slope Length</i>	12	FT	\$	-
13	<i>Freeboard (Ave.)</i>	1	FT	\$	-
14	<i>Imported Treatment Liner depth</i>	2	FT	\$	-
15				\$	-
16	Storage Volume			\$	-
17	<i>Pond Effective Storage Depth (Ave.)</i>	3	FT	\$	-
18	<i>Pond Storage Top Area</i>	7,387	SF	\$	-
19	<i>Storage Facility Interior Area (Ave.)</i>	5,943	SF	\$	-
20	<i>Effective Storage Volume</i>	23,773	CF	\$	-
21	<i>Storage Volume</i>	0.18	MG	\$	-
22				\$	-
23	Compacted Berm Assumptions (per KC Manual)			\$	-
24	<i>Berm Height (Average)</i>	3.5	FT	\$	-
25	<i>Berm slope Length@2:1 Slopes</i>	7	FT	\$	-
26	<i>Berm flat top Width</i>	6	FT	\$	-
27	<i>Berm Bottom Width</i>	20	FT	\$	-
28	<i>Distance to CL Berm - Width</i>	10	FT	\$	-
29	<i>Berm Centerline Length (for perimeter calcs)</i>	129	FT	\$	-
30	<i>Berm Centerline Width (for perimeter calcs)</i>	81	FT	\$	-
31	<i>Berm perimeter (at CL Length)</i>	420	FT	\$	-
32	<i>Berm Area/LF</i>	46	SF/FT	\$	-
33	<i>Imported Fill for Berm</i>	708	CY	\$ 44	\$ 31,142
34	<i>Embankment Compaction</i>	708	CY	\$ 22	\$ 15,571
35				\$	-
36	Spillway Assumptions KCSWDM Table 4.2.2A			\$	-
37	<i>RipRap Lining for Overflow</i>	5	CY	\$ 346	\$ 1,845
38	<i>Width</i>	6	FT	\$	-
39	<i>Length</i>	12	FT	\$	-
40	<i>RipRap Depth</i>	2	FT	\$	-
41	<i>Slope Run:Rise</i>	3:1		\$	-
42				\$	-
43	Wetpond Excavation and Liner			\$	-
44	<i>Facility Excavation to Berm and Waste</i>	962	CY	\$ 79	\$ 76,032
45	<i>Imported Treatment Liner @ 2' thick</i>	629	CY	\$ 105	\$ 66,055
46				\$	-
47	Outlet Pipe			\$	-
48	<i>Pipe - 12" Diameter</i>	100	LF	\$ 140	\$ 14,000
49	<i>5' Wide Trench x 6'D to waste</i>	111	CY	\$ 79	\$ 8,778
50	<i>Trench Box Shoring (Shallow)</i>	1,200	SF	\$ 10	\$ 12,000
51	<i>48" Maintenance hole</i>	1	EA	\$ 10,640	\$ 10,640
52	<i>Control Structure</i>	1	EA	\$ 24,860	\$ 24,860
53	<i>Imported Backfill</i>	108	CY	\$ 44	\$ 4,761
54	<i>Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick)</i>	7	CY	\$ 346	\$ 2,460
55	<i>Debris Barrier</i>	1	EA	\$ 14,808	\$ 14,808
56				\$	-
57	Conveyance Pipe			\$	-
58	<i>Pipe - 12" Diameter</i>	100	LF	\$ 140	\$ 14,000
59	<i>5' Wide Trench x 6'D to waste</i>	111	CY	\$ 79	\$ 8,778
60	<i>Trench Box Shoring (Shallow)</i>	1,200	SF	\$ 10	\$ 12,000
61	<i>Imported Backfill</i>	108	CY	\$ 44	\$ 4,761
62	<i>Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)</i>	7	CY	\$ 346	\$ 2,460
63	<i>48" Maintenance hole</i>	1	EA	\$ 10,640	\$ 10,640
64				\$	-
65	Site Removals and Restoration			\$	-
66	<i>Access Gate (16 ft wide gate)</i>	1	EA	\$ 3,085	\$ 3,085
67	<i>Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate</i>	267	SY	\$ 71	\$ 18,933
68	<i>Disking or tilling of compacted soil (180'W X 140'L est. disturbance)</i>	2,800	SY	\$ 4	\$ 10,332
69	<i>Seeding, mulching and compost (Emergent, Riparian & Upland)</i>	2,800	SY	\$ 10	\$ 27,552
70	<i>Plantings (Emergent & Riparian) est. @ 25% of the seeded area</i>	700	SY	\$ 19	\$ 13,300
71				\$	-
72	Additional Costs			\$	-
73	<i>Removals at 4 % Construction Costs</i>	4.0%	LS	\$ 408,794	\$ 16,352
74	<i>TESC at 2% of Construction</i>	2%	LS	\$ 425,146	\$ 8,503
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 433,649
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%		1	\$ -
	Mobilization/Demobilization	10%		1.1	\$ 43,365
	Overhead & Profit (OHP)	0%		1	\$ -
	Insurance	0.0%		1	\$ -
	Bonding	0.0%		1	\$ -
	Escalation Multiplier from ENR-CCI	0%		1.0000	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 477,013
Direct: Subtotal Construction Costs					\$ 477,000

Description: WQBE 12B Detention Pond With Property Cost

Surface basin that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Cost Estimating Assumptions:

The detention pond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 5.1.1 and is generally as described below:

The installation is on property and will require easement and property acquisition.
The detention pond has a bottom area of 4,500 s.f. and has a storage depth of 4' deep (48-inches).

The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 47 ft. width and is 95 ft. in length.

The pond is constructed with 3:1 side slopes.

The design includes 6 inches for freeboard and 6 inches for sediment storage.

The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.

An emergency overflow spillway is included.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H.V.

The spillway is strap lined per Table 4.4-1A and can accommodate discharge velocities from 5 fps to 10 fps.

The infiltration pond consists a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal

gravel and coarse content.

A flow restrictor (weir) is included in accordance with Figure 4.1-4C from the KC SWDM.

A pre-settling pond is not included.

Pipe length is 200' of 12" diameter pipe for both influent and effluent combined.

Dewatering is not required.

Project Box shown below.

A 200 ft. long and 12 ft. wide paved (HMA&GOSTC) maintenance access road is provided.

Property is assumed to be existing open space without building or pavement removal.

Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the

access area is already fenced to help restrict vehicular access.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices

between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A

Routing Indirect project cost complexity factor was assigned: 22% Design Engineering, 10% Construction Management, Permitting & Support 1%, and 6%

WTD Staff Labor

A 20% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE

International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimation process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE 13A_Infiltration Pond Till Soil on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 880,800
Capital cost	\$ 880,800 \$/Unit
Total Direct O&M/year	\$ 5,711
Direct O&M cost	\$ 5,711 \$/Unit
Capital Replacement Costs (10 Years)	\$ 11,100 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 1,016,100	\$/unit
Annual O&M Cost	\$ 5,900	\$/year
Annualized Cost	\$270	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Grass seeding	2023 dollars	\$ 113	\$/year
Chain Saw Rental	2023 dollars	\$ 56	\$/year
Subtotal		\$169	
Labor			
Remove Trash		10 hr	
Remove Dead/Diseased or Dying Trees		24 hr	
Remediation of erosion		8 hr	
		0 hr	
Total hours per year		42	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 2,284	
Labor cost, burdened	O/H 150.0%	\$ 5,711	\$ 135.98
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

Description: WQBE 13A_Infiltration Pond Till Soil on Public Property
Basin that stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal performed annually by a crew of two over a 5 hour workday.
Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as 24 needed (6 hour work day). Assume annual cost of \$56 for chainsaw rental.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit with 2 crew 8 members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of \$113 per year.

Capital Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 8,040		\$ 271,701	\$ 1,182,741	#####			
0	1.000	\$ 880,800		\$ 880,800	\$ 880,800	\$ 880,800	\$ 880,800	\$ 1,016,114	
1	0.950	\$ 169	\$ -	\$ 5,711	\$ 5,880	\$ 5,587	\$ 886,680	\$ 886,387	\$ 135,314
2	0.903	\$ 174	\$ -	\$ 5,882	\$ 6,056	\$ 5,467	\$ 892,736	\$ 891,854	\$ 129,727
3	0.858	\$ 179	\$ -	\$ 6,059	\$ 6,238	\$ 5,350	\$ 898,974	\$ 897,204	\$ 124,260
4	0.815	\$ 185	\$ -	\$ 6,241	\$ 6,425	\$ 5,236	\$ 905,400	\$ 902,440	\$ 118,909
5	0.774	\$ 190	\$ -	\$ 6,428	\$ 6,618	\$ 5,124	\$ 912,017	\$ 907,564	\$ 113,673
6	0.736	\$ 196	\$ -	\$ 6,621	\$ 6,816	\$ 5,014	\$ 918,834	\$ 912,579	\$ 108,549
7	0.699	\$ 202	\$ -	\$ 6,819	\$ 7,021	\$ 4,907	\$ 925,855	\$ 917,486	\$ 103,535
8	0.664	\$ 208	\$ -	\$ 7,024	\$ 7,232	\$ 4,802	\$ 933,086	\$ 922,286	\$ 98,628
9	0.631	\$ 214	\$ -	\$ 7,234	\$ 7,449	\$ 4,700	\$ 940,535	\$ 926,988	\$ 93,825
10	0.599	\$ 221	\$ 11,100	\$ 7,451	\$ 18,772	\$ 11,254	\$ 959,307	\$ 938,242	\$ 89,125
11	0.570	\$ 227	\$ -	\$ 7,675	\$ 7,902	\$ 4,501	\$ 967,209	\$ 942,743	\$ 77,872
12	0.541	\$ 234	\$ -	\$ 7,905	\$ 8,139	\$ 4,405	\$ 975,348	\$ 947,147	\$ 73,371
13	0.514	\$ 241	\$ -	\$ 8,142	\$ 8,383	\$ 4,311	\$ 983,732	\$ 951,458	\$ 68,966
14	0.489	\$ 248	\$ -	\$ 8,387	\$ 8,635	\$ 4,218	\$ 992,367	\$ 956,676	\$ 64,656
15	0.464	\$ 256	\$ -	\$ 8,638	\$ 8,894	\$ 4,128	\$ 1,001,261	\$ 959,805	\$ 60,437
16	0.441	\$ 263	\$ -	\$ 8,897	\$ 9,161	\$ 4,040	\$ 1,010,421	\$ 963,844	\$ 56,309
17	0.419	\$ 271	\$ -	\$ 9,164	\$ 9,436	\$ 3,954	\$ 1,019,857	\$ 967,798	\$ 52,269
18	0.398	\$ 279	\$ -	\$ 9,439	\$ 9,719	\$ 3,868	\$ 1,029,578	\$ 971,667	\$ 48,315
19	0.378	\$ 288	\$ -	\$ 9,723	\$ 10,010	\$ 3,788	\$ 1,039,586	\$ 975,454	\$ 44,446
20	0.359	\$ 296	\$ 11,100	\$ 10,014	\$ 21,411	\$ 7,694	\$ 1,060,996	\$ 983,148	\$ 40,660
21	0.341	\$ 305	\$ -	\$ 10,315	\$ 10,620	\$ 3,626	\$ 1,071,616	\$ 986,774	\$ 32,965
22	0.324	\$ 314	\$ -	\$ 10,624	\$ 10,938	\$ 3,549	\$ 1,082,555	\$ 990,323	\$ 29,339
23	0.308	\$ 324	\$ -	\$ 10,943	\$ 11,267	\$ 3,473	\$ 1,093,821	\$ 993,796	\$ 25,790
24	0.293	\$ 334	\$ -	\$ 11,271	\$ 11,605	\$ 3,399	\$ 1,105,426	\$ 997,194	\$ 22,318
25	0.278	\$ 344	\$ -	\$ 11,609	\$ 11,953	\$ 3,326	\$ 1,117,379	\$ 1,000,520	\$ 18,919
26	0.264	\$ 354	\$ -	\$ 11,957	\$ 12,311	\$ 3,255	\$ 1,129,690	\$ 1,003,775	\$ 15,593
27	0.251	\$ 364	\$ -	\$ 12,316	\$ 12,681	\$ 3,185	\$ 1,142,371	\$ 1,006,961	\$ 12,338
28	0.239	\$ 375	\$ -	\$ 12,686	\$ 13,061	\$ 3,117	\$ 1,155,432	\$ 1,010,078	\$ 9,153
29	0.227	\$ 387	\$ -	\$ 13,066	\$ 13,453	\$ 3,051	\$ 1,168,885	\$ 1,013,128	\$ 6,036
30	0.215	\$ 398	\$ -	\$ 13,458	\$ 13,856	\$ 2,985	\$ 1,182,741	\$ 1,016,114	\$ 2,985

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 13A_Infiltration Pond Till Soil on Public Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Pond on Public Property			\$	-
2	Pond Assumptions			\$	-
3	Pond Bottom Area	2,785	SF	\$	-
4	Pond Top Area	6,046	SF	\$	-
5	Pond Top Area			\$	-
6	Pond Bottom Length	75	FT	\$	-
7	Pond Top Length	99	FT	\$	-
8	Pond Bottom Width	37	FT	\$	-
9	Pond Top Width	61	FT	\$	-
10	Pond Exc. Depth	4	FT	\$	-
11	Slope Run/Rise	3:1		\$	-
12	Slope Length	12	FT	\$	-
13	Freeboard (Ave.)	1	FT	\$	-
14				\$	-
15				\$	-
16	Storage Volume			\$	-
17	Pond Effective Storage Depth (Ave.)	3	FT	\$	-
18	Pond Storage Top Area	5,123	SF	\$	-
19	Storage Facility Interior Area (Ave.)	3,954	SF	\$	-
20	Effective Storage Volume (15,500 cf target)	15,816	CF	\$	-
21	Storage Volume	0.12	MG	\$	-
22				\$	-
23	Compacted Berm Assumptions (per KC Manual)			\$	-
24	Berm Height (Average)	3.5	FT	\$	-
25	Berm slope Length@2:1 Slopes	7	FT	\$	-
26	Berm flat top Width	6	FT	\$	-
27	Berm Bottom Width	20	FT	\$	-
28	Distance to CL Berm - Width	10	FT	\$	-
29	Berm Centerline Length (for perimeter calcs)	109	FT	\$	-
30	Berm Centerline Width (for perimeter calcs)	71	FT	\$	-
31	Berm perimeter (at CL Length)	295	FT	\$	-
32	Berm Area/LF	45	SF/FT	\$	-
33	Imported Fill for Berm	492	CY	\$ 44	\$ 21,633
34	Embankment Compaction	492	CY	\$ 22	\$ 10,817
35				\$	-
36	Spillway Assumptions KCSWDM Table 4.2.2A			\$	-
37	RipRap Lining for Overflow	5	CY	\$ 346	\$ 1,845
38	Width	6	FT	\$	-
39	Length	12	FT	\$	-
40	RipRap Depth	2	FT	\$	-
41	Slope Run/Rise	3:1		\$	-
42				\$	-
43	Wetpond Excavation and Liner			\$	-
44	Facility Excavation to Berm and Waste	654	CY	\$ 79	\$ 51,680
45				\$	-
46				\$	-
47	Outlet Pipe			\$	-
48	Pipe - 12" Diameter	100	LF	\$ 140	\$ 14,000
49	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
50	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
51	48" Maintenance hole	1	EA	\$ 10,640	\$ 10,640
52	Control Structure	1	EA	\$ 24,860	\$ 24,860
53	Imported Backfill	108	CY	\$ 44	\$ 4,761
54	Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
55	Debris Barrier	1	EA	\$ 14,808	\$ 14,808
56				\$	-
57	Conveyance Pipe			\$	-
58	Pipe - 12" Diameter	100	LF	\$ 140	\$ 14,000
59	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
60	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
61	Imported Backfill	108	CY	\$ 44	\$ 4,761
62	Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
63	48" Maintenance hole	1	EA	\$ 10,640	\$ 10,640
64				\$	-
65	Site Removals and Restoration			\$	-
66	Access Gate (16 ft wide gate)	1	EA	\$ 3,085	\$ 3,085
67	Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate	267	SY	\$ 71	\$ 18,933
68	Disking or tilling of compacted soil (180'W X 140'L est. disturbance)	2,286	SY	\$ 4	\$ 8,437
69	Seeding, mulching and compost (Emergent, Riparian & Upland)	2,286	SY	\$ 10	\$ 22,499
70	Plantings (Emergent & Riparian) est. @ 25% of the seeded area	572	SY	\$ 19	\$ 10,861
71				\$	-
72	Additional Costs			\$	-
73	Removals at 4 % Construction Costs	4.0%	LS	\$ 294,735	\$ 11,789
74	TESC at 2% of Construction	2%	LS	\$ 306,525	\$ 6,130
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 312,655
DIRECT: CONSTRUCTION COST MARK-UPS					
General Conditions 0%					
Mobilization/Demobilization 10%					
Overhead & Profit (OHP) 0%					
Insurance 0.0%					
Bonding 0.0%					
Escalation Multiplier from ENR-CCI 0% 1.0000					
Item Subtotal Construction Costs (Year 2023)					\$ 343,921
Direct: Subtotal Construction Costs					\$ 343,900

Description: WQBE 13A_Infiltration Pond Till Soil on Public Property

Basin that stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:

It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.

The infiltration pond is located in till soils and has a bottom area of 2,785 s.f. and a storage depth of 4 feet deep (48 inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 37.3 ft. wide and 74.6 ft. long.

The pond is constructed with 3:1 side slopes.

The design includes 1' of freeboard.

An emergency overflow spillway is included.

The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.

The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content

A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.

Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included.

Dewatering is not required.

Trench Box shoring for pipe installation.

A 200 ft. long and 12 ft. wide paved maintenance access road is provided.

Property is assumed to be existing open space without building or pavement removal.

Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 13B_Infiltration Pond Outwash Soil on Public Property		Version:	2	
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Pond (1479 sf bottom area @ 4 ft. Storage Depth)	1	EA	\$ 308,000	\$ 308,000
					\$ -
					\$ -
					\$ -
					Subtotal Construction Costs \$ 308,000
					Allowance for Indeterminates (Design Allowance) \$ 61,600
					Street Use Permit (Y/N) N \$ -
					ESTIMATED PROBABLE COST OF CONSTRUCTION BID \$ 369,600
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
					Construction Change Order Allowance \$ 36,960
					Subtotal Primary Construction Amount \$ 406,560
					Construction Sales Tax \$ 41,672
					Outside Agency Construction \$ -
					TOTAL DIRECT CONSTRUCTION COSTS \$ 448,200
INDIRECT: NON-CONSTRUCTION COSTS					
					Design Engineering \$ 89,443
					Construction Management \$ 40,656
					Permitting & Support \$ 4,066
	s.f. Land Area		None	Land Purchase/ROW Acquisition	\$ -
	s.f. Land Area		None	Permanent Easements	\$ -
					WTD Staff Costs & Non-WTD Support \$ 24,394
					Subtotal Non-Construction Costs \$ 158,558
					Project Contingency \$ 182,028
					TOTAL INDIRECT NON-CONSTRUCTION COSTS \$ 340,600
					TOTAL PROJECT COST \$ 788,800

Description: WQBE 13B_Infiltration Pond Outwash Soil on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 788,800
Capital cost	\$ 788,800 /Unit
Total Direct O&M/Year	\$ 3,535
Direct O&M cost	\$ 3,535 /Unit
Capital Replacement Costs (10 Years)	\$ 11,100 /Unit
Discount rate (%)	5.25 /\$Unit

Total Cost (NPV)	\$ 878,000	\$/unit
Annual O&M Cost	\$ 3,700	\$/year
Annualized Cost	\$270	\$/year

Materials, Supplies, Other Costs

		\$ -
Grass seeding	2023 dollars	\$ 113
Chain Saw Rental	2023 dollars	\$ 56
Subtotal		\$169
Labor		
Remove Trash		6 hr
Remove Dead,Diseased or Dying Trees		12 hr
Remediation of erosion		8 hr
		0 hr
Total hours per year		26
Raw Labor Rate/Hr		\$ 54
Raw labor cost	(embedded)	\$ 1,414
Labor cost, burdened	O/H 150.0%	\$ 3,535
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:		30 years

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 8,040		\$ 168,196	\$ 987,236	\$ 877,985			
0	1.000	\$ 788,800		\$ 788,800	\$ 788,800	\$ 788,800	\$ 788,800	\$ 788,800	\$ 877,985
1	0.950	\$ 169	\$ -	\$ 3,535	\$ 3,704	\$ 3,520	\$ 792,504	\$ 792,320	\$ 89,185
2	0.903	\$ 174	\$ -	\$ 3,641	\$ 3,815	\$ 3,444	\$ 796,320	\$ 795,764	\$ 85,666
3	0.858	\$ 179	\$ -	\$ 3,751	\$ 3,930	\$ 3,371	\$ 800,250	\$ 799,135	\$ 82,221
4	0.815	\$ 185	\$ -	\$ 3,863	\$ 4,048	\$ 3,299	\$ 804,298	\$ 802,433	\$ 78,851
5	0.774	\$ 190	\$ -	\$ 3,979	\$ 4,169	\$ 3,228	\$ 808,467	\$ 805,661	\$ 75,552
6	0.736	\$ 196	\$ -	\$ 4,098	\$ 4,294	\$ 3,159	\$ 812,761	\$ 808,820	\$ 72,324
7	0.699	\$ 202	\$ -	\$ 4,221	\$ 4,423	\$ 3,092	\$ 817,184	\$ 811,912	\$ 69,165
8	0.664	\$ 208	\$ -	\$ 4,349	\$ 4,556	\$ 3,025	\$ 821,740	\$ 814,938	\$ 66,073
9	0.631	\$ 214	\$ -	\$ 4,478	\$ 4,693	\$ 2,961	\$ 826,433	\$ 817,898	\$ 63,048
10	0.599	\$ 221	\$ 11,100	\$ 4,613	\$ 15,933	\$ 9,582	\$ 842,366	\$ 827,450	\$ 60,087
11	0.570	\$ 227	\$ -	\$ 4,751	\$ 4,978	\$ 2,836	\$ 847,345	\$ 830,286	\$ 50,535
12	0.541	\$ 234	\$ -	\$ 4,894	\$ 5,128	\$ 2,775	\$ 852,472	\$ 833,061	\$ 47,699
13	0.514	\$ 241	\$ -	\$ 5,041	\$ 5,282	\$ 2,716	\$ 857,754	\$ 835,776	\$ 44,924
14	0.489	\$ 248	\$ -	\$ 5,192	\$ 5,440	\$ 2,658	\$ 863,194	\$ 838,434	\$ 42,209
15	0.464	\$ 256	\$ -	\$ 5,348	\$ 5,603	\$ 2,601	\$ 868,797	\$ 841,035	\$ 39,551
16	0.441	\$ 263	\$ -	\$ 5,508	\$ 5,771	\$ 2,545	\$ 874,568	\$ 843,580	\$ 36,951
17	0.419	\$ 271	\$ -	\$ 5,673	\$ 5,944	\$ 2,491	\$ 880,513	\$ 846,071	\$ 34,405
18	0.398	\$ 279	\$ -	\$ 5,843	\$ 6,123	\$ 2,438	\$ 886,635	\$ 848,508	\$ 31,915
19	0.378	\$ 288	\$ -	\$ 6,019	\$ 6,306	\$ 2,385	\$ 892,942	\$ 850,894	\$ 29,477
20	0.359	\$ 296	\$ 11,100	\$ 6,199	\$ 17,596	\$ 6,324	\$ 910,537	\$ 857,217	\$ 27,092
21	0.341	\$ 305	\$ -	\$ 6,385	\$ 6,690	\$ 2,285	\$ 917,228	\$ 859,502	\$ 20,768
22	0.324	\$ 314	\$ -	\$ 6,577	\$ 6,891	\$ 2,236	\$ 924,119	\$ 861,737	\$ 18,484
23	0.308	\$ 324	\$ -	\$ 6,774	\$ 7,098	\$ 2,188	\$ 931,217	\$ 863,925	\$ 16,248
24	0.293	\$ 334	\$ -	\$ 6,977	\$ 7,311	\$ 2,141	\$ 938,528	\$ 866,066	\$ 14,060
25	0.278	\$ 344	\$ -	\$ 7,187	\$ 7,530	\$ 2,095	\$ 946,058	\$ 868,162	\$ 11,919
26	0.264	\$ 354	\$ -	\$ 7,402	\$ 7,756	\$ 2,051	\$ 953,814	\$ 870,212	\$ 9,824
27	0.251	\$ 364	\$ -	\$ 7,624	\$ 7,989	\$ 2,007	\$ 961,803	\$ 872,219	\$ 7,773
28	0.239	\$ 375	\$ -	\$ 7,853	\$ 8,228	\$ 1,964	\$ 970,031	\$ 874,183	\$ 5,766
29	0.227	\$ 387	\$ -	\$ 8,089	\$ 8,475	\$ 1,922	\$ 978,506	\$ 876,104	\$ 3,803
30	0.215	\$ 398	\$ -	\$ 8,331	\$ 8,730	\$ 1,881	\$ 987,236	\$ 877,985	\$ 1,881

Description: WQBE 13B_Infiltration Pond Outwash Soil on Public Property
Basin that stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by

trash, sediment and debris removal performed annually by a crew of two over a 3 hour workday.

Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a

chainsaw as needed (3 hour work day). Assume annual cost of \$50 for chainsaw rental.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of \$100 per year.

Capital Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 13A_Infiltration Pond Till Soil on Public Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Pond on Public Property			\$	-
2	Pond Assumptions			\$	-
3	Pond Bottom Area	1,479	SF	\$	-
4	Pond Top Area	4,009	SF	\$	-
5	Pond Top Area			\$	-
6	Pond Bottom Length	54.0	FT	\$	-
7	Pond Top Length	78	FT	\$	-
8	Pond Bottom Width	27.4	FT	\$	-
9	Pond Top Width	51	FT	\$	-
10	Pond Exc. Depth	4	FT	\$	-
11	Slope Run/Rise	3:1		\$	-
12	Slope Length	12	FT	\$	-
13	Freeboard (Ave.)	1	FT	\$	-
14				\$	-
15				\$	-
16	Storage Volume			\$	-
17	Pond Effective Storage Depth (Ave.)	3	FT	\$	-
18	Pond Storage Top Area	3,268	SF	\$	-
19	Storage Facility Interior Area (Ave.)	2,374	SF	\$	-
20	Effective Storage Volume	9,495	CF	\$	-
21	Storage Volume	0.07	MG	\$	-
22				\$	-
23	Compacted Berm Assumptions (per KC Manual)			\$	-
24	Berm Height (Average)	3.5	FT	\$	-
25	Berm slope Length@2:1 Slopes	7	FT	\$	-
26	Berm flat top Width	6	FT	\$	-
27	Berm Bottom Width	20	FT	\$	-
28	Distance to CL Berm - Width	10	FT	\$	-
29	Berm Centerline Length (for perimeter calcs)	88	FT	\$	-
30	Berm Centerline Width (for perimeter calcs)	61	FT	\$	-
31	Berm perimeter (at CL Length)	245	FT	\$	-
32	Berm Area/LF	45	SF/FT	\$	-
33	Imported Fill for Berm	408	CY	\$ 44	\$ 17,967
34	Embankment Compaction	408	CY	\$ 22	\$ 8,983
35				\$	-
36	Spillway Assumptions KCSWDM Table 4.2.2A			\$	-
37	RipRap Lining for Overflow	5	CY	\$ 346	\$ 1,845
38	Width	6	FT	\$	-
39	Length	12	FT	\$	-
40	RipRap Depth	2	FT	\$	-
41	Slope Run:Rise	3:1		\$	-
42				\$	-
43	Pond Excavation and Liner			\$	-
44	Facility Excavation to Berm and Waste	406	CY	\$ 79	\$ 32,113
45				\$	-
46				\$	-
47	Outlet Pipe			\$	-
48	Pipe - 12" Diameter	100	LF	\$ 140	\$ 14,000
49	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
50	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
51	48" Maintenance hole	1	EA	\$ 10,640	\$ 10,640
52	Control Structure	1	EA	\$ 24,860	\$ 24,860
53	Imported Backfill	108	CY	\$ 44	\$ 4,761
54	Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
55	Debris Barrier	1	EA	\$ 14,808	\$ 14,808
56				\$	-
57	Conveyance Pipe			\$	-
58	Pipe - 12" Diameter	100	LF	\$ 140	\$ 14,000
59	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
60	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
61	Imported Backfill	108	CY	\$ 44	\$ 4,761
62	Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
63	48" Maintenance hole	1	EA	\$ 10,640	\$ 10,640
64				\$	-
65	Site Removals and Restoration			\$	-
66	Access Gate (16 ft wide gate)	1	EA	\$ 3,085	\$ 3,085
67	Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate	267	SY	\$ 71	\$ 18,933
68	Disking or tilling of compacted soil (180'W X 140'L est. disturbance)	1,972	SY	\$ 4	\$ 7,278
69	Seeding, mulching and compost (Emergent, Riparian & Upland)	1,972	SY	\$ 10	\$ 19,409
70	Plantings (Emergent & Riparian) est. @ 25% of the seeded area	493	SY	\$ 19	\$ 9,369
71				\$	-
72	Additional Costs			\$	-
73	Removals at 4 % Construction Costs	4.0%	LS	\$ 263,928	\$ 10,557
74	TESC at 2% of Construction	2%	LS	\$ 274,485	\$ 5,490
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 279,975
DIRECT: CONSTRUCTION COST MARK-UPS					
General Conditions 0%					
Mobilization/Demobilization 10%					
Overhead & Profit (OHP) 0%					
Insurance 0.0%					
Bonding 0.0%					
Escalation Multiplier from ENR-CCI 0% 1.0000					
Item Subtotal Construction Costs (Year 2023)					\$ 307,972
Direct: Subtotal Construction Costs					\$ 308,000

Description: WQBE 13B_Infiltration Pond Outwash Soil on Public Property

Basin that stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:

It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.

The infiltration pond is located in outwash soils and has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.

The pond is constructed with 3:1 side slopes.

The design includes 1' of freeboard.

An emergency overflow spillway is included.

The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.

The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.

A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.

The pond is approximately 8.5 feet long by 7 feet wide with 4 feet of storage depth.

Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included.

Dewatering is not required.

Trench Box shoring for pipe installation.

A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.

Property is assumed to be existing open space without building or pavement removal.

Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations.

Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10								
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024			
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)			
Description:	WQBE 13C_Infiltration Pond Till Soil with Property Cost			Version:	2			
DIRECT: SUBTOTAL CONSTRUCTION COSTS								
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost			
1	Infiltration Pond Till Soil (2785 sf bottom area @ 4 ft. Storage Depth)	1	EA	\$ 343,900	\$ 343,900			
					\$ -			
					\$ -			
					\$ -			
					\$ -			
					\$ 343,900			
				Allowance for Indeterminates (Design Allowance)	\$ 68,780			
				Street Use Permit (Y/N) N	\$ -			
					\$ 412,680			
ESTIMATED PROBABLE COST OF CONSTRUCTION BID								
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS								
				Construction Change Order Allowance	\$ 41,268			
				Subtotal Primary Construction Amount	\$ 453,948			
				Construction Sales Tax	\$ 46,530			
				Outside Agency Construction	\$ -			
				TOTAL DIRECT CONSTRUCTION COSTS	\$ 500,500			
INDIRECT: NON-CONSTRUCTION COSTS								
				Design Engineering	\$ 99,869			
				Construction Management	\$ 45,395			
				Permitting & Support	\$ 4,539			
10578	s.f. Land Area		Medium	Land Purchase/ROW Acquisition	\$ 850,789			
4000	s.f. Land Area		Low	Permanent Easements	\$ 40,400			
				WTD Staff Costs & Non-WTD Support	\$ 27,237			
				Subtotal Non-Construction Costs	\$ 1,068,228			
				Project Contingency	\$ 470,618			
				TOTAL INDIRECT NON-CONSTRUCTION COSTS	\$ 1,538,800			
				TOTAL PROJECT COST	\$ 2,039,300			

Description: WQBE 13C_Infiltration Pond Till Soil with Property Cost (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 2,039,300
Capital cost	\$ 2,039,300 \$/Unit
Total Direct O&M/year	\$ 5,711
Direct O&M cost	\$ 5,711 \$/Unit
Capital Replacement Costs (10 Years)	\$ 11,100 \$/unit
Discount rate (%)	5.25 \$/Unit

Total Cost (NPV)	\$ 2,174,600	\$/unit
Annual O&M Cost	\$ 5,900	\$/year
Annualized Cost	\$270	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Grass seeding	2023 dollars	\$ 113	\$/year
Chain Saw Rental	2023 dollars	\$ 56	\$/year
Subtotal		\$169	
Labor			
Remove Trash		10	hr
Remove Dead/Diseased or Dying Trees		24	hr
Remediation of erosion		8	hr
		0	hr
Total hours per year		42	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 2,284	
Labor cost, burdened	O/H 150.0%	\$ 5,711	
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

\$ 135.98

Description: WQBE 13C_Infiltration Pond Till Soil with Property Cost
Basin that stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal performed annually by a crew of two over a 5 hour workday.
Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as needed (6 hour work day). Assume annual cost of \$56 for chainsaw rental.
Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit with 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of \$113 8 per year.

Capital Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 8,040	\$ 271,701	\$ 2,341,241	\$ 2,174,614	\$ 2,039,300	\$ 2,039,300	\$ 2,039,300	\$ 2,174,614
0	1.000	\$ 2,039,300				\$ 2,039,300	\$ 2,039,300	\$ 2,039,300	\$ 2,174,614
1	0.950	\$169	\$ -	\$ 5,711	\$ 5,880	\$ 5,587	\$ 2,045,180	\$ 2,044,887	\$ 135,314
2	0.903	\$ 174	\$ -	\$ 5,882	\$ 6,056	\$ 5,467	\$ 2,051,238	\$ 2,050,354	\$ 129,727
3	0.858	\$ 179	\$ -	\$ 6,059	\$ 6,238	\$ 5,350	\$ 2,057,474	\$ 2,055,704	\$ 124,260
4	0.815	\$ 185	\$ -	\$ 6,241	\$ 6,425	\$ 5,238	\$ 2,063,904	\$ 2,060,940	\$ 118,909
5	0.774	\$ 190	\$ -	\$ 6,428	\$ 6,618	\$ 5,124	\$ 2,070,517	\$ 2,066,064	\$ 113,673
6	0.736	\$ 196	\$ -	\$ 6,621	\$ 6,816	\$ 5,014	\$ 2,077,334	\$ 2,071,079	\$ 108,549
7	0.699	\$ 202	\$ -	\$ 6,819	\$ 7,021	\$ 4,907	\$ 2,084,355	\$ 2,075,986	\$ 103,535
8	0.664	\$ 208	\$ -	\$ 7,024	\$ 7,232	\$ 4,802	\$ 2,091,586	\$ 2,080,788	\$ 98,626
9	0.631	\$ 214	\$ -	\$ 7,234	\$ 7,449	\$ 4,700	\$ 2,099,035	\$ 2,085,488	\$ 93,825
10	0.599	\$ 221	\$ 11,100	\$ 7,451	\$ 18,772	\$ 11,254	\$ 2,117,807	\$ 2,096,742	\$ 89,125
11	0.570	\$ 227	\$ -	\$ 7,675	\$ 7,902	\$ 4,501	\$ 2,125,708	\$ 2,101,243	\$ 77,872
12	0.541	\$ 234	\$ -	\$ 7,905	\$ 8,139	\$ 4,405	\$ 2,133,848	\$ 2,105,647	\$ 73,371
13	0.514	\$ 241	\$ -	\$ 8,142	\$ 8,383	\$ 4,311	\$ 2,142,234	\$ 2,109,958	\$ 68,966
14	0.489	\$ 248	\$ -	\$ 8,387	\$ 8,635	\$ 4,218	\$ 2,150,867	\$ 2,114,176	\$ 64,656
15	0.464	\$ 256	\$ -	\$ 8,638	\$ 8,894	\$ 4,128	\$ 2,159,761	\$ 2,118,305	\$ 60,437
16	0.441	\$ 263	\$ -	\$ 8,897	\$ 9,161	\$ 4,040	\$ 2,168,921	\$ 2,122,344	\$ 56,309
17	0.419	\$ 271	\$ -	\$ 9,164	\$ 9,436	\$ 3,954	\$ 2,178,357	\$ 2,126,298	\$ 52,269
18	0.398	\$ 279	\$ -	\$ 9,439	\$ 9,719	\$ 3,869	\$ 2,188,076	\$ 2,130,167	\$ 48,315
19	0.378	\$ 288	\$ -	\$ 9,723	\$ 10,010	\$ 3,786	\$ 2,198,086	\$ 2,133,954	\$ 44,446
20	0.359	\$ 296	\$ 11,100	\$ 10,014	\$ 21,411	\$ 7,695	\$ 2,219,496	\$ 2,141,648	\$ 40,660
21	0.341	\$ 305	\$ -	\$ 10,315	\$ 10,620	\$ 3,626	\$ 2,230,116	\$ 2,145,274	\$ 32,965
22	0.324	\$ 314	\$ -	\$ 10,624	\$ 10,938	\$ 3,549	\$ 2,241,056	\$ 2,148,823	\$ 29,339
23	0.308	\$ 324	\$ -	\$ 10,943	\$ 11,267	\$ 3,473	\$ 2,252,321	\$ 2,152,296	\$ 25,790
24	0.293	\$ 334	\$ -	\$ 11,271	\$ 11,605	\$ 3,399	\$ 2,263,926	\$ 2,155,694	\$ 22,318
25	0.278	\$ 344	\$ -	\$ 11,609	\$ 11,953	\$ 3,326	\$ 2,275,879	\$ 2,159,020	\$ 18,919
26	0.264	\$ 354	\$ -	\$ 11,957	\$ 12,311	\$ 3,256	\$ 2,288,190	\$ 2,162,275	\$ 15,593
27	0.251	\$ 364	\$ -	\$ 12,316	\$ 12,681	\$ 3,185	\$ 2,300,871	\$ 2,165,461	\$ 12,336
28	0.239	\$ 375	\$ -	\$ 12,686	\$ 13,061	\$ 3,117	\$ 2,313,936	\$ 2,168,578	\$ 9,153
29	0.227	\$ 387	\$ -	\$ 13,066	\$ 13,453	\$ 3,051	\$ 2,327,386	\$ 2,171,626	\$ 6,036
30	0.215	\$ 398	\$ -	\$ 13,458	\$ 13,856	\$ 2,985	\$ 2,341,241	\$ 2,174,614	\$ 2,985

Estimate - AAECI Class 10					Date:	6/7/2024		
Project Name:	King County Water Quality Benefits Evaluation			Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)			
Location:	#SPILL!			Version:	2			
CONSTRUCTION COSTS								
Item No.	Item Description		Quantity	Units	Unit Cost	Item Cost		
1	Infiltration Pond on Property				\$	-		
2	Pond Assumptions				\$	-		
3	Pond Bottom Area		2,785	SF	\$	-		
4	Pond Top Area		6,046	SF	\$	-		
5	Pond Top Area				\$	-		
6	Pond Bottom Length		75	FT	\$	-		
7	Pond Top Length		99	FT	\$	-		
8	Pond Bottom Width		37	FT	\$	-		
9	Pond Top Width		61		\$	-		
10	Pond Exc. Depth		4	FT	\$	-		
11	Slope Run/Rise		3.1		\$	-		
12	Slope Length		12	FT	\$	-		
13	Freeboard (Ave.)		1	FT	\$	-		
14					\$	-		
15					\$	-		
16	Storage Volume				\$	-		
17	Pond Effective Storage Depth (Ave.)		3	FT	\$	-		
18	Pond Storage Top Area		5,123	SF	\$	-		
19	Storage Facility Interior Area (Ave.)		3,954	SF	\$	-		
20	Effective Storage Volume (15,500 cf target)		15,816	CF	\$	-		
21	Storage Volume		0.12	MG	\$	-		
22					\$	-		
23	Compacted Berm Assumptions (per KC Manual)				\$	-		
24	Berm Height (Average)		3.5	FT	\$	-		
25	Berm slope Length@2:1 Slopes		7	FT	\$	-		
26	Berm flat top Width		6	FT	\$	-		
27	Berm Bottom Width		20	FT	\$	-		
28	Distance to CL Berm - Width		10	FT	\$	-		
29	Berm Centerline Length (for perimeter calcs)		109	FT	\$	-		
30	Berm Centerline Width (for perimeter calcs)		71	FT	\$	-		
31	Berm perimeter (at CL Length)		295	FT	\$	-		
32	Berm Area/LF		45	SF/FT	\$	-		
33	Imported Fill for Berm		492	CY	\$ 44	\$ 21,633		
34	Embankment Compaction		492	CY	\$ 22	\$ 10,817		
35					\$	-		
36	Spillway Assumptions KCSWDM Table 4.2.2A				\$	-		
37	RipRap Lining for Overflow		5	CY	\$ 346	\$ 1,845		
38	Width		6	FT	\$	-		
39	Length		12	FT	\$	-		
40	RipRap Depth		2	FT	\$	-		
41	Slope Run:Rise		3.1		\$	-		
42					\$	-		
43	Wetpond Excavation and Liner				\$	-		
44	Facility Excavation to Berm and Waste		654	CY	\$ 79	\$ 51,680		
45	Imported Treatment Liner @ 2' thick		0	CY	\$ 105	\$ -		
46					\$	-		
47	Outlet Pipe				\$	-		
48	Pipe - 12" Diameter		100	LF	\$ 140	\$ 14,000		
49	5' Wide Trench x 6'D to waste		111	CY	\$ 79	\$ 8,778		
50	Trench Box Shoring (Shallow)		1,200	SF	\$ 10	\$ 12,000		
51	48" Maintenance hole		1	EA	\$ 10,640	\$ 10,640		
52	Control Structure		1	EA	\$ 24,860	\$ 24,860		
53	Imported Backfill		108	CY	\$ 44	\$ 4,761		
54	Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick)		7	CY	\$ 346	\$ 2,460		
55	Debris Barrier		1	EA	\$ 14,808	\$ 14,808		
56					\$	-		
57	Conveyance Pipe				\$	-		
58	Pipe - 12" Diameter		100	LF	\$ 140	\$ 14,000		
59	5' Wide Trench x 6'D to waste		111	CY	\$ 79	\$ 8,778		
60	Trench Box Shoring (Shallow)		1,200	SF	\$ 10	\$ 12,000		
61	Imported Backfill		108	CY	\$ 44	\$ 4,761		
62	Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)		7	CY	\$ 346	\$ 2,460		
63	48" Maintenance hole		1	EA	\$ 10,640	\$ 10,640		
64					\$	-		
65	Site Removals and Restoration				\$	-		
66	Access Gate (16 ft wide gate)		1	EA	\$ 3,085	\$ 3,085		
67	Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate		267	SY	\$ 71	\$ 18,933		
68	Disking or tilling of compacted soil (180'W X 140'L est. disturbance)		2,286	SY	\$ 4	\$ 8,437		
69	Seeding, mulching and compost (Emergent, Riparian & Upland)		2,286	SY	\$ 10	\$ 22,499		
70	Plantings (Emergent & Riparian) est. @ 25% of the seeded area		572	SY	\$ 19	\$ 10,861		
71					\$	-		
72	Additional Costs				\$	-		
73	Removals at 4 % Construction Costs		4.0%	LS	\$ 294,735	\$ 11,789		
74	TESC at 2% of Construction		2%	LS	\$ 306,525	\$ 6,130		
					\$	-		
					\$	-		
					\$	-		
Item Subtotal Construction Costs (Year 2023)						\$ 312,655		
DIRECT: CONSTRUCTION COST MARK-UPS								
	General Conditions		0%		\$ 1	\$ -		
	Mobilization/Demobilization		10%		\$ 1.1	\$ 31,266		
	Overhead & Profit (OHP)		0%		\$ 1	\$ -		
	Insurance		0.0%		\$ 1	\$ -		
	Bonding		0.0%		\$ 1	\$ -		
	Escalation Multiplier from ENR-CCI		0%		\$ 1,000.00	\$ -		
	Item Subtotal Construction Costs (Year 2023)						\$ 343,921	
	Direct: Subtotal Construction Costs				\$	\$ 343,900		

Description: WQBE 13C_Infiltration Pond Till Soil with Property Cost

Basin that stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:

The infiltration pond is located in till soils and has a bottom area of 2,785 s.f. and a storage depth of 4 feet deep (48 inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 37.3 ft. wide and 74.6 ft. long.

The pond is constructed with 3:1 side slopes.

The design includes 1' of freeboard.

An emergency overflow spillway is included.

The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.

The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content

A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.

The pond is approximately 21 feet long by 10 feet wide with 4 feet of storage depth.

Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included.

Dewatering is not required.

Trench Box shoring for pipe installation.

A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.

Full width arterial roadway restoration is assumed, including the sidewalks and landscape areas on both sides of the roadway.

Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

Installation is on Property and includes easements and property acquisition.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10								
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024			
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)			
Description:	WQBE 13D_Infiltration Pond Outwash Soil with Property Cost			Version:	2			
DIRECT: SUBTOTAL CONSTRUCTION COSTS								
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost			
1	Infiltration Pond (1479 sf bottom area @ 4 ft. Storage Depth)	1	EA	\$ 308,000	\$ 308,000			
					\$ -			
					\$ -			
					\$ -			
					\$ -			
Subtotal Construction Costs					\$ 308,000			
Allowance for Indeterminates (Design Allowance)					\$ 61,600			
Street Use Permit (Y/N)					N \$ -			
ESTIMATED PROBABLE COST OF CONSTRUCTION BID								
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS								
Construction Change Order Allowance								
Subtotal Primary Construction Amount								
Construction Sales Tax								
Outside Agency Construction								
TOTAL DIRECT CONSTRUCTION COSTS								
INDIRECT: NON-CONSTRUCTION COSTS								
Design Engineering								
Construction Management								
Permitting & Support								
10578	s.f. Land Area	Medium	Land Purchase/ROW Acquisition					
4000	s.f. Land Area	Low	Permanent Easements					
WTD Staff Costs & Non-WTD Support								
Subtotal Non-Construction Costs								
Project Contingency								
TOTAL INDIRECT NON-CONSTRUCTION COSTS								
TOTAL PROJECT COST								
\$ 1,947,300								

Description: WQBE 13D_Infiltration Pond Outwash Soil with Property Cost (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 1,947,300
Capital cost	\$ 1,947,300 \$/Unit
Total Direct O&M/year	\$ 3,535
Direct O&M cost	\$ 3,535 \$/Unit
Capital Replacement Costs (10 Years)	\$ 11,100 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 2,036,500	\$/unit
Annual O&M Cost	\$ 3,700	\$/year
Annualized Cost	\$270	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Grass seeding	2023 dollars	\$ 113	\$/year
Chain Saw Rental	2023 dollars	\$ 56	\$/year
Subtotal		\$169	
Labor			
Remove Trash		6	hr
Remove Dead/Diseased or Dying Trees		12	hr
Remediation of erosion		8	hr
		0	hr
Total hours per year		26	
Raw Labor Rate/hr		\$ 54	
Raw labor cost	(embedded)	\$ 1,414	
Labor cost, burdened	O/H 150.0%	\$ 3,535	\$ 135.98
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 8,040		\$ 168,196	\$ 2,145,736	\$ 2,036,485			
0	1.000	\$ 1,947,300		\$ 1,947,300	\$ 1,947,300	\$ 1,947,300	\$ 1,947,300	\$ 1,947,300	\$ 2,036,485
1	0.950	\$169	\$ -	\$ 3,535	\$ 3,704	\$ 3,520	\$ 1,951,004	\$ 1,950,820	\$ 89,185
2	0.903	\$ 174	\$ -	\$ 3,641	\$ 3,815	\$ 3,444	\$ 1,954,820	\$ 1,954,264	\$ 85,666
3	0.858	\$ 179	\$ -	\$ 3,751	\$ 3,930	\$ 3,371	\$ 1,958,750	\$ 1,957,635	\$ 82,221
4	0.815	\$ 185	\$ -	\$ 3,863	\$ 4,048	\$ 3,299	\$ 1,962,798	\$ 1,960,933	\$ 78,851
5	0.774	\$ 190	\$ -	\$ 3,979	\$ 4,169	\$ 3,228	\$ 1,966,967	\$ 1,964,161	\$ 75,552
6	0.736	\$ 196	\$ -	\$ 4,098	\$ 4,294	\$ 3,159	\$ 1,971,261	\$ 1,967,320	\$ 72,324
7	0.699	\$ 202	\$ -	\$ 4,221	\$ 4,423	\$ 3,092	\$ 1,975,684	\$ 1,970,412	\$ 69,165
8	0.664	\$ 208	\$ -	\$ 4,348	\$ 4,556	\$ 3,025	\$ 1,980,240	\$ 1,973,438	\$ 66,073
9	0.631	\$ 214	\$ -	\$ 4,478	\$ 4,693	\$ 2,961	\$ 1,984,933	\$ 1,976,398	\$ 63,048
10	0.599	\$ 221	\$ 11,100	\$ 4,613	\$ 15,933	\$ 9,552	\$ 2,000,866	\$ 1,985,950	\$ 60,087
11	0.570	\$ 227	\$ -	\$ 4,751	\$ 4,978	\$ 2,836	\$ 2,005,845	\$ 1,988,786	\$ 50,535
12	0.541	\$ 234	\$ -	\$ 4,894	\$ 5,128	\$ 2,775	\$ 2,010,972	\$ 1,991,561	\$ 47,699
13	0.514	\$ 241	\$ -	\$ 5,041	\$ 5,282	\$ 2,716	\$ 2,016,254	\$ 1,994,276	\$ 44,924
14	0.489	\$ 248	\$ -	\$ 5,192	\$ 5,440	\$ 2,658	\$ 2,021,694	\$ 1,996,934	\$ 42,209
15	0.464	\$ 256	\$ -	\$ 5,348	\$ 5,603	\$ 2,601	\$ 2,027,297	\$ 1,999,535	\$ 39,551
16	0.441	\$ 263	\$ -	\$ 5,508	\$ 5,771	\$ 2,545	\$ 2,033,068	\$ 2,002,080	\$ 36,951
17	0.419	\$ 271	\$ -	\$ 5,673	\$ 5,944	\$ 2,491	\$ 2,039,013	\$ 2,004,571	\$ 34,405
18	0.398	\$ 279	\$ -	\$ 5,843	\$ 6,123	\$ 2,438	\$ 2,045,135	\$ 2,007,008	\$ 31,915
19	0.378	\$ 288	\$ -	\$ 6,019	\$ 6,306	\$ 2,385	\$ 2,051,442	\$ 2,009,394	\$ 29,477
20	0.359	\$ 296	\$ 11,100	\$ 6,199	\$ 17,596	\$ 6,324	\$ 2,069,037	\$ 2,015,717	\$ 27,092
21	0.341	\$ 305	\$ -	\$ 6,385	\$ 6,690	\$ 2,285	\$ 2,075,728	\$ 2,018,002	\$ 20,768
22	0.324	\$ 314	\$ -	\$ 6,577	\$ 6,891	\$ 2,236	\$ 2,082,619	\$ 2,020,237	\$ 18,484
23	0.308	\$ 324	\$ -	\$ 6,774	\$ 7,098	\$ 2,188	\$ 2,089,717	\$ 2,022,425	\$ 16,248
24	0.293	\$ 334	\$ -	\$ 6,977	\$ 7,311	\$ 2,141	\$ 2,097,028	\$ 2,024,566	\$ 14,060
25	0.278	\$ 344	\$ -	\$ 7,187	\$ 7,530	\$ 2,095	\$ 2,104,558	\$ 2,026,662	\$ 11,919
26	0.264	\$ 354	\$ -	\$ 7,402	\$ 7,756	\$ 2,051	\$ 2,112,314	\$ 2,028,712	\$ 9,824
27	0.251	\$ 364	\$ -	\$ 7,624	\$ 7,989	\$ 2,007	\$ 2,120,303	\$ 2,030,719	\$ 7,773
28	0.239	\$ 375	\$ -	\$ 7,853	\$ 8,228	\$ 1,964	\$ 2,128,531	\$ 2,032,683	\$ 5,766
29	0.227	\$ 387	\$ -	\$ 8,089	\$ 8,475	\$ 1,922	\$ 2,137,006	\$ 2,034,604	\$ 3,803
30	0.215	\$ 398	\$ -	\$ 8,331	\$ 8,730	\$ 1,881	\$ 2,145,736	\$ 2,036,485	\$ 1,881

Description: WQBE 13D_Infiltration Pond Outwash Soil with Property Cost
Basin stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal performed annually by a crew of two over a 3 hour workday. Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as needed (3 hour work day). Assume annual cost of \$56 for chainsaw rental. Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of \$113 per year.

Capital Replacement Assumptions:

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE 13D_Infiltration Pond Outwash Soil with Property Cost		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Pond on Property			\$	-
2	Pond Assumptions			\$	-
3	<i>Pond Bottom Area</i>	1,479	SF	\$	-
4	<i>Pond Top Area</i>	4,009	SF	\$	-
5	<i>Pond Top Area</i>			\$	-
6	<i>Pond Bottom Length</i>	54.0	FT	\$	-
7	<i>Pond Top Length</i>	78	FT	\$	-
8	<i>Pond Bottom Width</i>	27.4	FT	\$	-
9	<i>Pond Top Width</i>	51	FT	\$	-
10	<i>Pond Exc. Depth</i>	4	FT	\$	-
11	<i>Slope Run/Rise</i>	3:1		\$	-
12	<i>Slope Length</i>	12	FT	\$	-
13	<i>Freeboard (Ave.)</i>	1	FT	\$	-
14				\$	-
15				\$	-
16	Storage Volume			\$	-
17	<i>Pond Effective Storage Depth (Ave.)</i>	3	FT	\$	-
18	<i>Pond Storage Top Area</i>	3,268	SF	\$	-
19	<i>Storage Facility Interior Area (Ave.)</i>	2,374	SF	\$	-
20	<i>Effective Storage Volume</i>	9,495	CF	\$	-
21	<i>Storage Volume</i>	0.07	MG	\$	-
22				\$	-
23	Compacted Berm Assumptions (per KC Manual)			\$	-
24	<i>Berm Height (Average)</i>	3.5	FT	\$	-
25	<i>Berm slope Length@2:1 Slopes</i>	7	FT	\$	-
26	<i>Berm flat top Width</i>	6	FT	\$	-
27	<i>Berm Bottom Width</i>	20	FT	\$	-
28	<i>Distance to CL Berm - Width</i>	10	FT	\$	-
29	<i>Berm Centerline Length (for perimeter calcs)</i>	88	FT	\$	-
30	<i>Berm Centerline Width (for perimeter calcs)</i>	61	FT	\$	-
31	<i>Berm perimeter (at CL Length)</i>	245	FT	\$	-
32	<i>Berm Area/LF</i>	45	SF/FT	\$	-
33	<i>Imported Fill for Berm</i>	408	CY	\$ 44	\$ 17,967
34	<i>Embankment Compaction</i>	408	CY	\$ 22	\$ 8,983
35				\$	-
36	Spillway Assumptions KCSWDM Table 4.2.2A			\$	-
37	<i>RipRap Lining for Overflow</i>	5	CY	\$ 346	\$ 1,845
38	<i>Width</i>	6	FT	\$	-
39	<i>Length</i>	12	FT	\$	-
40	<i>RipRap Depth</i>	2	FT	\$	-
41	<i>Slope Run:Rise</i>	3:1		\$	-
42				\$	-
43	Pond Excavation and Liner			\$	-
44	<i>Facility Excavation to Berm and Waste</i>	406	CY	\$ 79	\$ 32,113
45				\$	-
46				\$	-
47	Outlet Pipe			\$	-
48	<i>Pipe - 12" Diameter</i>	100	LF	\$ 140	\$ 14,000
49	<i>5' Wide Trench x 6'D to waste</i>	111	CY	\$ 79	\$ 8,778
50	<i>Trench Box Shoring (Shallow)</i>	1,200	SF	\$ 10	\$ 12,000
51	<i>48" Maintenance hole</i>	1	EA	\$ 10,640	\$ 10,640
52	<i>Control Structure</i>	1	EA	\$ 24,860	\$ 24,860
53	<i>Imported Backfill</i>	108	CY	\$ 44	\$ 4,761
54	<i>Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick)</i>	7	CY	\$ 346	\$ 2,460
55	<i>Debris Barrier</i>	1	EA	\$ 14,808	\$ 14,808
56				\$	-
57	Conveyance Pipe			\$	-
58	<i>Pipe - 12" Diameter</i>	100	LF	\$ 140	\$ 14,000
59	<i>5' Wide Trench x 6'D to waste</i>	111	CY	\$ 79	\$ 8,778
60	<i>Trench Box Shoring (Shallow)</i>	1,200	SF	\$ 10	\$ 12,000
61	<i>Imported Backfill</i>	108	CY	\$ 44	\$ 4,761
62	<i>Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)</i>	7	CY	\$ 346	\$ 2,460
63	<i>48" Maintenance hole</i>	1	EA	\$ 10,640	\$ 10,640
64				\$	-
65	Site Removals and Restoration			\$	-
66	<i>Access Gate (16 ft wide gate)</i>	1	EA	\$ 3,085	\$ 3,085
67	<i>Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate</i>	267	SY	\$ 71	\$ 18,933
68	<i>Disking or tilling of compacted soil (180'W X 140'L est. disturbance)</i>	1,972	SY	\$ 4	\$ 7,278
69	<i>Seeding, mulching and compost (Emergent, Riparian & Upland)</i>	1,972	SY	\$ 10	\$ 19,409
70	<i>Plantings (Emergent & Riparian) est. @ 25% of the seeded area</i>	493	SY	\$ 19	\$ 9,369
71				\$	-
72	Additional Costs			\$	-
73	<i>Removals at 4 % Construction Costs</i>	4.0%	LS	\$ 263,928	\$ 10,557
74	<i>TESC at 2% of Construction</i>	2%	LS	\$ 274,485	\$ 5,490
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 279,975
DIRECT: CONSTRUCTION COST MARK-UPS					
General Conditions 0%					
Mobilization/Demobilization 10%					
Overhead & Profit (OHP) 0%					
Insurance 0.0%					
Bonding 0.0%					
Escalation Multiplier from ENR-CCI 0%					
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 307,972
Direct: Subtotal Construction Costs					\$ 308,000

Description: WQBE 13D_Infiltration Pond Outwash Soil with Property Cost

Basin that stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:

The infiltration pond is located in outwash soils and has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.

The pond is constructed with 3:1 side slopes.

The design includes 1' of freeboard.

An emergency overflow spillway is included.

The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.

The infiltration pond includes a compacted berm along three sides that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.

A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.

The pond is approximately 8.5 feet long by 7 feet wide with 4 feet of storage depth.

Storm overflows from the pre-settling pond outlet into the main infiltration pond via a riprap lined spillway.

Approximately 100 feet of 12-inch and 50 feet of 12-inch diameter pipes are included.

Dewatering is not required.

Trench Box shoring for pipe installation.

A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.

Full width arterial roadway restoration is assumed, including the sidewalks and landscape areas on both sides of the roadway.

Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Installation is on Property and includes easements and property acquisition.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A

Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)
Description:	WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property			Version:	2
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Pond (1479 sf bottom area @ 4 ft. Storage Depth) with High Rate Underground Filter (24 s.f. bottom area)	1	EA	\$ 363,800	\$ 363,800
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 363,800
	Allowance for Indeterminates (Design Allowance)			\$	72,760
	Street Use Permit (Y/N)	N		\$	-
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID			\$	436,560
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	43,656
	Subtotal Primary Construction Amount			\$	480,216
	Construction Sales Tax			\$	49,222
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	529,400
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	105,648
	Construction Management			\$	48,022
	Permitting & Support			\$	4,802
	s.f. Land Area	None		\$	-
	s.f. Land Area	None		\$	-
	WTD Staff Costs & Non-WTD Support			\$	28,813
	Subtotal Non-Construction Costs			\$	187,284
	Project Contingency			\$	215,005
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	402,300
	TOTAL PROJECT COST			\$	931,700

Description: WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property (2023 Dollars)

Unit	1	EA
Initial Capital Cost	\$ 931,700	
Capital cost	\$ 931,700	/Unit
Total Direct O&M/Year	\$ 5,439	
Direct O&M cost	\$ 5,439	/Unit
Capital Replacement Costs (10 Years)	\$ 11,100	/unit
Discount rate (%)	5.25	

Total Cost (NPV)	\$ 1,082,700	/unit
Annual O&M Cost	\$ 6,600	/year
Annualized Cost	\$ 1,870	/year

Materials, Supplies, Other Costs

Vacuum Truck Equipment + Labor	2023 dollars	\$ 360	\$/year
Grass seeding & Annual Plan Replacement	2023 dollars	\$ 766	\$/year
Chain Saw Rental	2023 dollars	\$ 56	\$/year
Subtotal Labor		\$ 1,182	
Remove Trash, Debris, and Sediment		12	hr
Remove Dead, Diseased, or Dying Trees		12	hr
Remediation of erosion		12	hr
Plant health		4	hr
Total hours per year		40	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 2,176	
Labor cost, burdened	O/H 150.0%	\$ 5,439	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Description: WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions (Pond):

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by

6 trash, sediment and debris removal performed annually by a crew of two over a 3 hour workday.

Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a

12 chainsaw as needed (3 hour work day). Assume annual cost of \$56 for chainsaw rental.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of

2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of

8 \$113 per year.

O&M Estimating Assumptions (Filter):

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

6 Assume use of vactor truck.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2

visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man

4 hours. Assumed annual cost of \$113 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit.

4 Total of 4 man hours.

Annual plant replacement allowance of \$540. Will allow for the replacement of approximately 10

shrubs or other medium sized plant material.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost

(including labor) \$360.

Capital Replacement Assumptions (Pond):

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

Capital Replacement Assumptions (Filter):

No capital replacement within 30-year life per Filterra Owner's Manual.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 56,234		\$ 258,763	\$ 1,268,897	#####			
0	1.000	\$ 931,700			\$ 931,700	\$ 931,700	\$ 931,700	\$ 931,700	\$ 1,082,726
1	0.950	\$ 1,182	\$ -	\$ 5,439	\$ 6,621	\$ 6,291	\$ 938,321	\$ 937,991	\$ 151,026
2	0.903	\$ 1,217	\$ -	\$ 5,602	\$ 6,820	\$ 6,156	\$ 945,141	\$ 944,147	\$ 144,735
3	0.858	\$ 1,254	\$ -	\$ 5,770	\$ 7,024	\$ 6,025	\$ 952,165	\$ 950,172	\$ 138,579
4	0.815	\$ 1,292	\$ -	\$ 5,943	\$ 7,235	\$ 5,896	\$ 959,400	\$ 956,067	\$ 132,554
5	0.774	\$ 1,330	\$ -	\$ 6,122	\$ 7,452	\$ 5,770	\$ 966,852	\$ 961,837	\$ 126,658
6	0.736	\$ 1,370	\$ -	\$ 6,305	\$ 7,676	\$ 5,646	\$ 974,527	\$ 967,484	\$ 120,888
7	0.699	\$ 1,411	\$ -	\$ 6,494	\$ 7,906	\$ 5,526	\$ 982,433	\$ 973,010	\$ 115,242
8	0.664	\$ 1,454	\$ -	\$ 6,681	\$ 8,143	\$ 5,408	\$ 990,576	\$ 978,417	\$ 109,716
9	0.631	\$ 1,497	\$ -	\$ 6,890	\$ 8,387	\$ 5,292	\$ 998,968	\$ 983,709	\$ 104,309
10	0.599	\$ 1,542	\$ 11,100	\$ 7,097	\$ 17,739	\$ 11,833	\$ 1,018,702	\$ 995,542	\$ 99,016
11	0.570	\$ 1,589	\$ -	\$ 7,310	\$ 8,698	\$ 5,068	\$ 1,027,600	\$ 1,000,611	\$ 87,183
12	0.541	\$ 1,636	\$ -	\$ 7,529	\$ 9,165	\$ 4,960	\$ 1,036,765	\$ 1,005,570	\$ 82,115
13	0.514	\$ 1,685	\$ -	\$ 7,755	\$ 9,440	\$ 4,854	\$ 1,046,205	\$ 1,010,424	\$ 77,155
14	0.489	\$ 1,736	\$ -	\$ 7,987	\$ 9,723	\$ 4,750	\$ 1,055,929	\$ 1,015,174	\$ 72,301
15	0.464	\$ 1,788	\$ -	\$ 8,227	\$ 10,015	\$ 4,649	\$ 1,065,943	\$ 1,019,823	\$ 67,551
16	0.441	\$ 1,842	\$ -	\$ 8,474	\$ 10,315	\$ 4,549	\$ 1,076,259	\$ 1,024,372	\$ 62,903
17	0.419	\$ 1,897	\$ -	\$ 8,728	\$ 10,626	\$ 4,452	\$ 1,086,883	\$ 1,028,824	\$ 58,354
18	0.398	\$ 1,954	\$ -	\$ 8,990	\$ 10,944	\$ 4,357	\$ 1,097,827	\$ 1,033,181	\$ 53,902
19	0.378	\$ 2,012	\$ -	\$ 9,260	\$ 11,272	\$ 4,264	\$ 1,109,099	\$ 1,037,444	\$ 49,545
20	0.359	\$ 2,073	\$ 11,100	\$ 9,537	\$ 22,710	\$ 8,162	\$ 1,131,809	\$ 1,045,606	\$ 45,262
21	0.341	\$ 2,135	\$ -	\$ 9,823	\$ 11,958	\$ 4,083	\$ 1,143,767	\$ 1,049,689	\$ 37,120
22	0.324	\$ 2,199	\$ -	\$ 10,118	\$ 12,317	\$ 3,996	\$ 1,156,084	\$ 1,053,688	\$ 33,037
23	0.308	\$ 2,265	\$ -	\$ 10,422	\$ 12,687	\$ 3,911	\$ 1,168,771	\$ 1,057,595	\$ 29,041
24	0.293	\$ 2,333	\$ -	\$ 10,734	\$ 13,067	\$ 3,827	\$ 1,181,838	\$ 1,061,422	\$ 25,130
25	0.278	\$ 2,403	\$ -	\$ 11,056	\$ 13,459	\$ 3,745	\$ 1,195,297	\$ 1,065,167	\$ 21,303
26	0.264	\$ 2,475	\$ -	\$ 11,388	\$ 13,863	\$ 3,665	\$ 1,209,160	\$ 1,068,832	\$ 17,558
27	0.251	\$ 2,549	\$ -	\$ 11,730	\$ 14,279	\$ 3,587	\$ 1,223,438	\$ 1,072,419	\$ 13,893
28	0.239	\$ 2,626	\$ -	\$ 12,082	\$ 14,707	\$ 3,510	\$ 1,238,148	\$ 1,075,929	\$ 10,307
29	0.227	\$ 2,704	\$ -	\$ 12,444	\$ 15,148	\$ 3,435	\$ 1,253,294	\$ 1,079,364	\$ 6,797
30	0.215	\$ 2,785	\$ -	\$ 12,817	\$ 15,603	\$ 3,362	\$ 1,268,897	\$ 1,082,726	\$ 3,362

Description: WQBE_13E_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Property

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

General

The installation is assumed to be on private property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

Trench Box shoring for pipe installation.

Infiltration Pond

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:

It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.

The infiltration pond has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.

The pond is constructed with 3:1 side slopes.

The design includes 1' of freeboard.

Infiltration pond is located on outwash soils.

An emergency overflow spillway is included.

The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.

The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.

A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.

Approximately 200 feet of 12-inch diameter pipes are included.

Dewatering is not required.

A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.

Property is assumed to be existing open space without building or pavement removal.

Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.

The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.

21" of proprietary Filterra treatment media is used.

An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.

Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.

A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.

A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.

An irrigation system is not included in the cost model.

Landscape restoration with one tree is assumed for each restoration site.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost (2023 Dollars)

Unit	1	EA
Initial Capital Cost	\$ 2,092,700	
Capital cost	\$ 2,092,700	/Unit
Total Direct O&M/Year	\$ 5,439	
Direct O&M cost	\$ 5,439	/Unit
Capital Replacement Costs (10 Years)	\$ 11,100	/unit
Discount rate (%)	5.25	

Total Cost (NPV)	\$ 2,243,700	/unit
Annual O&M Cost	\$ 6,600	/year
Annualized Cost	\$ 1,870	/year

Materials, Supplies, Other Costs

Vacuum Truck Equipment + Labor	2023 dollars	\$ 360	\$/year
Grass seeding & Annual Plan Replacement	2023 dollars	\$ 766	\$/year
Chain Saw Rental	2023 dollars	\$ 56	\$/year
Subtotal Labor		\$ 1,182	
Remove Trash, Debris, and Sediment		12	hr
Remove Dead, Diseased, or Dying Trees		12	hr
Remediation of erosion		12	hr
Plant health		4	hr
Total hours per year		40	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 2,176	
Labor cost, burdened	O/H 150.0%	\$ 5,439	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Description: WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System with Property Cost

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions (Pond):

Removal of trash, sediment and debris, and replacement of vegetation damaged or destroyed by trash, sediment and debris removal performed annually by a crew of two over a 3 hour workday.

Removal of dead, diseased or dying trees annually by a crew of four using hand tools and a chainsaw as needed (3 hour work day). Assume annual cost of \$56 for chainsaw rental.

Stabilization of eroded berms, slopes, embankments, and animal borrows. Assume annual visit of 2 crew members, 4 hour work day. Grass seed mix as needed to stabilize at an estimated cost of \$113 per year.

O&M Estimating Assumptions (Filter):

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year.

Assume use of vacuum truck.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit, 4 man hours per year, work performed by hand. Total of 4 man

hours. Assumed annual cost of \$113 for mulch.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 1 hour per visit.

Total of 4 man hours.

Annual plant replacement allowance of \$540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

Vector Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions (Pond):

Complete rebuild will take place every ten years and consist of complete vegetation replacement along with soils that have been compacted. Replacement will also include replacement of access gate every ten years. Items will include those highlighted in blue on the cost estimate sheet.

Capital Replacement Assumptions (Filter):

No capital replacement within 30-year life per Filtra Owner's Manual.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 56,234		\$ 258,763	\$ 2,429,897	#####			
0	1.000	\$ 2,092,700		\$ 5,439	\$ 2,092,700	#####	\$ 2,092,700	\$ 2,092,700	\$ 2,429,726
1	0.950	\$ 1,182	-	\$ 5,439	\$ 6,621	\$ 6,291	\$ 2,099,321	\$ 2,098,991	\$ 151,026
2	0.903	\$ 1,217	-	\$ 5,602	\$ 6,820	\$ 6,156	\$ 2,106,141	\$ 2,105,147	\$ 144,735
3	0.858	\$ 1,254	-	\$ 5,770	\$ 7,024	\$ 6,025	\$ 2,113,165	\$ 2,111,172	\$ 138,579
4	0.815	\$ 1,292	-	\$ 5,943	\$ 7,235	\$ 5,896	\$ 2,120,400	\$ 2,117,067	\$ 132,554
5	0.774	\$ 1,330	-	\$ 6,122	\$ 7,452	\$ 5,770	\$ 2,127,852	\$ 2,122,837	\$ 126,658
6	0.736	\$ 1,370	-	\$ 6,305	\$ 7,676	\$ 5,646	\$ 2,135,527	\$ 2,128,484	\$ 120,888
7	0.699	\$ 1,411	-	\$ 6,494	\$ 7,906	\$ 5,526	\$ 2,143,433	\$ 2,134,010	\$ 115,242
8	0.664	\$ 1,454	-	\$ 6,681	\$ 8,143	\$ 5,408	\$ 2,151,576	\$ 2,139,417	\$ 109,716
9	0.631	\$ 1,497	-	\$ 6,890	\$ 8,387	\$ 5,292	\$ 2,159,968	\$ 2,144,709	\$ 104,309
10	0.599	\$ 1,542	\$ 11,100	\$ 7,097	\$ 17,739	\$ 11,833	\$ 2,179,702	\$ 2,156,542	\$ 99,016
11	0.570	\$ 1,589	-	\$ 7,310	\$ 8,698	\$ 5,068	\$ 2,188,600	\$ 2,161,611	\$ 87,183
12	0.541	\$ 1,636	-	\$ 7,529	\$ 9,165	\$ 4,960	\$ 2,197,765	\$ 2,166,570	\$ 82,115
13	0.514	\$ 1,685	-	\$ 7,755	\$ 9,440	\$ 4,854	\$ 2,207,205	\$ 2,171,424	\$ 77,155
14	0.489	\$ 1,736	-	\$ 7,987	\$ 9,723	\$ 4,750	\$ 2,216,929	\$ 2,176,174	\$ 72,301
15	0.464	\$ 1,788	-	\$ 8,227	\$ 10,015	\$ 4,649	\$ 2,226,943	\$ 2,180,823	\$ 67,551
16	0.441	\$ 1,842	-	\$ 8,474	\$ 10,315	\$ 4,549	\$ 2,237,269	\$ 2,185,372	\$ 62,903
17	0.419	\$ 1,897	-	\$ 8,728	\$ 10,626	\$ 4,452	\$ 2,247,883	\$ 2,189,824	\$ 58,354
18	0.398	\$ 1,954	-	\$ 8,990	\$ 10,944	\$ 4,357	\$ 2,258,827	\$ 2,194,181	\$ 53,902
19	0.378	\$ 2,012	-	\$ 9,260	\$ 11,272	\$ 4,264	\$ 2,270,099	\$ 2,198,444	\$ 49,545
20	0.359	\$ 2,073	\$ 11,100	\$ 9,537	\$ 22,710	\$ 4,162	\$ 2,292,809	\$ 2,206,606	\$ 45,282
21	0.341	\$ 2,135	-	\$ 9,823	\$ 11,958	\$ 4,083	\$ 2,304,767	\$ 2,210,689	\$ 37,120
22	0.324	\$ 2,199	-	\$ 10,118	\$ 12,317	\$ 3,996	\$ 2,317,084	\$ 2,214,688	\$ 33,037
23	0.308	\$ 2,265	-	\$ 10,422	\$ 12,687	\$ 3,911	\$ 2,329,771	\$ 2,218,595	\$ 29,041
24	0.293	\$ 2,333	-	\$ 10,734	\$ 13,067	\$ 3,827	\$ 2,342,838	\$ 2,222,422	\$ 25,130
25	0.278	\$ 2,403	-	\$ 11,056	\$ 13,459	\$ 3,745	\$ 2,356,297	\$ 2,226,167	\$ 21,303
26	0.264	\$ 2,475	-	\$ 11,388	\$ 13,863	\$ 3,665	\$ 2,370,160	\$ 2,229,832	\$ 17,558
27	0.251	\$ 2,549	-	\$ 11,730	\$ 14,279	\$ 3,587	\$ 2,384,438	\$ 2,233,419	\$ 13,893
28	0.239	\$ 2,626	-	\$ 12,082	\$ 14,707	\$ 3,510	\$ 2,399,148	\$ 2,236,929	\$ 10,307
29	0.227	\$ 2,704	-	\$ 12,444	\$ 15,148	\$ 3,435	\$ 2,414,294	\$ 2,240,364	\$ 6,797
30	0.215	\$ 2,785	-	\$ 12,817	\$ 15,603	\$ 3,362	\$ 2,429,897	\$ 2,243,726	\$ 3,362

Estimate - AAECI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Andrew Staples (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Private Property with Property Cost		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Pond on Private Property With Property Cost			\$	-
2	Pond Assumptions			\$	-
3	Pond Bottom Area	1,479	SF	\$	-
4	Pond Top Area	4,009	SF	\$	-
5	Pond Top Area			\$	-
6	Pond Bottom Length	54.0	FT	\$	-
7	Pond Top Length	78	FT	\$	-
8	Pond Bottom Width	27.4	FT	\$	-
9	Pond Top Width	51	FT	\$	-
10	Pond Exc. Depth	4	FT	\$	-
11	Slope Run/Rise	3:1		\$	-
12	Slope Length	12	FT	\$	-
13	Freeboard (Ave.)	1	FT	\$	-
14				\$	-
15				\$	-
16	Storage Volume			\$	-
17	Pond Effective Storage Depth (Ave.)	3	FT	\$	-
18	Pond Storage Top Area	3,268	SF	\$	-
19	Storage Facility interior Area (Ave.)	2,374	SF	\$	-
20	Effective Storage Volume	9,495	CF	\$	-
21	Storage Volume	0.07	MG	\$	-
22				\$	-
23	Compacted Berm Assumptions (per KC Manual)			\$	-
24	Berm Height (Average)	3.5	FT	\$	-
25	Berm slope Length@2:1 Slopes	7	FT	\$	-
26	Berm flat top Width	6	FT	\$	-
27	Berm Bottom Width	20	FT	\$	-
28	Distance to CL Berm - Width	10	FT	\$	-
29	Berm Centerline Length (for perimeter calcs)	88	FT	\$	-
30	Berm Centerline Width (for perimeter calcs)	61	FT	\$	-
31	Berm perimeter (at CL Length)	245	FT	\$	-
32	Berm Area/LF	45	SF/FT	\$	-
33	Imported Fill for Berm	408	CY	\$ 44	\$ 17,967
34	Embankment Compaction	408	CY	\$ 22	\$ 8,983
35				\$	-
36	Spillway Assumptions KCSWDM Table 4.2.2A			\$	-
37	RipRap Lining for Overflow	5	CY	\$ 346	\$ 1,845
38	Width	6	FT	\$	-
39	Length	12	FT	\$	-
40	RipRap Depth	2	FT	\$	-
41	Slope Run:Rise	3:1		\$	-
42				\$	-
43	Pond Excavation and Liner			\$	-
44	Facility Excavation to Berm and Waste	406	CY	\$ 79	\$ 32,113
45				\$	-
46				\$	-
47	Outlet Pipe			\$	-
48	Pipe - 12" Diameter	100	LF	\$ 140	\$ 14,000
49	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
50	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
51	48" Maintenance hole	1	EA	\$ 10,640	\$ 10,640
52	Control Structure	1	EA	\$ 24,860	\$ 24,860
53	Imported Backfill	108	CY	\$ 44	\$ 4,761
54	Pipe Discharge Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
55	Debris Barrier	1	EA	\$ 14,808	\$ 14,808
56				\$	-
57	Conveyance Pipe			\$	-
58	Pipe - 12" Diameter	100	LF	\$ 140	\$ 14,000
59	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
60	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
61	Imported Backfill	108	CY	\$ 44	\$ 4,761
62	Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
63	48" Maintenance hole	1	EA	\$ 10,640	\$ 10,640
64				\$	-
65	Site Removals and Restoration			\$	-
66	Access Gate (16 ft wide gate)	1	EA	\$ 3,085	\$ 3,085
67	Access Roadway (12'W X 200'L) to site (4" HMA/4" CSBC) and gate	267	SY	\$ 71	\$ 18,933
68	Disking or tilling of compacted soil (180'W X 140'L est. disturbance)	1,972	SY	\$ 4	\$ 7,278
69	Seeding, mulching and compost (Emergent, Riparian & Upland)	1,972	SY	\$ 10	\$ 19,409
70	Plantings (Emergent & Riparian) est. @ 25% of the seeded area	493	SY	\$ 19	\$ 9,369
71				\$	-
72	High Rate Underground Filter			\$	-
73	Filterra Unit 4'X6' (complete)	1	EA	\$ 22,165	\$ 22,165
74	Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D)	78	CY	\$ 79	\$ 6,123
75	Imported Structural Fill	73	CY	\$ 44	\$ 3,247
76	Crushed Base	1	CY	\$ 64	\$ 64
77	Inlet Drain w/Energy Dissipating Rocks	1	EA	\$ 1,481	\$ 1,481
78	Catch Basin	1	EA	\$ 3,900	\$ 3,900
79	Pipe 8" dia	50	LF	\$ 80	\$ 4,000
80	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,838
81				\$	-
82	Restoration High Rate Underground Filter			\$	-
83	Landscaping, planting, and restoration (Filter and 8" Pipe)	39	SY	\$ 59	\$ 2,296
84	Street Tree	1	EA	\$ 720	\$ 720
85				\$	-
87	Additional Costs			\$	-
88	Removals at 4 % Construction Costs	4.0%	LS	\$ 311,761	\$ 12,470
89	TESC at 2% of Construction	2%	LS	\$ 324,231	\$ 6,485
				\$	-
				\$	-
				Item Subtotal Construction Costs (Year 2023)	\$ 330,716
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	33,072
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CLI	0%	1,0000	\$	-
	Item Subtotal Construction Costs (Year 2023)			\$	363,788
	Direct: Subtotal Construction Costs			\$	363,800

Description: WQBE_13F_Infiltration Pond Outwash Soil with High Rate Underground Filter System on Public Property

An infiltration pond is a basin that stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

General

The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium. Construction occurs outside of the right-of-way and no traffic control or street use permits are required. Trench Box shoring for pipe installation.

Infiltration Pond

The infiltration pond is designed in accordance with KC SW Manual Section 5.2.2 and is generally as described below:
It is assumed that stormwater will be pre-treated prior to conveyance to this facility and that a pre-settling pond will not be required.
The infiltration pond has a bottom area of 1,479 s.f. and a storage depth of 4 feet deep (48 inches).
The pond storage volume is generally located below grade.
The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 27.4 ft. wide and 54.0 ft. long.
The pond is constructed with 3:1 side slopes.
The design includes 1' of freeboard.
Infiltration pond is located on outwash soils.
An emergency overflow spillway is included.
The spillway is riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.
Emergency Spillway is 12 ft. long w/ a slope of 3:1, H:V.
The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content.
A Type 2 minimum 72" dia. flow restrictor (weir) is included with shear gate, and frame and grate for secondary inlet.
Approximately 200 feet of 12-inch diameter pipes are included.
Dewatering is not required.
A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.
Property is assumed to be existing open space without building or pavement removal.
Fencing is not required, but a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced to help restrict vehicular access.
Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Description:	WQBE_14A_Infiltration Vault Till Soil on Public Property			Version:	2
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Vault - Till Soil (1836 sf bottom area @ 0.08 MG Storage)	1	EA	\$ 1,554,500	\$ 1,554,500
				\$	-
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 1,554,500
	Allowance for Indeterminates (Design Allowance)			\$ 310,900	
	Street Use Permit (Y/N)	N		\$ -	
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID				\$ 1,865,400
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$ 186,540	
	Subtotal Primary Construction Amount			\$ 2,051,940	
	Construction Sales Tax			\$ 210,324	
	Outside Agency Construction			\$ -	
	TOTAL DIRECT CONSTRUCTION COSTS				\$ 2,262,300
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$ 451,427	
	Construction Management			\$ 205,194	
	Permitting & Support			\$ 20,519	
	s.f. Land Area	None		\$ -	
	s.f. Land Area	None		\$ -	
	WTD Staff Costs & Non-WTD Support			\$ 123,116	
	Subtotal Non-Construction Costs				\$ 800,257
	Project Contingency			\$ 918,767	
	TOTAL INDIRECT NON-CONSTRUCTION COSTS				\$ 1,719,000
	TOTAL PROJECT COST				\$ 3,981,300

Description: WQBE 14A - Infiltration Vault Till Soil on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 3,981,300
Capital cost	\$ 3,981,300 \$/Unit
Total Direct O&M/Year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,900 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 4,104,000	\$/unit
Annual O&M Cost	\$ 4,800	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$473	
Labor			
Remove Trash, Debris, and Sediment	16 hr		
Inspection and joint repair, crack repair	16 hr		
	0 hr		
	0 hr		
Total hours per year	32		
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 1,740	
Labor cost, burdened	O/H 150.0%	\$ 4,351	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Description: WQBE 14A - Infiltration Vault Till Soil on Public Property

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day,

16 work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 207,010	\$ 4,267,713	\$ 4,104,034			
0	1.000	\$ 3,981,300		\$ 3,981,300	\$ 3,981,300	\$ 3,981,300	\$ 3,981,300	\$ 4,104,034	
1	0.950	\$ 473	\$ -	\$ 4,351	\$ 4,824	\$ 4,584	\$ 3,986,124	\$ 3,985,884	\$ 122,734
2	0.903	\$ 487	\$ -	\$ 4,482	\$ 4,969	\$ 4,486	\$ 3,991,093	\$ 3,990,369	\$ 118,151
3	0.858	\$ 502	\$ -	\$ 4,616	\$ 5,118	\$ 4,390	\$ 3,996,211	\$ 3,994,759	\$ 113,665
4	0.815	\$ 517	\$ -	\$ 4,755	\$ 5,272	\$ 4,296	\$ 4,001,483	\$ 3,999,055	\$ 109,276
5	0.774	\$ 532	\$ -	\$ 4,897	\$ 5,430	\$ 4,204	\$ 4,006,912	\$ 4,003,259	\$ 104,980
6	0.736	\$ 548	\$ -	\$ 5,044	\$ 5,593	\$ 4,114	\$ 4,012,505	\$ 4,007,373	\$ 100,776
7	0.699	\$ 565	\$ -	\$ 5,196	\$ 5,760	\$ 4,026	\$ 4,018,265	\$ 4,011,399	\$ 96,662
8	0.664	\$ 582	\$ -	\$ 5,351	\$ 5,933	\$ 3,940	\$ 4,024,198	\$ 4,015,339	\$ 92,635
9	0.631	\$ 599	\$ -	\$ 5,512	\$ 6,111	\$ 3,856	\$ 4,030,310	\$ 4,019,195	\$ 88,695
10	0.599	\$ 617	\$ -	\$ 5,677	\$ 6,294	\$ 3,773	\$ 4,036,604	\$ 4,022,968	\$ 84,839
11	0.570	\$ 636	\$ -	\$ 5,848	\$ 6,483	\$ 3,693	\$ 4,043,087	\$ 4,026,661	\$ 81,066
12	0.541	\$ 655	\$ -	\$ 6,023	\$ 6,678	\$ 3,614	\$ 4,049,765	\$ 4,030,275	\$ 77,373
13	0.514	\$ 674	\$ -	\$ 6,204	\$ 6,878	\$ 3,537	\$ 4,056,643	\$ 4,033,812	\$ 73,759
14	0.489	\$ 695	\$ -	\$ 6,390	\$ 7,085	\$ 3,461	\$ 4,063,728	\$ 4,037,273	\$ 70,223
15	0.464	\$ 715	\$ -	\$ 6,582	\$ 7,297	\$ 3,387	\$ 4,071,025	\$ 4,040,660	\$ 66,762
16	0.441	\$ 737	\$ -	\$ 6,779	\$ 7,516	\$ 3,315	\$ 4,078,541	\$ 4,043,974	\$ 63,375
17	0.419	\$ 759	\$ -	\$ 6,982	\$ 7,741	\$ 3,244	\$ 4,086,282	\$ 4,047,218	\$ 60,060
18	0.398	\$ 782	\$ -	\$ 7,192	\$ 7,974	\$ 3,174	\$ 4,094,266	\$ 4,050,392	\$ 56,816
19	0.378	\$ 805	\$ -	\$ 7,408	\$ 8,213	\$ 3,107	\$ 4,102,469	\$ 4,053,499	\$ 53,642
20	0.359	\$ 829	\$ 56,900	\$ 7,630	\$ 65,359	\$ 23,489	\$ 4,167,828	\$ 4,076,988	\$ 50,935
21	0.341	\$ 854	\$ -	\$ 7,859	\$ 8,713	\$ 2,975	\$ 4,176,541	\$ 4,079,963	\$ 27,046
22	0.324	\$ 880	\$ -	\$ 8,095	\$ 8,974	\$ 2,912	\$ 4,185,516	\$ 4,082,875	\$ 24,071
23	0.308	\$ 906	\$ -	\$ 8,337	\$ 9,244	\$ 2,849	\$ 4,194,759	\$ 4,085,724	\$ 21,160
24	0.293	\$ 934	\$ -	\$ 8,587	\$ 9,521	\$ 2,788	\$ 4,204,280	\$ 4,088,512	\$ 18,310
25	0.278	\$ 962	\$ -	\$ 8,845	\$ 9,807	\$ 2,729	\$ 4,214,087	\$ 4,091,241	\$ 15,522
26	0.264	\$ 990	\$ -	\$ 9,110	\$ 10,101	\$ 2,670	\$ 4,224,188	\$ 4,093,911	\$ 12,793
27	0.251	\$ 1,020	\$ -	\$ 9,384	\$ 10,404	\$ 2,613	\$ 4,234,591	\$ 4,096,528	\$ 10,123
28	0.239	\$ 1,051	\$ -	\$ 9,665	\$ 10,716	\$ 2,557	\$ 4,245,307	\$ 4,099,082	\$ 7,510
29	0.227	\$ 1,082	\$ -	\$ 9,955	\$ 11,037	\$ 2,503	\$ 4,256,345	\$ 4,101,585	\$ 4,952
30	0.215	\$ 1,115	\$ -	\$ 10,254	\$ 11,369	\$ 2,449	\$ 4,267,713	\$ 4,104,034	\$ 2,449

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR)	
Description:	WQBE_14A_Infiltration Vault Till Soil on Public Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Vault on Property			\$	-
2	Vault Assumptions			\$	-
3	Exterior Length	54	FT	\$	-
4	Interior Length	51	FT	\$	-
5	Exterior Width	39	FT	\$	-
6	Interior Width	36	FT	\$	-
7	Interior Structure Height (Ave.)	7.5	FT	\$	-
8	Storage Depth (Ave.)	6.0	FT	\$	-
9	Sediment Storage Depth	0.5	FT	\$	-
10	Freeboard (Ave.)	1.0	FT	\$	-
11	Storage Facility Exterior Footprint Area	2,106	SF	\$	-
12				\$	-
13	Storage Volume			\$	-
14	Storage Facility Interior Area	1,836	SF	\$	-
15	Effective Storage Volume (11,016 cf target)	11,016	CF	\$	-
16	Vault Storage Volume	0.08	MG	\$	-
17				\$	-
18	Structure Concrete Assumptions			\$	-
19	Exterior Wall thickness	1.5	FT	\$	-
20	Top Slab Thickness	2	FT	\$	-
21	Flow Spreader Slab thickness	2	FT	\$	-
22	Center column footprint area (2'x2')	4	SF	\$	-
23	Center Column Spacing	5	FT	\$	-
24	Concrete Reinforcing Rebar	225	LB/CY	\$	-
25	Crushed Base Thickness	1	FT	\$	-
26				\$	-
27	Concrete Structure			\$	-
28	Vault Interior Columns at Midspan	11	CY	\$ 650	\$ 7,222
29	Slab under Flow Control/discharge (est. 6'W X 10'LX 2'D)	4	CY	\$ 320	\$ 1,422
30	Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W'	5	CY	\$ 320	\$ 1,707
31	Exterior Wall Concrete	78	CY	\$ 1,250	\$ 96,875
32	Top Slab Concrete	156	CY	\$ 1,250	\$ 195,000
33	Concrete Reinforcing Rebar	57,238	LBS	\$ 1.38	\$ 78,988
34	Crushed Base	78	CY	\$ 64	\$ 4,992
35				\$	-
36	Shoring and Excavation Assumptions			\$	-
37	Construction Room	3	FT	\$	-
38	Tank Bury Depth	2	FT	\$	-
39	Total Excavation Depth	13	FT	\$	-
40	Excavation Length	64	FT	\$	-
41	Excavation Width	49	FT	\$	-
42				\$	-
43	Soil Excavation and Disposal			\$	-
44	Excavation	1,452	CY	\$ 79	\$ 114,696
48	Imported Structure Backfill	633	CY	\$ 44	\$ 27,845
49				\$	-
50	Solder Pile Shoring			\$	-
51	Solder Pile Shaft Depth (3 x Exc. Depth)	38	FT	\$	-
52	Solder Pile Shaft Thickness	2	FT	\$	-
53	Center to Center Shaft Spacing	6	FT	\$	-
54	Rebar in Shaft	114	LB/CY	\$	-
55	Shoring Wall Perimeter	218	FT	\$	-
56	Number of Shafts	36	EA	\$	-
57	Drill Solder Pile Shafts	157	CY	\$ 262	\$ 41,155
58	Set Solder Pile and CDF	157	CY	\$ 391	\$ 61,418
59	Purchase and Salvage Solder Piles	153,900	LB	\$ 0.7	\$ 107,730
60	Tie Backs - one per soldier pile except corners	32	EA	\$ 2,477	\$ 79,264
61	Timber Lagging	9,831	BF	\$ 9	\$ 88,479
62				\$	-
63	Gates and Access			\$	-
64	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
65	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
66	Access Hatches	2	EA	\$ 13,038	\$ 26,076
67				\$	-
68	Conveyance Pipe			\$	-
69	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
70	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
71	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
72	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
73	Imported Backfill	883	CY	\$ 44	\$ 38,855
74	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
75	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
76	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100')	444	SY	\$ 71	\$ 31,556
77				\$	-
78	Site Removals and Restoration			\$	-
79	Disking or tilling of compacted soil (assumed 1.5 times structure footprint)	523	SY	\$ 4	\$ 2,091
80	Seeding, mulching and compost	523	SY	\$ 10	\$ 5,227
81	Demolish Existing Surface	348	SY	\$ 14	\$ 4,878
82	Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC	348	SY	\$ 71	\$ 24,740
83	Removals at 4 % Construction Costs	4.0%	LS	\$ 1,332,215	\$ 53,289
84	TESC at 2% of Construction	2%	LS	\$ 1,385,503	\$ 27,710
				\$	-
				\$	-
				Item Subtotal Construction Costs (Year 2023)	\$ 1,413,214
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	141,321
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
				Item Subtotal Construction Costs (Year 2023)	\$ 1,554,535
				Direct: Subtotal Construction Costs	\$ 1,554,500

Description: WQBE 14A - Infiltration Vault Till Soil on Public Property

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

The vault is assumed to be sited on till soils.

It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.08 MG.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1836 square feet and a maximum storage depth of 6 feet deep.

Vault has interior dimensions of 36'W x 51'L with an average interior height of 7.5'.

The minimum vault height is 7' deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

Infiltration is achieved through the native soils at the bottom of the structure.

A minimum of 0.5 feet for sediment storage and a minimum of 1 foot of freeboard depth are assumed.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet.

The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.

The side walls extend to 1 feet below the vault floor.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

There will be two maintenance hole access locations with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and lagging is required for construction of the structure.

A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.

Trench Box shoring is used.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

It is assumed that the tank restoration will consist of parking lot restoration with 4" HMA/4" CSTC.

It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Allowance fore removals estimated at 4% of the construction costs.

The facility is located on property and traffic control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A

Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_14B_Infiltration Vault Outwash Soil on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 3,291,300
Capital cost	\$ 3,291,300 \$/Unit
Total Direct O&M/year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,900 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 3,414,000	\$/unit
Annual O&M Cost	\$ 4,800	\$/year
Annualized Cost	\$750	

Materials, Supplies, Other Costs

	\$ -	\$/year
Cement Patching	2023 dollars	\$ 113 \$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360 \$/year
Subtotal		\$473
Labor		
Remove Trash, Debris, and Sediment	16	hr
Inspection and joint repair, crack repair	16	hr
	0	hr
	0	hr
Total hours per year	32	
Raw Labor Rate/Hr		\$ 54
Raw labor cost	(embedded)	\$ 1,740
Labor cost, burdened	O/H 150.0%	\$ 4,351
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30	years

\$ 135.98

Description: WQBE_14B_Infiltration Vault Outwash Soil on Public Property

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 207,010	\$ 3,577,713	\$ 3,414,034			
0	1.000	\$ 3,291,300		\$ 3,291,300	\$ 3,291,300	\$ 3,291,300	\$ 3,291,300	\$ 3,291,300	\$ 3,414,034
1	0.950	\$ 473	\$ -	\$ 4,351	\$ 4,824	\$ 4,584	\$ 3,296,124	\$ 3,295,884	\$ 122,734
2	0.903	\$ 487	\$ -	\$ 4,482	\$ 4,969	\$ 4,486	\$ 3,301,093	\$ 3,300,369	\$ 118,151
3	0.858	\$ 502	\$ -	\$ 4,616	\$ 5,118	\$ 4,390	\$ 3,306,211	\$ 3,304,759	\$ 113,665
4	0.815	\$ 517	\$ -	\$ 4,755	\$ 5,272	\$ 4,296	\$ 3,311,483	\$ 3,309,055	\$ 109,276
5	0.774	\$ 532	\$ -	\$ 4,897	\$ 5,430	\$ 4,204	\$ 3,316,912	\$ 3,313,259	\$ 104,980
6	0.736	\$ 548	\$ -	\$ 5,044	\$ 5,593	\$ 4,114	\$ 3,322,505	\$ 3,317,373	\$ 100,776
7	0.699	\$ 565	\$ -	\$ 5,196	\$ 5,760	\$ 4,026	\$ 3,328,265	\$ 3,321,399	\$ 96,662
8	0.664	\$ 582	\$ -	\$ 5,351	\$ 5,933	\$ 3,940	\$ 3,334,198	\$ 3,325,339	\$ 92,635
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11	0.570	\$ 636	\$ -	\$ 5,848	\$ 6,483	\$ 3,693	\$ 3,353,087	\$ 3,336,661	\$ 81,066
12	0.541	\$ 655	\$ -	\$ 6,023	\$ 6,678	\$ 3,614	\$ 3,359,765	\$ 3,340,275	\$ 77,373
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14	0.489	\$ 695	\$ -	\$ 6,390	\$ 7,085	\$ 3,461	\$ 3,373,728	\$ 3,347,273	\$ 70,223
15	0.464	\$ 715	\$ -	\$ 6,582	\$ 7,297	\$ 3,387	\$ 3,381,025	\$ 3,350,660	\$ 66,762
16	0.441	\$ 737	\$ -	\$ 6,779	\$ 7,516	\$ 3,315	\$ 3,388,541	\$ 3,353,974	\$ 63,375
17	0.419	\$ 759	\$ -	\$ 6,982	\$ 7,741	\$ 3,244	\$ 3,396,282	\$ 3,357,218	\$ 60,060
18	0.398	\$ 782	\$ -	\$ 7,192	\$ 7,974	\$ 3,174	\$ 3,404,256	\$ 3,360,392	\$ 56,816
19	0.378	\$ 805	\$ -	\$ 7,408	\$ 8,213	\$ 3,107	\$ 3,412,469	\$ 3,363,499	\$ 53,642
20	0.359	\$ 829	\$ 56,900	\$ 7,630	\$ 65,359	\$ 23,489	\$ 3,477,828	\$ 3,386,988	\$ 50,935
21	0.341	\$ 854	\$ -	\$ 7,859	\$ 8,713	\$ 2,975	\$ 3,486,541	\$ 3,389,963	\$ 27,046
22	0.324	\$ 880	\$ -	\$ 8,095	\$ 8,974	\$ 2,912	\$ 3,495,516	\$ 3,392,875	\$ 24,071
23	0.308	\$ 906	\$ -	\$ 8,337	\$ 9,244	\$ 2,849	\$ 3,504,759	\$ 3,395,724	\$ 21,160
24	0.293	\$ 934	\$ -	\$ 8,587	\$ 9,521	\$ 2,788	\$ 3,514,280	\$ 3,398,512	\$ 18,310
25	0.278	\$ 962	\$ -	\$ 8,845	\$ 9,807	\$ 2,729	\$ 3,524,087	\$ 3,401,241	\$ 15,522
26	0.264	\$ 990	\$ -	\$ 9,110	\$ 10,101	\$ 2,670	\$ 3,534,188	\$ 3,403,911	\$ 12,793
27	0.251	\$ 1,020	\$ -	\$ 9,384	\$ 10,404	\$ 2,613	\$ 3,544,591	\$ 3,406,528	\$ 10,123
28	0.239	\$ 1,051	\$ -	\$ 9,665	\$ 10,716	\$ 2,557	\$ 3,555,307	\$ 3,409,082	\$ 7,510
29	0.227	\$ 1,082	\$ -	\$ 9,955	\$ 11,037	\$ 2,503	\$ 3,566,345	\$ 3,411,585	\$ 4,952
30	0.215	\$ 1,115	\$ -	\$ 10,254	\$ 11,369	\$ 2,449	\$ 3,577,713	\$ 3,414,034	\$ 2,449

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR)	
Description:	WQBE 14B Infiltration Vault Outwash Soil on Public Property		Version:	Jess Dexheimer (HDR) 2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Vault on Property			\$	-
2	Vault Assumptions			\$	-
3	Exterior Length	37	FT	\$	-
4	Interior Length	34	FT	\$	-
5	Exterior Width	37	FT	\$	-
6	Interior Width	34	FT	\$	-
7	Interior Structure Height (Ave.)	7.5	FT	\$	-
8	Storage Depth (Ave.)	6.0	FT	\$	-
9	Sediment Storage Depth	0.5	FT	\$	-
10	Freeboard (Ave.)	1.0	FT	\$	-
11	Storage Facility Exterior Footprint Area	1,369	SF	\$	-
12				\$	-
13	Storage Volume			\$	-
14	Storage Facility interior Area	1,156	SF	\$	-
15	Effective Storage Volume (15,500 cf target)	6,936	CF	\$	-
16	Vault Storage Volume	0.05	MG	\$	-
17				\$	-
18	Structure Concrete Assumptions			\$	-
19	Exterior Wall thickness	1.5	FT	\$	-
20	Top Slab Thickness	2	FT	\$	-
21	Flow Spreader Slab thickness	2	FT	\$	-
22	Center column footprint area (2'x2')	4	SF	\$	-
23	Center Column Spacing	5	FT	\$	-
24	Concrete Reinforcing Rebar	225	LB/CY	\$	-
25	Crushed Base Thickness	1	FT	\$	-
26				\$	-
27	Concrete Structure			\$	-
28	Vault Interior Columns at Midspan	8	CY	\$ 650	\$ 5,056
29	Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D)	4	CY	\$ 320	\$ 1,422
30	Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W'	5	CY	\$ 320	\$ 1,612
31	Exterior Wall Concrete	62	CY	\$ 1,250	\$ 77,083
32	Top Slab Concrete	101	CY	\$ 1,250	\$ 126,759
33	Concrete Reinforcing Rebar	40,575	LBS	\$ 1.38	\$ 55,994
34	Crushed Base	51	CY	\$ 64	\$ 3,245
35				\$	-
36	Shoring and Excavation Assumptions			\$	-
37	Construction Room	3	FT	\$	-
38	Tank Bury Depth	2	FT	\$	-
39	Total Excavation Depth	13	FT	\$	-
40	Excavation Length	47	FT	\$	-
41	Excavation Width	47	FT	\$	-
42				\$	-
43	Soil Excavation and Disposal			\$	-
44	Excavation to waste	1,023	CY	\$ 79	\$ 80,792
45	Imported Structure Backfill	490	CY	\$ 44	\$ 21,573
46				\$	-
47	Solder Pile Shoring			\$	-
51	Solder Pile Shaft Depth (3 x Exc. Depth)	38	FT	\$	-
52	Solder Pile Shaft Thickness	2	FT	\$	-
53	Center to Center Shaft Spacing	6	FT	\$	-
54	Rebar in Shaft	114	LB/CY	\$	-
55	Shoring Wall Perimeter	180	FT	\$	-
56	Number of Shafts	30	EA	\$	-
57	Drill Solder Pile Shafts	131	CY	\$ 262	\$ 34,296
58	Set Solder Pile and CDF	131	CY	\$ 391	\$ 51,182
59	Purchase and Salvage Solder Piles	128,250	LB	\$ 0.7	\$ 89,775
60	Tie Backs - one per soldier pile except corners	26	EA	\$ 2,477	\$ 64,402
61	Timber Lagging (64'W X 70'L @ approx. 20'H)	8,178	BF	\$ 9	\$ 73,602
62				\$	-
63	Gates and Access			\$	-
64	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
65	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
66	Access Hatches	2	EA	\$ 13,038	\$ 26,076
67				\$	-
68	Conveyance Pipe			\$	-
69	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
70	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
71	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
72	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
73	Imported Backfill	883	CY	\$ 44	\$ 38,855
74	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
75	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
76	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100')	444	SY	\$ 71	\$ 31,556
77				\$	-
78	Site Removals and Restoration			\$	-
79	Disking or tilling of compacted soil (assumed 1.5 times structure footprint)	368	SY	\$ 4	\$ 1,473
80	Seeding, mulching and compost	368	SY	\$ 10	\$ 3,682
81	Demolish Existing Surface	245	SY	\$ 14	\$ 3,436
82	Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC	245	SY	\$ 71	\$ 17,427
83				\$	-
84	Removals at 4 % Construction Costs	4.0%	LS	\$ 1,101,296	\$ 44,052
85	TESC at 2% of Construction	2%	LS	\$ 1,145,347	\$ 22,907
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 1,168,254
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	116,825
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CC	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 1,285,080
Direct: Subtotal Construction Costs					\$ 1,285,100

Description: WQBE 14B - Infiltration Vault Outwash Soil on Public Property

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

The vault is assumed to be sited on Outwash soils.

It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.

Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.

The minimum vault height is 7' deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

Infiltration is achieved through the native soils at the bottom of the structure.

A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet.

The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.

The side walls extend to 1 feet below the vault floor.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

There will be two maintenance hole access locations with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and lagging is required for construction of the structure.

A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.

Trench Box shoring is used.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control is not required.

A street use permit is not required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A

Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE 14C- Infiltration Vault Till Soil in ROW (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 4,821,100
Capital cost	\$ 4,821,100 \$/Unit
Total Direct O&M/year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,858 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 4,943,800	\$/unit
Annual O&M Cost	\$ 4,800	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

Cement Patching	\$ -	\$/year
2023 dollars	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	\$ 360	\$/year
Subtotal	\$473	
Labor		
Remove Trash, Debris, and Sediment	16	hr
Inspection and joint repair, crack repair	16	hr
	0	hr
	0	hr
Total hours per year	32	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	\$ 1,740	
(embedded)	\$ 4,351	\$ 135.98
Labor cost, burdened	O/H 150.0%	\$ 4,351
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30	years

Description: WQBE 14C - Infiltration Vault Till Soil in ROW

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 207,010	\$ 5,107,472	\$ 4,943,819			
0	1.000	\$ 4,821,100		\$ 4,821,100	\$ 4,821,100	\$ 4,821,100	\$ 4,821,100	\$ 4,821,100	\$ 4,943,819
1	0.950	\$ 473		\$ 4,351	\$ 4,824	\$ 4,584	\$ 4,625,924	\$ 4,625,684	\$ 122,719
2	0.903	\$ 487		\$ 4,482	\$ 4,969	\$ 4,486	\$ 4,830,893	\$ 4,830,169	\$ 118,136
3	0.858	\$ 502		\$ 4,616	\$ 5,118	\$ 4,390	\$ 4,836,011	\$ 4,834,559	\$ 113,650
4	0.815	\$ 517		\$ 4,755	\$ 5,272	\$ 4,296	\$ 4,841,283	\$ 4,838,855	\$ 109,261
5	0.774	\$ 532		\$ 4,897	\$ 5,430	\$ 4,204	\$ 4,846,712	\$ 4,843,059	\$ 104,965
6	0.736	\$ 548		\$ 5,044	\$ 5,593	\$ 4,114	\$ 4,852,305	\$ 4,847,173	\$ 100,761
7	0.699	\$ 565		\$ 5,196	\$ 5,760	\$ 4,026	\$ 4,858,065	\$ 4,851,199	\$ 96,647
8	0.664	\$ 582		\$ 5,351	\$ 5,933	\$ 3,940	\$ 4,863,998	\$ 4,855,139	\$ 92,620
9	0.631	\$ 599		\$ 5,512	\$ 6,111	\$ 3,856	\$ 4,870,110	\$ 4,858,995	\$ 88,680
10	0.599	\$ 617		\$ 5,677	\$ 6,294	\$ 3,773	\$ 4,876,404	\$ 4,862,768	\$ 84,624
11	0.570	\$ 636		\$ 5,848	\$ 6,483	\$ 3,693	\$ 4,882,887	\$ 4,866,461	\$ 81,051
12	0.541	\$ 655		\$ 6,023	\$ 6,678	\$ 3,614	\$ 4,889,565	\$ 4,870,075	\$ 77,358
13	0.514	\$ 674		\$ 6,204	\$ 6,878	\$ 3,537	\$ 4,896,443	\$ 4,873,612	\$ 73,744
14	0.489	\$ 695		\$ 6,390	\$ 7,085	\$ 3,461	\$ 4,903,528	\$ 4,877,073	\$ 70,208
15	0.464	\$ 715		\$ 6,582	\$ 7,297	\$ 3,387	\$ 4,910,825	\$ 4,880,460	\$ 66,747
16	0.441	\$ 737		\$ 6,779	\$ 7,516	\$ 3,315	\$ 4,918,341	\$ 4,883,774	\$ 63,360
17	0.419	\$ 759		\$ 6,982	\$ 7,741	\$ 3,244	\$ 4,926,082	\$ 4,887,018	\$ 60,045
18	0.398	\$ 782		\$ 7,192	\$ 7,974	\$ 3,174	\$ 4,934,056	\$ 4,890,192	\$ 56,801
19	0.378	\$ 805		\$ 7,408	\$ 8,213	\$ 3,107	\$ 4,942,269	\$ 4,893,299	\$ 53,627
20	0.359	\$ 829	\$ 56,858	\$ 7,630	\$ 65,318	\$ 23,474	\$ 5,007,587	\$ 4,916,773	\$ 50,521
21	0.341	\$ 854		\$ 7,859	\$ 8,713	\$ 2,975	\$ 5,016,300	\$ 4,919,748	\$ 27,046
22	0.324	\$ 880		\$ 8,095	\$ 8,974	\$ 2,912	\$ 5,025,274	\$ 4,922,660	\$ 24,071
23	0.308	\$ 906		\$ 8,337	\$ 9,244	\$ 2,849	\$ 5,034,518	\$ 4,925,509	\$ 21,160
24	0.293	\$ 934		\$ 8,587	\$ 9,521	\$ 2,788	\$ 5,044,039	\$ 4,928,297	\$ 18,310
25	0.278	\$ 962		\$ 8,845	\$ 9,807	\$ 2,729	\$ 5,053,845	\$ 4,931,026	\$ 15,522
26	0.264	\$ 990		\$ 9,110	\$ 10,101	\$ 2,670	\$ 5,063,946	\$ 4,933,697	\$ 12,793
27	0.251	\$ 1,020		\$ 9,384	\$ 10,404	\$ 2,613	\$ 5,074,350	\$ 4,936,310	\$ 10,123
28	0.239	\$ 1,051		\$ 9,665	\$ 10,716	\$ 2,557	\$ 5,085,066	\$ 4,938,867	\$ 7,510
29	0.227	\$ 1,082		\$ 9,955	\$ 11,037	\$ 2,503	\$ 5,096,103	\$ 4,941,370	\$ 4,952
30	0.215	\$ 1,115		\$ 10,254	\$ 11,369	\$ 2,449	\$ 5,107,472	\$ 4,943,819	\$ 2,449

Estimate - AACEI Class 10				
Project Name: King County Water Quality Benefits Evaluation				Date: 6/7/2024
Location: King County, WA				Estimator: Troy Gibbs (HDR)
Description: WQBE_14C_Infiltration Vault Till Soil in ROW				Version: 2
CONSTRUCTION COSTS				
Item No.	Item Description	Quantity	Units	Unit Cost
1	Infiltration Vault in ROW			\$ -
2	Vault Assumptions			\$ -
3	Exterior Length	54 FT	FT	\$ -
4	Interior Length	51 FT	FT	\$ -
5	Exterior Width	39 FT	FT	\$ -
6	Interior Width	36 FT	FT	\$ -
7	Interior Structure Height (Ave.)	7.5 FT	FT	\$ -
8	Storage Depth (Ave.)	6.0 FT	FT	\$ -
9	Sediment Storage Depth	0.5 FT	FT	\$ -
10	Freeboard (Ave.)	1.0 FT	FT	\$ -
11	Storage Facility Exterior Footprint Area	2,106 SF	SF	\$ -
12				\$ -
13	Storage Volume			\$ -
14	Storage Facility interior Area	1,836 SF	SF	\$ -
15	Effective Storage Volume (11,016 cf target)	11,016 CF	CF	\$ -
16	Vault Storage Volume	0.08 MG	MG	\$ -
17				\$ -
18	Structure Concrete Assumptions			\$ -
19	Exterior Wall thickness	1.5 FT	FT	\$ -
20	Top Slab Thickness	2 FT	FT	\$ -
21	Flow Spreader Slab thickness	2 FT	FT	\$ -
22	Center column footprint area (2'x2')	4 SF	SF	\$ -
23	Center Column Spacing	5 FT	FT	\$ -
24	Concrete Reinforcing Rebar	225 LB/CY	LB/CY	\$ -
25	Crushed Base Thickness	1 FT	FT	\$ -
26				\$ -
27	Concrete Structure			\$ -
28	Vault Interior Columns at Midspan	11 CY	CY	\$ 650 \$ 7,222
29	Slab under Flow Control/Discharge (est. 6'W X 10'L X 2'D)	4 CY	CY	\$ 320 \$ 1,422
30	Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W'	5 CY	CY	\$ 320 \$ 1,707
31	Exterior Wall Concrete	78 CY	CY	\$ 1,250 \$ 96,875
32	Top Slab Concrete	156 CY	CY	\$ 3,250 \$ 195,000
33	Concrete Reinforcing Rebar	57,238 LBS	LBS	\$ 1.38 \$ 78,988
34	Crushed Base	78 CY	CY	\$ 64 \$ 4,992
35				\$ -
36	Shoring and Excavation Assumptions			\$ -
37	Construction Room	3 FT	FT	\$ -
38	Tank Bury Depth	2 FT	FT	\$ -
39	Total Excavation Depth	13 FT	FT	\$ -
40	Excavation Length	64 FT	FT	\$ -
41	Excavation Width	49 FT	FT	\$ -
42				\$ -
43	Soil Excavation and Disposal			\$ -
44	Excavation	1,452 CY	CY	\$ 79 \$ 114,696
45	Imported Structure Backfill	633 CY	CY	\$ 44 \$ 27,845
46				\$ -
50	Solder Pile Shoring			\$ -
51	Solder Pile Shaft Depth (3 x Exc. Depth)	38 FT	FT	\$ -
52	Solder Pile Shaft Thickness	2 FT	FT	\$ -
53	Center to Center Shaft Spacing	6 FT	FT	\$ -
54	Rebar in Shaft	114 LB/CY	LB/CY	\$ -
55	Shoring Wall Perimeter	218 FT	FT	\$ -
56	Number of Shafts	36 EA	EA	\$ -
57	Drill Solder Pile Shafts	157 CY	CY	\$ 262 \$ 41,155
58	Set Solder Pile and CDF	157 CY	CY	\$ 391 \$ 61,418
59	Purchase and Salvage Solder Piles	153,900 LB	LB	\$ 0.7 \$ 107,730
60	Tie Backs - one per soldier pile except corners	32 EA	EA	\$ 2,477 \$ 79,264
61	Timber Lagging	9,831 BF	BF	\$ 9 \$ 88,479
62				\$ -
63	Gates and Access			\$ -
64	Flow Restrictor	1 EA	EA	\$ 24,600 \$ 24,600
65	Confined Space Safety	1 LS	LS	\$ 32,595 \$ 32,595
66	Access Hatches	2 EA	EA	\$ 13,038 \$ 26,076
67				\$ -
68	Conveyance Pipe			\$ -
69	12" Storm Pipe (upstream and discharge)	200 LF	LF	\$ 140 \$ 28,000
70	Trench Excavation to waste (8'W X 15'D)	889 CY	CY	\$ 79 \$ 70,222
71	Trench Box Shoring	6,000 SF	SF	\$ 10 \$ 60,000
72	48" Diameter Maintenance holes	4 EA	EA	\$ 10,640 \$ 42,560
73	Imported Backfill	883 CY	CY	\$ 44 \$ 38,855
74	Dewater Trench - Sumps	200 LF	LF	\$ 139 \$ 27,800
75	Demolish Surface incl. room for construction (@20' wide)	444 SY	SY	\$ 14 \$ 6,222
76	Road Restoration (for pipe) - 6" HMA/6"CSBC x 20' W X 100'	444 SY	SY	\$ 110 \$ 48,889
77				\$ -
78	Site Removals and Restoration			\$ -
79	Demolish Existing Surface	348 SY	SY	\$ 14 \$ 4,878
80	Road Restoration - 6" HMA/6"CSBC (for Vault -71'X56')	348 SY	SY	\$ 110 \$ 38,329
81	Sidewalk Est. one side x 5' Wide	42 SY	SY	\$ 125 \$ 5,208
82	Planting Strip Est one side x 8' Wide	67 SY	SY	\$ 10 \$ 656
83	Landscape/Lawn Restoration	67 SY	SY	\$ 59 \$ 3,936
84	Irrigation System Repair est @ 10% Landscape/Lawn	10% LS	LS	\$ 3,936 \$ 394
85	Trees both new and replacements Est @ 4 per 100'	3 EA	EA	\$ 720 \$ 2,160
86				\$ -
87	Traffic Control Arterial (HMA)	6 MO	MO	\$ 20,000 \$ 120,000
88	Removals at 4 % Construction Costs	4.0% LS	LS	\$ 1,366,014 \$ 54,641
89	TESC at 2% of Construction	2% LS	LS	\$ 1,542,815 \$ 30,856
				\$ -
				\$ -
	Item Subtotal Construction Costs (Year 2023)			\$ 1,573,671
DIRECT: CONSTRUCTION COST MARK-UPS				
	General Conditions	0%	1	\$ -
	Mobilization/Demobilization	10%	1.1	\$ 157,367
	Overhead & Profit (OHP)	0%	1	\$ -
	Insurance	0.0%	1	\$ -
	Bonding	0.0%	1	\$ -
	Escalation Multiplier from ENR-CCI	0%	1,0000	\$ -
	Item Subtotal Construction Costs (Year 2023)			\$ 1,731,038
	Direct: Subtotal Construction Costs			\$ 1,731,038

Description: WQBE 14C - Infiltration Vault Till Soil in ROW

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.

The vault is assumed to be sited on till soils.

It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.08 MG.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1836 square feet and a maximum storage depth of 6 feet deep.

Vault has interior dimensions of 36'W x 51'L with an average interior height of 7.5'.

The minimum vault height is 7' deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

Infiltration is achieved through the native soils at the bottom of the structure.

A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet.

The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.

The side walls extend to 1 feet below the vault floor.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

There will be two maintenance hole access locations with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and lagging is required for construction of the structure.

A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.

Trench Box shoring is used.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

It is assumed that the tank restoration will consist of parking lot restoration with 4" HMA/4" CSTC.

It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required.

Traffic conditions are assumed to be heavy.

A street use permit is required.

Installation is in right-of-way and does not include easements or acquisition

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations.

Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_14D_Infiltration Vault Outwash Soil In ROW (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 3,956,300
Capital cost	\$ 3,956,300 \$/Unit
Total Direct O&M/year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,858 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 4,079,000	\$/unit
Annual O&M Cost	\$ 4,800	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

Cement Patching	\$ -	\$/year
2023 dollars	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	\$ 360	\$/year
Subtotal	\$473	
Labor		
Remove Trash, Debris, and Sediment	16	hr
Inspection and joint repair, crack repair	16	hr
	0	hr
	0	hr
Total hours per year	32	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	\$ 1,740	
(embedded)	\$ 4,351	
Labor cost, burdened	O/H 150.0%	\$ 4,351
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30	years

\$ 135.98

Description: WQBE_14D_Infiltration Vault Outwash Soil In ROW

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 207,010	\$ 4,242,672	\$ 4,079,019			
0	1.000	\$ 3,956,300		\$ 3,956,300	\$ 3,956,300	\$ 3,956,300	\$ 3,956,300	\$ 4,079,019	
1	0.950	\$ 473	\$ -	\$ 4,351	\$ 4,824	\$ 4,584	\$ 3,961,124	\$ 3,960,884	\$ 122,719
2	0.903	\$ 487	\$ -	\$ 4,482	\$ 4,969	\$ 4,486	\$ 3,966,093	\$ 3,965,369	\$ 118,136
3	0.858	\$ 502	\$ -	\$ 4,616	\$ 5,118	\$ 4,390	\$ 3,971,211	\$ 3,969,759	\$ 113,650
4	0.815	\$ 517	\$ -	\$ 4,755	\$ 5,272	\$ 4,296	\$ 3,976,483	\$ 3,974,055	\$ 109,261
5	0.774	\$ 532	\$ -	\$ 4,897	\$ 5,430	\$ 4,204	\$ 3,981,912	\$ 3,978,259	\$ 104,965
6	0.736	\$ 548	\$ -	\$ 5,044	\$ 5,593	\$ 4,114	\$ 3,987,505	\$ 3,982,373	\$ 100,761
7	0.699	\$ 565	\$ -	\$ 5,196	\$ 5,760	\$ 4,026	\$ 3,993,265	\$ 3,986,399	\$ 96,647
8	0.664	\$ 582	\$ -	\$ 5,351	\$ 5,933	\$ 3,940	\$ 3,999,198	\$ 3,990,339	\$ 92,620
9	0.631	\$ 599	\$ -	\$ 5,512	\$ 6,111	\$ 3,856	\$ 4,005,310	\$ 3,994,195	\$ 88,680
10	0.599	\$ 617	\$ -	\$ 5,677	\$ 6,294	\$ 3,773	\$ 4,011,604	\$ 3,997,968	\$ 84,824
11	0.570	\$ 636	\$ -	\$ 5,848	\$ 6,483	\$ 3,693	\$ 4,018,087	\$ 4,001,661	\$ 81,051
12	0.541	\$ 655	\$ -	\$ 6,023	\$ 6,678	\$ 3,614	\$ 4,024,765	\$ 4,005,275	\$ 77,358
13	0.514	\$ 674	\$ -	\$ 6,204	\$ 6,878	\$ 3,537	\$ 4,031,643	\$ 4,008,812	\$ 73,744
14	0.489	\$ 695	\$ -	\$ 6,390	\$ 7,085	\$ 3,461	\$ 4,038,728	\$ 4,012,273	\$ 70,208
15	0.464	\$ 715	\$ -	\$ 6,582	\$ 7,297	\$ 3,387	\$ 4,046,025	\$ 4,015,660	\$ 66,747
16	0.441	\$ 737	\$ -	\$ 6,779	\$ 7,516	\$ 3,315	\$ 4,053,541	\$ 4,018,974	\$ 63,360
17	0.419	\$ 759	\$ -	\$ 6,982	\$ 7,741	\$ 3,244	\$ 4,061,282	\$ 4,022,218	\$ 60,045
18	0.398	\$ 782	\$ -	\$ 7,192	\$ 7,974	\$ 3,174	\$ 4,069,256	\$ 4,025,392	\$ 56,801
19	0.378	\$ 805	\$ -	\$ 7,408	\$ 8,213	\$ 3,107	\$ 4,077,469	\$ 4,028,499	\$ 53,627
20	0.359	\$ 829	\$ 56,858	\$ 7,630	\$ 65,318	\$ 23,474	\$ 4,142,787	\$ 4,051,973	\$ 50,521
21	0.341	\$ 854	\$ -	\$ 7,859	\$ 8,713	\$ 2,975	\$ 4,151,500	\$ 4,054,948	\$ 27,046
22	0.324	\$ 880	\$ -	\$ 8,095	\$ 8,974	\$ 2,912	\$ 4,160,474	\$ 4,057,860	\$ 24,071
23	0.308	\$ 906	\$ -	\$ 8,337	\$ 9,244	\$ 2,849	\$ 4,169,718	\$ 4,060,709	\$ 21,160
24	0.293	\$ 934	\$ -	\$ 8,587	\$ 9,521	\$ 2,788	\$ 4,179,238	\$ 4,063,497	\$ 18,310
25	0.278	\$ 962	\$ -	\$ 8,845	\$ 9,807	\$ 2,729	\$ 4,189,045	\$ 4,066,226	\$ 15,522
26	0.264	\$ 990	\$ -	\$ 9,110	\$ 10,101	\$ 2,670	\$ 4,199,146	\$ 4,068,897	\$ 12,793
27	0.251	\$ 1,020	\$ -	\$ 9,384	\$ 10,404	\$ 2,613	\$ 4,209,550	\$ 4,071,510	\$ 10,123
28	0.239	\$ 1,051	\$ -	\$ 9,665	\$ 10,716	\$ 2,557	\$ 4,220,266	\$ 4,074,067	\$ 7,510
29	0.227	\$ 1,082	\$ -	\$ 9,955	\$ 11,037	\$ 2,503	\$ 4,231,303	\$ 4,076,570	\$ 4,952
30	0.215	\$ 1,115	\$ -	\$ 10,254	\$ 11,369	\$ 2,449	\$ 4,242,672	\$ 4,079,019	\$ 2,449

Description: WQBE 14D - Infiltration Vault Outwash Soil in ROW

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.

Installation is in right-of-way and does not include easements or acquisition

The vault is assumed to be sited on Outwash soils.

It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.

Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.

The minimum vault height is 7' deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

Infiltration is achieved through the native soils at the bottom of the structure.

A minimum of 0.5 feet for sediment storage and a minimum of 0.5 feet of freeboard depth are assumed.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet.

The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.

The side walls extend to 1 foot below the vault floor.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

There will be two maintenance hole access locations with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and lagging is required for construction of the structure.

A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.

Trench Box shoring is used.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located within the ROW and Traffic control is required.

Traffic conditions are assumed to be heavy.

A street use permit is required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_14E_Infiltration Vault Till Soil With Property Cost (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 4,423,500
Capital cost	\$ 4,423,500 \$/Unit
Total Direct O&M/Year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,858 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 4,546,200	\$/unit
Annual O&M Cost	\$ 4,800	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ -	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 113	\$/year
Subtotal		\$ 360	\$/year
Labor		\$473	
Remove Trash, Debris, and Sediment	16	hr	
Inspection and joint repair, crack repair	16	hr	
	0	hr	
	0	hr	
Total hours per year	32		
Raw Labor Rate/hr	\$ 54		
Raw labor cost	(embedded)	\$ 1,740	
Labor cost, burdened	O/H 150.0%	\$ 4,351	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Description: WQBE_14E_Infiltration Vault Till Soil With Property Cost

Box-shaped underground facility that provides temporary storage of stormwater runoff. Stormwater is then released through a control structure at an attenuated rate.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an

16 8 hour work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 207,010	\$ 4,709,872	\$ 4,546,219			
0	1.000	\$ 4,423,500		\$ 4,423,500	\$ 4,423,500	\$ 4,423,500	\$ 4,423,500	\$ 4,423,500	\$ 4,546,219
1	0.950	\$ 473	\$ -	\$ 4,351	\$ 4,824	\$ 4,584	\$ 4,428,324	\$ 4,428,084	\$ 122,719
2	0.903	\$ 487	\$ -	\$ 4,482	\$ 4,969	\$ 4,486	\$ 4,433,293	\$ 4,432,569	\$ 118,136
3	0.858	\$ 502	\$ -	\$ 4,616	\$ 5,118	\$ 4,390	\$ 4,438,411	\$ 4,436,959	\$ 113,650
4	0.815	\$ 517	\$ -	\$ 4,755	\$ 5,272	\$ 4,296	\$ 4,443,683	\$ 4,441,255	\$ 109,261
5	0.774	\$ 532	\$ -	\$ 4,897	\$ 5,430	\$ 4,204	\$ 4,449,112	\$ 4,445,459	\$ 104,965
6	0.736	\$ 548	\$ -	\$ 5,044	\$ 5,593	\$ 4,114	\$ 4,454,705	\$ 4,449,573	\$ 100,761
7	0.699	\$ 565	\$ -	\$ 5,196	\$ 5,760	\$ 4,026	\$ 4,460,465	\$ 4,453,599	\$ 96,647
8	0.664	\$ 582	\$ -	\$ 5,351	\$ 5,933	\$ 3,940	\$ 4,466,398	\$ 4,457,539	\$ 92,620
9	0.631	\$ 599	\$ -	\$ 5,512	\$ 6,111	\$ 3,856	\$ 4,472,510	\$ 4,461,395	\$ 88,680
10	0.599	\$ 617	\$ -	\$ 5,677	\$ 6,294	\$ 3,773	\$ 4,478,804	\$ 4,465,168	\$ 84,824
11	0.570	\$ 636	\$ -	\$ 5,848	\$ 6,483	\$ 3,693	\$ 4,485,287	\$ 4,468,861	\$ 81,051
12	0.541	\$ 655	\$ -	\$ 6,023	\$ 6,678	\$ 3,614	\$ 4,491,968	\$ 4,472,476	\$ 77,358
13	0.514	\$ 674	\$ -	\$ 6,204	\$ 6,878	\$ 3,537	\$ 4,498,843	\$ 4,476,012	\$ 73,744
14	0.489	\$ 695	\$ -	\$ 6,390	\$ 7,085	\$ 3,461	\$ 4,505,928	\$ 4,479,473	\$ 70,208
15	0.464	\$ 715	\$ -	\$ 6,582	\$ 7,297	\$ 3,387	\$ 4,513,225	\$ 4,482,860	\$ 66,747
16	0.441	\$ 737	\$ -	\$ 6,779	\$ 7,516	\$ 3,315	\$ 4,520,741	\$ 4,486,174	\$ 63,360
17	0.419	\$ 759	\$ -	\$ 6,982	\$ 7,741	\$ 3,244	\$ 4,528,482	\$ 4,489,418	\$ 60,045
18	0.398	\$ 782	\$ -	\$ 7,192	\$ 7,974	\$ 3,174	\$ 4,536,456	\$ 4,492,592	\$ 56,801
19	0.378	\$ 805	\$ -	\$ 7,408	\$ 8,213	\$ 3,107	\$ 4,544,669	\$ 4,495,699	\$ 53,627
20	0.359	\$ 829	\$ 56,858	\$ 7,630	\$ 65,318	\$ 23,474	\$ 4,609,987	\$ 4,519,173	\$ 50,521
21	0.341	\$ 854	\$ -	\$ 7,859	\$ 8,713	\$ 2,975	\$ 4,618,700	\$ 4,522,148	\$ 27,046
22	0.324	\$ 880	\$ -	\$ 8,095	\$ 8,974	\$ 2,912	\$ 4,627,674	\$ 4,525,060	\$ 24,071
23	0.308	\$ 906	\$ -	\$ 8,337	\$ 9,244	\$ 2,849	\$ 4,636,918	\$ 4,527,909	\$ 21,160
24	0.293	\$ 934	\$ -	\$ 8,587	\$ 9,521	\$ 2,788	\$ 4,646,439	\$ 4,530,697	\$ 18,310
25	0.278	\$ 962	\$ -	\$ 8,845	\$ 9,807	\$ 2,729	\$ 4,656,245	\$ 4,533,426	\$ 15,622
26	0.264	\$ 990	\$ -	\$ 9,110	\$ 10,101	\$ 2,670	\$ 4,666,346	\$ 4,536,097	\$ 12,793
27	0.251	\$ 1,020	\$ -	\$ 9,384	\$ 10,404	\$ 2,613	\$ 4,676,750	\$ 4,538,710	\$ 10,123
28	0.239	\$ 1,051	\$ -	\$ 9,665	\$ 10,716	\$ 2,557	\$ 4,687,466	\$ 4,541,267	\$ 7,510
29	0.227	\$ 1,082	\$ -	\$ 9,955	\$ 11,037	\$ 2,503	\$ 4,698,503	\$ 4,543,770	\$ 4,952
30	0.215	\$ 1,115	\$ -	\$ 10,254	\$ 11,369	\$ 2,449	\$ 4,709,872	\$ 4,546,219	\$ 2,449

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR)	
Description:	WQBE_14E_Infiltration Vault Till Soil With Property Cost		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Vault on Property			\$	-
2	Vault Assumptions			\$	-
3	Exterior Length	54	FT	\$	-
4	Interior Length	51	FT	\$	-
5	Exterior Width	39	FT	\$	-
6	Interior Width	36	FT	\$	-
7	Interior Structure Height (Ave.)	7.5	FT	\$	-
8	Storage Depth (Ave)	6.0	FT	\$	-
9	Sediment Storage Depth	0.5	FT	\$	-
10	Freeboard (Ave.)	1.0	FT	\$	-
11	Storage Facility Exterior Footprint Area	2,106	SF	\$	-
12				\$	-
13	Storage Volume			\$	-
14	Storage Facility Interior Area	1,836	SF	\$	-
15	Effective Storage Volume (11,016 cf target)	11,016	CF	\$	-
16	Vault Storage Volume	0.08	MG	\$	-
17				\$	-
18	Structure Concrete Assumptions			\$	-
19	Exterior Wall thickness	1.5	FT	\$	-
20	Top Slab Thickness	2	FT	\$	-
21	Flow Spreader Slab thickness	2	FT	\$	-
22	Center column footprint area (2'x2')	4	SF	\$	-
23	Center Column Spacing	5	FT	\$	-
24	Concrete Reinforcing Rebar	225	LB/CY	\$	-
25	Crushed Base Thickness	1	FT	\$	-
26				\$	-
27	Concrete Structure			\$	-
28	Vault Interior Columns at Midspan	11	CY	\$ 650	\$ 7,222
29	Slab under Flow Control/discharge (est. 6'W X 10'LX 2'D)	4	CY	\$ 320	\$ 1,422
30	Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W'	5	CY	\$ 320	\$ 1,707
31	Exterior Wall Concrete	78	CY	\$ 1,250	\$ 96,875
32	Top Slab Concrete	156	CY	\$ 1,250	\$ 195,000
33	Concrete Reinforcing Rebar	57,238	LBS	\$ 1.38	\$ 78,988
34	Crushed Base	78	CY	\$ 64	\$ 4,992
35				\$	-
36	Shoring and Excavation Assumptions			\$	-
37	Construction Room	3	FT	\$	-
38	Tank Bury Depth	2	FT	\$	-
39	Total Excavation Depth	13	FT	\$	-
40	Excavation Length	64	FT	\$	-
41	Excavation Width	49	FT	\$	-
42				\$	-
43	Soil Excavation and Disposal			\$	-
44	Mass Excavate, in the dry	1,452	CY	\$ 79	\$ 114,696
48	Imported Structure Backfill	633	CY	\$ 44	\$ 27,845
49				\$	-
50	Solder Pile Shoring			\$	-
51	Solder Pile Shaft Depth (3 x Exc. Depth)	38	FT	\$	-
52	Solder Pile Shaft Thickness	2	FT	\$	-
53	Center to Center Shaft Spacing	6	FT	\$	-
54	Rebar in Shaft	114	LB/CY	\$	-
55	Shoring Wall Perimeter	218	FT	\$	-
56	Number of Shafts	36	EA	\$	-
57	Drill Solder Pile Shafts	157	CY	\$ 262	\$ 41,155
58	Set Solder Pile and CDF	157	CY	\$ 391	\$ 61,418
59	Purchase and Salvage Solder Piles	153,900	LB	\$ 0.7	\$ 107,730
60	Tie Backs - one per soldier pile except corners	32	EA	\$ 2,477	\$ 79,264
61	Timber Lagging	9,831	BF	\$ 9	\$ 88,479
62				\$	-
63	Gates and Access			\$	-
64	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
65	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
66	Access Hatches	2	EA	\$ 13,038	\$ 26,076
67				\$	-
68	Conveyance Pipe			\$	-
69	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
70	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
71	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
72	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
73	Imported Backfill	883	CY	\$ 44	\$ 38,855
74	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
75	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
76	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100')	444	SY	\$ 71	\$ 31,556
77				\$	-
78	Site Removals and Restoration			\$	-
79	Disking or tilling of compacted soil (assumed 1.5 times structure footprint)	523	SY	\$ 4	\$ 2,091
80	Seeding, mulching and compost	523	SY	\$ 10	\$ 5,227
81	Demolish Existing Surface	348	SY	\$ 14	\$ 4,878
82	Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC	348	SY	\$ 71	\$ 24,740
83	Removals at 4 % Construction Costs	4.0%	LS	\$ 1,332,215	\$ 53,289
84	TESC at 2% of Construction	2%	LS	\$ 1,385,503	\$ 27,710
				\$	-
				\$	-
				Item Subtotal Construction Costs (Year 2023)	\$ 1,413,214
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	141,321
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
				Item Subtotal Construction Costs (Year 2023)	\$ 1,554,535
				Direct: Subtotal Construction Costs	\$ 1,554,535

Description: WQBE 14E - Infiltration Vault Till Soil With Property Cost

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.

The vault is assumed to be sited on till soils.

It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.08 MG.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1836 square feet and a maximum storage depth of 6 feet deep.

Vault has interior dimensions of 36'W x 51'L with an average interior height of 7.5'.

The minimum vault height is 7' deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

Infiltration is achieved through the native soils at the bottom of the structure.

A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet.

The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.

The side walls extend to 1 feet below the vault floor.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

There will be two maintenance hole access locations with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and lagging is required for construction of the structure.

A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.

Trench Box shoring is used.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control is not required.

A street use permit is not required.

The installation is assumed to be on property with easements and acquisition required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_14F_Infiltration Vault Outwash Soil With Property Cost (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 3,733,400
Capital cost	\$ 3,733,400 \$/Unit
Total Direct O&M/year	\$ 4,351
Direct O&M cost	\$ 4,351 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,900 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 3,856,100	\$/unit
Annual O&M Cost	\$ 4,800	\$/year
Annualized Cost	\$750	\$/year

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ 113	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal	\$473		
Labor			
Remove Trash, Debris, and Sediment	16 hr		
Inspection and joint repair, crack repair	16 hr		
	0 hr		
	0 hr		
Total hours per year	32		
Raw Labor Rate/Hr	\$ 54		
Raw labor cost	(embedded)	\$ 1,740	\$
Labor cost, burdened	O/H 150.0%	\$ 4,351	\$
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

\$ 135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 22,503		\$ 207,010	\$ 4,019,813	\$ 3,856,134			
0	1.000	\$ 3,733,400		\$ 3,733,400	\$ 3,733,400	\$ 3,733,400	\$ 3,733,400	\$ 3,733,400	\$ 3,856,134
1	0.950	\$ 473	\$ -	\$ 4,351	\$ 4,824	\$ 4,584	\$ 3,738,224	\$ 3,737,964	\$ 122,734
2	0.903	\$ 487	\$ -	\$ 4,482	\$ 4,969	\$ 4,486	\$ 3,743,193	\$ 3,742,469	\$ 118,151
3	0.858	\$ 502	\$ -	\$ 4,616	\$ 5,118	\$ 4,390	\$ 3,748,311	\$ 3,746,859	\$ 113,665
4	0.815	\$ 517	\$ -	\$ 4,755	\$ 5,272	\$ 4,296	\$ 3,753,583	\$ 3,751,155	\$ 109,276
5	0.774	\$ 532	\$ -	\$ 4,897	\$ 5,430	\$ 4,204	\$ 3,759,012	\$ 3,755,359	\$ 104,980
6	0.736	\$ 548	\$ -	\$ 5,044	\$ 5,593	\$ 4,114	\$ 3,764,605	\$ 3,759,473	\$ 100,776
7	0.699	\$ 565	\$ -	\$ 5,196	\$ 5,760	\$ 4,026	\$ 3,770,365	\$ 3,763,499	\$ 96,662
8	0.664	\$ 582	\$ -	\$ 5,351	\$ 5,933	\$ 3,940	\$ 3,776,298	\$ 3,767,439	\$ 92,635
9	0.631	\$ 599	\$ -	\$ 5,512	\$ 6,111	\$ 3,856	\$ 3,782,410	\$ 3,771,295	\$ 88,695
10	0.599	\$ 617	\$ -	\$ 5,677	\$ 6,294	\$ 3,773	\$ 3,788,704	\$ 3,775,068	\$ 84,839
11	0.570	\$ 636	\$ -	\$ 5,848	\$ 6,483	\$ 3,693	\$ 3,795,187	\$ 3,778,761	\$ 81,066
12	0.541	\$ 655	\$ -	\$ 6,023	\$ 6,678	\$ 3,614	\$ 3,801,865	\$ 3,782,375	\$ 77,373
13	0.514	\$ 674	\$ -	\$ 6,204	\$ 6,878	\$ 3,537	\$ 3,808,743	\$ 3,785,912	\$ 73,759
14	0.489	\$ 695	\$ -	\$ 6,390	\$ 7,085	\$ 3,461	\$ 3,815,828	\$ 3,789,373	\$ 70,223
15	0.464	\$ 715	\$ -	\$ 6,582	\$ 7,297	\$ 3,387	\$ 3,823,125	\$ 3,792,760	\$ 66,762
16	0.441	\$ 737	\$ -	\$ 6,779	\$ 7,516	\$ 3,315	\$ 3,830,641	\$ 3,796,074	\$ 63,375
17	0.419	\$ 759	\$ -	\$ 6,982	\$ 7,741	\$ 3,244	\$ 3,838,382	\$ 3,799,318	\$ 60,060
18	0.398	\$ 782	\$ -	\$ 7,192	\$ 7,974	\$ 3,174	\$ 3,846,356	\$ 3,802,492	\$ 56,816
19	0.378	\$ 805	\$ -	\$ 7,408	\$ 8,213	\$ 3,107	\$ 3,854,569	\$ 3,805,599	\$ 53,642
20	0.359	\$ 829	\$ 56,900	\$ 7,630	\$ 65,359	\$ 23,489	\$ 3,919,928	\$ 3,829,088	\$ 50,935
21	0.341	\$ 854	\$ -	\$ 7,859	\$ 8,713	\$ 2,975	\$ 3,928,641	\$ 3,832,063	\$ 27,046
22	0.324	\$ 880	\$ -	\$ 8,095	\$ 8,974	\$ 2,912	\$ 3,937,616	\$ 3,834,975	\$ 24,071
23	0.308	\$ 906	\$ -	\$ 8,337	\$ 9,244	\$ 2,849	\$ 3,946,859	\$ 3,837,824	\$ 21,160
24	0.293	\$ 934	\$ -	\$ 8,587	\$ 9,521	\$ 2,788	\$ 3,956,380	\$ 3,840,612	\$ 18,310
25	0.278	\$ 962	\$ -	\$ 8,845	\$ 9,807	\$ 2,729	\$ 3,966,187	\$ 3,843,341	\$ 15,522
26	0.264	\$ 990	\$ -	\$ 9,110	\$ 10,101	\$ 2,670	\$ 3,976,288	\$ 3,846,011	\$ 12,793
27	0.251	\$ 1,020	\$ -	\$ 9,384	\$ 10,404	\$ 2,613	\$ 3,986,691	\$ 3,848,625	\$ 10,123
28	0.239	\$ 1,051	\$ -	\$ 9,665	\$ 10,716	\$ 2,557	\$ 3,997,407	\$ 3,851,182	\$ 7,510
29	0.227	\$ 1,082	\$ -	\$ 9,955	\$ 11,037	\$ 2,503	\$ 4,008,445	\$ 3,853,685	\$ 4,952
30	0.215	\$ 1,115	\$ -	\$ 10,254	\$ 11,369	\$ 2,449	\$ 4,019,813	\$ 3,856,134	\$ 2,449

Description: WQBE_14F_Infiltration Vault Outwash Soil With Property Cost

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA			Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR)	
Description:	WQBE 14F Infiltration Vault Outwash Soil With Property Cost		Estimator:	Jess Dexheimer (HDR)	Version: 2
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Vault on Property			\$	-
2	Vault Assumptions			\$	-
3	Exterior Length	37	FT	\$	-
4	Interior Length	34	FT	\$	-
5	Exterior Width	37	FT	\$	-
6	Interior Width	34	FT	\$	-
7	Interior Structure Height (Ave.)	7.5	FT	\$	-
8	Storage Depth (Ave.)	6.0	FT	\$	-
9	Sediment Storage Depth	0.5	FT	\$	-
10	Freeboard (Ave.)	1.0	FT	\$	-
11	Storage Facility Exterior Footprint Area	1,369	SF	\$	-
12				\$	-
13	Storage Volume			\$	-
14	Storage Facility interior Area	1,156	SF	\$	-
15	Effective Storage Volume (15,500 cf target)	6,936	CF	\$	-
16	Vault Storage Volume	0.05	MG	\$	-
17				\$	-
18	Structure Concrete Assumptions			\$	-
19	Exterior Wall thickness	1.5	FT	\$	-
20	Top Slab Thickness	2	FT	\$	-
21	Flow Spreader Slab thickness	2	FT	\$	-
22	Center column footprint area (2'x2')	4	SF	\$	-
23	Center Column Spacing	5	FT	\$	-
24	Concrete Reinforcing Rebar	225	LB/CY	\$	-
25	Crushed Base Thickness	1	FT	\$	-
26				\$	-
27	Concrete Structure			\$	-
28	Vault Interior Columns at Midspan	8	CY	\$ 650	\$ 5,056
29	Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D)	4	CY	\$ 320	\$ 1,422
30	Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W'	5	CY	\$ 320	\$ 1,612
31	Exterior Wall Concrete	62	CY	\$ 1,250	\$ 77,083
32	Top Slab Concrete	101	CY	\$ 1,250	\$ 126,759
33	Concrete Reinforcing Rebar	40,575	LBS	\$ 1.38	\$ 55,994
34	Crushed Base	51	CY	\$ 64	\$ 3,245
35				\$	-
36	Shoring and Excavation Assumptions			\$	-
37	Construction Room	3	FT	\$	-
38	Tank Bury Depth	2	FT	\$	-
39	Total Excavation Depth	13	FT	\$	-
40	Excavation Length	47	FT	\$	-
41	Excavation Width	47	FT	\$	-
42				\$	-
43	Soil Excavation and Disposal			\$	-
44	Excavation	1,023	CY	\$ 79	\$ 80,792
48	Imported Structure Backfill	490	CY	\$ 44	\$ 21,573
49				\$	-
50	Solder Pile Shoring			\$	-
51	Solder Pile Shaft Depth (3 x Exc. Depth)	38	FT	\$	-
52	Solder Pile Shaft Thickness	2	FT	\$	-
53	Center to Center Shaft Spacing	6	FT	\$	-
54	Rebar in Shaft	114	LB/CY	\$	-
55	Shoring Wall Perimeter	180	FT	\$	-
56	Number of Shafts	30	EA	\$	-
57	Drill Solder Pile Shafts	131	CY	\$ 262	\$ 34,296
58	Set Solder Pile and CDF	131	CY	\$ 391	\$ 51,182
59	Purchase and Salvage Solder Piles	128,250	LB	\$ 0.7	\$ 89,775
60	Tie Backs - one per soldier pile except corners	26	EA	\$ 2,477	\$ 64,402
61	Timber Lagging (64'W X 70'L @ approx. 20'H)	8,178	BF	\$ 9	\$ 73,602
62				\$	-
63	Gates and Access			\$	-
64	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
65	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
66	Access Hatches	2	EA	\$ 13,038	\$ 26,076
67				\$	-
68	Conveyance Pipe			\$	-
69	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
70	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
71	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
72	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
73	Imported Backfill	883	CY	\$ 44	\$ 38,855
74	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
75	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
76	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100')	444	SY	\$ 71	\$ 31,556
77				\$	-
78	Site Removals and Restoration			\$	-
79	Disking or tilling of compacted soil (assumed 1.5 times structure footprint)	368	SY	\$ 4	\$ 1,473
80	Seeding, mulching and compost	368	SY	\$ 10	\$ 3,682
81	Demolish Existing Surface	245	SY	\$ 14	\$ 3,436
82	Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC	245	SY	\$ 71	\$ 17,427
83				\$	-
84	Removals at 4 % Construction Costs	4.0%	LS	\$ 1,101,296	\$ 44,052
85	TESC at 2% of Construction	2%	LS	\$ 1,145,347	\$ 22,907
				\$	-
				\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 1,168,254
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	116,825
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CC	0%	1.0000	\$	-
Item Subtotal Construction Costs (Year 2023)					\$ 1,285,080
Direct: Subtotal Construction Costs					\$ 1,285,100

Description: WQBE 14F - Infiltration Vault Outwash Soil With Property Cost

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Cost Estimating Assumptions:

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.

The vault is assumed to be sited on Outwash soils.

It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.

The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.

Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.

The minimum vault height is 7' deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

Infiltration is achieved through the native soils at the bottom of the structure.

A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet.

The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.

The side walls extend to 1 feet below the vault floor.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

There will be two maintenance hole access locations with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and lagging is required for construction of the structure.

A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.

Trench Box shoring is used.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

Removals are estimated at 4% of the item construction costs.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control is not required.

A street use permit is not required.

The installation is assumed to be on property with easements and acquisition required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10							
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024		
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR)		
Description:	WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW			Version:	2		
DIRECT: SUBTOTAL CONSTRUCTION COSTS							
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost		
1	Infiltration Vault - Outwash Soil (1156 sf bottom area @ 6' Ave. Storage Depth) with High Rate Underground Filter (24 s.f. bottom area) in ROW	1	EA	\$ 1,363,807	\$ 1,363,807		
				\$	-		
				\$	-		
				\$	-		
				\$	-		
				Subtotal Construction Costs	\$ 1,363,807		
	Allowance for Indeterminates (Design Allowance)			\$ 272,761			
	Street Use Permit (Y/N)	Y		\$ 90,000			
	ESTIMATED PROBABLE COST OF CONSTRUCTION BID				\$ 1,726,568		
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS							
	Construction Change Order Allowance			\$ 163,657			
	Subtotal Primary Construction Amount			\$ 1,890,225			
	Construction Sales Tax			\$ 184,523			
	Outside Agency Construction			\$ 136,381			
	TOTAL DIRECT CONSTRUCTION COSTS			\$ 2,211,100			
INDIRECT: NON-CONSTRUCTION COSTS							
	Design Engineering			\$ 415,849			
	Construction Management			\$ 189,022			
	Permitting & Support			\$ 18,902			
	s.f. Land Area	None		Land Purchase/ROW Acquisition	\$ -		
	s.f. Land Area	None		Permanent Easements	\$ -		
				WTD Staff Costs & Non-WTD Support	\$ 113,413		
				Subtotal Non-Construction Costs	\$ 737,188		
				Project Contingency	\$ 884,486		
	TOTAL INDIRECT NON-CONSTRUCTION COSTS				\$ 1,621,700		
	TOTAL PROJECT COST				\$ 3,832,800		

Description: WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW (2023 Dollars)

Unit	1	EA
Initial Capital Cost	\$ 3,832,800	
Capital cost	\$ 3,832,800	/Unit
Total Direct O&M/year	\$ 5,439	
Direct O&M cost	\$ 5,439	/Unit
Capital Replacement Costs (10 Years)	\$ -	/unit
Capital Replacement Costs (20 year equipment)	\$ 56,858	/unit
Discount rate (%)	5.25	

Total Cost (NPV)	\$ 3,992,400	\$/unit
Annual O&M Cost	\$ 6,600	\$/year
Annualized Cost	\$ 1,790	/year

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ 113
Mulch Replacement and Plants	2023 dollars	\$ 653
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360
Subtotal		\$ 1,126
Labor		
Remove Trash, Debris, and Sediment	16	hr
Inspection and joint repair, crack repair	16	hr
Plant Health & Mulch replacement	8	hr
Total hours per year	40	
Raw Labor Rate/Hr		\$ 54
Raw labor cost	(embedded)	\$ 2,176
Labor cost, burdened	O/H 150.0%	\$ 5,439
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30	years

\$ 135.98

Description: WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions (vault):

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

O&M Estimating Assumptions (filter):

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Assume use of vacuum truck. Trips consolidated with vault cleaning.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit. 4 man hours per year, work performed by hand. Total of 4 man hours.

Assumed annual cost of \$113 for mulch.

Annual plant replacement allowance of \$540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

Capital Replacement Assumptions (vault):

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Capital Replacement Assumptions (filter):

No capital replacement within 30-year life per Filterra Owner's Manual.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 53,570		\$ 258,763	\$ 4,201,991	\$ 3,992,429			
0	1.000	\$ 3,832,800		\$ 3,832,800	\$ 3,832,800	\$ 3,832,800	\$ 3,832,800	\$ 3,832,800	\$ 3,992,429
1	0.950	\$ 1,126	\$ -	\$ 5,439	\$ 6,565	\$ 6,238	\$ 3,839,365	\$ 3,839,038	\$ 159,229
2	0.903	\$ 1,160	\$ -	\$ 5,602	\$ 6,762	\$ 6,104	\$ 3,846,127	\$ 3,845,142	\$ 153,391
3	0.858	\$ 1,195	\$ -	\$ 5,770	\$ 6,965	\$ 5,974	\$ 3,853,092	\$ 3,851,118	\$ 147,287
4	0.815	\$ 1,230	\$ -	\$ 5,943	\$ 7,174	\$ 5,846	\$ 3,860,266	\$ 3,856,961	\$ 141,313
5	0.774	\$ 1,267	\$ -	\$ 6,122	\$ 7,389	\$ 5,721	\$ 3,867,654	\$ 3,862,682	\$ 135,467
6	0.736	\$ 1,305	\$ -	\$ 6,305	\$ 7,611	\$ 5,599	\$ 3,875,263	\$ 3,868,281	\$ 129,746
7	0.699	\$ 1,345	\$ -	\$ 6,494	\$ 7,839	\$ 5,479	\$ 3,883,104	\$ 3,873,760	\$ 124,148
8	0.664	\$ 1,385	\$ -	\$ 6,689	\$ 8,074	\$ 5,362	\$ 3,891,178	\$ 3,879,122	\$ 118,669
9	0.631	\$ 1,426	\$ -	\$ 6,890	\$ 8,316	\$ 5,247	\$ 3,899,495	\$ 3,884,369	\$ 113,307
10	0.599	\$ 1,469	\$ -	\$ 7,097	\$ 8,566	\$ 5,135	\$ 3,908,060	\$ 3,888,504	\$ 108,060
11	0.570	\$ 1,513	\$ -	\$ 7,310	\$ 8,823	\$ 5,025	\$ 3,916,883	\$ 3,894,530	\$ 102,924
12	0.541	\$ 1,559	\$ -	\$ 7,529	\$ 9,087	\$ 4,918	\$ 3,925,971	\$ 3,899,448	\$ 97,899
13	0.514	\$ 1,605	\$ -	\$ 7,755	\$ 9,360	\$ 4,813	\$ 3,935,331	\$ 3,904,260	\$ 92,981
14	0.489	\$ 1,654	\$ -	\$ 7,987	\$ 9,641	\$ 4,710	\$ 3,944,972	\$ 3,909,970	\$ 88,168
15	0.464	\$ 1,703	\$ -	\$ 8,227	\$ 9,930	\$ 4,609	\$ 3,954,902	\$ 3,913,579	\$ 83,459
16	0.441	\$ 1,754	\$ -	\$ 8,474	\$ 10,228	\$ 4,511	\$ 3,965,130	\$ 3,918,090	\$ 78,849
17	0.419	\$ 1,807	\$ -	\$ 8,728	\$ 10,535	\$ 4,414	\$ 3,975,665	\$ 3,922,504	\$ 74,339
18	0.398	\$ 1,861	\$ -	\$ 8,980	\$ 10,851	\$ 4,320	\$ 3,986,516	\$ 3,926,824	\$ 69,925
19	0.378	\$ 1,917	\$ -	\$ 9,260	\$ 11,176	\$ 4,228	\$ 3,997,692	\$ 3,931,052	\$ 65,605
20	0.359	\$ 1,974	\$ 56,858	\$ 9,537	\$ 68,370	\$ 24,571	\$ 4,066,062	\$ 3,955,023	\$ 61,377
21	0.341	\$ 2,034	\$ -	\$ 9,823	\$ 11,857	\$ 4,049	\$ 4,077,920	\$ 3,959,672	\$ 56,806
22	0.324	\$ 2,095	\$ -	\$ 10,118	\$ 12,213	\$ 3,962	\$ 4,090,132	\$ 3,963,634	\$ 52,757
23	0.308	\$ 2,158	\$ -	\$ 10,422	\$ 12,579	\$ 3,877	\$ 4,102,712	\$ 3,967,511	\$ 48,795
24	0.293	\$ 2,222	\$ -	\$ 10,734	\$ 12,957	\$ 3,795	\$ 4,115,668	\$ 3,971,306	\$ 44,918
25	0.278	\$ 2,289	\$ -	\$ 11,056	\$ 13,345	\$ 3,713	\$ 4,129,014	\$ 3,975,019	\$ 41,123
26	0.264	\$ 2,358	\$ -	\$ 11,388	\$ 13,746	\$ 3,634	\$ 4,142,759	\$ 3,978,653	\$ 37,410
27	0.251	\$ 2,428	\$ -	\$ 11,730	\$ 14,158	\$ 3,556	\$ 4,156,917	\$ 3,982,209	\$ 33,776
28	0.239	\$ 2,501	\$ -	\$ 12,082	\$ 14,583	\$ 3,480	\$ 4,171,500	\$ 3,985,690	\$ 30,219
29	0.227	\$ 2,576	\$ -	\$ 12,444	\$ 15,020	\$ 3,406	\$ 4,186,520	\$ 3,989,096	\$ 6,739
30	0.215	\$ 2,653	\$ -	\$ 12,817	\$ 15,471	\$ 3,333	\$ 4,201,991	\$ 3,992,429	\$ 3,333

Description: WQBE_14G_Infiltration Vault Outwash Soil with High Rate Underground Filter System in ROW

An infiltration vault is an open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

General

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of-way. No property easements or acquisition are required.
Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.

Infiltration Vault

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost

Unit	1	EA
Initial Capital Cost	\$ 4,215,800	
Capital cost	\$ 4,215,800	/Unit
Total Direct O&M/year	\$ 5,439	
Direct O&M cost	\$ 5,439	/Unit
Capital Replacement Costs (10 Years)	\$ -	/unit
Capital Replacement Costs (20 year equipment)	\$ 56,900	/unit
Discount rate (%)	5.25	

Total Cost (NPV)	\$ 4,375,400	\$/unit
Annual O&M Cost	\$ 6,600	\$/year
Annualized Cost	\$ 1,790	/year

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ 113
Mulch Replacement and Plants	2023 dollars	\$ 653
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360

Subtotal \$ 1,126

Labor

Remove Trash, Debris, and Sediment	16 hr
Inspection and joint repair, crack repair	16 hr
Plant Health & Mulch replacement	8 hr
Total hours per year	40
Raw Labor Rate/hr	\$ 54
Raw labor cost	(embedded) \$ 2,176
Labor cost, burdened	O/H 150.0% \$ 5,439
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System with Property Cost

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions (vault):

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

O&M Estimating Assumptions (filter):

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Assume use of vacuum truck. Trips consolidated with vault cleaning.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit. 4 man hours per year, work performed by hand. Total of 4 man hours.

Assumed annual cost of \$113 for mulch.

Annual plant replacement allowance of \$540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

Capital Replacement Assumptions (vault):

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Capital Replacement Assumptions (filter):

No capital replacement within 30-year life per Filtra Owner's Manual.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 53,570		\$ 258,763	\$ 4,585,033	\$ 4,375,444			
0	1.000	\$ 4,215,800		\$ 4,215,800	\$ 4,215,800	\$ 4,215,800	\$ 4,215,800	\$ 4,375,444	
1	0.950	\$ 1,126	\$ -	\$ 5,439	\$ 6,565	\$ 6,238	\$ 4,222,365	\$ 4,222,038	\$ 159,644
2	0.903	\$ 1,160	\$ -	\$ 5,602	\$ 6,762	\$ 6,104	\$ 4,229,127	\$ 4,228,142	\$ 153,406
3	0.858	\$ 1,195	\$ -	\$ 5,770	\$ 6,965	\$ 5,974	\$ 4,236,092	\$ 4,234,115	\$ 147,302
4	0.815	\$ 1,230	\$ -	\$ 5,943	\$ 7,174	\$ 5,846	\$ 4,243,266	\$ 4,239,961	\$ 141,326
5	0.774	\$ 1,267	\$ -	\$ 6,122	\$ 7,389	\$ 5,721	\$ 4,250,654	\$ 4,245,682	\$ 135,482
6	0.736	\$ 1,305	\$ -	\$ 6,305	\$ 7,611	\$ 5,599	\$ 4,258,265	\$ 4,251,281	\$ 129,761
7	0.699	\$ 1,345	\$ -	\$ 6,494	\$ 7,839	\$ 5,479	\$ 4,266,104	\$ 4,256,760	\$ 124,163
8	0.664	\$ 1,385	\$ -	\$ 6,689	\$ 8,074	\$ 5,362	\$ 4,274,178	\$ 4,262,122	\$ 118,684
9	0.631	\$ 1,426	\$ -	\$ 6,870	\$ 8,316	\$ 5,247	\$ 4,282,495	\$ 4,267,369	\$ 113,322
10	0.599	\$ 1,469	\$ -	\$ 7,097	\$ 8,566	\$ 5,135	\$ 4,291,060	\$ 4,272,504	\$ 108,074
11	0.570	\$ 1,513	\$ -	\$ 7,310	\$ 8,823	\$ 5,025	\$ 4,299,883	\$ 4,277,530	\$ 102,939
12	0.541	\$ 1,559	\$ -	\$ 7,529	\$ 9,087	\$ 4,918	\$ 4,308,971	\$ 4,282,448	\$ 97,914
13	0.514	\$ 1,605	\$ -	\$ 7,755	\$ 9,360	\$ 4,813	\$ 4,318,331	\$ 4,287,260	\$ 92,996
14	0.489	\$ 1,654	\$ -	\$ 7,987	\$ 9,641	\$ 4,710	\$ 4,327,972	\$ 4,291,970	\$ 88,183
15	0.464	\$ 1,703	\$ -	\$ 8,227	\$ 9,930	\$ 4,609	\$ 4,337,902	\$ 4,296,579	\$ 83,474
16	0.441	\$ 1,754	\$ -	\$ 8,474	\$ 10,228	\$ 4,511	\$ 4,346,130	\$ 4,301,090	\$ 78,864
17	0.419	\$ 1,807	\$ -	\$ 8,728	\$ 10,535	\$ 4,414	\$ 4,358,668	\$ 4,305,504	\$ 74,354
18	0.398	\$ 1,861	\$ -	\$ 8,990	\$ 10,851	\$ 4,320	\$ 4,369,516	\$ 4,309,824	\$ 69,939
19	0.378	\$ 1,917	\$ -	\$ 9,260	\$ 11,176	\$ 4,228	\$ 4,380,692	\$ 4,314,052	\$ 65,620
20	0.359	\$ 1,974	\$ 56,900	\$ 9,537	\$ 68,412	\$ 4,228	\$ 4,449,104	\$ 4,338,638	\$ 61,392
21	0.341	\$ 2,034	\$ -	\$ 9,823	\$ 11,857	\$ 4,049	\$ 4,460,961	\$ 4,342,686	\$ 36,806
22	0.324	\$ 2,095	\$ -	\$ 10,118	\$ 12,213	\$ 3,962	\$ 4,473,174	\$ 4,346,649	\$ 32,757
23	0.308	\$ 2,158	\$ -	\$ 10,422	\$ 12,579	\$ 3,877	\$ 4,485,753	\$ 4,350,526	\$ 28,795
24	0.293	\$ 2,222	\$ -	\$ 10,734	\$ 12,957	\$ 3,795	\$ 4,498,710	\$ 4,354,321	\$ 24,918
25	0.278	\$ 2,289	\$ -	\$ 11,056	\$ 13,345	\$ 3,713	\$ 4,512,059	\$ 4,358,034	\$ 21,123
26	0.264	\$ 2,358	\$ -	\$ 11,388	\$ 13,746	\$ 3,634	\$ 4,525,801	\$ 4,361,668	\$ 17,410
27	0.251	\$ 2,428	\$ -	\$ 11,730	\$ 14,158	\$ 3,556	\$ 4,539,959	\$ 4,365,224	\$ 13,776
28	0.239	\$ 2,501	\$ -	\$ 12,082	\$ 14,583	\$ 3,480	\$ 4,554,542	\$ 4,368,705	\$ 10,219
29	0.227	\$ 2,576	\$ -	\$ 12,444	\$ 15,020	\$ 3,406	\$ 4,569,562	\$ 4,372,111	\$ 6,739
30	0.215	\$ 2,653	\$ -	\$ 12,817	\$ 15,471	\$ 3,333	\$ 4,585,033	\$ 4,375,444	\$ 3,333

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kirner (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System With Property Cost		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Infiltration Vault on Property			\$	-
2	Vault Assumptions			\$	-
3	Exterior Length	37	FT	\$	-
4	Interior Length	34	FT	\$	-
5	Exterior Width	37	FT	\$	-
6	Interior Width	34	FT	\$	-
7	Interior Structure Height (Ave.)	7.5	FT	\$	-
8	Storage Depth (Ave.)	6.0	FT	\$	-
9	Sediment Storage Depth	0.5	FT	\$	-
10	Freeboard (Ave.)	1.0	FT	\$	-
11	Storage Facility Exterior Footprint Area	1,369	SF	\$	-
12				\$	-
13	Storage Volume			\$	-
14	Storage Facility interior Area	1,156	SF	\$	-
15	Effective Storage Volume (15,500 cf target)	6,936	CF	\$	-
16	Vault Storage Volume	0.05	MG	\$	-
17				\$	-
18	Structure Concrete Assumptions			\$	-
19	Exterior Wall thickness	1.5	FT	\$	-
20	Top Slab Thickness	2	FT	\$	-
21	Flow Spreader Slab thickness	2	FT	\$	-
22	Center column footprint area (2'x2')	4	SF	\$	-
23	Center Column Spacing	5	FT	\$	-
24	Concrete Reinforcing Rebar	225	LB/CY	\$	-
25	Crushed Base Thickness	1	FT	\$	-
26				\$	-
27	Concrete Structure			\$	-
28	Vault Interior Columns at Midspan	8	CY	\$ 650	\$ 5,056
29	Slab under Flow Control/discharge (est. 6'W X 10'L X 2'D)	4	CY	\$ 320	\$ 1,422
30	Stormwater Flow Spreader Sump w/Lip Bottom Slab - 2' D x 2XL X 36W'	5	CY	\$ 320	\$ 1,612
31	Exterior Wall Concrete	62	CY	\$ 1,250	\$ 77,983
32	Top Slab Concrete	101	CY	\$ 1,250	\$ 126,759
33	Concrete Reinforcing Rebar	40,575	LBS	\$ 1.38	\$ 55,994
34	Crushed Base	51	CY	\$ 64	\$ 3,245
35				\$	-
36	Shoring and Excavation Assumptions			\$	-
37	Construction Room	3	FT	\$	-
38	Tank Bury Depth	2	FT	\$	-
39	Total Excavation Depth	13	FT	\$	-
40	Excavation Length	47	FT	\$	-
41	Excavation Width	47	FT	\$	-
42				\$	-
43	Soil Excavation and Disposal			\$	-
44	Excavation	1,023	CY	\$ 79	\$ 80,792
45	Imported Structure Backfill	490	CY	\$ 44	\$ 21,573
46				\$	-
50	Solder Pile Shoring			\$	-
51	Solder Pile Shaft Depth (3 x Exc. Depth)	38	FT	\$	-
52	Solder Pile Shaft Thickness	2	FT	\$	-
53	Center to Center Shaft Spacing	6	FT	\$	-
54	Rebar in Shaft	114	LB/CY	\$	-
55	Shoring Wall Perimeter	180	FT	\$	-
56	Number of Shafts	30	EA	\$	-
57	Drill Solder Pile Shafts	131	CY	\$ 262	\$ 34,296
58	Set Solder Pile and CDF	131	CY	\$ 391	\$ 51,182
59	Purchase and Salvage Solder Piles	128,250	LB	\$ 0.7	\$ 89,775
60	Tie Backs - one per soldier pile except corners	26	EA	\$ 2,477	\$ 64,402
61	Timber Lagging (64'W X 70'L @ approx. 20'H)	8,178	BF	\$ 9	\$ 73,602
62				\$	-
63	Gates and Access			\$	-
64	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
65	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
66	Access Hatches	2	EA	\$ 13,038	\$ 26,076
67				\$	-
68	Conveyance Pipe			\$	-
69	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
70	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
71	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
72	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
73	Imported Backfill	883	CY	\$ 44	\$ 38,855
74	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
75	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
76	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20' X 100')	444	SY	\$ 71	\$ 31,556
77				\$	-
78	Site Removals and Restoration			\$	-
79	Disking or tilling of compacted soil (assumed 1.5 times structure footprint)	368	SY	\$ 4	\$ 1,473
80	Seeding, mulching and compost	368	SY	\$ 10	\$ 3,682
81	Demolish Existing Surface	245	SY	\$ 14	\$ 3,436
82	Pavement Remove and Restoration (Vault) - 4" HMA/4"CSBC	245	SY	\$ 71	\$ 17,427
83				\$	-
72	High Rate Underground Filter			\$	-
73	Filterra Unit 4X6" (complete)	1	EA	\$ 22,165	\$ 22,165
74	Structural Excavation to Waste (10'W X12'L X 5'D) + (50'LX5'WX6'D)	78	CY	\$ 79	\$ 6,123
75	Imported Structural Fill	73	CY	\$ 44	\$ 3,247
76	Crushed Base	1	CY	\$ 64	\$ 64
77	Inlet Drain w/Energy Dissipating Rocks	1	EA	\$ 1,481	\$ 1,481
78	Catch Basin	1	EA	\$ 3,900	\$ 3,900
79	Pipe 8" dia.	50	LF	\$ 80	\$ 4,000
80	Trench Box Shoring (Shallow)	390	SF	\$ 10	\$ 3,838
81				\$	-
82	Restoration High Rate Underground Filter			\$	-
83	Landscaping, planting, and restoration (Filter and 8" Pipe)	39	SY	\$ 59	\$ 2,296
84	Street Tree	1	EA	\$ 720	\$ 720
103				\$	-
104	Removals at 4 % Construction Costs	4.0%	LS	\$ 1,149,129	\$ 45,965
105	TESC at 2% of Construction	2%	LS	\$ 1,395,094	\$ 23,902
				\$	-
				\$	-
				Item Subtotal Construction Costs (Year 2023)	\$ 1,218,996
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	121,900
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
	Item Subtotal Construction Costs (Year 2023)			\$	1,340,895
				Direct: Subtotal Construction Costs	\$ 1,340,895

Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System With Property Cost

An infiltration vault is an open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

General

Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

Infiltration Vault

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSDWM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **.50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter
System without Property Cost

Unit	1 EA
Initial Capital Cost	\$ 3,771,200
Capital cost	\$ 3,771,200 \$/Unit
Total Direct O&M/year	\$ 5,439
Direct O&M cost	\$ 5,439 \$/Unit
Capital Replacement Costs (10 Years)	\$ - \$/unit
Capital Replacement Costs (20 year equipment)	\$ 56,858 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 3,930,800	\$/unit
Annual O&M Cost	\$ 6,600	\$/year
Annualized Cost	\$ 1,790	\$/year

Materials, Supplies, Other Costs

Cement Patching	2023 dollars	\$ 113
Mulch Replacement and Plants	2023 dollars	\$ 653 \$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360 \$/year

Subtotal \$ 1,126

Labor

Remove Trash, Debris, and Sediment	16 hr
Inspection and joint repair, crack repair	16 hr
Plant Health & Mulch replacement	8 hr
Total hours per year	40
Raw Labor Rate/hr	\$ 54
Raw labor cost	(embedded) \$ 2,176
Labor cost, burdened	O/H 150.0% \$ 5,439
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Description: WQBE_14I_Infiltration Vault Outwash Soil with High Rate Underground Filter
System without Property Cost

Open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions (vault):

Removal of all sediment and debris from storage area annually with a crew of 2 over an 8 hour work day, assume use of vactor truck.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Inspection and repair of joints, vault walls, cracks wider than 1/2 inch annually with a crew of 2 over an 8 hour work day. Assume annual cost of \$113 for cement patching mix.

O&M Estimating Assumptions (filter):

Removal of trash, debris and sediment from facility performed biannually and an assumed 1 major storm event (3 visits) by 2 crew members, 1 hour per visit for a total of 6 man hours per year. Assume use of vacuum truck. Trips consolidated with vault cleaning.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 1 hour per visit. 4 man hours per year, work performed by hand. Total of 4 man hours.

Assumed annual cost of \$113 for mulch.

Annual plant replacement allowance of \$540. Will allow for the replacement of approximately 10 shrubs or other medium sized plant material.

Capital Replacement Assumptions (vault):

Complete replacement of mechanical equipment every twenty years (flow restrictor) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 53,570	\$ 258,763	\$ 4,140,391	\$ 3,930,829				
0	1.000	\$ 3,771,200		\$ 3,771,200	\$ 3,771,200	\$ 3,771,200	\$ 3,771,200	\$ 3,771,200	\$ 3,771,200
1	0.950	\$ 1,126	\$ -	\$ 5,439	\$ 6,565	\$ 6,238	\$ 3,777,765	\$ 3,777,438	\$ 159,629
2	0.903	\$ 1,160	\$ -	\$ 5,602	\$ 6,762	\$ 6,104	\$ 3,784,527	\$ 3,783,542	\$ 153,391
3	0.858	\$ 1,195	\$ -	\$ 5,770	\$ 6,965	\$ 5,974	\$ 3,791,492	\$ 3,789,515	\$ 147,287
4	0.815	\$ 1,230	\$ -	\$ 5,943	\$ 7,174	\$ 5,846	\$ 3,798,666	\$ 3,795,361	\$ 141,313
5	0.774	\$ 1,267	\$ -	\$ 6,122	\$ 7,389	\$ 5,721	\$ 3,806,054	\$ 3,801,082	\$ 135,467
6	0.736	\$ 1,305	\$ -	\$ 6,305	\$ 7,611	\$ 5,599	\$ 3,813,665	\$ 3,806,681	\$ 129,746
7	0.699	\$ 1,345	\$ -	\$ 6,494	\$ 7,839	\$ 5,479	\$ 3,821,504	\$ 3,812,160	\$ 124,148
8	0.664	\$ 1,385	\$ -	\$ 6,689	\$ 8,074	\$ 5,362	\$ 3,829,578	\$ 3,817,522	\$ 118,669
9	0.631	\$ 1,426	\$ -	\$ 6,870	\$ 8,316	\$ 5,247	\$ 3,837,895	\$ 3,822,769	\$ 113,307
10	0.599	\$ 1,469	\$ -	\$ 7,097	\$ 8,566	\$ 5,135	\$ 3,846,460	\$ 3,827,904	\$ 108,060
11	0.570	\$ 1,513	\$ -	\$ 7,310	\$ 8,823	\$ 5,025	\$ 3,855,283	\$ 3,832,930	\$ 102,924
12	0.541	\$ 1,559	\$ -	\$ 7,529	\$ 9,087	\$ 4,918	\$ 3,864,371	\$ 3,837,848	\$ 97,899
13	0.514	\$ 1,605	\$ -	\$ 7,755	\$ 9,360	\$ 4,813	\$ 3,873,731	\$ 3,842,660	\$ 92,981
14	0.489	\$ 1,654	\$ -	\$ 7,987	\$ 9,641	\$ 4,710	\$ 3,883,372	\$ 3,847,370	\$ 88,168
15	0.464	\$ 1,703	\$ -	\$ 8,227	\$ 9,930	\$ 4,609	\$ 3,893,302	\$ 3,851,979	\$ 83,459
16	0.441	\$ 1,754	\$ -	\$ 8,474	\$ 10,228	\$ 4,511	\$ 3,903,530	\$ 3,856,490	\$ 78,849
17	0.419	\$ 1,807	\$ -	\$ 8,728	\$ 10,535	\$ 4,414	\$ 3,914,068	\$ 3,860,904	\$ 74,339
18	0.398	\$ 1,861	\$ -	\$ 8,990	\$ 10,851	\$ 4,320	\$ 3,924,916	\$ 3,865,224	\$ 69,925
19	0.378	\$ 1,917	\$ -	\$ 9,260	\$ 11,176	\$ 4,228	\$ 3,936,092	\$ 3,869,452	\$ 65,605
20	0.359	\$ 1,974	\$ 56,858	\$ 9,537	\$ 68,370	\$ 24,571	\$ 4,004,462	\$ 3,894,023	\$ 61,377
21	0.341	\$ 2,034	\$ -	\$ 9,823	\$ 11,857	\$ 4,049	\$ 4,016,320	\$ 3,898,072	\$ 36,806
22	0.324	\$ 2,095	\$ -	\$ 10,118	\$ 12,213	\$ 3,962	\$ 4,028,532	\$ 3,902,034	\$ 32,757
23	0.308	\$ 2,158	\$ -	\$ 10,422	\$ 12,579	\$ 3,877	\$ 4,041,112	\$ 3,905,911	\$ 28,795
24	0.293	\$ 2,222	\$ -	\$ 10,734	\$ 12,957	\$ 3,795	\$ 4,054,068	\$ 3,909,706	\$ 24,918
25	0.278	\$ 2,289	\$ -	\$ 11,056	\$ 13,345	\$ 3,713	\$ 4,067,414	\$ 3,913,419	\$ 21,123
26	0.264	\$ 2,358	\$ -	\$ 11,388	\$ 13,746	\$ 3,634	\$ 4,081,159	\$ 3,917,053	\$ 17,410
27	0.251	\$ 2,428	\$ -	\$ 11,730	\$ 14,158	\$ 3,556	\$ 4,095,317	\$ 3,920,609	\$ 13,776
28	0.239	\$ 2,501	\$ -	\$ 12,082	\$ 14,583	\$ 3,480	\$ 4,109,900	\$ 3,924,090	\$ 10,219
29	0.227	\$ 2,576	\$ -	\$ 12,444	\$ 15,020	\$ 3,406	\$ 4,124,920	\$ 3,927,496	\$ 6,739
30	0.215	\$ 2,653	\$ -	\$ 12,817	\$ 15,471	\$ 3,333	\$ 4,140,391	\$ 3,930,829	\$ 3,333

Description: WQBE_14H_Infiltration Vault Outwash Soil with High Rate Underground Filter System Without Property Cost

An infiltration vault is an open bottomed, box-shaped underground facility stores and infiltrates stormwater runoff. Pretreatment is provided by a High Rate Underground Filter, described as an underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in ultra urban settings and may be proprietary.

Cost Estimating Assumptions:

General

Removals are estimated at 4% of the item construction costs.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control is not required.
A street use permit is not required.
The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

Infiltration Vault

The infiltration vault installation is per the King Co. Stormwater Design Manual Section 5.2.4.
The vault is assumed to be sited on Outwash soils.
It is assumed that the area soils are considered suitable for an infiltration facility and that dewatering is not required. Geotechnical and groundwater evaluation are recommended should this option move forward to conceptual design.
The vault is assumed to drain by gravity via a flow restricting device and has an effective storage of approximately 0.05 MG.
The flow control device meets the applicable requirements of KCSDWM Section 5.1.4.
The facility is an underground cast in place concrete structure with an interior storage and infiltration area of 1156 square feet and a maximum storage depth of 6 feet deep.
Vault has interior dimensions of 34'W x 34'L with an average interior height of 7.5'.
The minimum vault height is 7' deep at the shallowest end.
The vault side slopes are a minimum of 5% towards the center of the vault.
Infiltration is achieved through the native soils at the bottom of the structure.
A minimum of 0.5 feet for sediment storage and a minimum of 1 feet of freeboard depth are assumed.
Exterior and interior wall thickness is 1.5 feet.
Top slab thickness is 2 feet.
The bottom is open with a flow spreader provided at the entrance and a concrete base provided near the outlet.
The side walls extend to 1 feet below the vault floor.
The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.
No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.
The shafts are 3 times the excavation depth
The vault is open bottom and it is assumed to be sited where it will not be subject to buoyancy factors. It is assumed that the vault will be positively anchored to the shoring piles.
All metal is galvanized or stainless steel per SW Manual.
Access hatches are provided as shown on the WTD detail.
There will be two maintenance hole access locations with ladder rungs.
The excavated material is unsuitable for use as backfill.
An excavation width of 3 feet is assumed on each side of the structure.
Shoring and lagging is required for construction of the structure.
A total of 200 LF of 12" storm pipe is required to connect to the upstream and downstream main or structure.
Trench Box shoring is used.
The storage vault, facility inlet and outlet pipes are sited beneath a parking area.
It is assumed that the construction and staging work will be completed in an area that requires seeding for restoration.

High Rate Underground Filter

Facility design is per Filterra Design Recommendations. Prototypical sizing based on Filterra Bioscape External Bypass. The structure walls and bottom are assumed to be 6" thick.
The facility treatment area is 24 sf (4'X6') with dimensions per Filterra Detail Sheets.
21" of proprietary Filterra treatment media is used.
An excavation width of 3 feet is assumed on each side of the precast box. Construction is as shown on the Calculation tab.
Facility is sited on the roadside and assumes curb and gutter and roadway restoration to accommodate the facility width.
A total of 50 LF of 8" storm pipe is required to connect to the deep UIC well.
A stormwater catch basin and structure inlets and rock energy dissipators are included with the installation.
Concrete curb, gutter, and sidewalk removal and restoration will be required for the installation.
An irrigation system is not included in the cost model.
Landscape restoration with one tree is assumed for each restoration site.
The facility is located within the ROW and Traffic control is required. Traffic conditions are assumed to be heavy for the urban setting and light for the rural setting.

Planning Basis Assumptions:

No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.
Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **.50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE 18A_Wetpond on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 869,200
Capital cost	\$ 869,200 \$/Unit
Total Direct O&M/Year	\$ 1,632
Direct O&M cost	\$ 1,632 \$/Unit
Capital Replacement Costs (10 Years)	\$ 13,124 \$/unit
Discount rate (%)	5.25
Total Cost (NPV)	\$ 929,200 \$/unit
Annual O&M Cost	\$ 2,200 \$/year
Annualized Cost	\$960 \$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Erosion Repair Materials	2023 dollars	\$ 246	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$606	
Labor			
Remove Trash, Debris, and Sediment		4 hr	
Removal of oil sheen		2 hr	
Remediation of erosion		6 hr	
		0 hr	
Total hours per year		12	
Raw Labor Rate/Hr		\$ 54	
Raw labor cost	(embedded)	\$ 653	
Labor cost, burdened	O/H 150.0%	\$ 1,632	
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 28,831		\$ 77,629	\$ 1,001,907	\$ 929,229			
0	1.000	\$ 869,200		\$ -	\$ 869,200	\$ 869,200	\$ 869,200	\$ 869,200	\$ 929,229
1	0.950	\$ 606	\$ -	\$ 1,632	\$ 2,238	\$ 2,126	\$ 871,438	\$ 871,326	\$ 60,029
2	0.903	\$ 624	\$ -	\$ 1,681	\$ 2,305	\$ 2,081	\$ 873,743	\$ 873,407	\$ 57,903
3	0.858	\$ 643	\$ -	\$ 1,731	\$ 2,374	\$ 2,036	\$ 876,117	\$ 875,443	\$ 55,822
4	0.815	\$ 662	\$ -	\$ 1,783	\$ 2,445	\$ 1,993	\$ 878,562	\$ 877,435	\$ 53,786
5	0.774	\$ 682	\$ -	\$ 1,836	\$ 2,519	\$ 1,950	\$ 881,080	\$ 879,386	\$ 51,793
6	0.736	\$ 703	\$ -	\$ 1,892	\$ 2,594	\$ 1,908	\$ 883,674	\$ 881,294	\$ 49,843
7	0.699	\$ 724	\$ -	\$ 1,948	\$ 2,672	\$ 1,868	\$ 886,346	\$ 883,161	\$ 47,935
8	0.664	\$ 745	\$ -	\$ 2,007	\$ 2,752	\$ 1,828	\$ 889,098	\$ 884,989	\$ 46,067
9	0.631	\$ 768	\$ -	\$ 2,067	\$ 2,835	\$ 1,789	\$ 891,933	\$ 886,778	\$ 44,240
10	0.599	\$ 791	\$ 13,124	\$ 2,129	\$ 16,043	\$ 9,618	\$ 907,976	\$ 896,395	\$ 42,451
11	0.570	\$ 814	\$ -	\$ 2,193	\$ 3,007	\$ 1,713	\$ 910,984	\$ 898,108	\$ 32,834
12	0.541	\$ 839	\$ -	\$ 2,259	\$ 3,098	\$ 1,676	\$ 914,081	\$ 899,784	\$ 31,121
13	0.514	\$ 864	\$ -	\$ 2,326	\$ 3,190	\$ 1,640	\$ 917,271	\$ 901,425	\$ 29,444
14	0.489	\$ 890	\$ -	\$ 2,396	\$ 3,286	\$ 1,605	\$ 920,558	\$ 903,030	\$ 27,804
15	0.464	\$ 917	\$ -	\$ 2,468	\$ 3,385	\$ 1,571	\$ 923,942	\$ 904,601	\$ 26,199
16	0.441	\$ 944	\$ -	\$ 2,542	\$ 3,486	\$ 1,537	\$ 927,429	\$ 906,139	\$ 24,627
17	0.419	\$ 972	\$ -	\$ 2,618	\$ 3,591	\$ 1,505	\$ 931,019	\$ 907,643	\$ 23,090
18	0.398	\$ 1,002	\$ -	\$ 2,697	\$ 3,699	\$ 1,472	\$ 934,718	\$ 909,116	\$ 21,585
19	0.378	\$ 1,032	\$ -	\$ 2,778	\$ 3,810	\$ 1,441	\$ 938,528	\$ 910,557	\$ 20,113
20	0.359	\$ 1,063	\$ 13,124	\$ 2,861	\$ 17,047	\$ 6,127	\$ 955,575	\$ 916,683	\$ 18,672
21	0.341	\$ 1,095	\$ -	\$ 2,947	\$ 4,042	\$ 1,380	\$ 959,616	\$ 918,063	\$ 12,545
22	0.324	\$ 1,127	\$ -	\$ 3,035	\$ 4,163	\$ 1,351	\$ 963,779	\$ 919,414	\$ 11,165
23	0.308	\$ 1,161	\$ -	\$ 3,127	\$ 4,288	\$ 1,322	\$ 968,067	\$ 920,735	\$ 9,815
24	0.293	\$ 1,196	\$ -	\$ 3,220	\$ 4,416	\$ 1,293	\$ 972,483	\$ 922,029	\$ 8,493
25	0.278	\$ 1,232	\$ -	\$ 3,317	\$ 4,549	\$ 1,266	\$ 977,032	\$ 923,295	\$ 7,200
26	0.264	\$ 1,269	\$ -	\$ 3,416	\$ 4,685	\$ 1,239	\$ 981,717	\$ 924,533	\$ 5,934
27	0.251	\$ 1,307	\$ -	\$ 3,519	\$ 4,826	\$ 1,212	\$ 986,543	\$ 925,745	\$ 4,696
28	0.239	\$ 1,346	\$ -	\$ 3,624	\$ 4,971	\$ 1,186	\$ 991,514	\$ 926,932	\$ 3,483
29	0.227	\$ 1,386	\$ -	\$ 3,733	\$ 5,120	\$ 1,161	\$ 996,633	\$ 928,093	\$ 2,297
30	0.215	\$ 1,428	\$ -	\$ 3,845	\$ 5,273	\$ 1,136	\$ 1,001,907	\$ 929,229	\$ 1,136

Description: WQBE 18A_Wetpond on Public Property

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment. Labor shall include 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck and 4 man hours each year.

Removal of visible oil sheen by using a vactor truck. Labor shall include 2 crew members, 1 visit per 2 year, 1 hours per visit; 2 man hours each year.

Areas that have over 6 inches of erosion shall be repaired biannually or after a major storm event. 2 crew members, 3 visits per year, 1 hour per visit, 6 man hours per year. Assume annual cost of 6 erosion repair materials of \$246.

Capital Replacement Assumptions:

Replacement of items highlighted in blue on estimate sheet every 10 years (i.e. riprap pads, gates, etc.)

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR)
Description:	WQBE 18A_Wetpond on Public Property			Version:	Jess Dexheimer (HDR) 2
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Pond Upper Cell #1 (Sediment)	4	FT Depth	\$ -	\$ -
2	Bottom Area @ 1/3 Volume of Wetpond Facility	40	SF	\$ -	\$ -
3	Top Area@ 3:1 Side Slopes	928	SF	\$ -	\$ -
4	Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner	140	CY	\$ 79	\$ 11,095
5	Imported Treatment Liner @ 2' thick	69	CY	\$ 105	\$ 7,218
6				\$ -	\$ -
7	Wetpond Excavation Volume (16.7'W X 33.3'L X 4'D)	4	FT Depth	\$ -	\$ -
8	Bottom Area @ 3:1 Side Slopes	553	SF	\$ -	\$ -
9	Top Area@ 3:1 Side Slopes	2329	SF	\$ -	\$ -
10	Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner	386	CY	\$ 79	\$ 30,494
11	Imported Fill for Compacted Berm Embankment - Between First & Second Cell (@244 LF and 45 sq ft./ft cross section area)	407	CY	\$ 44	\$ 17,893
12	Embankment Compaction	407	CY	\$ 22	\$ 8,947
13	Imported Treatment Liner @ 2' thick	173	CY	\$ 105	\$ 18,114
14	Riprap Lining for Pre-settling and Infiltration Pond Overflow Spillways (6'WX12'LX2'D)	11	CY	\$ 346	\$ 3,691
15	Access Roadway to site (4" HMA/4" CSBC)	267	SY	\$ 71	\$ 18,933
16	Access Gate (16 ft wide gate)	1	EA	\$ 3,085	\$ 3,085
17				\$ -	\$ -
18	Outlet Pipe			\$ -	\$ -
19	Pipe - 12" PVC	100	LF	\$ 140	\$ 14,000
20	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
21	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
22	Control Structure with grate, clean out drain, and gate	1	EA	\$ 24,860	\$ 24,860
23	Imported Backfill	108	CY	\$ 44	\$ 4,761
24	Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick)	7	SF	\$ 346	\$ 2,460
25	Debris Barrier	1	EA	\$ 14,808	\$ 14,808
26				\$ -	\$ -
27	Inlet Pipe			\$ -	\$ -
28	Pipe - 12" PVC	100	LF	\$ 140	\$ 14,000
29	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
30	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
31	Imported Backfill	108	CY	\$ 44	\$ 4,761
32	Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick)	7	SF	\$ 346	\$ 2,460
33	Catch Basin Structure (spill control)	1	EA	\$ 3,900	\$ 3,900
34				\$ -	\$ -
35	Restoration			\$ -	\$ -
36	Disking or tilling of compacted soil (assumed 100'X100' construction staging/stockpiling)	1,556	SY	\$ 4	\$ 6,222
37	Seeding, mulching and compost (Emergent, Riparian & Upland) facility + staging	1,814	SY	\$ 10	\$ 18,143
38	Plantings (Emergent & Riparian)	454	SY	\$ 19	\$ 8,618
39	Trees (both sides of the facility and opportunistic areas)	15	EA	\$ 720	\$ 10,800
40				\$ -	\$ -
41				\$ -	\$ -
42	Additional Costs			\$ -	\$ -
43	Removals @ 4% Construction Costs	4.0%	LS	\$ 290,820	\$ 11,633
44	TESC @2% Construction Costs	2%	LS	\$ 302,453	\$ 6,049
				\$ -	\$ -
	Item Subtotal Construction Costs (Year 2023)			\$ 308,502	
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 30,850
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1,0000	\$ -	\$ -
	Item Subtotal Construction Costs (Year 2023)			\$ 339,352	
	Direct: Subtotal Construction Costs			\$ 339,352	

Description: WQBE 18A_Wetpond on Public Property

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

Cost Estimating Assumptions:

The Wetpond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 6.4.1 and is generally as described below. The wetpond has a bottom area of 553 sf and has a storage depth of 4 feet deep (48 inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 33.3 ft. width and is 16.7 ft. in length.

The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.

The length to width ratio is less than 4:1 and a dividing berm is required. In accordance with Section 6.4 design recommendations, the wetpool will have 2 cells, with the upper cell designed to accommodate sediment storage.

The first wetpool cell is sized to approximately 1/3 of the required storage volume of the second wet pool storage. The pool is designed to meet the 4 foot minimum required depth.

The pond is constructed with 3:1 side slopes.

The design includes 1 foot for freeboard.

A min 72" Dia. flow control maintenance hole with a cone grate, clean out drain and gate that meets the requirements of Section 6.1.4.2 and Section 5.1.4 is provided at the facility outlet.

A minimum of a 54" Type 2 CB spill control structure that meets the requirements of section 4.2.1 and section 5.1.4.A is assumed for the inflow pipe.

A spillway is provided between pond cell 1 and pond cell 2 and an emergency overflow spillway is included.

Both the pond and emergency spillways are 12 ft. long w/ a slope of 3:1, H:V.

The spillways are riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content

Approximately 200 feet of 12-inch diameter pipe is included for upstream and downstream conveyance.

It is assumed that dewatering will not be required.

Trench Box shoring for pipe installation.

A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.

The area for the wetpond is assumed to be existing open space without building or pavement removal.

Fencing is not included in the estimate, a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

The pond is tree-lined along both sides (length) and at opportunistic locations per KC Section 6.4.

The pond is assumed to be located in either KC right of way (away from the roadsides) or in King Co. owned property. It is assumed that real estate acquisition and easements are NOT required.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE 18B_ Wetpond with Property Cost (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 1,669,300
Capital cost	\$ 1,669,300 \$/Unit
Total Direct O&M/Year	\$ 1,632
Direct O&M cost	\$ 1,632 \$/Unit
Capital Replacement Costs (10 Years)	\$ 13,124 \$/unit
Discount rate (%)	5.25
Total Cost (NPV)	\$ 1,729,300 \$/unit
Annual O&M Cost	\$ 2,200 \$/year
Annualized Cost	\$960 \$/year

Description: WQBE 18B_ Wetpond with Property Cost

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of trash, debris and sediment. Labor shall include 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck and 4 man hours each year.

Removal of visible oil sheen by using a vactor truck. Labor shall include 2 crew members, 1 visit per 2 year, 1 hours per visit; 2 man hours each year.

Areas that have over 6 inches of erosion shall be repaired biannually or after a major storm event. 2 crew members, 3 visits per year, 1 hour per visit, 6 man hours per year. Assume annual cost of erosion 6 repair materials of \$246.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Replacement of items highlighted in blue on estimate sheet every 10 years (i.e. riprap pads, gates, etc.)

Materials, Supplies, Other Costs

		\$ -	\$/year
Erosion Repair Materials	2023 dollars	\$ 246	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$606	
Labor			
Remove Trash, Debris, and Sediment	4 hr		
Removal of oil sheen	2 hr		
Remediation of erosion	6 hr		
	0 hr		
Total hours per year	12		
Raw Labor Rate/hr	\$ 54		
Raw labor cost	(embedded)	\$ 653	
Labor cost, burdened	O/H 150.0%	\$ 1,632	\$ 135.98
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30 years		

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 28,831		\$ 77,629	\$ 1,802,007	\$ 1,729,329			
0	1.000	\$ 1,669,300		\$ 1,669,300	\$ 1,669,300	\$ 1,669,300	\$ 1,669,300	\$ 1,669,300	\$ 1,729,329
1	0.950	\$606	\$ -	\$ 1,632	\$ 2,238	\$ 2,126	\$ 1,671,538	\$ 1,671,426	\$ 60,029
2	0.903	\$624	\$ -	\$ 1,681	\$ 2,305	\$ 2,081	\$ 1,673,843	\$ 1,673,507	\$ 57,903
3	0.858	\$643	\$ -	\$ 1,731	\$ 2,374	\$ 2,036	\$ 1,676,217	\$ 1,675,543	\$ 55,822
4	0.815	\$662	\$ -	\$ 1,783	\$ 2,445	\$ 1,993	\$ 1,678,662	\$ 1,677,535	\$ 53,786
5	0.774	\$682	\$ -	\$ 1,836	\$ 2,519	\$ 1,950	\$ 1,681,180	\$ 1,679,486	\$ 51,793
6	0.736	\$703	\$ -	\$ 1,892	\$ 2,594	\$ 1,908	\$ 1,683,774	\$ 1,681,394	\$ 49,843
7	0.699	\$724	\$ -	\$ 1,948	\$ 2,672	\$ 1,868	\$ 1,686,446	\$ 1,683,261	\$ 47,935
8	0.664	\$745	\$ -	\$ 2,007	\$ 2,752	\$ 1,828	\$ 1,689,198	\$ 1,685,089	\$ 46,067
9	0.631	\$768	\$ -	\$ 2,067	\$ 2,835	\$ 1,788	\$ 1,692,033	\$ 1,686,878	\$ 44,240
10	0.599	\$791	\$ 13,124	\$ 2,129	\$ 16,043	\$ 9,618	\$ 1,708,076	\$ 1,696,495	\$ 42,451
11	0.570	\$814	\$ -	\$ 2,193	\$ 3,007	\$ 1,713	\$ 1,711,084	\$ 1,698,208	\$ 32,834
12	0.541	\$839	\$ -	\$ 2,259	\$ 3,098	\$ 1,676	\$ 1,714,181	\$ 1,699,884	\$ 31,121
13	0.514	\$864	\$ -	\$ 2,326	\$ 3,190	\$ 1,640	\$ 1,717,371	\$ 1,701,525	\$ 29,444
14	0.489	\$890	\$ -	\$ 2,396	\$ 3,286	\$ 1,605	\$ 1,720,658	\$ 1,703,130	\$ 27,804
15	0.464	\$917	\$ -	\$ 2,468	\$ 3,385	\$ 1,571	\$ 1,724,042	\$ 1,704,701	\$ 26,199
16	0.441	\$944	\$ -	\$ 2,542	\$ 3,486	\$ 1,537	\$ 1,727,529	\$ 1,706,239	\$ 24,627
17	0.419	\$972	\$ -	\$ 2,618	\$ 3,591	\$ 1,505	\$ 1,731,119	\$ 1,707,743	\$ 23,090
18	0.398	\$1,002	\$ -	\$ 2,697	\$ 3,699	\$ 1,472	\$ 1,734,818	\$ 1,709,216	\$ 21,585
19	0.378	\$1,032	\$ -	\$ 2,778	\$ 3,810	\$ 1,441	\$ 1,738,628	\$ 1,710,657	\$ 20,113
20	0.359	\$1,063	\$ 13,124	\$ 2,861	\$ 17,047	\$ 6,127	\$ 1,755,675	\$ 1,716,783	\$ 18,672
21	0.341	\$1,095	\$ -	\$ 2,947	\$ 4,042	\$ 1,380	\$ 1,759,716	\$ 1,718,163	\$ 12,545
22	0.324	\$1,127	\$ -	\$ 3,035	\$ 4,163	\$ 1,351	\$ 1,763,879	\$ 1,719,514	\$ 11,168
23	0.308	\$1,161	\$ -	\$ 3,127	\$ 4,288	\$ 1,322	\$ 1,768,167	\$ 1,720,835	\$ 9,815
24	0.293	\$1,196	\$ -	\$ 3,220	\$ 4,416	\$ 1,293	\$ 1,772,582	\$ 1,722,129	\$ 8,493
25	0.278	\$1,232	\$ -	\$ 3,317	\$ 4,549	\$ 1,266	\$ 1,777,132	\$ 1,723,395	\$ 7,200
26	0.264	\$1,269	\$ -	\$ 3,416	\$ 4,685	\$ 1,239	\$ 1,781,817	\$ 1,724,633	\$ 5,934
27	0.251	\$1,307	\$ -	\$ 3,519	\$ 4,826	\$ 1,212	\$ 1,786,643	\$ 1,725,845	\$ 4,696
28	0.239	\$1,346	\$ -	\$ 3,624	\$ 4,971	\$ 1,186	\$ 1,791,614	\$ 1,727,032	\$ 3,483
29	0.227	\$1,386	\$ -	\$ 3,733	\$ 5,120	\$ 1,161	\$ 1,796,733	\$ 1,728,193	\$ 2,297
30	0.215	\$1,428	\$ -	\$ 3,845	\$ 5,273	\$ 1,136	\$ 1,802,007	\$ 1,729,329	\$ 1,136

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Ryan Oberg (HDR) Cindy Kinzer (HDR)	
Description:	WQBE 18B_Wetpond with Property Cost		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Pond Upper Cell #1 (Sediment)	4	FT Depth	\$ -	\$ -
2	Bottom Area @ 1/3 Volume of Wetpond Facility	40	SF	\$ -	\$ -
3	Top Area@ 3:1 Side Slopes	928	SF	\$ -	\$ -
4	Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner	140	CY	\$ 79	\$ 11,095
5	Imported Treatment Liner @ 2' thick	69	CY	\$ 105	\$ 7,218
6				\$ -	\$ -
7	Wetpond Excavation Volume (16.7'W X 33.3'L X 4'D)	4	FT Depth	\$ -	\$ -
8	Bottom Area @ 3:1 Side Slopes	553	SF	\$ -	\$ -
9	Top Area@ 3:1 Side Slopes	2329	SF	\$ -	\$ -
10	Facility Excavation to Waste @ 4 ft 'D + Sub-exc. for Liner	386	CY	\$ 79	\$ 30,494
11	Imported Fill for Compacted Berm Embankment - Between First & Second Cell (@244 LF and 45 sq ft./ft cross section area)	407	CY	\$ 44	\$ 17,893
12	Embankment Compaction	407	CY	\$ 22	\$ 8,947
13	Imported Treatment Liner @ 2' thick	173	CY	\$ 105	\$ 18,114
14	Riprap Lining for Pre-settling and Infiltration Pond Overflow Spillways (6'WX12'LX2'D)	11	CY	\$ 346	\$ 3,691
15	Access Roadway to site (4" HMA/4" CSBC)	267	SY	\$ 71	\$ 18,933
16	Access Gate (16 ft wide gate)	1	EA	\$ 3,085	\$ 3,085
17				\$ -	\$ -
18	Outlet Pipe			\$ -	\$ -
19	Pipe - 12" PVC	100	LF	\$ 140	\$ 14,000
20	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
21	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
22	Control Structure with grate, clean out drain, and gate	1	EA	\$ 24,860	\$ 24,860
23	Imported Backfill	108	CY	\$ 44	\$ 4,761
24	Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick)	7	SF	\$ 346	\$ 2,460
25	Debris Barrier	1	EA	\$ 14,808	\$ 14,808
26				\$ -	\$ -
27	Inlet Pipe			\$ -	\$ -
28	Pipe - 12" PVC	100	LF	\$ 140	\$ 14,000
29	5' Wide Trench x 6'D to waste	111	CY	\$ 79	\$ 8,778
30	Trench Box Shoring (Shallow)	1,200	SF	\$ 10	\$ 12,000
31	Imported Backfill	108	CY	\$ 44	\$ 4,761
32	Pipe Discharge Rock Lining Riprap (12' Long by 8' wide x 2 ft thick)	7	SF	\$ 346	\$ 2,460
33	Catch Basin Structure (spill control)	1	EA	\$ 3,900	\$ 3,900
34				\$ -	\$ -
35	Restoration			\$ -	\$ -
36	Disking or tilling of compacted soil (assumed 100'X100' construction staging/stockpiling)	1,556	SY	\$ 4	\$ 6,222
37	Seeding, mulching and compost (Emergent, Riparian & Upland) facility + staging	1,814	SY	\$ 10	\$ 18,143
38	Plantings (Emergent & Riparian)	454	SY	\$ 19	\$ 8,618
39	Trees (both sides of the facility and opportunistic areas)	15	EA	\$ 720	\$ 10,800
40				\$ -	\$ -
41				\$ -	\$ -
42	Additional Costs			\$ -	\$ -
43	Removals @ 4% Construction Costs	4.0%	LS	\$ 290,820	\$ 11,633
44	TESC @2% Construction Costs	2%	LS	\$ 302,453	\$ 6,049
				\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 308,502
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ -	\$ 30,850
	Overhead & Profit (OHP)	0%	1	\$ -	\$ -
	Insurance	0.0%	1	\$ -	\$ -
	Bonding	0.0%	1	\$ -	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$ -	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 339,352
<i>Direct: Subtotal Construction Costs (553 SF Area)</i>					\$ 339,352

Description: WQBE 18B_Wetpond with Property Cost

Constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. Wetpool volume is related to the pond's effectiveness in settling particulate pollutants.

Cost Estimating Assumptions:

The Wetpond is designed in accordance with the King Co. Surface Water Design Manual (KC SWDM) Section 6.4.1 and is generally as described below: The wetpond has a bottom area of 553 sf and has a storage depth of 4 feet deep (48 inches).

The pond storage volume is generally located below grade.

The pond has an approximate length to width ratio of 2:1 with a bottom dimension of 33.3 ft. width and is 16.7 ft. in length.

The facility is assumed to be lined with a 2 ft. deep treatment liner in accordance with KC SWDM Section 6.2.4.

The length to width ratio is less than 4:1 and a dividing berm is required. In accordance with Section 6.4 design recommendations, the wetpool will have 2 cells, with the upper cell designed to accommodate sediment storage.

The first wetpool cell is sized to approximately 1/3 of the required storage volume of the second wet pool storage. The pool is designed to meet the 4 foot minimum required depth.

The pond is constructed with 3:1 side slopes.

The design includes 1 foot for freeboard.

A min 72" Dia. flow control maintenance hole with a cone grate, clean out drain and gate that meets the requirements of Section 6.1.4.2 and Section 5.1.4 is provided at the facility outlet.

A minimum of a 54" Type 2 CB spill control structure that meets the requirements of section 4.2.1 and section 5.1.4.A is assumed for the inflow pipe. A spillway is provided between pond cell 1 and pond cell 2 and an emergency overflow spillway is included.

Both the pond and emergency spillways are 12 ft. long w/ a slope of 3:1, H:V.

The spillways are riprap lined per Table 4.4.1A and can accommodate discharge velocities from 5 fps to 10 fps.

The infiltration pond includes a compacted berm that has a minimum of 20% silt and clay, a maximum of 60% sand, max of 60% silt and clay with nominal gravel and cobble content

Approximately 100 feet of 12-inch and 100 feet of 12-inch diameter pipes are included for upstream and downstream conveyance.

It is assumed that dewatering will not be required.

Trench Box shoring for pipe installation.

A 200 ft. long and 12 ft. wide paved (4"HMA/4"CSTC) maintenance access road is provided.

Property is assumed to be existing open space without building or pavement removal.

Fencing is not included in the estimate, a 16 ft. wide access gate is provided to prevent unwanted access to the maintenance access road. It is assumed that the access area is already fenced.

Disturbed areas are seeded and it is assumed that a portion of the area has plantings.

The pond is tree-lined along both sides (length) and at opportunistic locations per KC Section 6.4.

The pond is located on property and real estate acquisition and easements are required.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024 Troy Gidoss (HDR) Andrew Staples (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)
Location:	King County, WA			Estimator:	
Description:	WQBE_19A_WetVault on Public Property			Version:	2
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Wet Vault (1615 sf @ 4 ft. Storage Depth)	1	EA	\$ 2,048,600	\$ 2,048,600
				\$	-
				\$	-
				\$	-
				\$	-
				Subtotal Construction Costs	\$ 2,048,600
	Allowance for Indeterminates (Design Allowance)			\$	409,720
	Street Use Permit (Y/N)	N		\$	-
ESTIMATED PROBABLE COST OF CONSTRUCTION BID					
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
	Construction Change Order Allowance			\$	245,832
	Subtotal Primary Construction Amount			\$	2,704,152
	Construction Sales Tax			\$	277,176
	Outside Agency Construction			\$	-
	TOTAL DIRECT CONSTRUCTION COSTS			\$	2,981,300
INDIRECT: NON-CONSTRUCTION COSTS					
	Design Engineering			\$	594,913
	Construction Management			\$	270,415
	Permitting & Support			\$	27,042
s.f. Land Area	None			\$	-
s.f. Land Area	None			\$	-
	Permanent Easements			\$	-
	WTD Staff Costs & Non-WTD Support			\$	162,249
	Subtotal Non-Construction Costs			\$	1,054,619
	Project Contingency			\$	1,210,776
	TOTAL INDIRECT NON-CONSTRUCTION COSTS			\$	2,265,400
	TOTAL PROJECT COST			\$	5,246,700

Description: WQBE_19A_WetVault on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 5,246,700
Capital cost	\$ 5,246,700 \$/Unit
Total Direct O&M/Year	\$ 2,720
Direct O&M cost	\$ 2,720 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,900 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 5,333,600	\$/unit
Annual O&M Cost	\$ 3,100	\$/year
Annualized Cost	\$660	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Cement Patching	2023 dollars	\$ 56	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$416	

Labor

Vactor to remove sediment and debris	4 hr
Inspection and joint repair, crack repair	16 hr
	0 hr
	0 hr
Total hours per year	20
Raw Labor Rate/hr	\$ 54
Raw labor cost.	(embedded) \$ 1,088
Labor cost, burdened	O/H 150.0% \$ 2,720
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

\$ 135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 19,791		\$ 129,381	\$ 5,452,773	\$ 5,333,630			
0	1.000	\$ 5,246,700			\$ 5,246,700	\$ 5,246,700	\$ 5,246,700	\$ 5,246,700	\$ 5,333,630
1	0.950	\$ 416	\$ -	\$ 2,720	\$ 3,136	\$ 2,979	\$ 5,249,836	\$ 5,249,679	\$ 86,930
2	0.903	\$ 428	\$ -	\$ 2,801	\$ 3,230	\$ 2,915	\$ 5,253,065	\$ 5,252,695	\$ 83,950
3	0.858	\$ 441	\$ -	\$ 2,885	\$ 3,326	\$ 2,853	\$ 5,256,392	\$ 5,255,448	\$ 81,035
4	0.815	\$ 455	\$ -	\$ 2,972	\$ 3,426	\$ 2,792	\$ 5,259,818	\$ 5,258,240	\$ 78,182
5	0.774	\$ 468	\$ -	\$ 3,061	\$ 3,529	\$ 2,732	\$ 5,263,347	\$ 5,260,972	\$ 75,390
6	0.736	\$ 482	\$ -	\$ 3,153	\$ 3,635	\$ 2,674	\$ 5,266,982	\$ 5,263,946	\$ 72,657
7	0.699	\$ 497	\$ -	\$ 3,247	\$ 3,744	\$ 2,617	\$ 5,270,726	\$ 5,266,263	\$ 69,983
8	0.664	\$ 512	\$ -	\$ 3,345	\$ 3,856	\$ 2,561	\$ 5,274,582	\$ 5,268,824	\$ 67,367
9	0.631	\$ 527	\$ -	\$ 3,445	\$ 3,972	\$ 2,506	\$ 5,278,554	\$ 5,271,330	\$ 64,806
10	0.599	\$ 543	\$ -	\$ 3,548	\$ 4,091	\$ 2,453	\$ 5,282,645	\$ 5,273,783	\$ 62,300
11	0.570	\$ 559	\$ -	\$ 3,655	\$ 4,214	\$ 2,400	\$ 5,286,859	\$ 5,276,183	\$ 59,847
12	0.541	\$ 576	\$ -	\$ 3,764	\$ 4,340	\$ 2,349	\$ 5,291,199	\$ 5,278,531	\$ 57,447
13	0.514	\$ 593	\$ -	\$ 3,877	\$ 4,470	\$ 2,299	\$ 5,295,670	\$ 5,280,830	\$ 55,098
14	0.489	\$ 611	\$ -	\$ 3,994	\$ 4,605	\$ 2,249	\$ 5,300,274	\$ 5,283,080	\$ 52,799
15	0.464	\$ 629	\$ -	\$ 4,113	\$ 4,743	\$ 2,201	\$ 5,305,017	\$ 5,285,281	\$ 50,550
16	0.441	\$ 648	\$ -	\$ 4,237	\$ 4,885	\$ 2,154	\$ 5,309,902	\$ 5,287,435	\$ 48,349
17	0.419	\$ 668	\$ -	\$ 4,364	\$ 5,032	\$ 2,108	\$ 5,314,933	\$ 5,289,544	\$ 46,194
18	0.398	\$ 688	\$ -	\$ 4,495	\$ 5,183	\$ 2,063	\$ 5,320,116	\$ 5,291,607	\$ 44,086
19	0.378	\$ 708	\$ -	\$ 4,630	\$ 5,338	\$ 2,019	\$ 5,325,454	\$ 5,293,626	\$ 42,023
20	0.359	\$ 729	\$ 56,900	\$ 4,769	\$ 62,398	\$ 22,425	\$ 5,387,852	\$ 5,316,051	\$ 40,004
21	0.341	\$ 751	\$ -	\$ 4,912	\$ 5,663	\$ 1,934	\$ 5,393,515	\$ 5,317,984	\$ 37,579
22	0.324	\$ 774	\$ -	\$ 5,059	\$ 5,833	\$ 1,803	\$ 5,399,349	\$ 5,318,877	\$ 35,645
23	0.308	\$ 797	\$ -	\$ 5,211	\$ 6,008	\$ 1,652	\$ 5,405,356	\$ 5,321,729	\$ 33,753
24	0.293	\$ 821	\$ -	\$ 5,367	\$ 6,188	\$ 1,512	\$ 5,411,544	\$ 5,323,541	\$ 31,901
25	0.278	\$ 846	\$ -	\$ 5,528	\$ 6,374	\$ 1,774	\$ 5,417,918	\$ 5,325,315	\$ 30,089
26	0.264	\$ 871	\$ -	\$ 5,694	\$ 6,565	\$ 1,736	\$ 5,424,483	\$ 5,327,050	\$ 8,315
27	0.251	\$ 897	\$ -	\$ 5,865	\$ 6,762	\$ 1,699	\$ 5,431,245	\$ 5,328,749	\$ 6,579
28	0.239	\$ 924	\$ -	\$ 6,041	\$ 6,965	\$ 1,662	\$ 5,438,210	\$ 5,330,411	\$ 4,881
29	0.227	\$ 952	\$ -	\$ 6,222	\$ 7,174	\$ 1,627	\$ 5,445,384	\$ 5,332,038	\$ 3,219
30	0.215	\$ 980	\$ -	\$ 6,409	\$ 7,389	\$ 1,592	\$ 5,452,773	\$ 5,333,630	\$ 1,592

Description: WQBE_19A_WetVault on Public Property

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Trash, debris and sediment shall be removed annually from areas in the wet vault where accumulation may occur. 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck, total of 4 man hours per year.

Vault inlets, outlets, cracks wider than 1/2 inch, shall be inspected and/or repaired annually. 2 crew members, 1 visit per year, 8 hours per visit, total of 16 man hours per year. Assume annual cost for cement patching mix of \$56.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (outlet structure and baffle) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Troy Gibbs (HDR) Andrew Staples (HDR) Jeremy Hollingsworth (HDR) Cindy Kinzer (HDR) Jess Dexheimer (HDR)	
Description:	WQBE_19A_WetVault on Public Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Wet Vault on Public Property			\$	-
2	Vault Assumptions			\$	-
3	Exterior Length	83	FT	\$	-
4	Interior Length	80	FT	\$	-
5	Sump Length	4	FT	\$	-
6	Sump Wall Width	20	FT	\$	-
7	Sump Interior Depth	4	FT	\$	-
8	Sump Wall Total Length	54	FT	\$	-
9	Exterior Width	23	FT	\$	-
10	Interior Width	20.2	FT	\$	-
11	Interior Structure Height (Ave.)	7.3	FT	\$	-
12	Storage Depth (Ave)	4.0	FT	\$	-
13	Sediment Storage Depth	1.0	FT	\$	-
14	Freeboard (Ave.)	2.3	FT	\$	-
15	Storage Facility Exterior Footprint Area	1,925	SF	\$	-
16				\$	-
17	Storage Volume			\$	-
18	Storage Facility Interior Area	1,615	SF	\$	-
19	Effective Storage Volume (15,500 cf target)	6,460	CF	\$	-
20	Vault Storage Volume	0.05	MG	\$	-
21				\$	-
22	Structure Concrete Assumptions			\$	-
23	Exterior Wall thickness	1.5	FT	\$	-
24	Sump Wall Thickness	1.5	FT	\$	-
25	Top Slab Thickness	2	FT	\$	-
26	Foundation Slab thickness	3	FT	\$	-
27	Concrete Reinforcing Rebar	225	LB/CY	\$	-
28	Crushed Base Thickness	1	FT	\$	-
29				\$	-
30	Concrete Structure			\$	-
31	Vault Interior Walls Concrete @2' Thick (partial for supports)	5	CY	\$ 650	\$ 3,293
32	Sump Wall Concrete	12	CY	\$ 1,250	\$ 15,104
33	Exterior Wall Concrete	86	CY	\$ 1,250	\$ 107,662
34	Top Slab Concrete	143	CY	\$ 1,250	\$ 178,200
35	Foundation Slab Concrete	214	CY	\$ 950	\$ 203,148
36	Stormwater Treatment Rebar @ 225 lbs/cy	103,428	LBS	\$ 1.38	\$ 142,731
37	Crushed Base	71	CY	\$ 64	\$ 4,562
38				\$	-
39	Shoring and Excavation Assumptions			\$	-
40	Construction Room	3	FT	\$	-
41	Tank Bury Depth	2	FT	\$	-
42	Total Excavation Depth	15	FT	\$	-
43	Excavation Length	93	FT	\$	-
44	Excavation Width	33	FT	\$	-
45				\$	-
46	Soil Excavation and Disposal			\$	-
47	Excavation	1,749	CY	\$ 79	\$ 138,170
51	Imported Structure Backfill	801	CY	\$ 44	\$ 35,242
52				\$	-
53				\$	-
54	Solder Pile Shoring			\$	-
55	Solder Pile Shaft Depth (3 x Exc. Depth)	46	FT	\$	-
56	Solder Pile Shaft Thickness	2	FT	\$	-
57	Center to Center Shaft Spacing	6	FT	\$	-
58	Rebar in Shaft	114	LB/CY	\$	-
59	Shoring Wall Perimeter	244	FT	\$	-
60	Number of Shafts	41	EA	\$	-
61	Drill Solder Pile Shafts	219	CY	\$ 262	\$ 57,370
62	Set Solder Pile and CDF	219	CY	\$ 391	\$ 85,617
63	Purchase and Salvage Solder Piles	214,537	LB	\$ 0.7	\$ 150,176
64	Tie Backs - one per solder pile except corners	37	EA	\$ 2,477	\$ 91,649
65	Timber Lagging (64'W X 70'L @ approx. 20'H)	13,098	BF	\$ 9	\$ 117,884
66				\$	-
67	Gates and Access			\$	-
68	Flow Restrictor	1	EA	\$ 24,600	\$ 24,600
69	Confined Space Safety	1	LS	\$ 32,595	\$ 32,595
70	Access Hatches	2	EA	\$ 13,038	\$ 26,076
71				\$	-
72	Conveyance Pipe			\$	-
73	12" Storm Pipe (upstream and discharge)	200	LF	\$ 140	\$ 28,000
74	Trench Excavation to waste (8'W X 15'D)	889	CY	\$ 79	\$ 70,222
75	Trench Box Shoring	6,000	SF	\$ 10	\$ 60,000
76	48" Diameter Maintenance holes	4	EA	\$ 10,640	\$ 42,560
77	Imported Backfill	883	CY	\$ 44	\$ 38,855
78	Dewater Trench - Sumps	200	LF	\$ 139	\$ 27,800
79	Demolish Surface incl. room for construction (@20' wide)	444	SY	\$ 14	\$ 6,222
80	Pavement Restoration for Pipe - 4" HMA/4"CSBC (20'X 100')	444	SY	\$ 71	\$ 31,556
81				\$	-
82				\$	-
83	Site Removals and Restoration			\$	-
84	Disking or tilling of compacted soil (assumed 100'X100')	514	SY	\$ 4	\$ 2,056
85	Seeding, mulching and compost	514	SY	\$ 10	\$ 5,144
86	Demolish Existing Surface	343	SY	\$ 14	\$ 4,801
87	Pavement Restoration (Vault) - 4" HMA/4"CSBC	343	SY	\$ 71	\$ 24,349
88				\$	-
89	Removals at 4% Construction Costs	4.0%	LS	\$ 1,755,646	\$ 70,226
90	TESC at 2% of Construction	2%	LS	\$ 1,825,872	\$ 36,517
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 1,862,389
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	186,239
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
	<i>Item Subtotal Construction Costs (Year 2023)</i>			\$	2,048,628
	Direct: Subtotal Construction Costs			\$	2,048,600

Description: WQBE 19A_WetVault on Public Property

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

Cost Estimating Assumptions:

Wetvault design basis is per KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2).

It is assumed that no agency mitigation costs will be required.

The vault is an online storage facility and does not include flow control.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The vault is an underground cast in place concrete structure with an interior storage area of 1,615 s.f. and a maximum storage depth of 4 feet deep.

The vault is assumed to drain by gravity and has an effective storage of approximately 0.05 MG.

Vault has average interior dimensions of 20.2'W x 80'L x 7.3'H.

The minimum vault height is 7 feet deep at the shallowest end.

The vault floor side slopes are a minimum of 5% towards the center of the vault.

The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.

An average of 1 foot of additional storage depth is provided for sediment storage.

Exterior and interior wall thickness is 1.5 feet.

Top slab thickness is 2 feet

Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)

There is a 1 foot layer of crushed base beneath the base/ballast slab.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is positively anchored to the shoring piles.

Vault is designed for traffic loading.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

Two maintenance hole access with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and Lagging is required for construction of the structure.

A total of 200' of 12" diameter pipe is assumed for connection to the upstream and downstream mains.

The storage vault, facility inlet and outlet pipes are sited beneath a parking area.

Parking lot restoration is assumed to consist of 4" HMA / 4" CSTC.

Concrete curb, gutter, and sidewalk removal and restoration will not be required for the installation.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

Construction occurs outside of the right-of-way and no traffic control or street use permits are required.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Routine** indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE 19B_WetVault in ROW (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 5,790,300
Capital cost	\$ 5,790,300 \$/Unit
Total Direct O&M/Year	\$ 2,720
Direct O&M cost	\$ 2,720 \$/Unit
Capital Replacement Costs (20 year equipment)	\$ 56,900 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 5,877,200	\$/unit
Annual O&M Cost	\$ 3,100	\$/year
Annualized Cost	\$660	\$/year

Materials, Supplies, Other Costs

		\$ -	\$/year
Cement Patching	2023 dollars	\$ 56	\$/year
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360	\$/year
Subtotal		\$416	
Labor			
Vactor to remove sediment and debris		4	hr
Inspection and joint repair, crack repair		16	hr
		0	hr
		0	hr
Total hours per year		20	
Raw Labor Rate/hr		\$ 54	
Raw labor cost,	(embedded)	\$ 1,088	
Labor cost, burdened	O/H 150.0%	\$ 2,720	
General and Labor Cost Escalation/Year		3.0%	
Life Cycle Period:		30 years	

\$ 135.98

Description: WQBE 19B_WetVault in ROW

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Trash, debris and sediment shall be removed annually from areas in the wet vault where accumulation may occur. 2 crew members, 1 visit per year, 2 hours per visit; assume use of vactor truck, total of 4 man hours per year.

Vault inlets, outlets, cracks wider than 1/2 inch, shall be inspected and/or repaired annually. 2 crew members, 1 visit per year, 8 hours per visit, total of 16 man hours per year. Assume annual cost for cement patching mix of \$56.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Capital Replacement Assumptions:

Complete replacement of mechanical equipment every twenty years (outlet structure and baffle) and access hatch. Items will include those highlighted in blue on the cost estimate sheet.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 19,791		\$ 129,381	\$ 5,996,373	\$ 5,877,230			
0	1.000	\$ 5,790,300			\$ 5,790,300	\$ 5,790,300	\$ 5,790,300	\$ 5,790,300	\$ 5,790,300
1	0.950	\$ 416	\$ -	\$ 2,720	\$ 3,136	\$ 2,979	\$ 5,793,436	\$ 5,793,279	\$ 86,930
2	0.903	\$ 428	\$ -	\$ 2,801	\$ 3,230	\$ 2,915	\$ 5,796,665	\$ 5,796,195	\$ 83,950
3	0.858	\$ 441	\$ -	\$ 2,885	\$ 3,326	\$ 2,853	\$ 5,799,992	\$ 5,799,048	\$ 81,035
4	0.815	\$ 455	\$ -	\$ 2,972	\$ 3,426	\$ 2,792	\$ 5,803,418	\$ 5,801,840	\$ 78,182
5	0.774	\$ 468	\$ -	\$ 3,061	\$ 3,529	\$ 2,732	\$ 5,806,947	\$ 5,804,572	\$ 75,390
6	0.736	\$ 482	\$ -	\$ 3,153	\$ 3,635	\$ 2,674	\$ 5,810,582	\$ 5,807,246	\$ 72,657
7	0.699	\$ 497	\$ -	\$ 3,247	\$ 3,744	\$ 2,617	\$ 5,814,326	\$ 5,809,863	\$ 69,983
8	0.664	\$ 512	\$ -	\$ 3,345	\$ 3,856	\$ 2,561	\$ 5,818,182	\$ 5,812,424	\$ 67,367
9	0.631	\$ 527	\$ -	\$ 3,445	\$ 3,972	\$ 2,506	\$ 5,822,154	\$ 5,814,930	\$ 64,806
10	0.599	\$ 543	\$ -	\$ 3,548	\$ 4,091	\$ 2,453	\$ 5,826,245	\$ 5,817,383	\$ 62,300
11	0.570	\$ 559	\$ -	\$ 3,655	\$ 4,214	\$ 2,400	\$ 5,830,459	\$ 5,819,783	\$ 59,847
12	0.541	\$ 576	\$ -	\$ 3,764	\$ 4,340	\$ 2,349	\$ 5,834,799	\$ 5,822,131	\$ 57,447
13	0.514	\$ 593	\$ -	\$ 3,877	\$ 4,470	\$ 2,299	\$ 5,839,270	\$ 5,824,430	\$ 55,098
14	0.489	\$ 611	\$ -	\$ 3,994	\$ 4,605	\$ 2,249	\$ 5,843,674	\$ 5,826,680	\$ 52,799
15	0.464	\$ 629	\$ -	\$ 4,113	\$ 4,743	\$ 2,201	\$ 5,848,617	\$ 5,828,881	\$ 50,550
16	0.441	\$ 648	\$ -	\$ 4,237	\$ 4,885	\$ 2,154	\$ 5,853,502	\$ 5,831,035	\$ 48,349
17	0.419	\$ 668	\$ -	\$ 4,364	\$ 5,032	\$ 2,108	\$ 5,858,533	\$ 5,833,144	\$ 46,194
18	0.398	\$ 688	\$ -	\$ 4,495	\$ 5,183	\$ 2,063	\$ 5,863,716	\$ 5,835,207	\$ 44,086
19	0.378	\$ 708	\$ -	\$ 4,630	\$ 5,338	\$ 2,019	\$ 5,869,054	\$ 5,837,226	\$ 42,023
20	0.359	\$ 729	\$ 56,900	\$ 4,769	\$ 62,398	\$ 22,425	\$ 5,931,452	\$ 5,869,651	\$ 40,004
21	0.341	\$ 751	\$ -	\$ 4,912	\$ 5,663	\$ 1,934	\$ 5,937,115	\$ 5,861,584	\$ 17,579
22	0.324	\$ 774	\$ -	\$ 5,059	\$ 5,833	\$ 1,892	\$ 5,942,948	\$ 5,863,477	\$ 15,645
23	0.308	\$ 797	\$ -	\$ 5,211	\$ 6,008	\$ 1,852	\$ 5,948,956	\$ 5,865,329	\$ 13,753
24	0.293	\$ 821	\$ -	\$ 5,367	\$ 6,188	\$ 1,812	\$ 5,955,144	\$ 5,867,141	\$ 11,901
25	0.278	\$ 846	\$ -	\$ 5,528	\$ 6,374	\$ 1,774	\$ 5,961,518	\$ 5,868,915	\$ 10,089
26	0.264	\$ 871	\$ -	\$ 5,694	\$ 6,565	\$ 1,736	\$ 5,968,083	\$ 5,870,650	\$ 8,315
27	0.251	\$ 897	\$ -	\$ 5,865	\$ 6,762	\$ 1,699	\$ 5,974,845	\$ 5,872,349	\$ 6,579
28	0.239	\$ 924	\$ -	\$ 6,041	\$ 6,965	\$ 1,662	\$ 5,981,810	\$ 5,874,011	\$ 4,881
29	0.227	\$ 952	\$ -	\$ 6,222	\$ 7,174	\$ 1,627	\$ 5,988,984	\$ 5,875,638	\$ 3,219
30	0.215	\$ 980	\$ -	\$ 6,409	\$ 7,389	\$ 1,592	\$ 5,996,373	\$ 5,877,230	\$ 1,592

Description: WQBE 19B_WetVault in ROW

A wetvault is an underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants.

Cost Estimating Assumptions:

Wetvault design basis is per KCSWDM, "Wetvaults" (Chapter 6, Section 6.4.2).

The vault is an online storage facility and does not include flow control.

The flow control device meets the applicable requirements of KCSWDM Section 5.1.4.

The vault is an underground cast in place concrete structure with an interior storage area of 1,615 s.f. and a maximum storage depth of 4 feet deep.

The vault is assumed to drain by gravity and has an effective storage of approximately 0.05 MG.

Vault has average interior dimensions of 20.2'W x 80'L x 7.3'H.

The minimum vault height is 7 feet deep at the shallowest end.

The vault side slopes are a minimum of 5% towards the center of the vault.

The vault is a flow through system with a minimum of 2 feet above the outlet flow control device (orifice) to retain oil within the vault.

An average of 1 foot of additional storage depth is provided for sediment storage.

Exterior and interior wall thickness is 2-1.5 feet.

Top slab thickness is 2 feet

Base/Ballast slab thickness is 3 feet (sized to counteract buoyancy)

There is a 1 foot layer of crushed base beneath the base/ballast slab.

The vault depth of bury is assumed to be 2 feet from the top of the vault to the ground surface. .

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

Excavation and shoring system: Shoring and lagging system with 2 feet diameter shafts with an assumed spacing of 6-feet from center to center.

The shafts are 3 times the excavation depth

The vault is positively anchored to the shoring piles.

Vault is designed for traffic loading.

All metal is galvanized or stainless steel per SW Manual.

Access hatches are provided as shown on the WTD detail.

Two maintenance hole access with ladder rungs.

The excavated material is unsuitable for use as backfill.

An excavation width of 3 feet is assumed on each side of the structure.

Shoring and Lagging is required for construction of the structure.

A total of 200' of 12" diameter pipe is assumed for connection to the upstream and downstream mains.

The storage vault, facility inlet and outlet pipes are sited beneath a roadway in right-of-way.

Full width arterial roadway restoration is assumed, including the sidewalks and landscape areas on both sides of the roadway.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP GSI cost estimates.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located in right-of-way and traffic control is required.

A street use permit is required.

The installation is on public Right of Way and will not require easement and property acquisition.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A

Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor

A **20%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

It is assumed that utility work will be required. Due to the facility width, utility relocation work is estimated at 10% of the total construction costs.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Updated on: 06/07/24

Phase 2 Updated on: 5/6/21

Item No.	Action	Class	Complexity	Description	Sub-Action Number	Subcategory	PHASE 3 COSTS (2023 Dollars)							PHASE 2 COSTS (2019 Dollars)							
							Action Unit	Design Drainage Area	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)	Action Unit	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)
22	Regional Vegetated Media	Class 10	Moderate	WQBE_22A_Regional Vegetated Media SW Facility on Public Property	22A	On property without Acquisition	5,940 SF	17,249,760 SF	\$4,021,600	\$0	\$3,672,400	\$7,694,000	\$11,300	\$8,006,000	5,940 SF	\$2,965,000	\$0	\$3,073,000	\$6,038,000	\$12,000	\$6,562,000
				WQBE_22B_Regional Vegetated Media SW Facility With Property Cost	22B	On Property with Acquisition	5,940 SF	17,249,760 SF	\$4,021,600	\$583,580	\$4,431,000	\$8,452,600	\$11,300	\$8,764,600	5,940 SF	\$2,965,000	\$910,760	\$4,259,000	\$7,224,000	\$12,000	\$7,741,000

MANDATORY INPUTS		
Input Category	Inputs	Comments
Retail Sales Tax Rate	10.25%	Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle
Allowance for Indeterminates (AFI), Dependent Upon Project Phase	25%	Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%)
Construction Change Order Allowance	10%	
Project Contingency	30%	Complexity Inputs (Moderate, & Routine = 30%; Override for Low = 15%)

SECONDARY INPUTS		
Input Category	Inputs	Comments
Street Use Permit	\$ 90,000	In ROW only - Arterial @ \$90,000/Unit; Non-Arterial @use \$30000/unit
Outside Agency Construction	2%	For Projects in ROW Utility coordination assumed to be at 2% construction cost.

PROJECT CATEGORY AND INDIRECT PROJECT INPUTS		
Input Category	Inputs	Comments

PROPERTY COST

Cost Category	\$/sf
Low	\$ 10.10
Medium	\$ 80.43
High	\$ 284.37
None	\$ -

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Meaghan McGinn (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jeffrey Price (HDR) Jess Dexheimer (HDR)
Description:	WQBE_22A_Regional Vegetated Media SW Facility on Public Property			Version:	2
DIRECT: SUBTOTAL CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Regional Vegetated Media SW Facility (5940 SF Area)	1	EA	\$ 2,652,900	\$ 2,652,900
					\$ -
					\$ -
					\$ -
					Subtotal Construction Costs \$ 2,652,900
					Allowance for Indeterminates (Design Allowance) \$ 663,225
					Street Use Permit (Y/N) N \$ -
					ESTIMATED PROBABLE COST OF CONSTRUCTION BID \$ 3,316,125
DIRECT: SUBTOTAL ADDITIONAL CONSTRUCTION COSTS					
					Construction Change Order Allowance \$ 331,613
					Subtotal Primary Construction Amount \$ 3,647,738
					Construction Sales Tax \$ 373,893
					Outside Agency Construction \$ -
					TOTAL DIRECT CONSTRUCTION COSTS \$ 4,021,600
INDIRECT: NON-CONSTRUCTION COSTS					
					Design Engineering \$ 1,021,367
					Construction Management \$ 474,206
					Permitting & Support \$ 72,955
	s.f. Land Area		None	Land Purchase/ROW Acquisition	\$ -
	s.f. Land Area		None	Permanent Easements	\$ -
					WTD Staff Costs & Non-WTD Support \$ 328,296
					Subtotal Non-Construction Costs \$ 1,896,824
					Project Contingency \$ 1,775,527
					TOTAL INDIRECT NON-CONSTRUCTION COSTS \$ 3,672,400
					TOTAL PROJECT COST \$ 7,694,000

Description: WQBE_22A_Regional Vegetated Media SW Facility on Public Property (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 7,694,000
Capital cost	\$ 7,694,000 \$/Unit
Total Direct O&M/Year	\$ 6,527
Direct O&M cost	\$ 6,527 \$/Unit
Capital Replacement Costs (10 Years)	\$ 76,400 \$/unit
Discount rate (%)	5.25

Total Cost (NPV)	\$ 8,006,000	\$/unit
Annual O&M Cost	\$ 11,300	\$/year
Annualized Cost	\$ 7,510	\$/year

Description: WQBE_22A_Regional Vegetated Media SW Facility on Public Property

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of foreign debris, silt and trash from filter surface shall occur biannually or after a major storm event. This will include 2 crew members, 3 visits per year, 4 hours per visit, vactor truck included. Total of 24 man hours.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 4 hours per visit, 16 man hours per year, includes dump truck and backhoe loader. Total of 16 man hours.

16 Annual cost of \$2215 for mulch. Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 2 hours per visit. Total of 8 man hours.

Annual plant replacement allowance of \$2,160. Will allow for the replacement of approximately 40 shrubs or other medium sized plant material.

Materials, Supplies, Other Costs

Mulch	2023 dollars	\$ 2,215
Annual plant replacement	2023 dollars	\$ 2,160
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360
Subtotal		\$ 4,735
Labor		
Mulch Replacement	16	hr
Plant Health	8	hr
Removal of Debris with Vactor truck	24	hr
0	0	hr
Total hours per year	48	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded) \$ 2,611	
Labor cost, burdened	O/H 150.0% \$ 6,527	
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30 years	

\$ 135.98

Capital Replacement Assumptions:

Replacement of mulch, plantings, and pipe discharge riprap every 10 years.

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 225,270		\$ 310,515	\$ 8,382,585	\$ 8,006,037			
0	1.000	\$ 7,694,000		\$ 7,694,000	\$ 7,694,000	\$ 7,694,000	\$ 7,694,000	\$ 8,006,037	
1	0.950	\$ 4,735		\$ 6,527	\$ 11,262	\$ 10,700	\$ 7,705,262	\$ 7,704,700	\$ 312,037
2	0.903	\$ 4,877		\$ 6,723	\$ 11,600	\$ 10,471	\$ 7,716,861	\$ 7,715,171	\$ 301,337
3	0.858	\$ 5,023		\$ 6,924	\$ 11,948	\$ 10,247	\$ 7,728,809	\$ 7,725,419	\$ 290,865
4	0.815	\$ 5,174		\$ 7,132	\$ 12,306	\$ 10,028	\$ 7,741,115	\$ 7,735,447	\$ 280,618
5	0.774	\$ 5,329		\$ 7,346	\$ 12,675	\$ 9,814	\$ 7,753,790	\$ 7,745,265	\$ 270,590
6	0.736	\$ 5,489		\$ 7,566	\$ 13,056	\$ 9,604	\$ 7,766,846	\$ 7,754,866	\$ 260,776
7	0.699	\$ 5,654		\$ 7,793	\$ 13,447	\$ 9,399	\$ 7,780,293	\$ 7,764,264	\$ 251,171
8	0.664	\$ 5,823		\$ 8,027	\$ 13,851	\$ 9,198	\$ 7,794,144	\$ 7,773,462	\$ 241,772
9	0.631	\$ 5,998		\$ 8,268	\$ 14,266	\$ 9,001	\$ 7,808,410	\$ 7,782,464	\$ 232,575
10	0.599	\$ 6,178	\$ 76,400	\$ 8,516	\$ 9,094	\$ 54,610	\$ 7,899,504	\$ 7,837,073	\$ 223,573
11	0.570	\$ 6,363		\$ 8,771	\$ 15,135	\$ 6,621	\$ 7,914,639	\$ 7,845,694	\$ 168,964
12	0.541	\$ 6,554		\$ 9,035	\$ 15,589	\$ 4,436	\$ 7,930,228	\$ 7,854,130	\$ 160,343
13	0.514	\$ 6,751		\$ 9,306	\$ 16,057	\$ 2,856	\$ 7,946,284	\$ 7,862,388	\$ 151,907
14	0.489	\$ 6,954		\$ 9,585	\$ 16,536	\$ 8,079	\$ 7,962,823	\$ 7,870,465	\$ 143,651
15	0.464	\$ 7,162		\$ 9,872	\$ 17,034	\$ 7,907	\$ 7,979,857	\$ 7,878,372	\$ 135,571
16	0.441	\$ 7,377		\$ 10,169	\$ 17,546	\$ 7,738	\$ 7,997,403	\$ 7,886,110	\$ 127,665
17	0.419	\$ 7,598		\$ 10,474	\$ 18,073	\$ 7,572	\$ 8,015,475	\$ 7,893,682	\$ 119,927
18	0.398	\$ 7,826		\$ 10,788	\$ 18,614	\$ 7,410	\$ 8,034,089	\$ 7,901,093	\$ 112,355
19	0.378	\$ 8,061		\$ 11,111	\$ 19,172	\$ 7,252	\$ 8,053,261	\$ 7,908,345	\$ 104,944
20	0.359	\$ 8,303	\$ 76,400	\$ 11,445	\$ 96,148	\$ 34,554	\$ 8,149,409	\$ 7,942,899	\$ 97,692
21	0.341	\$ 8,552		\$ 11,788	\$ 20,340	\$ 6,945	\$ 8,169,749	\$ 7,949,844	\$ 63,138
22	0.324	\$ 8,808		\$ 12,142	\$ 20,950	\$ 6,797	\$ 8,190,699	\$ 7,956,641	\$ 56,193
23	0.308	\$ 9,073		\$ 12,506	\$ 21,579	\$ 6,651	\$ 8,212,278	\$ 7,963,292	\$ 49,396
24	0.293	\$ 9,345		\$ 12,881	\$ 22,226	\$ 6,509	\$ 8,234,504	\$ 7,969,801	\$ 42,745
25	0.278	\$ 9,625		\$ 13,268	\$ 22,893	\$ 6,370	\$ 8,257,397	\$ 7,976,171	\$ 36,235
26	0.264	\$ 9,914		\$ 13,666	\$ 23,580	\$ 6,234	\$ 8,280,977	\$ 7,982,405	\$ 29,865
27	0.251	\$ 10,211		\$ 14,076	\$ 24,287	\$ 6,101	\$ 8,305,264	\$ 7,988,506	\$ 23,631
28	0.239	\$ 10,518		\$ 14,498	\$ 25,016	\$ 5,970	\$ 8,330,279	\$ 7,994,476	\$ 17,531
29	0.227	\$ 10,833		\$ 14,933	\$ 25,766	\$ 5,843	\$ 8,356,046	\$ 8,000,319	\$ 11,560
30	0.215	\$ 11,158		\$ 15,381	\$ 26,539	\$ 5,718	\$ 8,382,585	\$ 8,006,037	\$ 5,718

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Meaghan McGinn (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jeffrey Price (HDR)	
Description:	WQBE_22A_Regional Vegetated Media SW Facility on Public Property		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Flow Spreader Concrete Sump Box	4	FT Depth	\$ -	\$ -
2	Spreader Interior Dimensions 70'W X 3'L	210	SF	\$ -	\$ -
3	Facility Excavation to Waste @ 3 ft 'D	93	CY	\$ 79	\$ 7,315
4	Concrete Walls @ 0.67'	11	CY	\$ 1,250	\$ 13,586
5	Concrete Base (4.3'L X 71.3'W X 1'T)	11	CY	\$ 950	\$ 10,787
6	Structure Rebar @ 225 lbs/cy	5,000	LBS	\$ 1.38	\$ 6,901
7	Crushed Aggregate Base	6	CY	\$ 64	\$ 363
8	Trench Shoring Facility	560	SF	\$ 10	\$ 5,600
9				\$ -	\$ -
10	Energy Dissipating Concrete Structure	6	FT Depth	\$ -	\$ -
11	Structure Interior Dimensions 10'L X 6'W	210	SF	\$ -	\$ -
12	Facility Excavation to Waste - Open Cut 2:1 SS (@ 12'D)	235	CY	\$ 79	\$ 18,570
13	Imported Structural Fill	208	CY	\$ 44	\$ 9,133
14	Concrete Walls @ 0.67'T	5	CY	\$ 1,250	\$ 6,812
15	Concrete Base (7.3'W X 11.3'L X 1.67'T)	5	CY	\$ 950	\$ 4,847
16	Outfall Slab (5'L X 7'W X 1.67'T)	2	CY	\$ 320	\$ 693
17	Concrete Top Slab (0.67'T)	2	CY	\$ 1,250	\$ 2,559
18	Structure Rebar @ 225 lbs/cy	3,322	LBS	\$ 1.38	\$ 4,584
19	Crushed Aggregate Base (structure+slab)	2	CY	\$ 64	\$ 139
20				\$ -	\$ -
21	Regional Media Filter - Property	5,940	SF	\$ -	\$ -
22	Treatment Facility Bottom Area : 84.9'L X 70'W			\$ -	\$ -
23	Curbed, vertical sides - Top Area	5,940	SF	\$ -	\$ -
24	Structural Excavation to Waste - Open Cut 2:1 SS (@ 6'D)	2,344	CY	\$ 79	\$ 185,157
25	Imported Structural Fill	1,069	CY	\$ 44	\$ 47,046
26	Vault Concrete Walls (85.9'L X 71.5'W X 5'H @ 1'T)	58	CY	\$ 1,250	\$ 72,639
27	Vault Concrete Base (86.9'L X 72'W X 2'T)	463	CY	\$ 320	\$ 148,309
28	Vault Rebar @ 225 lbs/cy	117,355	LBS	\$ 1.38	\$ 161,950
29	Crushed Aggregate Base	116	CY	\$ 64	\$ 7,415
30	Proprietary Treatment Media (@ 1.5'D)	330	CY	\$ 707	\$ 233,310
31	Mulch Compost (@ 0.3'D)	66	CY	\$ 86	\$ 5,676
32	Flow Discharge 6" Spalls	13	CY	\$ 74	\$ 959
33				\$ -	\$ -
34	Underdrain	594	LF	\$ -	\$ -
35	Underdrain Aggregate (10'W X 84.9'L X 1.5'D)	330	CY	\$ 133	\$ 43,890
36	Pipe 12" Slotted Drain, PVC	594	LF	\$ 111	\$ 65,756
37				\$ -	\$ -
38	Restoration and Landscaping			\$ -	\$ -
39	Landscaping, Planting, and Restoration (100' X 90')	1,000	SY	\$ 59	\$ 59,000
40	Trees Along the Perimeter	10	EA	\$ 720	\$ 7,200
41	Irrigation System	9,000	SF	\$ 1.2	\$ 10,800
42				\$ -	\$ -
43	Inlet Pipe			\$ -	\$ -
44	Pipe - 12" Diameter	1,000	LF	\$ 140	\$ 140,000
45	5' Wide Trench x 6' D to waste	1,111	CY	\$ 79	\$ 87,778
46	Trench Box Shoring (Shallow)	12,000	SF	\$ 10	\$ 120,000
47	Imported Backfill	1,082	CY	\$ 44	\$ 47,609
48	Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
49	48" Maintenance Hole	1	EA	\$ 10,640	\$ 10,640
50	Seeding and Restoration	889	SY	\$ 10	\$ 8,889
51				\$ -	\$ -
52	Outlet Pipe			\$ -	\$ -
53	Pipe - 8" Diameter	1,000	LF	\$ 80	\$ 80,000
54	5' Wide Trench x 7'D to waste	1,296	CY	\$ 79	\$ 102,407
55	Trench Box Shoring (Shallow)	14,000	SF	\$ 10	\$ 140,000
56	Imported Backfill	1,283	CY	\$ 44	\$ 56,468
57	Catch Basin	1	EA	\$ 3,900	\$ 3,900
58	Seeding and Restoration	889	SY	\$ 10	\$ 8,889
59				\$ -	\$ -
60	Treatment Facility Low Flow Bypass System			\$ -	\$ -
61	Pipe - 12" Diameter	200	LF	\$ 140	\$ 28,000
62	Bypass Structure	1	EA	\$ 42,000	\$ 42,000
63	Pipe - 8" Diameter	500	LF	\$ 80	\$ 40,000
64	5' Wide Trench x 9'D to waste	1,033	CY	\$ 79	\$ 81,633
65	Trench Box Shoring (Shallow)	7,000	SF	\$ 10	\$ 70,000
66	Imported Backfill	1,021	CY	\$ 44	\$ 44,926
67	48" Maintenance Hole	1	EA	\$ 10,640	\$ 10,640
68	Seeding and Restoration	622	SY	\$ 10	\$ 6,222
69				\$ -	\$ -
70	Additional Costs			\$ -	\$ -
71	Removals @ 4%	4.0%	LS	\$ 2,273,458	\$ 90,938
72	TESC @ 2% of Construction Costs	2%	LS	\$ 2,364,396	\$ 47,288
				Item Subtotal Construction Costs (Year 2023)	\$ 2,411,684
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$ 241,168	
	Overhead & Profit (OHP)	0%	1	\$ -	
	Insurance	0.0%	1	\$ -	
	Bonding	0.0%	1	\$ -	
	Escalation Multiplier from ENR-CCI	0%	1,000	\$ -	
	Item Subtotal Construction Costs (Year 2023)			\$ 2,652,853	
	Direct: Subtotal Construction Costs			\$ 2,652,900	

Description: WQBE 22A - Regional Vegetated Media SW Facility on Public Property

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

Cost Assumptions

Regional Media Filter Facility installation is per Filterra product specification. The concept design is based upon the Kitsap County Regional Media - Manchester SW Retrofit project.

The design includes requirements from the KC SWDM for Section 6.2, Water Quality Facilities.

A concrete sump box flow spreader is included that conforms to Section 6.2.6 of the KC SWDM.

The regional media facility is assumed to be a below grade cast-in-place closed facility for the cost model. The costs should be re-evaluated should smaller pre-cast modular systems be used.

The concrete walls are flush with ground surface.

The facility is a concrete open top structure with an interior bottom footprint of 5,940 square feet and a ponding depth of 0.70'.

Treatment vault has interior dimensions of 70'W x 84.9 x 5'H.

The exterior wall thickness is 1 foot wide and the base foundation slab is 2 feet thick.

The media and drain sections within the regional treatment facility consists of 0.3' of composting mulch, 1.8' of proprietary treatment media, and a 1.5' deep aggregate underdrain system.

The facility contains 12" slotted PVC underdrains that are spaced at 10 foot intervals within the facility. The underdrain piping system is approximately 594 feet in length.

There is a 0.5' layer of crushed base beneath the base/ballast slab.

The excavation for the structures are assumed to be open cut with 2:1 (run:rise) temporary construction slopes. A geotechnical report is required to confirm the required construction slope used.

It is assumed that the facility is located above the ground water table and that buoyancy considerations are not a factor and dewatering is not required.

A concrete flow dissipating structure is included with interior dimensions of 6' wide by 10' long and 6' high. The concrete structure is assumed to have the following:

The exterior wall thickness is 8" wide, a top slab that is 8" thick, and the base foundation slab is 1'-8" thick.

The media treatment facility is preceded by a concrete flow spreading facility that meets the requirements of the King Co. Surface Water Design Manual Section 6.2.6B.

The flow spreader is a below grade, cast-in-place concrete structure with interior average dimensions of 69 feet wide by 2 feet long by 2 feet deep.

Gravel pads are used to dissipate energy at the locations where flow crests the flow spreading structure to enter the treatment structure.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

The treatment facility is assumed to drain by gravity via a surface grate inlet.

Approximately 1000 LF of 12" diameter Inlet piping and 1000 LF and 8" diameter outlet pipe.

Trench Box shoring for pipe installation.

Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Restoration along the facility and pipe alignment is assumed to be seeded grass.

Landscape with trees, shrubs, and an irrigation system are assumed for restoration.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located outside of the roadway right-of-way and traffic control will not be required.

A street use permit is not required.

The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside right-of way. No property easements or acquisition are required.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A

Moderate indirect project cost complexity factor was assigned: 28% Design Engineering, 13%; Construction Management, Permitting & Support 2%, and 9% WTD Staff Labor

A **25%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation and Indirect Burden.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_22B_Regional_Vegetated Media_SW_Facility With Propert Cost (2023 Dollars)

Unit	1 EA
Initial Capital Cost	\$ 8,452,600
Capital cost	\$ 8,452,600 \$/Unit
Total Direct O&M/Year	\$ 6,527
Direct O&M cost	\$ 6,527 \$/Unit
Capital Replacement Costs (10 Years)	\$ 76,400 \$/unit
Discount rate (%)	5.25 \$/Unit

Total Cost (NPV)	\$ 8,764,600 \$/unit
Annual O&M Cost	\$ 11,300 \$/year
Annualized Cost	\$ 7,510 \$/year

Materials, Supplies, Other Costs

Mulch	2023 dollars	\$ 2,215
Annual plant replacement	2023 dollars	\$ 2,160
Vactor Truck Equipment + Labor Cost	2023 dollars	\$ 360
Subtotal		\$ 4,735
Labor		
Mulch Replacement	16 hr	
Plant Health	8 hr	
Removal of Debris with Vactor truck	24 hr	
	0 hr	
Total hours per year	48	
Raw Labor Rate/Hr	\$ 54	
Raw labor cost	(embedded)	\$ 2,611
Labor cost, burdened	O/H 150.0%	\$ 6,527
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30 years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 225,270		\$ 310,515	\$ 9,141,185	\$ 8,764,637			
0	1.000	\$ 8,452,600		\$ 8,452,600	\$ 8,452,600	\$ 8,452,600	\$ 8,452,600	\$ 8,452,600	\$ 8,764,637
1	0.950	\$ 4,735	\$ -	\$ 6,527	\$ 11,262	\$ 10,700	\$ 8,463,862	\$ 8,463,300	\$ 312,037
2	0.903	\$ 4,877	\$ -	\$ 6,723	\$ 11,600	\$ 10,471	\$ 8,475,461	\$ 8,473,771	\$ 301,337
3	0.858	\$ 5,023	\$ -	\$ 6,924	\$ 11,948	\$ 10,247	\$ 8,487,409	\$ 8,484,019	\$ 290,865
4	0.815	\$ 5,174	\$ -	\$ 7,132	\$ 12,306	\$ 10,028	\$ 8,499,715	\$ 8,494,047	\$ 280,618
5	0.774	\$ 5,329	\$ -	\$ 7,346	\$ 12,675	\$ 9,814	\$ 8,512,390	\$ 8,503,861	\$ 270,590
6	0.736	\$ 5,489	\$ -	\$ 7,566	\$ 13,056	\$ 9,604	\$ 8,525,446	\$ 8,513,465	\$ 260,776
7	0.699	\$ 5,654	\$ -	\$ 7,793	\$ 13,447	\$ 9,399	\$ 8,538,893	\$ 8,522,864	\$ 251,171
8	0.664	\$ 5,823	\$ -	\$ 8,027	\$ 13,854	\$ 9,198	\$ 8,552,744	\$ 8,532,069	\$ 241,772
9	0.631	\$ 5,998	\$ -	\$ 8,268	\$ 14,266	\$ 9,001	\$ 8,567,010	\$ 8,541,064	\$ 232,575
10	0.599	\$ 6,178	\$ 76,400	\$ 8,516	\$ 91,094	\$ 4,610	\$ 8,658,100	\$ 8,595,673	\$ 223,573
11	0.570	\$ 6,363	\$ -	\$ 8,771	\$ 15,135	\$ 8,621	\$ 8,673,239	\$ 8,604,294	\$ 168,964
12	0.541	\$ 6,554	\$ -	\$ 9,035	\$ 15,589	\$ 8,436	\$ 8,688,828	\$ 8,612,730	\$ 160,343
13	0.514	\$ 6,751	\$ -	\$ 9,306	\$ 16,057	\$ 8,256	\$ 8,704,884	\$ 8,620,986	\$ 151,907
14	0.489	\$ 6,954	\$ -	\$ 9,585	\$ 16,538	\$ 8,079	\$ 8,721,423	\$ 8,629,065	\$ 143,651
15	0.464	\$ 7,162	\$ -	\$ 9,872	\$ 17,034	\$ 7,907	\$ 8,738,457	\$ 8,636,972	\$ 135,571
16	0.441	\$ 7,377	\$ -	\$ 10,169	\$ 17,546	\$ 7,738	\$ 8,756,000	\$ 8,644,710	\$ 127,665
17	0.419	\$ 7,598	\$ -	\$ 10,474	\$ 18,072	\$ 7,572	\$ 8,774,075	\$ 8,652,282	\$ 119,927
18	0.398	\$ 7,826	\$ -	\$ 10,788	\$ 18,614	\$ 7,410	\$ 8,792,688	\$ 8,659,694	\$ 112,355
19	0.378	\$ 8,061	\$ -	\$ 11,111	\$ 19,172	\$ 7,252	\$ 8,811,861	\$ 8,666,945	\$ 104,944
20	0.359	\$ 8,303	\$ 76,400	\$ 11,445	\$ 96,148	\$ 34,554	\$ 8,908,000	\$ 8,701,499	\$ 97,692
21	0.341	\$ 8,552	\$ -	\$ 11,788	\$ 20,340	\$ 6,945	\$ 8,928,349	\$ 8,708,444	\$ 63,138
22	0.324	\$ 8,808	\$ -	\$ 12,142	\$ 20,950	\$ 6,797	\$ 8,949,299	\$ 8,715,241	\$ 56,193
23	0.308	\$ 9,073	\$ -	\$ 12,506	\$ 21,579	\$ 6,651	\$ 8,970,878	\$ 8,721,892	\$ 49,396
24	0.293	\$ 9,345	\$ -	\$ 12,881	\$ 22,226	\$ 6,509	\$ 8,993,100	\$ 8,728,401	\$ 42,745
25	0.278	\$ 9,625	\$ -	\$ 13,268	\$ 22,893	\$ 6,370	\$ 9,015,997	\$ 8,734,771	\$ 36,235
26	0.264	\$ 9,914	\$ -	\$ 13,666	\$ 23,580	\$ 6,234	\$ 9,039,577	\$ 8,741,005	\$ 29,865
27	0.251	\$ 10,211	\$ -	\$ 14,076	\$ 24,287	\$ 6,101	\$ 9,063,868	\$ 8,747,105	\$ 23,631
28	0.239	\$ 10,518	\$ -	\$ 14,498	\$ 25,016	\$ 5,970	\$ 9,088,879	\$ 8,753,076	\$ 17,531
29	0.227	\$ 10,833	\$ -	\$ 14,933	\$ 25,768	\$ 5,843	\$ 9,114,646	\$ 8,758,919	\$ 11,560
30	0.215	\$ 11,158	\$ -	\$ 15,381	\$ 26,539	\$ 5,718	\$ 9,141,185	\$ 8,764,637	\$ 5,718

Description: WQBE_22B_Regional_Vegetated Media_SW_Facility With Propert Cost

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

Life-Cycle Cost Model Input Assumptions:

Capital replacement is input as total project cost and not construction cost.

O&M Estimating Assumptions:

Removal of foreign debris, silt and trash from filter surface shall occur biannually or after a major storm event. This will include 2 crew members, 3 visits per year, 4 hours per visit, vactor truck included. Total of 24 man 24 hours.

Vactor Catch Basin annually with 0.5 hour equipment time and 0.5 hour with a crew of 2. Total cost (including labor) \$360.

Biannual evaluation of plant material health, 2 crew members, 2 visits per year, 2 hours per visit. Total of 8 man 8 hours.

Annual plant replacement allowance of \$2,160. Will allow for the replacement of approximately 40 shrubs or other medium sized plant material.

Biannually 3" mulch layer shall be removed and replaced; this will include two crew members, 2 visits per year, 4 hours per visit, 16 man hours per year, includes dump truck and backhoe loader. Total of 16 man hours. Annual 16 cost of \$22215 for mulch.

Capital Replacement Assumptions:

Replacement of mulch, plantings, and pipe discharge riprap every 10 years.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Meaghan McGinn (HDR) Cindy Kinzer (HDR) Troy Gibbs (HDR) Jeffrey Price (HDR)	
Description:	WQBE_22B_Regional_Vegetated Media_SW_Facility With Propert Cost		Version:	2	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Flow Spreader Concrete Sump Box	4	FT Depth	\$ -	\$ -
2	Spreader Interior Dimensions 70'W X 3'L	210	SF	\$ -	\$ -
3	Facility Excavation to Waste @ 3 ft 'D	93	CY	\$ 79	\$ 7,315
4	Concrete Walls @ 0.67'	11	CY	\$ 1,250	\$ 13,586
5	Concrete Base (4.3'L X 71.3'W X 1'T)	11	CY	\$ 950	\$ 10,787
6	Structure Rebar @ 225 lbs/cy	5,000	LBS	\$ 1.38	\$ 6,901
7	Crushed Aggregate Base	6	CY	\$ 64	\$ 363
8	Trench Shoring Facility	560	SF	\$ 10	\$ 5,600
9				\$ -	\$ -
10	Energy Dissipating Concrete Structure	6	FT Depth	\$ -	\$ -
11	Structure Interior Dimensions 10'L X 6'W	210	SF	\$ -	\$ -
12	Facility Excavation to Waste - Open Cut 2:1 SS (@ 12'D)	235	CY	\$ 79	\$ 18,570
13	Imported Structural Fill	208	CY	\$ 44	\$ 9,133
14	Concrete Walls @ 0.67'T	5	CY	\$ 1,250	\$ 6,812
15	Concrete Base (7.3'W X 11.3'L X 1.67'T)	5	CY	\$ 950	\$ 4,847
16	Outfall Slab (5'L X 7'W X 1.67'T)	2	CY	\$ 320	\$ 693
17	Concrete Top Slab (0.67'T)	2	CY	\$ 1,250	\$ 2,559
18	Structure Rebar @ 225 lbs/cy	3,322	LBS	\$ 1.38	\$ 4,584
19	Crushed Aggregate Base (structure+slab)	2	CY	\$ 64	\$ 139
20				\$ -	\$ -
21	Regional Media Filter - Property	5,940	SF	\$ -	\$ -
22	Treatment Facility Bottom Area : 84.9'L X 70'W			\$ -	\$ -
23	Curbed, vertical sides - Top Area	5,940	SF	\$ -	\$ -
24	Structural Excavation to Waste - Open Cut 2:1 SS (@ 6'D)	2,344	CY	\$ 79	\$ 185,157
25	Imported Structural Fill	1,069	CY	\$ 44	\$ 47,046
26	Vault Concrete Walls (85.9'L X 71.5'W X 5'H @ 1'T)	58	CY	\$ 1,250	\$ 72,639
27	Vault Concrete Base (86.9'L X 72'W X 2'T)	463	CY	\$ 320	\$ 148,309
28	Vault Rebar @ 225 lbs/cy	117,355	LBS	\$ 1.38	\$ 161,950
29	Crushed Aggregate Base	116	CY	\$ 64	\$ 7,415
30	Proprietary Treatment Media (@ 1.5'D)	330	CY	\$ 707	\$ 233,310
31	Mulch Compost (@ 0.3'D)	66	CY	\$ 86	\$ 5,676
32	Flow Discharge 6" Spalls	13	CY	\$ 74	\$ 959
33				\$ -	\$ -
34	Underdrain	594	LF	\$ -	\$ -
35	Underdrain Aggregate (10'W X 84.9'L X 1.5'D)	330	CY	\$ 133	\$ 43,890
36	Pipe 12" Slotted Drain, PVC	594	LF	\$ 111	\$ 65,756
37				\$ -	\$ -
38	Restoration and Landscaping			\$ -	\$ -
39	Landscaping, Planting, and Restoration (100' X 90')	1,000	SY	\$ 59	\$ 59,000
40	Trees Along the Perimeter	10	EA	\$ 720	\$ 7,200
41	Irrigation System	9,000	SF	\$ 1.2	\$ 10,800
42				\$ -	\$ -
43	Inlet Pipe			\$ -	\$ -
44	Pipe - 12" Diameter	1,000	LF	\$ 140	\$ 140,000
45	5' Wide Trench x 6' D to waste	1,111	CY	\$ 79	\$ 87,778
46	Trench Box Shoring (Shallow)	12,000	SF	\$ 10	\$ 120,000
47	Imported Backfill	1,082	CY	\$ 44	\$ 47,609
48	Pipe Discharge - Riprap (12' Long by 8' wide x 2 ft thick)	7	CY	\$ 346	\$ 2,460
49	48" Maintenance hole	1	EA	\$ 10,640	\$ 10,640
50	Seeding and Restoration	889	SY	\$ 10	\$ 8,889
51				\$ -	\$ -
52	Outlet Pipe			\$ -	\$ -
53	Pipe - 8" Diameter	1,000	LF	\$ 80	\$ 80,000
54	5' Wide Trench x 7'D to waste	1,296	CY	\$ 79	\$ 102,407
55	Trench Box Shoring (Shallow)	14,000	SF	\$ 10	\$ 140,000
56	Imported Backfill	1,283	CY	\$ 44	\$ 56,468
57	Catch Basin	1	EA	\$ 3,900	\$ 3,900
58	Seeding and Restoration	889	SY	\$ 10	\$ 8,889
59				\$ -	\$ -
60	Treatment Facility Low Flow Bypass System			\$ -	\$ -
61	Pipe - 12" Diameter	200	LF	\$ 140	\$ 28,000
62	Bypass Structure	1	EA	\$ 42,000	\$ 42,000
63	Pipe - 8" Diameter	500	LF	\$ 80	\$ 40,000
64	5' Wide Trench x 7'D to waste	1,033	CY	\$ 79	\$ 81,633
65	Trench Box Shoring (Shallow)	7,000	SF	\$ 10	\$ 70,000
66	Imported Backfill	1,021	CY	\$ 44	\$ 44,926
67	48" Maintenance Hole	1	EA	\$ 10,640	\$ 10,640
68	Seeding and Restoration	622	SY	\$ 10	\$ 6,222
69				\$ -	\$ -
70	Additional Costs			\$ -	\$ -
71	Removals @ 4%	4.0%	LS	\$ 2,273,458	\$ 90,938
72	TESC @ 2% of Construction Costs	2%	LS	\$ 2,364,396	\$ 47,288
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 2,411,684
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$ -	\$ -
	Mobilization/Demobilization	10%	1.1	\$	\$ 241,168
	Overhead & Profit (OHP)	0%	1	\$	\$ -
	Insurance	0.0%	1	\$	\$ -
	Bonding	0.0%	1	\$	\$ -
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	\$ -
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 2,652,853
<i>Direct: Subtotal Construction Costs (4 SF Area)</i>					\$ 2,652,900

Description: WQBE 22B - Regional Vegetated Media SW Facility With Property Cost

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area.

Cost Assumptions

Regional Media Filter Facility installation is per Filterra product specification. The concept design is based upon the Kitsap County Regional Media - Manchester SW Retrofit project.

The design includes requirements from the KC SWDM for Section 6.2, Water Quality Facilities.

A concrete sump box flow spreader is included that conforms to Section 6.2.6 of the KC SWDM.

The regional media facility is assumed to be a below grade cast-in-place closed facility for the cost model. The costs should be re-evaluated should smaller pre-cast modular systems be used.

The concrete walls are flush with ground surface.

The facility is a concrete open top structure with an interior bottom footprint of 5,940 square feet and a ponding depth of 0.70'.

Treatment vault has interior dimensions of 70'W x 84.9 x 5'H.

The exterior wall thickness is 1 foot wide and the base foundation slab is 2 feet thick.

The media and drain sections within the regional treatment facility consists of 0.3' of composting mulch, 1.8' of proprietary treatment media, and a 1.5' deep aggregate underdrain system.

The facility contains 12" slotted PVC underdrains that are spaced at 10 foot intervals within the facility. The underdrain piping system is approximately 594 feet in length.

There is a 0.5' layer of crushed base beneath the base/ballast slab.

The excavation for the structures are assumed to be open cut with 2:1 (run:rise) temporary construction slopes. A geotechnical report is required to confirm the required construction slope used.

It is assumed that the facility is located above the ground water table and that buoyancy considerations are not a factor and dewatering is not required.

A concrete flow dissipating structure is included with interior dimensions of 6' wide by 10' long and 6' high. The concrete structure is assumed to have the following:

The exterior wall thickness is 8" wide, a top slab that is 8" thick, and the base foundation slab is 1'-8" thick.

The media treatment facility is preceded by a concrete flow spreading facility that meets the requirements of the King Co. Surface Water Design Manual Section 6.2.6B.

The flow spreader is a below grade, cast-in-place concrete structure with interior average dimensions of 69 feet wide by 2 feet long by 2 feet deep.

Gravel pads are used to dissipate energy at the locations where flow crests the flow spreading structure to enter the treatment structure.

No contaminated soil or groundwater is assumed to exist at the proposed vault location.

The treatment facility is assumed to drain by gravity via a surface grate inlet.

Approximately 1000 LF of 12" diameter Inlet piping and 1000 LF and 8" diameter outlet pipe.

Trench Box shoring for pipe installation.

Concrete curb, gutter, and sidewalk removal and restoration is not required for the installation.

Restoration along the facility and pipe alignment is assumed to be seeded grass.

Landscape with trees, shrubs, and an irrigation system are assumed for restoration.

Removals are estimated at 4% of the item construction costs, in conformance with LTCP.

Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.

The facility is located on property and traffic control is not required.

A street use permit is not required.

The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to High.

Planning Basis Assumptions:

No project construction plan is in place at this time.

The assumed execution strategy is a standard work week with limited overtime.

No alternative procurement methods have been considered as part of delivery of this concept.

No unusual site conditions have been considered as part of this estimate.

Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.

Cost Basis Assumptions:

All construction, direct and indirect costs were estimated utilizing local unit price analysis and databases of the estimating provider.

Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.

Allowances:

The level and types of allowances used in the estimate are as follows:

Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.

Allowance of 10% for potential change orders.

This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A **Moderate** indirect project cost complexity factor was assigned: 22% Design Engineering, 13%; Construction Management, and 8% WTD Staff Cost

A **25%** Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.

Costs were not included for Local Agency Mitigation.

The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were **not** included.

Costs were not included for utility relocation work.

Estimating Assumptions:

This estimate is classified as a **Class 10** ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of **-50% to +100%**, for the scope as known at the time of the estimate preparation.

It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.

It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.

It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.

It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

A **30%** Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Updated on 06/13/24

Item No.	Action	Class	Complexity	Description	Sub-Action Number	Subcategory	PHASE 3 COSTS (2023 Dollars)							
							Action Unit	Design Drainage Area	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)
23	Sports Field	Class 10	Routine	WQBE_23_Sports Field and Park Detention	N/A	On property, no property acquisition.	29,600	103,800 SF	\$ 10,224,600	\$0	\$ 7,769,300	\$ 17,993,900	\$ 33,300	\$ 18,700,900

MANDATORY INPUTS		
Input Category	Inputs	Comments
Retail Sales Tax Rate	10.25%	Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle
Allowance for Indeterminates (AFI), Dependent Upon Project Phase	20%	Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%)
Construction Change Order Allowance	10%	
Project Contingency	30%	

SECONDARY INPUTS		
Input Category	Inputs	Comments
Street Use Permit	\$ 90,000	In ROW only - Arterial @ \$90,000/Unit; Non-Arterial @use \$30000/unit
Outside Agency Construction	2%	For Projects in ROW Utility coordination assumed to be at 2% construction cost.

PROJECT CATEGORY AND INDIRECT PROJECT INPUTS		
Input Category	Inputs	Comments

PROPERTY COST

Cost Category	\$/sf
Low	\$ 10.10
Medium	\$ 80.43
High	\$ 284.37
None	\$ -

Description: WQBE 23 - Sports Field and Park Detention (2023 Dollars)		
Unit	29,600	hr
Initial Capital Cost	\$ 17,993,900	
Capital cost	\$ 608	/Unit
Total Direct O&M/year	\$ 5,983	
Direct O&M cost	\$ 0.20	/Unit
Capital Replacement Costs (10 Years)	\$ -	/unit
Discount rate (%)	5.25	/Unit

Total Cost (NPV)	\$ 18,700,900	/unit
Annual O&M Cost	\$ 33,300	/year
Annualized Cost	\$43,390	/year

Equipment, Supplies, Other Costs		
	\$ -	/year
Storm Facility Vactor Equipment Cost	2023 dollars	\$ 4,320
Vactor Truck Equipment	2023 dollars	\$ 23,040
Subtotal		\$27,360
Labor		
Remove Trash, debris, clean storm structures	12	hr
ADS Isolator Row Cleaning and Mtc.	32	hr
	0	hr
	0	hr
Total hours per year	44	
Raw Labor Rate/Hr		\$ 54
Raw labor cost	(embedded)	\$ 2,393
Labor cost, burdened	O/H 150.0%	\$ 5,983
General and Labor Cost Escalation/Year	3.0%	
Life Cycle Period:	30	years

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 1,301,663		\$ 284,639	\$ 19,580,202	\$ 18,700,855			
0	1.000	\$ 17,993,900		\$ -	\$ 17,993,900	\$ 17,993,900	\$ 17,993,900	\$ 17,993,900	\$ 18,700,855
1	0.950	\$27,360		\$ 5,983	\$ 33,343	\$ 31,680	\$ 18,027,243	\$ 18,027,243	\$ 706,955
2	0.903	\$ 28,181		\$ 6,162	\$ 34,343	\$ 31,002	\$ 18,061,588	\$ 18,061,588	\$ 675,276
3	0.858	\$ 29,026		\$ 6,347	\$ 35,373	\$ 30,340	\$ 18,096,960	\$ 18,096,960	\$ 644,273
4	0.815	\$ 29,897		\$ 6,538	\$ 36,435	\$ 29,691	\$ 18,133,394	\$ 18,133,394	\$ 613,933
5	0.774	\$ 30,794		\$ 6,734	\$ 37,528	\$ 29,056	\$ 18,170,922	\$ 18,170,922	\$ 584,242
6	0.736	\$ 31,718		\$ 6,936	\$ 38,654	\$ 28,435	\$ 18,209,576	\$ 18,209,576	\$ 555,186
7	0.699	\$ 32,669		\$ 7,144	\$ 39,813	\$ 27,827	\$ 18,249,385	\$ 18,249,385	\$ 526,751
8	0.664	\$ 33,649		\$ 7,358	\$ 41,008	\$ 27,232	\$ 18,290,396	\$ 18,290,396	\$ 498,923
9	0.631	\$ 34,659		\$ 7,579	\$ 42,238	\$ 26,650	\$ 18,332,634	\$ 18,332,634	\$ 471,691
10	0.599	\$ 35,699		\$ 7,806	\$ 43,505	\$ 26,081	\$ 18,376,139	\$ 18,376,139	\$ 445,040
11	0.570	\$ 36,770		\$ 8,041	\$ 44,810	\$ 25,523	\$ 18,420,949	\$ 18,420,949	\$ 418,960
12	0.541	\$ 37,873		\$ 8,282	\$ 46,154	\$ 24,977	\$ 18,467,103	\$ 18,467,103	\$ 393,437
13	0.514	\$ 39,009		\$ 8,530	\$ 47,539	\$ 24,443	\$ 18,514,642	\$ 18,514,642	\$ 368,459
14	0.489	\$ 40,179		\$ 8,786	\$ 48,965	\$ 23,921	\$ 18,563,603	\$ 18,563,603	\$ 344,016
15	0.464	\$ 41,384		\$ 9,050	\$ 50,434	\$ 23,410	\$ 18,614,042	\$ 18,614,042	\$ 320,095
16	0.441	\$ 42,626		\$ 9,321	\$ 51,947	\$ 22,909	\$ 18,665,989	\$ 18,665,989	\$ 296,686
17	0.419	\$ 43,905		\$ 9,601	\$ 53,506	\$ 22,419	\$ 18,719,494	\$ 18,719,494	\$ 273,776
18	0.398	\$ 45,222		\$ 9,889	\$ 55,111	\$ 21,940	\$ 18,774,605	\$ 18,774,605	\$ 251,357
19	0.378	\$ 46,579		\$ 10,185	\$ 56,764	\$ 21,471	\$ 18,831,369	\$ 18,831,369	\$ 229,417
20	0.359	\$ 47,976		\$ 10,491	\$ 58,467	\$ 21,012	\$ 18,889,836	\$ 18,889,836	\$ 207,946
21	0.341	\$ 49,415		\$ 10,806	\$ 60,221	\$ 20,563	\$ 18,950,057	\$ 18,950,057	\$ 185,934
22	0.324	\$ 50,896		\$ 11,130	\$ 62,028	\$ 20,123	\$ 19,012,085	\$ 19,012,085	\$ 166,371
23	0.308	\$ 52,425		\$ 11,464	\$ 63,888	\$ 19,693	\$ 19,075,973	\$ 19,075,973	\$ 146,248
24	0.293	\$ 53,997		\$ 11,808	\$ 65,805	\$ 19,272	\$ 19,141,778	\$ 19,141,778	\$ 126,555
25	0.278	\$ 55,617		\$ 12,162	\$ 67,779	\$ 18,860	\$ 19,209,558	\$ 19,209,558	\$ 107,283
26	0.264	\$ 57,286		\$ 12,527	\$ 69,813	\$ 18,457	\$ 19,279,370	\$ 19,279,370	\$ 88,422
27	0.251	\$ 59,004		\$ 12,903	\$ 71,907	\$ 18,062	\$ 19,351,277	\$ 19,351,277	\$ 69,965
28	0.239	\$ 60,774		\$ 13,290	\$ 74,064	\$ 17,676	\$ 19,425,341	\$ 19,425,341	\$ 51,903
29	0.227	\$ 62,598		\$ 13,688	\$ 76,286	\$ 17,298	\$ 19,501,628	\$ 19,501,628	\$ 34,227
30	0.215	\$ 64,476		\$ 14,099	\$ 78,575	\$ 16,929	\$ 19,580,202	\$ 19,580,202	\$ 16,929

Description: WQBE 02A - Bioretention Planter on Property

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Inspection and removal of trash, debris and obstruction limiting flow into slot drain storm piping, structures to remove trash, sediment and debris (2 visits/year, 3 hour per visit) performed by a 12 crew of 2. Equipment costs at \$360/hr not including labor costs.

Replacement Assumptions:

Per ADS Stormtech Life span is greater than 50 years if per mfg. and AASHTO design criteria
Replacement Artificial Turf Assumed to be part of the sports field operational costs and not included with the ADS system.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/13/2024
Location:	King County, WA			Estimator:	Cindy Kinzer Jess Dexheimer Trooper Shaw
Description:	WQBE_23 - Sports Field and Park Detention			Version:	2
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Sportsfield Soccer Field Area	29,600	SF	\$	-
	Field Length	150	FT	\$	-
	Field Width	185	FT	\$	-
				\$	-
	Drains and Infiltration Layer Input			\$	-
	Synthetic Turf System (infilled) @ 2" Depth	0.17	FT	\$	-
	Well Graded Sandy Gravel @ 2" Depth	0.17	FT	\$	-
	Crushed Surfacing (Choker Course) @ 2" Depth	0.17	FT	\$	-
	Depth from Choker Course to Top of ADS	1.5	FT	\$	-
	ADS System Height	2.5	FT	\$	-
	Sub-Exc for ADS layers	1.5	FT	\$	-
				\$	-
	Removals and Restoration			\$	-
	Clearing and Grubbing	3,289	SY	\$ 8	\$ 26,311
	Artificial Turf System (installed)	29,600	SF	\$ 35	\$ 1,036,000
				\$	-
	Excavation and Backfill			\$	-
	Total Exc. Depth	6.0	FT	\$	-
	Excavation and Disposal, Including Haul	6,578	CY	\$ 79	\$ 519,644
	WSDOT Permeable Ballast	2,219	CY	\$ 95	\$ 210,759
				\$	-
	Drains and Infiltration Layers			\$	-
	ADS SC-740 Stormtech Chambers (length per unit)	75	LF	\$	-
	Number of Chambers	78	EA	\$	-
	Observation Cleanout Ports @ 2/chamber	156	EA	\$ 250	\$ 39,000
	ADS SC-740 Stormtech Chambers (4' 3" Wide by 2' 6 3/4" High)	5,850	LF	\$ 530	\$ 3,100,500
	ADS Chamber Ends, Fittings, and Manifold Connections (for 78 chambers)	1	LS	\$ 415,740	\$ 415,740
	Crushed Surfacing (Choker) Course	183	CY	\$ 105	\$ 19,185
	Well Graded Sandy Gravel	183	CY	\$ 85	\$ 15,531
	Geofabric system (1 top layer + 1 bottom layer)	3,289	SY	\$ 24	\$ 78,933
	Stone with Liner System and end caps at 0.5 depth	1,644	CY	\$ 110	\$ 180,889
				\$	-
	Drainage Facilities and Inlet Piping			\$	-
	12"x12" Curb with 6" Pipe and Slot Drain (Field Edge)	150	LF	\$ 228	\$ 34,200
	Crushed Aggregate (6" thick)	3	CY	\$ 133	\$ 369
	Slot drain pipe connection 8" Dia.	50	LF	\$ 48	\$ 2,400
	4" Wide Trench x 7'D to waste	52	CY	\$ 79	\$ 4,096
	48" Diameter Manholes (pipe connections)	2	EA	\$ 10,640	\$ 21,280
	36" Storm Pipe	220	LF	\$ 480	\$ 105,600
	36" Storm Pipe (Influent)	250	LF	\$ 480	\$ 120,000
	5' Wide Trench x 7'D to waste	609	CY	\$ 79	\$ 48,131
	Assume Open Cut & No Trench Box Shoring			\$	-
	60" Type 2 Catch Basin	2	EA	\$ 21,200	\$ 42,400
				\$	-
	Additional Costs			\$	-
	Removals @ 4% Construction Costs	4.0%	LS	\$ 6,020,970	\$ 240,839
	TESC @2% Construction Costs	2%	LS	\$ 6,261,809	\$ 125,236
				\$	-
				\$	-
				\$	-
				\$	-
	Item Subtotal Construction Costs (Year 2023)			\$	6,387,045
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	638,705
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
	Item Subtotal Construction Costs (Year 2023)			\$	7,025,750
	Direct: Subtotal Construction Costs (29600 SF Area)			\$	7,025,750

Description: WQBE 23A - Sportsfield
Install subsurface storage at existing sportsfield or park to provide flow control while preserving recreational site use
Cost Estimating Assumptions:
The field area is assumed to be 150' long by 185' in width and a total of 29,600 sf area.
Field Restoration using an artificial turf system
The synthetic turf system (infilled) depth is 2-inches
the crushed surfacing (choker) course and well graded sandy gravel layer are each assumed to be 2-inches in depth.
the depth from the crushed surfacing to the ADS pipe system is 1.5 feet.
Array of ADS StormTech SC-740 that is 2 feet - 6 and 3/4 inches high by 4' - 3" wide.
The ADS stormtech chambers are 75 feet in length and a total of 78 chambers will be installed.
The chambers are capped on each end and connected with a manifold pipe.
Observation (cleanout) ports are provided at each end.
In-situ soils will not be suitable for re-use as backfill and trench material.
A 12 inch by 12 inch concrete curb with 6 inch slotted drain pipe will be installed along the upstream perimeter.
Two layers of geosynthetic liners will be installed at the bottom of the subsurface storage system.
Crushed gravel will be installed per ADS manufacturer requirements beneath the ADS storm tec system.
It is assumed that an 8" diameter pipe and two 48" manholes will be used to connect the slotted drain system to the main drain system.
the storm piping is 36 inches in diameter with two 60 inch diameter Type 2 Catch basins.
It is assumed that the ADS system and storm piping may be installed with open cut and trench shoring is not included.
Removals are assumed at 4% of the construction costs.
Erosion and sediment controls are assumed at 2% of the construction costs.
The installation is assumed to be on public property that is owned by King Co. or in King Co. non-roadside, right-of way. No property easements or acquisition are required.
Planning Basis Assumptions:
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.
Cost Basis Assumptions:
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.
Allowances:
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor
A 20% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI is accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included.
Costs were not included for utility relocation work.
Estimating Assumptions:
This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100% , for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.
A 30% Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Updated on 6/7/24

Item No.	Action	Class	Complexity	Description	Sub-Action Number	Subcategory	Action Unit	PHASE 3 COSTS (2023 Dollars)						
								Design Drainage Area	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)
24	Blue Roof	Class 10	Low	WQBE_24_Blue_Roof	N/A	On property, no property acquisition.	1,000 SF	1,000 SF	\$ 82,300	\$0	\$ 34,200	\$ 116,500	\$ 2,600	\$ 170,900

MANDATORY INPUTS		
Input Category	Inputs	Comments
Retail Sales Tax Rate	10.25%	Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle
Allowance for Indeterminates (AFI), Dependent Upon Project Phase	15%	Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%)
Construction Change Order Allowance	10%	
Project Contingency	15%	Override due to low complexity

SECONDARY INPUTS		
Input Category	Inputs	Comments
Street Use Permit	\$ 90,000	In ROW only - Arterial @ \$90,000/Unit; Non-Arterial @use \$30000/unit
Outside Agency Construction	5%	Assumes Utility coordination and work will be required est. at 5% construction cost.

PROJECT CATEGORY AND INDIRECT PROJECT INPUTS		
Input Category	Inputs	Comments

PROPERTY COST

Cost Category	\$/sf
Low	\$ 10.10
Medium	\$ 80.43
High	\$ 284.37
None	\$ -

Description: WQBE_25 Blue Roof (2023 Dollars)

Unit	1,000	ft ²
Initial Capital Cost	\$ 116,500	
Capital cost	\$ 117	/Unit
Total Direct O&M/Year	\$ 2,448	
Direct O&M cost	\$ 2.45	/Unit
Capital Replacement Costs (20 Years)	\$ -	/unit
Discount rate (%)	5.25	/Unit

Total Cost (NPV)	\$ 170,900	\$/unit
Annual O&M Cost	\$ 2,600	\$/year
Annualized Cost	\$4,070	\$/year

Materials, Supplies, Other Costs

	\$ -	\$ -	\$/year
Leak Sealant	1 2023 dollars	\$ 120	\$/year
	2023 dollars	\$ -	\$/year
Subtotal			\$120
Labor			
Inspection monthly to check for debris and clean drains	12	hr	
Remove sediment and debris and clean drains	6	hr	
0 hr	0	hr	
hr	hr	hr	
Total hours per year	18		
Raw Labor Rate/Hr	\$ 54		
Raw labor cost	(embedded)	\$ 979	
Labor cost, burdened	O/H 150.0%	\$ 2,448	
General and Labor Cost Escalation/Year	3.0%		
Life Cycle Period:	30	years	

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)	\$ 5,709	\$ 116,443	\$ 238,652	\$ 170,939					
0	1.000	\$ 116,500		\$ 116,500	\$ 116,500	\$ 116,500	\$ 116,500	\$ 116,500	\$ 170,939
1	0.950	\$ 120	\$ -	\$ 2,448	\$ 3,668	\$ 2,439	\$ 119,068	\$ 118,939	\$ 54,439
2	0.903	\$ 124	\$ -	\$ 2,521	\$ 2,645	\$ 2,387	\$ 121,712	\$ 121,327	\$ 51,099
3	0.858	\$ 127	\$ -	\$ 2,597	\$ 2,724	\$ 2,336	\$ 124,436	\$ 123,663	\$ 49,612
4	0.815	\$ 131	\$ -	\$ 2,675	\$ 2,806	\$ 2,286	\$ 127,242	\$ 125,949	\$ 47,276
5	0.774	\$ 135	\$ -	\$ 2,755	\$ 2,890	\$ 2,237	\$ 130,131	\$ 128,187	\$ 44,989
6	0.736	\$ 139	\$ -	\$ 2,837	\$ 2,976	\$ 2,190	\$ 133,108	\$ 130,377	\$ 42,752
7	0.699	\$ 143	\$ -	\$ 2,920	\$ 3,066	\$ 2,143	\$ 136,174	\$ 132,519	\$ 40,562
8	0.664	\$ 148	\$ -	\$ 3,010	\$ 3,158	\$ 2,097	\$ 139,332	\$ 134,616	\$ 38,419
9	0.631	\$ 152	\$ -	\$ 3,100	\$ 3,252	\$ 2,052	\$ 142,584	\$ 136,669	\$ 36,322
10	0.599	\$ 157	\$ -	\$ 3,193	\$ 3,350	\$ 2,008	\$ 145,934	\$ 138,677	\$ 34,270
11	0.570	\$ 161	\$ -	\$ 3,289	\$ 3,451	\$ 1,965	\$ 149,385	\$ 140,642	\$ 32,262
12	0.541	\$ 166	\$ -	\$ 3,388	\$ 3,554	\$ 1,923	\$ 152,939	\$ 142,566	\$ 30,296
13	0.514	\$ 171	\$ -	\$ 3,490	\$ 3,661	\$ 1,882	\$ 156,599	\$ 144,448	\$ 28,373
14	0.489	\$ 176	\$ -	\$ 3,594	\$ 3,771	\$ 1,842	\$ 160,370	\$ 146,290	\$ 26,491
15	0.464	\$ 182	\$ -	\$ 3,702	\$ 3,884	\$ 1,803	\$ 164,254	\$ 148,093	\$ 24,649
16	0.441	\$ 187	\$ -	\$ 3,813	\$ 4,000	\$ 1,764	\$ 168,254	\$ 149,857	\$ 22,846
17	0.419	\$ 193	\$ -	\$ 3,928	\$ 4,120	\$ 1,726	\$ 172,374	\$ 151,583	\$ 21,082
18	0.398	\$ 198	\$ -	\$ 4,045	\$ 4,244	\$ 1,689	\$ 176,618	\$ 153,273	\$ 19,356
19	0.378	\$ 204	\$ -	\$ 4,167	\$ 4,371	\$ 1,653	\$ 180,989	\$ 154,926	\$ 17,666
20	0.359	\$ 210	\$ -	\$ 4,292	\$ 4,502	\$ 1,618	\$ 185,491	\$ 156,544	\$ 16,013
21	0.341	\$ 217	\$ -	\$ 4,421	\$ 4,637	\$ 1,583	\$ 190,128	\$ 158,127	\$ 14,395
22	0.324	\$ 223	\$ -	\$ 4,553	\$ 4,776	\$ 1,550	\$ 194,905	\$ 159,677	\$ 12,811
23	0.308	\$ 230	\$ -	\$ 4,691	\$ 4,920	\$ 1,516	\$ 199,824	\$ 161,193	\$ 11,262
24	0.293	\$ 237	\$ -	\$ 4,830	\$ 5,067	\$ 1,484	\$ 204,892	\$ 162,677	\$ 9,745
25	0.278	\$ 244	\$ -	\$ 4,975	\$ 5,219	\$ 1,452	\$ 210,111	\$ 164,130	\$ 8,261
26	0.264	\$ 251	\$ -	\$ 5,125	\$ 5,376	\$ 1,421	\$ 215,487	\$ 165,551	\$ 6,809
27	0.251	\$ 259	\$ -	\$ 5,278	\$ 5,537	\$ 1,391	\$ 221,024	\$ 166,942	\$ 5,388
28	0.239	\$ 267	\$ -	\$ 5,437	\$ 5,703	\$ 1,361	\$ 226,727	\$ 168,303	\$ 3,997
29	0.227	\$ 275	\$ -	\$ 5,600	\$ 5,874	\$ 1,332	\$ 232,602	\$ 169,635	\$ 2,636
30	0.215	\$ 283	\$ -	\$ 5,768	\$ 6,051	\$ 1,304	\$ 238,652	\$ 170,939	\$ 1,304

Description: WQBE_25 Blue Roof

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.

Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

Inspection once per month for 1 person at 1 hour. Inspect regularly following wind storm and rain 12 events, look for agas and debris, and check drains.

Remove sediment and debris and clean drains by a one person using hand tools twice per year (2 visits per year, 3 hours per visit). Materials for sealing leaks estimated at \$120/yr.

Replacement Assumptions:

Blue roof life expectancy is 40 years with no replacement costs.

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation			Date:	6/7/2024
Location:	King County, WA			Estimator:	Cindy Kinzer Jess Dexheimer Trooper Shaw
Description:	WQBE_25 - Blue Roof			Version:	1
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Blue Roof Area	1,000	SF	\$	-
2	Blue Roof Storage Depth (4-inches)	0.33	FT	\$	-
3	Water Storage Volume	333	CF	\$	-
4				\$	-
5	Demolition and Removals			\$	-
6	Remove and dispose existing roofing	1,000	SF	\$ 2	\$ 2,000
	Remove and reset HVAC (incl. new base)	1	LS	\$ 8,400	\$ 8,400
				\$	-
	Blue Roof and Drain System			\$	-
	Install PVC Roof Membrane Assembly (40 - 45 mil), Insulation, Coverboard, Taping)	1,000	SF	\$ 27	\$ 27,000
				\$	-
	Roof Drain Riser Commercial Grade (Overflow) @ 1 drain per 250 SF	4	EA	\$ 2,500	\$ 10,000
	Roof Drain Piping (4" to 6" dia.) w/orifice, screen, and fittings	200	LF	\$ 31	\$ 6,200
				\$	-
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 53,600
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	5,360
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 58,960
<i>Direct: Subtotal Construction Costs (1000 SF Area)</i>					\$ 58,960

Description: WQBE 25 - Blue Roof
Rooftop detention designed to provide temporary storage and slow release of stormwater runoff
Retrofit of existing roof (flat with parapet) to provide up to 4 inches of storage draining to one control structure
Cost Estimating Assumptions:
Blue Roof for 1,000 sf area.
Roof drainage system reconfigured to direct runoff from 500 sf (of the 1,000 sf total) to control structure.
HVAC/utilities on roof raised 6 inches
Control structure has 0.25 inch orifice and redundant overflow with protective screening (e.g. sand filter to protect orifice from clogging)
Assumes structural upgrades not required
No additional sewer connections will be required.
Assume 1 overflow drain per 250 sf (4 total)
Roof drainage system piping 6" PVC with 200 LF total piping
No TESC measures are assumed for building retrofit system.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.
It is assumed that this facility is on public property and no acquisition or easements are required.
Planning Basis Assumptions:
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.
Cost Basis Assumptions:
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.
Allowances:
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8%; Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included.
Costs were not included for utility relocation work.
Estimating Assumptions:
This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100% , for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Updated on 6/7/24

Item No.	Action	Class	Difficulty	Description	Sub-Action Number	Subcategory	PHASE 3 COSTS (2023 Dollars)							
							Action Unit	Design Drainage Area	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)
25	Compost Amendment	Class 10	Low	WQBE_25_Compost_Amendment	N/A	On property, no acquisition	500 sf	500 SF	\$ 4,200	\$0	\$ 1,700	\$ 5,900	300	\$ 13,400

MANDATORY INPUTS		
Input Category	Inputs	Comments
Retail Sales Tax Rate	10.25%	Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle
Allowance for Indeterminates (AFI), Dependent Upon Project Phase	15%	Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%)
Construction Change Order Allowance	10%	
Project Contingency	15%	Override due to low complexity

SECONDARY INPUTS		
Input Category	Inputs	Comments
Street Use Permit	\$ 700	In ROW only - Arterial @ \$700/Unit; Non-Arterial @use \$300/unit
Outside Agency Construction	2%	For Projects in ROW Utility coordination assumed to be at 2% construction cost.

PROJECT CATEGORY AND INDIRECT PROJECT INPUTS		
Input Category	Inputs	Comments

PROPERTY COST

Cost Category	\$/sf
Low	\$ 10.10
Medium	\$ 80.43
High	\$ 284.37
None	\$ -

Description: WQBE 25 - Compost Amendment (2023 Dollars)

	Unit	500 ft ²
Initial Capital Cost	\$	5,900
Capital cost	\$	12 \$/Unit
Total Direct O&M/year	\$	136
Direct O&M cost	\$	0.27 \$/Unit
Capital Replacement Costs (10 Years)	\$	1,046 \$/unit
Discount rate (%)	\$	5.25 \$/Unit
1/3 total replacement every 10 years.		
Total Cost (NPV)	\$	13,400 \$/unit
Annual O&M Cost	\$	300 \$/year
Annualized Cost	\$	250 \$/year

Description: WQBE 25 - Compost Amendment

Life-Cycle Cost Model Input Assumptions:

Initial capital cost is input into LCC Model as total project cost and not construction cost.
Capital replacement is input into LCC Model as total project cost and not construction cost.

O&M Estimating Assumptions:

1 Aerating by crew of one (one visit per year, 1 hour per visit). Equipment cost \$160/hr.

Replacement Assumptions:

Replacement of 1/3 sod and mulch area every 10 years.

Materials, Supplies, Other Costs

		\$	-	\$/year
Aerator Equipment	2023 dollars	\$	160	\$/year
	2023 dollars	\$		\$/year

Subtotal Labor

Aerating soil	1 hr
	hr
	hr
	0 hr
Total hours per year	1
Raw Labor Rate/Hr	\$ 54
Raw labor cost (embedded)	\$ 54
Labor cost, burdened	O/H 150.0% \$ 136
General and Labor Cost Escalation/Year	3.0%
Life Cycle Period:	30 years

135.98

Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 7,612		\$ 6,469	\$ 23,118	\$ 13,403			
0	1.000	\$ 5,900			\$ 5,900	\$ 5,900	\$ 5,900	\$ 5,900	\$ 13,403
1	0.950	\$ 160	-	\$ 136	\$ 296	\$ 281	\$ 6,196	\$ 6,181	\$ 7,503
2	0.903	\$ 165	-	\$ 140	\$ 305	\$ 275	\$ 6,501	\$ 6,456	\$ 7,222
3	0.858	\$ 170	-	\$ 144	\$ 314	\$ 269	\$ 6,815	\$ 6,726	\$ 6,947
4	0.815	\$ 175	-	\$ 149	\$ 323	\$ 264	\$ 7,138	\$ 6,989	\$ 6,677
5	0.774	\$ 180	-	\$ 153	\$ 333	\$ 258	\$ 7,471	\$ 7,247	\$ 6,414
6	0.736	\$ 185	-	\$ 158	\$ 343	\$ 252	\$ 7,814	\$ 7,500	\$ 6,156
7	0.699	\$ 191	-	\$ 162	\$ 353	\$ 247	\$ 8,168	\$ 7,747	\$ 5,904
8	0.664	\$ 197	-	\$ 167	\$ 364	\$ 242	\$ 8,532	\$ 7,988	\$ 5,657
9	0.631	\$ 203	-	\$ 172	\$ 375	\$ 237	\$ 8,907	\$ 8,225	\$ 5,415
10	0.599	\$ 209	\$ 1,046	\$ 177	\$ 1,432	\$ 858	\$ 10,339	\$ 9,083	\$ 5,178
11	0.570	\$ 215	-	\$ 183	\$ 398	\$ 227	\$ 10,736	\$ 9,310	\$ 4,320
12	0.541	\$ 221	-	\$ 188	\$ 410	\$ 222	\$ 11,146	\$ 9,532	\$ 4,093
13	0.514	\$ 228	-	\$ 194	\$ 422	\$ 217	\$ 11,568	\$ 9,748	\$ 3,872
14	0.489	\$ 235	-	\$ 200	\$ 435	\$ 212	\$ 12,003	\$ 9,961	\$ 3,655
15	0.464	\$ 242	-	\$ 206	\$ 448	\$ 208	\$ 12,450	\$ 10,169	\$ 3,442
16	0.441	\$ 249	-	\$ 212	\$ 461	\$ 203	\$ 12,911	\$ 10,372	\$ 3,235
17	0.419	\$ 257	-	\$ 218	\$ 475	\$ 199	\$ 13,386	\$ 10,571	\$ 3,031
18	0.398	\$ 264	-	\$ 225	\$ 489	\$ 195	\$ 13,876	\$ 10,766	\$ 2,832
19	0.378	\$ 272	-	\$ 231	\$ 504	\$ 191	\$ 14,380	\$ 10,956	\$ 2,637
20	0.359	\$ 281	\$ 1,046	\$ 238	\$ 1,565	\$ 562	\$ 15,944	\$ 11,519	\$ 2,447
21	0.341	\$ 289	-	\$ 246	\$ 535	\$ 183	\$ 16,479	\$ 11,701	\$ 1,885
22	0.324	\$ 298	-	\$ 253	\$ 561	\$ 179	\$ 17,029	\$ 11,880	\$ 1,702
23	0.308	\$ 307	-	\$ 261	\$ 567	\$ 175	\$ 17,596	\$ 12,055	\$ 1,523
24	0.293	\$ 316	-	\$ 268	\$ 584	\$ 171	\$ 18,180	\$ 12,226	\$ 1,349
25	0.278	\$ 325	-	\$ 276	\$ 602	\$ 167	\$ 18,782	\$ 12,393	\$ 1,178
26	0.264	\$ 335	-	\$ 285	\$ 620	\$ 164	\$ 19,402	\$ 12,557	\$ 1,010
27	0.251	\$ 345	-	\$ 293	\$ 638	\$ 160	\$ 20,040	\$ 12,717	\$ 846
28	0.239	\$ 355	-	\$ 302	\$ 657	\$ 157	\$ 20,698	\$ 12,874	\$ 686
29	0.227	\$ 366	-	\$ 311	\$ 677	\$ 154	\$ 21,375	\$ 13,028	\$ 529
30	0.215	\$ 377	\$ 1,046	\$ 320	\$ 1,743	\$ 376	\$ 23,118	\$ 13,403	\$ 376

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	6/7/2024	
Location:	King County, WA		Estimator:	Jess Dexheimer (HDR) Tatiana Skadorwa (HDR) Cindy Kinzer (HDR)	
Description:	WQBE_25 - Compost Amendment		Version:	1	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Compost Amendment Area	500	SF	\$	-
2	Removal and Preparation				
3	Clearing and Grubbing	56	SY	\$ 8	\$ 444
4	Scarifying, diskng, or tilling Soil with bed preparation	56	SY	\$ 6	\$ 333
				\$	-
	Restoration:			\$	-
	Mulch Compost (@ 1.75" depth)	3	CY	\$ 80	\$ 240
	Rototill Mulch Compost 6.25" Depth	56	SY	\$ 6	\$ 333
	Subgrade Preparation (compact to 85% max dry density)	56	SY	\$ 10	\$ 556
	Grass Sod	56	SY	\$ 16	\$ 889
				\$	-
	Additional Costs			\$	-
	TESC @2% Construction Costs	2%	LS	\$ 2,796	\$ 56
				\$	-
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 2,851
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	285
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 3,137
Direct: Subtotal Construction Costs (500 SF Area)					\$ 3,137

Description: WQBE 25 Compost Amendment
Install subsurface storage at existing sportsfield or park to provide flow control while preserving recreational site use
Cost Estimating Assumptions:
Design is based on Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13" Option 2 (amending existing site soil or subsoil)
Remove lawn vegetation & Scarify (loosen) subgrade to 8 inches depth
Place 1.75 inches of compost and rototill into 6.25 inches of soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches)
Scarify (loosen) subsoil 4 inches below the amended layer to produce a 12-inch depth of uncompacted soil
Roll to compact to 85% of maximum dry density
Rake to level and remove surface woody debris and rocks larger than 1 inch diameter
Restoration is with Sod Grass.
Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs.
The facility is located on property and traffic control will not be required.
The facility is located outside of the ROW and a street use permit is not required.
It is assumed that this facility is on public property and no acquisition or easements are required.
Planning Basis Assumptions:
No project construction plan is in place at this time.
The assumed execution strategy is a standard work week with limited overtime.
No alternative procurement methods have been considered as part of delivery of this concept.
No unusual site conditions have been considered as part of this estimate.
Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.
Cost Basis Assumptions:
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.
Allowances:
The level and types of allowances used in the estimate are as follows:
Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies.
Allowance of 10% for potential change orders.
This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Low indirect project cost complexity factor was assigned: 12% Design Engineering, 8% Construction Management, Permitting & Support 0.5%, and 5% WTD Staff Labor
A 15% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process.
Costs were not included for Local Agency Mitigation and Indirect Burden.
The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included.
Costs were not included for utility relocation work.
Estimating Assumptions:
This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100% , for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project.
It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials.
It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces.
It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

PHASE 3 COSTS (2023 Dollars)														
Item No.	Action	Class	Difficulty	Description	Sub-Action Number	Subcategory	Action Unit	Design Drainage Area	Total Direct Construction Cost	Property acquisition	Total Indirect Non-Construction Costs	Total Project Cost	O&M Costs (Annual)	Life Cycle Cost (NPV)
26	Reforestation	Class 10	Routine	WQBE_26A Reforest High Density Development	26A	On property without Acquisition w/Building Demolition	1 Acre	43,560 SF	\$ 11,075,000	\$ -	\$ 8,415,500	\$ 19,490,500	\$ 3,300	\$ 19,577,100
				WQBE_26B Reforest High Density Development w/Property Cost	26B	On property with Acquisition w/Building Demolition	1 Acre	43,560 SF	\$ 11,075,000	\$ 3,503,531	\$ 12,970,100	\$ 24,045,100	\$ 3,300	\$ 24,131,700
				WQBE_26C Reforest Previous Area	26C	On property without Acquisition	1 Acre	43,560 SF	\$ 992,900	\$ -	\$ 754,500	\$ 1,747,400	\$ -	\$ 1,747,400
				WQBE_26D Reforest Previous Area w/Property Cost	26D	On property with Acquisition	1 Acre	43,560 SF	\$ 992,900	\$ 3,503,531	\$ 5,309,100	\$ 6,302,000	\$ -	\$ 6,302,000

MANDATORY INPUTS		
Input Category	Inputs	Comments
Retail Sales Tax Rate	10.25%	Current Rate within City of Seattle is 10.25%, 10.1% outside of Seattle
Allowance for Indeterminates (AFI), Dependent Upon Project Phase	20%	Complexity Inputs for AFI (High = 30%; Moderate = 25%; Routine = 20%; Low = 15%)
Construction Change Order Allowance	10%	
Project Contingency	30%	
SECONDARY INPUTS		
Input Category	Inputs	Comments
Street Use Permit	\$ 90,000	In ROW only - Arterial @ \$90,000/Unit; Non-Arterial @use \$30000/unit
Outside Agency Construction	2%	For Projects in ROW Utility coordination assumed to be at 2% construction cost.
PROJECT CATEGORY AND INDIRECT PROJECT INPUTS		
Input Category	Inputs	Comments

PROPERTY COST	Cost Category	\$/sf
	Low	\$ 10.10
	Medium	\$ 80.43
	High	\$ 284.37
	None	\$ -

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	7/21/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer Trooper Shaw Jess Dexheimer	
Description:	WQBE_26A - Reforestation High Density Development - On Property		Version:	1	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
1	Reforestation On Property (43,560 SF Area)	43,560	SF	\$	-
2	Existing Building % of total area	40%		\$	-
3	Existing Parking Lot % of total area	60%		\$	-
4	Building foundation depth	4	FT	\$	-
5				\$	-
6	Demolition and Removals			\$	-
7	Remove Existing Pavement	2,904	SY	\$ 14	\$ 40,656
8	Demolition, Haul, and Disposal Existing Building & Utilities (Standard Construction)	40,656	SF	\$ 30	\$ 1,219,680
9	Remove, Haul, Disposal Concrete Building Foundation	12,046	TN	\$ 334	\$ 4,023,438
10	Allowance for removal, haul, and Disposal of Existing Site Utilities	1	LS	\$ 50,000	\$ 50,000
11				\$	-
12	Earthwork and Site Preparation			\$	-
13	Site Grading, Shaping, and Building Foundation Backfill (No Import)	2,420	CY	\$ 28	\$ 67,760
14	Scarifying subsoil (to 6" Depth)	2,904	SY	\$ 4	\$ 11,616
15	Topsoil @ 18" depth	2,420	CY	\$ 105	\$ 254,100
16	Mulch Compost @4" depth	538	CY	\$ 80	\$ 43,022
17				\$	-
18	Site Restoration & Reforestation			\$	-
19	Paved Trail Length	1,200	LF	\$	-
20	Paved Trail Width	12	FT	\$	-
21	Trail 4" HMA/4"CSBC	1,600	SY	\$ 71	\$ 113,600
22	Trees @ 2 trees/1000 sf	88	EA	\$ 720	\$ 63,360
23	Bareroot shrubs @62/1000 sf for 90% area	2,701	EA	\$ 50	\$ 135,050
24	Bareroot groundcover @13/1000 sf	567	EA	\$ 42	\$ 23,814
25	Temporary Irrigation System	1	LS	\$ 39,410	\$ 39,410
25	Landscape Establishment - 2 years	1	LS	\$ 74,500	\$ 74,500
25	Trail Signage Allowance	1	LS	\$ 6,000	\$ 6,000
25				\$	-
25	Additional Costs			\$	-
25	Removals @ 10% Construction Costs	10%	LS	\$ 6,166,006	\$ 616,601
25	TESC @ 2% of Construction Costs	2%	LS	\$ 6,782,607	\$ 135,652
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 6,918,259
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	691,826
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 7,610,085
Direct: Subtotal Construction Costs (43560 SF Area)					\$ 7,610,085

	Description: WQBE 26A - Reforestation High Density Development On Property Convert existing impervious surfaces to forest by uncompacting/amending soil and planting trees and understory vegetation. Typical "strip mall" no acquisition; structure and parking lot razed/removed; parcel restored as forest cover with simple trail.
	Cost Estimating Assumptions: Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9. Reforestation On Property no property aquistition (43,560 SF Area) The total removal footprint = 1 acre (43,560 sf) with a 1:1 length to width ratio. Assume strip mall; parcel area coverage = 60% parking (26,136 sf) and 40% single story structure (17,424 sf) The cost model assumes a commercial parking lot type application. Site soils and CSBC may be used for backfill of building foundation removals and import will not be required. Existing impervious surface 4" HMA and 4" CSBC (e.g., crushed rock, gravel, etc.) removal. Scarfify subsoil to 6" depth and place 18 inches of topsoil type A A minimum of 4 inches of compost amendment is added and mixed into the scarified soils. Plant multi-layer native plant communities: --Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft). --Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 shrubs/1,000 sqft). --Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft) Assume simple trail 4" HMA/4" CSBC @ 8' width through forest Maintain plants during 2 year plant establishment period Temporary irrigation system will be required during the establishment period. The existing water and power service will be available for the temporary irrigation system and utilities will not be required. The project is located in a developed and potentially urbanized area. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. A removal allowance estimated at 10% of the construction cost is assumed for removals of existing utilities, storm structures, and unidentified existing structures and obstructions. The facility is located on property and traffic control will not be required. The facility is located outside of the ROW and a street use permit is not required. No property easements or acquisition are required.
	Planning Basis Assumptions: No project construction plan is in place at this time. The assumed execution strategy is a standard work week with limited overtime. No alternative procurement methods have been considered as part of delivery of this concept. No unusual site conditions have been considered as part of this estimate. Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.
	Cost Basis Assumptions: Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.
	Allowances: The level and types of allowances used in the estimate are as follows: Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. Allowance of 10% for potential change orders. This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor A 20% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden. The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included. Costs were not included for utility relocation work.
	Estimating Assumptions: This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100% , for the scope as known at the time of the estimate preparation. It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. It is assumed that there will be some degree of minimal cost rounding during the normal estimating process. A 30% Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_26B - Reforestation High Density Development - On Property w/Property Cost (2023 Dollars)									
Unit	43,560 ft ²								
WQBE_26 - Reforestation On Property with Property Cost	\$ 24,045,100								
Capital cost	\$ 552 /Unit								
Total Direct O&M/Year	\$ 3,263								
Reforestation On Property with Property Cost (43,560 SF Area)	\$ 0.07 /Unit								
Capital Replacement Costs (10 Years)	\$ 19,096 /unit								
Discount rate (%)	5.25 %/Unit								
Total Cost (NPV)	\$ 24,131,700 \$/unit								
Annual O&M Cost	\$ 3,300 \$/year								
Annualized Cost	\$5,180 \$/year								
Materials, Supplies, Other Costs									
	\$ -	\$ -	\$ /year						
	2023 dollars	\$ -	\$ /year						
	2023 dollars	\$ -	\$ /year						
Subtotal			\$0						
Labor									
Remove Trash and trail maintenance	16 hr								
Plant inspections	8 hr								
	0 hr								
Total hours per year	24								
Raw Labor Rate/Hr	\$ 54								
Raw labor cost	(embedded) \$ 1,305								
Labor cost, burdened	O/H 150.0% \$ 3,263 \$ 135.98								
General and Labor Cost Escalation/Year	3.0%								
Life Cycle Period:	30 years								
Year	Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
							Cash	Present Value	Discounted Cost per Year
Cash Sum (\$)		\$ 155,258	\$ 24,238,550	\$ 24,131,690					
0	1.000	\$ 24,045,100		\$ 24,045,100	\$ 24,045,100	\$ 24,045,100	\$ 24,045,100	\$ 24,131,690	
1	0.950	\$ 0	\$ -	\$ 3,263	\$ 3,263	\$ 3,101	\$ 24,048,363	\$ 24,048,201	\$ 86,590
2	0.903	\$ -	\$ -	\$ 3,361	\$ 3,361	\$ 3,034	\$ 24,051,725	\$ 24,051,235	\$ 83,489
3	0.858	\$ -	\$ -	\$ 3,462	\$ 3,462	\$ 2,969	\$ 24,055,187	\$ 24,054,204	\$ 80,455
4	0.815	\$ -	\$ -	\$ 3,566	\$ 3,566	\$ 2,906	\$ 24,058,753	\$ 24,057,110	\$ 77,485
5	0.774	\$ -	\$ -	\$ 3,673	\$ 3,673	\$ 2,844	\$ 24,062,426	\$ 24,059,954	\$ 74,579
6	0.736	\$ -	\$ -	\$ 3,783	\$ 3,783	\$ 2,783	\$ 24,066,209	\$ 24,062,737	\$ 71,735
7	0.699	\$ -	\$ -	\$ 3,897	\$ 3,897	\$ 2,724	\$ 24,070,106	\$ 24,065,461	\$ 68,952
8	0.664	\$ -	\$ -	\$ 4,014	\$ 4,014	\$ 2,665	\$ 24,074,119	\$ 24,068,126	\$ 66,229
9	0.631	\$ -	\$ -	\$ 4,134	\$ 4,134	\$ 2,608	\$ 24,078,253	\$ 24,070,735	\$ 63,563
10	0.599	\$ -	\$ -	\$ 4,258	\$ 4,258	\$ 2,553	\$ 24,082,511	\$ 24,073,287	\$ 60,955
11	0.570	\$ -	\$ 19,096	\$ 4,386	\$ 23,482	\$ 13,375	\$ 24,105,993	\$ 24,086,662	\$ 58,402
12	0.541	\$ -	\$ -	\$ 4,517	\$ 4,517	\$ 2,445	\$ 24,110,510	\$ 24,089,107	\$ 45,028
13	0.514	\$ -	\$ -	\$ 4,653	\$ 4,653	\$ 2,392	\$ 24,115,163	\$ 24,091,499	\$ 42,583
14	0.489	\$ -	\$ -	\$ 4,792	\$ 4,792	\$ 2,341	\$ 24,119,956	\$ 24,093,840	\$ 40,191
15	0.464	\$ -	\$ -	\$ 4,936	\$ 4,936	\$ 2,291	\$ 24,124,892	\$ 24,096,131	\$ 37,849
16	0.441	\$ -	\$ -	\$ 5,084	\$ 5,084	\$ 2,242	\$ 24,129,976	\$ 24,098,374	\$ 35,558
17	0.419	\$ -	\$ -	\$ 5,237	\$ 5,237	\$ 2,194	\$ 24,135,213	\$ 24,100,568	\$ 33,316
18	0.398	\$ -	\$ -	\$ 5,394	\$ 5,394	\$ 2,147	\$ 24,140,607	\$ 24,102,715	\$ 31,122
19	0.378	\$ -	\$ -	\$ 5,556	\$ 5,556	\$ 2,101	\$ 24,146,162	\$ 24,104,817	\$ 28,974
20	0.359	\$ -	\$ -	\$ 5,722	\$ 5,722	\$ 2,057	\$ 24,151,885	\$ 24,106,873	\$ 26,873
21	0.341	\$ -	\$ 19,096	\$ 5,894	\$ 24,990	\$ 8,533	\$ 24,176,875	\$ 24,115,406	\$ 24,816
22	0.324	\$ -	\$ -	\$ 6,071	\$ 6,071	\$ 1,970	\$ 24,182,946	\$ 24,117,376	\$ 16,283
23	0.308	\$ -	\$ -	\$ 6,253	\$ 6,253	\$ 1,927	\$ 24,189,199	\$ 24,119,303	\$ 14,314
24	0.293	\$ -	\$ -	\$ 6,441	\$ 6,441	\$ 1,886	\$ 24,195,639	\$ 24,121,190	\$ 12,386
25	0.278	\$ -	\$ -	\$ 6,634	\$ 6,634	\$ 1,846	\$ 24,202,273	\$ 24,123,035	\$ 10,500
26	0.264	\$ -	\$ -	\$ 6,833	\$ 6,833	\$ 1,806	\$ 24,209,106	\$ 24,124,842	\$ 8,654
27	0.251	\$ -	\$ -	\$ 7,038	\$ 7,038	\$ 1,768	\$ 24,216,144	\$ 24,126,610	\$ 6,848
28	0.239	\$ -	\$ -	\$ 7,249	\$ 7,249	\$ 1,730	\$ 24,223,393	\$ 24,128,340	\$ 5,080
29	0.227	\$ -	\$ -	\$ 7,466	\$ 7,466	\$ 1,693	\$ 24,230,859	\$ 24,130,033	\$ 3,350
30	0.215	\$ -	\$ -	\$ 7,690	\$ 7,690	\$ 1,657	\$ 24,238,550	\$ 24,131,690	\$ 1,657

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	7/21/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer Trooper Shaw Jess Dexheimer	
Description:	WQBE_26B - Reforestation High Density Development - On Property with Property Cost		Version:	1	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
	Reforestation On Property with Property Cost (43,560 SF Area)	43,560	SF	\$	-
	Existing Building % of total area	40%		\$	-
	Existing Parking Lot % of total area	60%		\$	-
	Building foundation depth	4	FT	\$	-
				\$	-
	Demolition and Removals			\$	-
	Remove Existing Pavement	2,904	SY	\$ 14	\$ 40,656
	Demolition, Haul, and Disposal Existing Building & Utilities (Standard Construction)	40,656	SF	\$ 30	\$ 1,219,680
	Remove, Haul, Disposal Concrete Building Foundation	12,046	TN	\$ 334	\$ 4,023,438
	Allowance for removal, haul, and Disposal of Existing Site Utilities	1	LS	\$ 50,000	\$ 50,000
				\$	-
	Earthwork and Site Preparation			\$	-
	Site Grading, Shaping, and Building Foundation Backfill (No Import)	2,420	CY	\$ 28	\$ 67,760
	Scarifying subsoil (to 6" Depth)	2,904	SY	\$ 4	\$ 11,616
	Topsoil @ 18" depth	2,420	CY	\$ 105	\$ 254,100
	Mulch Compost @4" depth	538	CY	\$ 80	\$ 43,022
				\$	-
	Site Restoration & Reforestation			\$	-
	Paved Trail Length	1,200	LF	\$	-
	Paved Trail Width	12	FT	\$	-
	Trail 4" HMA/4"CSBC	1,600	SY	\$ 71	\$ 113,600
	Trees @ 2 trees/1000 sf	88	EA	\$ 720	\$ 63,360
	Bareroot shrubs @62/1000 sf for 90% area	2,701	EA	\$ 50	\$ 135,050
	Bareroot groundcover @13/1000 sf	567	EA	\$ 42	\$ 23,814
	Temporary Irrigation System	1	LS	\$ 39,410	\$ 39,410
	Landscape Establishment - 2 years	1	LS	\$ 74,500	\$ 74,500
	Trail Signage Allowance	1	LS	\$ 6,000	\$ 6,000
				\$	-
	Additional Costs			\$	-
	Removals @ 10% Construction Costs	10%	LS	\$ 6,166,006	\$ 616,601
	TESC @ 2% of Construction Costs	2%	LS	\$ 6,782,607	\$ 135,652
				\$	-
	Item Subtotal Construction Costs (Year 2023)				\$ 6,918,259
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	691,826
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
	Item Subtotal Construction Costs (Year 2023)				\$ 7,610,085
	Direct: Subtotal Construction Costs (43560 SF Area)				\$ 7,610,085

	Description: WQBE 26B - Reforestation On Property w/Property Cost Convert existing impervious surfaces to forest by uncompacting/amending soil and planting trees and understory vegetation. Typical "strip mall" parcel acquired; structure and parking lot razed/removed; parcel restored as forest cover with simple trail.
	Cost Estimating Assumptions: Pavement removal per the King Co. SW Design Manual Appendix C, Section C.2.9. Reforestation On Property with Property Cost (43,560 SF Area) The total removal footprint = 1 acre (43,560 sf) with a 1:1 length to width ratio. Assume strip mall; parcel area coverage = 60% parking (26,136 sf) and 40% single story structure (17,424 sf) The cost model assumes a commercial parking lot type application. Site soils and CSBC may be used for backfill of building foundation removals and import will not be required. Existing impervious surface 4" HMA and 4" CSBC (e.g., crushed rock, gravel, etc.) removal. Scarf subsoil to 6" depth and place 18 inches of topsoil type A A minimum of 4 inches of compost amendment is added and mixed into the scarified soils. Plant multi-layer native plant communities: --Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft). --Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 shrubs/1,000 sqft). --Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft) Assume simple trail 4" HMA/4" CSBC @ 8' width through forest Maintain plants during 2 year plant establishment period Temporary irrigation system will be required during the establishment period. The existing water and power service will be available for the temporary irrigation system and utilities will not be required. The project is located in a developed and potentially urbanized area. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. A removal allowance estimated at 10% of the construction cost is assumed for removals of existing utilities, storm structures, and unidentified existing structures and obstructions. The facility is located on property and traffic control will not be required. The facility is located outside of the ROW and a street use permit is not required. The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.
	Planning Basis Assumptions: No project construction plan is in place at this time. The assumed execution strategy is a standard work week with limited overtime. No alternative procurement methods have been considered as part of delivery of this concept. No unusual site conditions have been considered as part of this estimate. Limited downtime for area/traffic/utility disruptions will be required during construction to minimize neighborhood and community impacts.
	Cost Basis Assumptions: Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.
	Allowances: The level and types of allowances used in the estimate are as follows: Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. Allowance of 10% for potential change orders. This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor A 20% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden. The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included. Costs were not included for utility relocation work.
	Estimating Assumptions: This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100% , for the scope as known at the time of the estimate preparation. It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces. It is assumed that there will be some degree of minimal cost rounding during the normal estimating process. A 30% Project Contingency was added to the base estimate of Total Project Costs (direct and indirect) as a result of the project estimating process.

Description: WQBE_26C - Reforestation Pervious Area On Property (2023 Dollars)									
Unit: 43,560 ft ²									
E_26 - Reforestation On Cleared Property with Property Cost \$ 1,747,400					Description: WQBE_26C - Reforestation Pervious Area On Property				
Capital cost \$ 40 \$/Unit					Life-Cycle Cost Model Input Assumptions:				
Reforestation On Property with Property Cost (43,560 SF Area) \$ - \$/Unit					Initial capital cost is input into LCC Model as total project cost and not construction cost.				
Capital Replacement Costs (10 Years) \$ - \$/unit					Capital replacement is input into LCC Model as total project cost and not construction cost.				
Discount rate (%) 5.25 \$/Unit					O&M Estimating Assumptions:				
Total Cost (NPV) \$ 1,747,400 \$/unit					The property is assumed to be rural and not accessible for public use.				
Annual O&M Cost \$ - \$/year					Replacement Assumptions:				
Annualized Cost \$0 \$/year					The irrigation system is to be abandoned in place and will not be replaced.				
Materials, Supplies, Other Costs									
\$ - \$ - \$/year					It is assumed that the reforested area will remain natural and plant replacement beyond the establishment period will not be required.				
2023 dollars \$ - \$/year									
2023 dollars \$ - \$/year									
Subtotal \$0									
Labor									
0 hr									
0 hr									
0 hr									
0 hr									
Total hours per year 0									
Raw Labor Rate/Hr \$ 54									
Raw labor cost (embedded) \$ -									
Labor cost, burdened O/H 150.0% \$ -					\$ 135.98				
General and Labor Cost Escalation/Year 3.0%									
Life Cycle Period: 30 years									
Year		Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs	
Cash Sum (\$)		\$ -	\$ -	\$ -	\$ 1,747,400	\$ 1,747,400	Cash	Present Value	Discounted Cost per Year
0	1.000	\$ 1,747,400			\$ 1,747,400	\$ 1,747,400	\$ 1,747,400	\$ 1,747,400	\$ 1,747,400
1	0.950	\$0	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
2	0.903	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
3	0.858	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
4	0.815	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
5	0.774	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
6	0.736	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
7	0.699	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
8	0.664	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
9	0.631	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
10	0.599	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
11	0.570	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
12	0.541	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
13	0.514	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
14	0.489	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
15	0.464	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
16	0.441	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
17	0.419	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
18	0.398	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
19	0.378	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
20	0.359	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
21	0.341	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
22	0.324	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
23	0.308	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
24	0.293	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
25	0.278	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
26	0.264	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
27	0.251	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
28	0.239	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
29	0.227	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
30	0.215	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	7/21/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer Trooper Shaw Jess Dexheimer	
Description:	WQBE_26C - Reforestation Pervious Area on Property (43560 SF Area)		Version:	1	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
	Reforestation On Property with Property Cost (43,560 SF Area)	43,560	SF	\$	-
				\$	-
	Demolition and Removals			\$	-
	Clearing and Grubbing	4,840	SY	\$ 12	\$ 58,080
				\$	-
	Earthwork and Site Preparation			\$	-
	Scarifying subsoil (to 6" Depth)	2,420	SY	\$ 4	\$ 9,680
	Topsoil @ 12" depth	1,613	CY	\$ 105	\$ 169,400
	Mulch Compost @4" depth	538	CY	\$ 80	\$ 43,022
				\$	-
	Site Restoration & Reforestation			\$	-
	Trees @ 2 trees/1000 sf	88	EA	\$ 720	\$ 63,360
	Bareroot shrubs @62/1000 sf for 90% area	2,701	EA	\$ 50	\$ 135,050
	Bareroot groundcover @13/1000 sf	567	EA	\$ 42	\$ 23,814
	Temporary Irrigation System	1	LS	\$ 39,410	\$ 39,410
	Landscape Establishment - 1 year	1	LS	\$ 37,300	\$ 37,300
				\$	-
	Additional Costs			\$	-
	Removals @ 5% Construction Costs	5%	LS	\$ 579,116	\$ 28,956
	TESC @ 2% of Construction Costs	2%	LS	\$ 608,072	\$ 12,161
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 620,233
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	62,023
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 682,257
<i>Direct: Subtotal Construction Costs (43560 SF Area)</i>					\$ 682,257

Description: WQBE 26C - Reforestation Pervious Area On Property
Convert existing developed areas to forest by uncompacting/amending soil and planting trees and understory vegetation. Cleared parcel; parking lot razed/removed; parcel restored as forest cover with simple trail.
Cost Estimating Assumptions:
Pavement removal is not included. Reforestation On Cleared Property No Property Cost (43,560 SF Area)
The cost model assumes a rural, open area. 1/2 of the area will require scarification and topsoil application. Scarify subsoil to 6" depth and place 12 inches of topsoil type A A minimum of 4 inches of compost amendment is added and mixed into the scarified soils.
Plant multi-layer native plant communities: --Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft). --Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 shrubs/1,000 sqft). --Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft)
Maintain plants during 1 year plant establishment period Temporary irrigation system will be required during the establishment period. The irrigation system will operate with gravity feed and will not have an electrical controller. The existing water and power service will not be available for the temporary irrigation system.
The project is located in a developed in rural areas. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. A removal allowance estimated at 5% of the construction cost is assumed for removals of existing obstructions. The facility is located on property and traffic control will not be required. The facility is located outside of the ROW and a street use permit is not required. No property easements or acquisition are required.
Planning Basis Assumptions:
No project construction plan is in place at this time. The assumed execution strategy is a standard work week with limited overtime. No alternative procurement methods have been considered as part of delivery of this concept. No unusual site conditions have been considered as part of this estimate.
Cost Basis Assumptions:
Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.
Allowances:
The level and types of allowances used in the estimate are as follows: Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. Allowance of 10% for potential change orders. This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor A 20% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden. The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included. Costs were not included for utility relocation work.
Estimating Assumptions:
This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100% , for the scope as known at the time of the estimate preparation.
It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces. It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Description: WQBE_26D - Reforestation Pervious Area w/Property Cost (2023 Dollars)										
Unit: 43,560 ft ²										
E_26 - Reforestation On Cleared Property with Property Cost \$ 6,302,000										
Capital cost \$ 145 /Unit										
Total Direct O&M/Year \$ -										
Reforestation On Property with Property Cost (43,560 SF Area) \$ - /Unit										
Capital Replacement Costs (10 Years) \$ - /unit										
Discount rate (%) 5.25 %/Unit										
Total Cost (NPV) \$ 6,302,000 \$/unit										
Annual O&M Cost \$ - \$/year										
Annualized Cost \$0 \$/year										
Materials, Supplies, Other Costs										
\$ - \$ - \$/year										
2023 dollars \$ - \$/year										
2023 dollars \$ - \$/year										
Subtotal \$0										
Labor										
0 hr										
0 hr										
0 hr										
0 hr										
Total hours per year 0										
Raw Labor Rate/Hr \$ 54										
Raw labor cost (embedded) \$ -										
Labor cost, burdened O/H 150.0% \$ -										
General and Labor Cost Escalation/Year 3.0%										
Life Cycle Period: 30 years										
Year		Discount Factor	Capital & Assoc. Costs	Capital Replacement Costs	Regular Maint. Costs	Total Costs	Present Value of Costs	Cumulative Costs		
Cash Sum (\$)		\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	Cash	Present Value	Discounted Cost per Year
0	1.000	\$ 6,302,000				\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000
1	0.950	\$0	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
2	0.903	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
3	0.858	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
4	0.815	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
5	0.774	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
6	0.736	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
7	0.699	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
8	0.664	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
9	0.631	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
10	0.599	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
11	0.570	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
12	0.541	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
13	0.514	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
14	0.489	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
15	0.464	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
16	0.441	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
17	0.419	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
18	0.398	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
19	0.378	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
20	0.359	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
21	0.341	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
22	0.324	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
23	0.308	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
24	0.293	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
25	0.278	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
26	0.264	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
27	0.251	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
28	0.239	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
29	0.227	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -
30	0.215	\$ -	\$ -	\$ -	\$ -	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ 6,302,000	\$ -

Estimate - AACEI Class 10					
Project Name:	King County Water Quality Benefits Evaluation		Date:	7/21/2024	
Location:	King County, WA		Estimator:	Cindy Kinzer Trooper Shaw Jess Dexheimer	
Description:	WQBE_26D - Reforestation Pervious Area On Property w/Property Cost		Version:	1	
CONSTRUCTION COSTS					
Item No.	Item Description	Quantity	Units	Unit Cost	Item Cost
	Reforestation On Property with Property Cost (43,560 SF Area)	43,560	SF	\$	-
				\$	-
	Demolition and Removals			\$	-
	Clearing and Grubbing	4,840	SY	\$ 12	\$ 58,080
				\$	-
	Earthwork and Site Preparation			\$	-
	Scarifying subsoil (to 6" Depth)	2,420	SY	\$ 4	\$ 9,680
	Topsoil @ 18" depth	1,613	CY	\$ 105	\$ 169,400
	Mulch Compost @4" depth	538	CY	\$ 80	\$ 43,022
				\$	-
	Site Restoration & Reforestation			\$	-
	Trees @ 2 trees/1000 sf	88	EA	\$ 720	\$ 63,360
	Bareroot shrubs @62/1000 sf for 90% area	2,701	EA	\$ 50	\$ 135,050
	Bareroot groundcover @13/1000 sf	567	EA	\$ 42	\$ 23,814
	Temporary Irrigation System	1	LS	\$ 39,410	\$ 39,410
	Landscape Establishment - 1 year	1	LS	\$ 37,300	\$ 37,300
				\$	-
	Additional Costs			\$	-
	Removals @ 5% Construction Costs	5%	LS	\$ 579,116	\$ 28,956
	TESC @ 2% of Construction Costs	2%	LS	\$ 608,072	\$ 12,161
				\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 620,233
DIRECT: CONSTRUCTION COST MARK-UPS					
	General Conditions	0%	1	\$	-
	Mobilization/Demobilization	10%	1.1	\$	62,023
	Overhead & Profit (OHP)	0%	1	\$	-
	Insurance	0.0%	1	\$	-
	Bonding	0.0%	1	\$	-
	Escalation Multiplier from ENR-CCI	0%	1.0000	\$	-
<i>Item Subtotal Construction Costs (Year 2023)</i>					\$ 682,257
<i>Direct: Subtotal Construction Costs (43560 SF Area)</i>					\$ 682,257

	Description: WQBE 26D - Reforestation Pervious Area On Property w/Property Cost
	Convert existing developed areas to forest by uncompacting/amending soil and planting trees and understory vegetation. Cleared parcel; parking lot razed/removed; parcel restored as forest cover with simple trail.
	Cost Estimating Assumptions:
	Pavement removal is not included. Reforestation On Cleared Property with Property Cost (43,560 SF Area)
	The cost model assumes a rural, open area. 1/2 of the area will require scarification and topsoil application. Scarify subsoil to 6" depth and place 12 inches of topsoil type A A minimum of 4 inches of compost amendment is added and mixed into the scarified soils.
	Plant multi-layer native plant communities: --Plant with 5-gallon container trees at a spacing of 25 ft on center (2 trees/1,000 sqft). --Plant with bareroot shrubs at a spacing of 5 ft on center for 90% of remaining area (62 shrubs/1,000 sqft). --Plant with bareroot groundcover at a spacing of 3 ft on center for 10% of remaining area (13 groundcovers/1,000 sqft)
	Maintain plants during 1 year plant establishment period Temporary irrigation system will be required during the establishment period. The irrigation system will operate with gravity feed and will not have an electrical controller. The existing water and power service will not be available for the temporary irrigation system.
	The project is located in a developed in rural areas. Temporary erosion and sediment control measures are required and estimated at 2% of the construction costs. A removal allowance estimated at 5% of the construction cost is assumed for removals of existing obstructions. The facility is located on property and traffic control will not be required. The facility is located outside of the ROW and a street use permit is not required. The installation is on property and will require easements and property acquisition. The land acquisition cost input was set to Medium.
	Planning Basis Assumptions:
	No project construction plan is in place at this time. The assumed execution strategy is a standard work week with limited overtime. No alternative procurement methods have been considered as part of delivery of this concept. No unusual site conditions have been considered as part of this estimate.
	Cost Basis Assumptions:
	Unit prices as identified in the Project Estimate reflect the complexity and scope of the individual project, as identified. There may be variation in unit prices between individual projects because unique circumstances and productivities.
	Allowances:
	The level and types of allowances used in the estimate are as follows: Sales Tax was included as 10.25% applied to the base construction cost including the design and change order contingencies. Allowance of 10% for potential change orders. This action is intended for regional facilities and may require additional design, permitting, environmental, and community relations considerations. A Routine indirect project cost complexity factor was assigned: 22% Design Engineering, 10%; Construction Management, Permitting & Support 1%, and 6% WTD Staff Labor A 20% Allowance for Indeterminates (AFI) is applied to the base construction cost. The AFI accounts for the cost of known but undefined requirements necessary for a complete and workable project. The AFI accounts for elements that are not explicitly shown in the conceptual alternative documents and will be further defined as part of the design development and project delivery process. The AFI percentage carried is based on the WTD project delivery process. Costs were not included for Local Agency Mitigation and Indirect Burden. The work is not part of an art eligible project and the allowance of 1% for art and 1% for sustainability allowances were not included. Costs were not included for utility relocation work.
	Estimating Assumptions:
	This estimate is classified as a Class 10 ROM estimate with no exceptions per the King County WTD project process and in accordance with AACE International with an accuracy range of -50% to +100% , for the scope as known at the time of the estimate preparation.
	It is assumed that any community impact costs are minimal. Any substantial impacts and their subsequent costs are beyond the scope of this project. It is assumed that there is no contaminated soil and groundwater on the site and a quality analysis and unit price costing is not included in the estimate for handling and disposal of contaminated materials. It is assumed that construction of the facility is feasible without adversely affecting nearby basements and crawl spaces. It is assumed that there will be some degree of minimal cost rounding during the normal estimating process.

Attachment B

Cost Estimates with Life-Cycle Cost Analysis Workbooks





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The contents of this attachment are provided in a separate electronic file.

Attachment C

Benchmarking Review Form





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FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

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Project #:	1136613
Subtask:	Subtask 439 - Flow Control Action and Program Development
Contact:	Carly Greyell (carly.greyell@kingcounty.gov)

DOCUMENT INFORMATION	
Title:	WQBE WO12 Action Estimates (LCC_DRAFT_2024.01.31)
Created by:	HDR
Contact:	Cindy Kinzer (cindy.kinzer@hdrinc.com)
Type:	Spreadsheets
Date:	1/16/2024
Purpose:	Estimate unit cost of project implementation for full suite of WQBE Actions including design, construction, CM, and agency support + overall contingency.

REVIEWERS	Reviewer #1	Reviewer #2
Name:	Robert Dusenbury (RD)	
Company:	Lotus Water	
Title:	Senior QA/QC Reviewer	
Review Date:	1/29/2024	
Email:	rdusenbury@lotuswater.com	

Comment Type Category:
G - General
T - Technical
E - Editorial
C - Coordination

RESPONDER	
Name:	Cindy Kinzer
Company/Agency:	HDR
Title:	Stormwater Lead
Response Date:	6/7/2024
Email:	Cindy.Kinzer@hdrinc.com

Response Code:
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4 - Unacceptable for reasons given

Comment Status Code:
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Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
1	RD	T	01 Rain Garden: Recommend lowering unit cost for Rain Garden Landscape to \$25/sf and \$500 lump sum to restore existing landscape around the new Rain Garden (in place of 125 sf @ \$10/sf). This facility is similar to a swale in that it involves grading, soil amendments, and plants + compost, yet it is ~3X the unit cost to account for homeowners wanting things' "just so" in their backyard. I would expect total project cost for a 25 sf rain garden in a residential backyard to be <\$10K.	CK	2	Raingarden restoration estimating basis assumptions were coordinated with Lotus and Herrera on 02/26/24 and revised to match review recommendations.	OW	1
2	RD	G	02 Bioretention Planter: Looks go be in reasonable range.	CK	2	Noted with no action required.	OW	1

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3	RD	T	03 Bioretention: Would expect lack of form work to drive down cost more compared to 02 BP, plus economies of scale are better. A closer look revealed that method of scaling costs for line items under Outlet Pipe were biased against this Action and should be revisited to lower those costs. Recommend lowering those line-item costs. Recommend lowering Landscaping and Restoration to \$25/sf.	CK	2	The first comment was coordinated with the HEC team based on similar projects within a high density residential setting (vs. urban). Comment 3a was implemented. Comment 3b was rejected since costs were set at \$59/SY.	OW	1
4	RD	G	04 Bioswale: Looks to be in reasonable range.	CK	2	Noted with no action required.	OW	1
5	RD	G	05 Media Filter: I have no particular insight into costs for this Action. They are not used much in the SF Bay Area.	CK	2	Noted with no action required.	OW	1

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6	RD	T	06 Drywell: Contractors advertise installation of residential dry wells in suburban settings on the Peninsula south of SF for half of this WQBE estimate. Recommend revisiting and potentially lowering to be consistent with costs for installed systems in suburban Seattle.	CK	4	Costs were based on SPU standard details for a drywell and catch basin w/piping system. The costs were considered consistent with complete installations of the system described.	OW	1
7	RD	G	07 Deep UIC Well: I have no particular insight into costs for this Action.	CK	2	Noted with no action required.	OW	1
8	RD	G	08 Permeable Pavement: These costs look reasonable for all types considered.	CK	2	Noted with no action required.	OW	1
9	RD	G	09 Depaving: These costs look reasonable.	CK	2	Noted with no action required.	OW	1

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Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
10	RD	T	11 Detention Vault: The unit cost for this Action remains stubbornly high as compared to system installed by SWS at Evans Creek in 2017. Even with 5% annual escalation, WQBE costs are 4X on a unit basis. This has been attributed to updates in the design basis, but it is a very large difference from actual built costs not that long ago.	CK	4	Per the Benchmarking TM, wet vaults at Evans Ck. were retrofit and there may be dissimilarities in design/estimating basis assumptions. It is recommended that the ratio to dead storage vs. live storage be evaluated for the vault actions (#11 14, & 19), which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington.	OW	1
11	RD	T	12 Detention Pond: No cost basis for comparison, but costs seem reasonable given headboard and overflow structure design basis.	CK	2	Noted with no action required.	OW	1

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12	RD	T	13 Infiltration Pond: No cost basis for comparison, but costs seem reasonable given headboard, overflow structure, and treatment layer design basis.	CK	2	Noted with no action required.	OW	1
13	RD	T	14 Infiltration Vault: No cost basis for comparison, but comments apply from Action 19 Wet Vault.	CK	4	Refer to Infiltration vault response under #13.	OW	1

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14	RD	T	<p>18 Wet Pond: Unit cost is \$929/sf, which is 6X those of Action 12 Detention Pond and seems unreasonably high. SWS installed 2 Wet Pond projects (Seola Creek in 2012 and White Center in 2012-13). With 5% annual escalation, the WQBE unit cost estimate is still 7X those systems. As with the Vaults, this has been attributed to updates in the design basis, but it is a very large difference from actual built costs. It should be noted the built installations were orders of magnitude larger so enjoyed positive economies of scale. Recommend Ponds for use as regional collection facilities at large scale.</p>	CK	4	Costs on the pond and SW treatment wetland actions (#12, 13, 18, and 20) were based on minimum to low storage depth for the facility area which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington.	OW	1

FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

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15	RD	T	19 Wet Vault: The unit cost for this Action remains stubbornly high as compared to system installed by SWS at Evans Creek in 2017. Even with 5% annual escalation, WQBE costs are 4X on a unit basis. This has been attributed to updates in the design basis, but it is a very large difference from actual built costs not that long ago.	CK	4	Per the Benchmarking TM prepared by Lotus Water (Feb. 2021), wet vaults at Evans Ck. were retrofit and there may be dissimilarities in design/estimating basis assumptions. It is recommended that the ratio to dead storage vs. live storage be evaluated for the vault actions (#11 14, & 19), which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington.	OW	1

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16	RD	G	20 SW Treatment Wetland: I don't have specific cost info, but \$958/sf is an order of magnitude higher than reported costs I have heard for these systems.	CK	2	Costs on the pond and SW treatment wetland actions (#12, 13, 18, and 20) are based on minimum to low storage depth for the facility area which can be a cost driver. It is recommended that the storage depth/small storage volume assumptions be evaluated using a depth to storage cost sensitivity analysis or in comparison with existing regional facility installations within King Co. or western Washington.	OW	1
17	RD	G	21 High Rate Underground Filter: I have no particular insights into costs for this Action.	CK	2	Noted with no action required.	OW	1
18	RD	G	22 Regional Vegetated Media Systems: I have no particular insights into costs for this Action. Overall project cost seems appropriate, though.	CK	2	Noted with no action required.	OW	1

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4 - Rolled over to next submittal

Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
19	RD	T	<p>23 Sports Field and Park Detention: The sizing ratio of 30% seems very low. It was explained that is due to assumed till soil conditions at project site. Recommend assuming outwash and lowering both sizing ratio and feasibility %. For costs, a regional capture project in South SF completed in May 2022 had an instream diversion, more complex capture/infiltration/reuse components, 1.8 MG of deep subsurface storage, and an advanced reuse system, and it came in for less than this. The WQBE Action has ~0.5M gal of storage and is a pretty basic system. There is a \$4.6M line item for geomembrane+fabric liner for a 30,000 sf facility; recommend assuming wrapped in geotextile only with no geomembrane. I expect that taking the sizing and costing together, the projected cost-effectiveness is off by orders of magnitude from a built project in outwash soils. Costs for artificial turf at the South SF project came in at \$104,500 with a total area of 100,000 sf.</p>	CK	2	The design and estimating basis assumptions were coordinated with Lotus and Herrera on 02/26/24. The design basis was revised to allow infiltration and geomembrane liner was deleted from the cost model. Sports field assumed that excavated soils would be unsuitable for re-use. It is recommended that the estimate be evaluated (as a sub-category) with the facility placed in outwash soils during a future phase.	OW	1

FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

PROJECT INFORMATION	
Project Name:	King County Water Quality Benefits Evaluation (WQBE)
Project #:	1136613
Subtask:	Subtask 439 - Flow Control Action and Program Development
Contact:	Carly Greyell (carly.greyell@kingcounty.gov)

DOCUMENT INFORMATION	
Title:	WQBE WO12 Action Estimates (LCC_DRAFT_2024.01.31)
Created by:	HDR
Contact:	Cindy Kinzer (cindy.kinzer@hdrinc.com)
Type:	Spreadsheets
Date:	1/16/2024
Purpose:	Estimate unit cost of project implementation for full suite of WQBE Actions including design, construction, CM, and agency support + overall contingency.
REVIEWERS	
Reviewer #1	
Name:	Robert Dusenbury (RD)
Company:	Lotus Water
Title:	Senior QA/QC Reviewer
Review Date:	1/29/2024
Email:	rdusenbury@lotuswater.com

Comment Type Category:
G - General
T - Technical
E - Editorial
C - Coordination

RESPONDER	
Name:	Cindy Kinzer
Company/Agency:	HDR
Title:	Stormwater Lead
Response Date:	6/7/2024
Email:	Cindy.Kinzer@hdrinc.com

Response Code:
1 - Accepted - Will comply
2 - Accepted - Action completed
3 - Discussion or clarification required
4 - Unacceptable for reasons given

Comment Status Code:
1 - Resolved
2 - Resolution pending
3 - Unresolved
4 - Rolled over to next submittal

Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
20		T	<p>24 Blue Roof: I think of this Action as a relatively inexpensive alternative to green roofs without the multiple benefits, but the \$154/sf estimate is at the high end of what I have seen for green roofs. The only agency in the U.S. that I know of that has installed a decent # of green roofs is NYC Dept of the Environment. That was about a decade ago, but they were advertising blue roof costs at \$5/sf. Recommend eliminating Permavoid and the leak detection system entirely. Consider costing these as the differential between a blue roof and regular roof replacement and reduce feasibility % to be based on building already needing a new roof. Full response from former NYC Director of GI program forwarded separately.</p>	CK	2	The design and estimating basis assumptions were coordinated with Lotus and Herrera on 02/26/24. The leak detection system was eliminated (replaced with frequent inspections) and permavoid was eliminated from the cost model. Blue roof costs for the retrofit described were based on contractor provided information for Seattle/Portland area.	OW	1

FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

PROJECT INFORMATION	
Project Name:	King County Water Quality Benefits Evaluation (WQBE)
Project #:	1136613
Subtask:	Subtask 439 - Flow Control Action and Program Development
Contact:	Carly Greyell (carly.greyell@kingcounty.gov)

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Title:	WQBE WO12 Action Estimates (LCC_DRAFT_2024.01.31)
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Type:	Spreadsheets
Date:	1/16/2024
Purpose:	Estimate unit cost of project implementation for full suite of WQBE Actions including design, construction, CM, and agency support + overall contingency.

REVIEWERS	Reviewer #1	Reviewer #2
Name:	Robert Dusenbury (RD)	
Company:	Lotus Water	
Title:	Senior QA/QC Reviewer	
Review Date:	1/29/2024	
Email:	rdusenbury@lotuswater.com	

Comment Type Category:
G - General
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RESPONDER	
Name:	Cindy Kinzer
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Title:	Stormwater Lead
Response Date:	6/7/2024
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Response Code:
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2 - Accepted - Action completed
3 - Discussion or clarification required
4 - Unacceptable for reasons given

Comment Status Code:
1 - Resolved
2 - Resolution pending
3 - Unresolved
4 - Rolled over to next submittal

Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
21		G	25 Compost Amendment: I have no particular insight into costs for this Action.	CK	2	Noted with no action required.	OW	1
22		G	26 Reforestation: I have no particular insight into costs for this Action.	CK	2	Noted with no action required.	OW	1

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Appendix F

Phase 3 Program Development

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TECHNICAL MEMORANDUM

Date: October 4, 2024
To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division
From: Alice Lancaster, Herrera Environmental Consultants, Inc.
Olivia Wright, Herrera Environmental Consultants, Inc.
John Lenth, Herrera Environmental Consultants, Inc.
Subject: WQBE Phase 3 Program Development (Appendix F to 439-TM1)

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Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages", for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020):** Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021-2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022a). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- **Phase 3 (2023-2024):** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the four new Flow Control Programs developed in Phase 3 for the WQBE Toolkit. The following information is provided: an overview of the Programs, an introduction to the Program Fact Sheets, the assumptions and technical basis for the Program Fact Sheet content, and key limitations/future considerations.

Program Development Process

The Core Team (Consultant and County staff directly overseeing WQBE toolkit development) held a workshop with King County staff on April 18, 2023, to select and define the WQBE flow control Programs to be developed under Phase 3. The results of this workshop are summarized in a companion memorandum (Herrera 2023). The following Programs were recommended for development:

- GSI Incentive Flow Control Program
- Roadway Retrofit Flow Control Program
- Regional Facility Flow Control Program
- Reforestation Flow Control Program

Program Overview

This section provides a high-level description of the WQBE Programs from Phase 3 and the component Actions and introduces the Program Fact Sheets.

Flow Control Programs

Four flow control Programs were developed in Phase 3. A high-level description of each Program is provided below. Detailed Program descriptions are provided in the Program Fact Sheets (see Appendix H of Herrera 2024).

The **Green Stormwater Infrastructure (GSI) Incentive Flow Control Program** would provide incentives for property owners to install small scale GSI practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide grants, rebates, or other financial incentives to eligible property owners for installing and maintaining GSI on their properties. This Program's objective is to provide flow control for stormwater runoff from developed parcels with little or no stormwater controls.

The **Roadway Retrofit Flow Control Program** would fund, plan, and implement capital improvement projects to construct flow control practices to manage runoff from roads and highways in King County. The Program would be administered by King County in partnership with the Washington State Department of Transportation (WSDOT), other jurisdictions and nongovernmental agencies. The objective of this Program is to provide flow control for stormwater runoff from road surfaces along County and partner rights-of-way.

The **Regional Facility Flow Control Program** would fund, plan, and implement capital improvement projects to construct regional stormwater flow control facilities to manage runoff from large drainage areas that may include multiple types of land uses. The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies. The objective of this Program is to provide flow control for stormwater runoff from a variety of land uses with centralized regional facilities located on both private and public parcels. For private parcels, cost for land acquisition is included.

The **Reforestation Flow Control Program** would fund, plan, and implement reforestation projects on public lands and acquired private parcels in King County. The Program would be administered by King County, potentially in partnership with other jurisdictions and nongovernmental agencies. The objective of this Program is to provide flow control for stormwater runoff from previously developed areas.

The four Programs were developed with the intention of modeling them together in SUSTAIN to identify the most cost-effective combination of Actions in the project area.

Component Actions

Programs are composed of a suite of unit Actions (structural or nonstructural stormwater controls) that could be implemented to provide flow control and/or improve water quality across a geographic area.

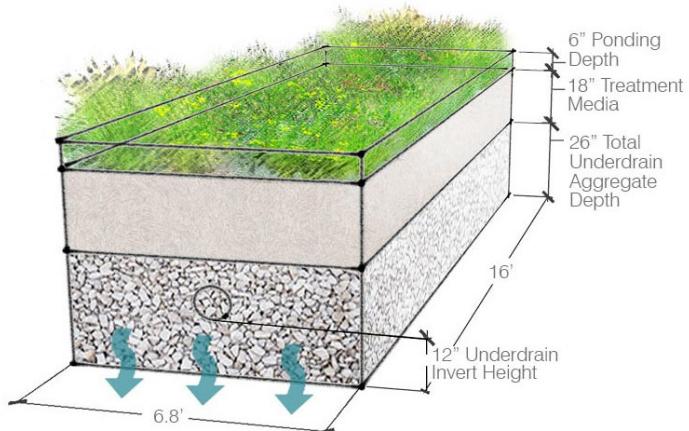
In Phase 2, nineteen Actions were developed, including GSI, traditional (retention, detention, infiltration), and regional stormwater management practices. These Actions are documented under in Appendix B of Herrera (2024). The costs for these Actions were updated under Phase 3 (HDR and Herrera 2024).

In Phase 3, five new flow control-focused Actions were developed, including:

- Sports Fields and Parks Detention,
- Blue Roofs,
- Compost Amendment,
- Reforest High Density Development, and
- Reforest Pervious Area.

The details of these Actions are documented under a separate Phase 3 memorandum (see Appendix C of Herrera 2024).

Figure 1. Schematic for a Unit of Bioretention.



Phase 3 flow control Programs include a mix of Actions developed under Phase 2 and Phase 3.

Program Fact Sheets

Program Fact Sheets were developed to compile detailed Program descriptions and information to support Program optimization using the SUSTAIN model. They include the following:

- Detailed description of the Program
- Actions that could be included in the Program
- Program implementation area, including a map showing eligible basins
- Program applicability by jurisdiction, drainage basin type, property type, land use and surface type
- A runoff routing schematic showing how flow is routed through Actions in the SUSTAIN model
- Program implementation constraints that are used to quantify the maximum area that could be managed by each Action
- Program cost information
- Approach for optimizing the Program using the SUSTAIN model
- Program linkages to causal models

Phase 3 Program Fact Sheets for the Flow Control Programs are included in Appendix H of Herrera 2024.

Program Assumptions and Technical Basis

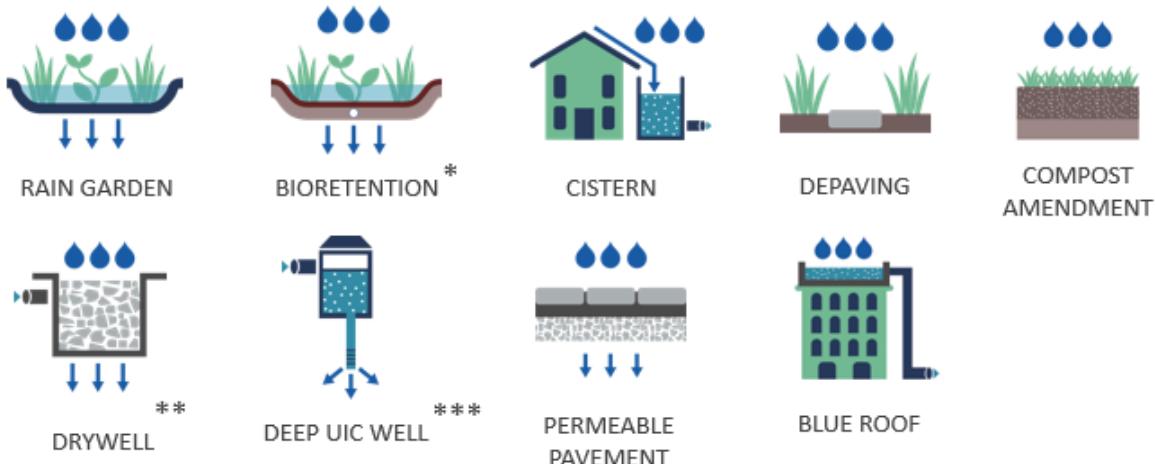
The key assumptions and technical basis for information included in the Program Fact Sheets are provided below.

Actions Included in Programs

Each Fact Sheet includes a suite of Actions that could be included in the Program (see example in Figure 2). The most cost-effective combination of Actions for each Program will be identified using the SUSTAIN model.

Figure 2. "Actions Included" Example from GSI Incentive Flow Control Program Fact Sheet.

ACTIONS INCLUDED IN PROGRAM



* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Paired with upstream bioretention planter for pre-treatment

*** Paired with upstream high-rate filter for pre-treatment

Table 1 summarizes the Actions included in each Program. The GSI Incentive Flow Control Program includes a suite of small-scale GSI Actions that are appropriate for parcel retrofits. The Roadway Retrofit Flow Control Program includes a suite of stormwater flow control Actions that are applicable in a range of roadway and highway settings, including linear and centralized treatment facilities. The Regional Facility Flow Control Program includes a suite of regional stormwater flow control Actions to manage runoff from large drainage areas. The Reforestation Program includes reforestation of high-density development and pervious areas.

Some Actions require pretreatment as indicated in Table 1. These are paired with upstream treatment Actions.

Table 1. Water Quality Actions included in Flow Control Programs.

Action	GSI Incentive Flow Control Program	Roadway Retrofit Flow Control Program	Regional Facility Flow Control Program	Reforestation Flow Control Program
Rain Garden	•			
Bioretention	•	•		
Bioretention Planter ^a				
Deep UIC Well ^b	•	•		
Cistern	•			
Drywell ^b	•			
Permeable Pavement	•			
Depaving	•			
Bioswale ^a				
Media Filter Drain ^a				
Stormwater Treatment Wetland ^a				
High-Rate Underground Filter System ^a				
Wetpond ^a				
Wetvault ^a				
Infiltration Pond ^b		•	•	
Infiltration Vault ^b		•	•	
Regional Vegetated Media Filtration Facility ^a				
Detention Pond		•	•	
Detention Vault		•	•	
Stormwater Field and Park Detention			•	
Blue Roof	•			
Compost Amendment	•			
Reforest High Density Development				•
Reforest Easement				•

^a Actions not included in flow control Programs are intended for water quality treatment and provide limited flow control benefits.

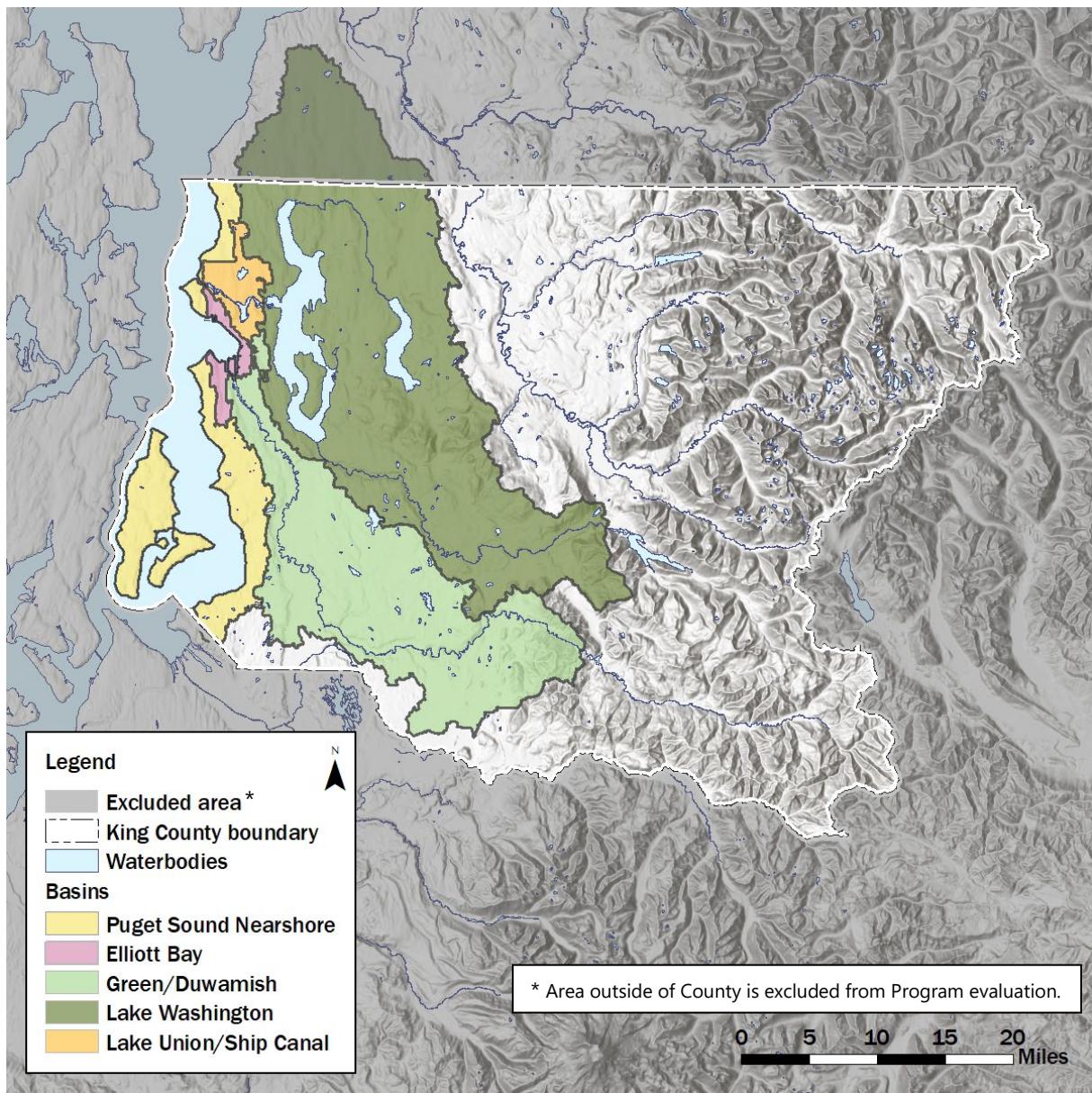
^b Requires pretreatment; paired with upstream treatment Action in runoff routing schematic.

UIC = Underground Injection Control

Program Implementation Area and Applicability

Each Fact Sheet includes an “Implementation Area” map showing the eligible basin areas. The WQBE target basins are shown in Figure 3.

Figure 3. Target Basins for Programs within King County.



Fact Sheets also list the Program applicability by jurisdiction, drainage basin type, property type, land use, and surface type to summarize where the Programs are intended to be implemented. Program implementation area and applicability are summarized in Table 2.

Table 2. Comparison of Program Implementation Area and Applicability.

Implementation Area/Applicability		GSI Incentive Flow Control Program	Roadway Retrofit Flow Control Program	Regional Facility Flow Control Program	Reforestation Flow Control Program
Eligible Basins	Puget Sound Nearshore	●	●	●	●
	Elliott Bay	●	●	●	●
	Green/Duwamish	●	●	●	●
	Lake Washington	●	●	●	●
	Lake Union/Ship Canal	●	●	●	●
Jurisdictions	Unincorporated County	●	●	●	●
	Incorporated Cities	●	●	●	●
Drainage Basin Type Managed	Separated	●	●	●	●
	Partially Separated ^{a,b}	●	●	●	●
	Combined ^b				
Land Uses/Surface Types Managed	Low Density Residential	Road		●	●
		Roof	●		●
		Other Impervious	●		●
		Pervious	●		●
	High Density Residential	Road		●	●
		Roof	●		●
		Other Impervious	●		●
		Pervious	●		●
	Commercial	Road		●	●
		Roof	●		●
		Other Impervious	●		●
		Pervious	●		●
	Industrial	Road		●	●
		Roof	●		●
		Other Impervious	●		●
		Pervious	●		●
	Highway	Road		●	●
		Pervious			●
Land Uses/Surface Types Managed (continued)	Agriculture	Road		●	●
		Roof	●		●
		Other Impervious	●		●
		Pervious			●
	Forest	Impervious			●
		Pervious			●
Land Uses/Surface Types Managed (continued)	Private Parcels	●		●	●
	Public Parcels	●		●	●
	Right of Way		●	●	

^a Only includes disconnected impervious areas in partially separated basins (i.e. areas not connected to the combined sewer).

^b The Programs could be adapted for application in combined drainage areas with the objective to reduce combined sewer overflows.

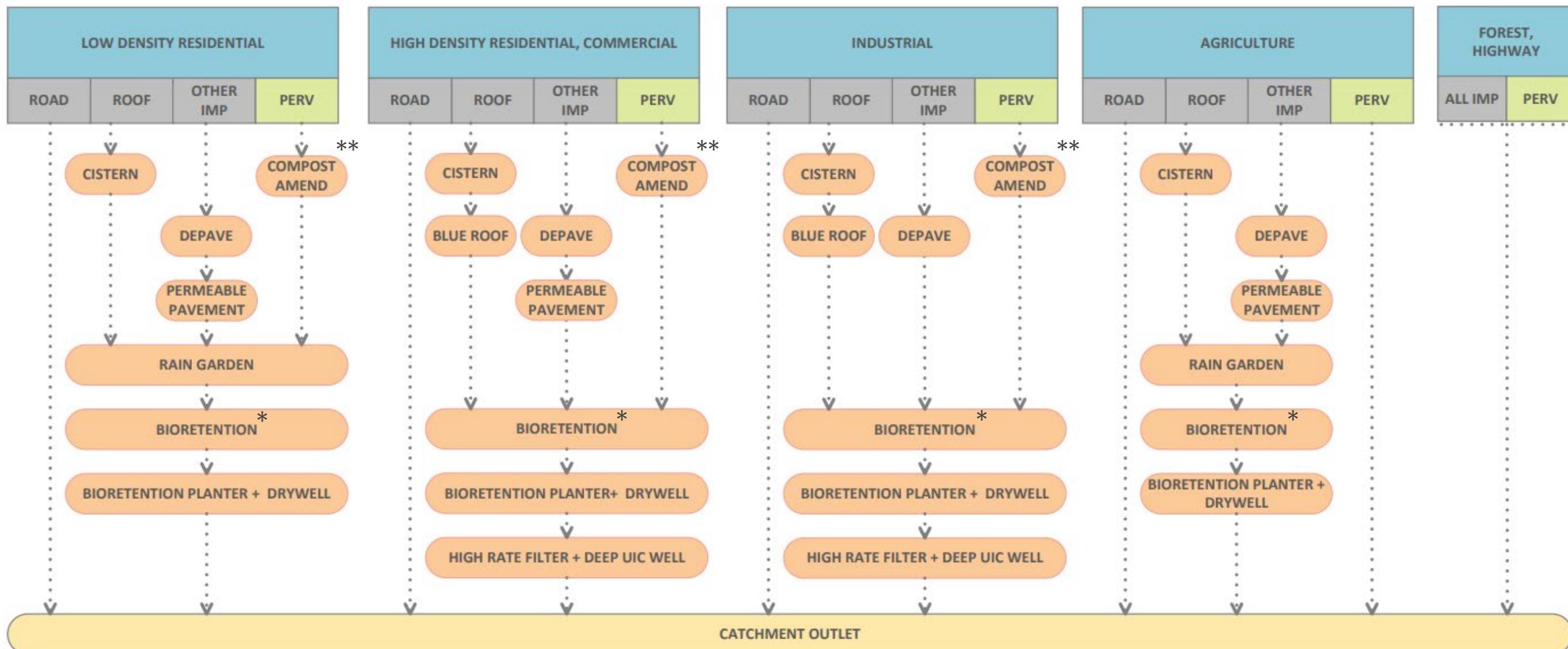
Runoff Routing

Fact Sheets include diagrams showing how stormwater runoff is routed through Actions in the SUSTAIN model (see example for the GSI Incentive Flow Control Program in Figure 4). The arrows characterize the routing of runoff from each drainage area (land use and surface combination, such as high-density residential roof) to the Actions. Overflow from the Actions and unmanaged runoff is routed to the catchment outlet. Actions are sometimes listed in a sequence ("treatment train") where runoff from one drainage area is routed to a number of sequential Actions. In these cases, SUSTAIN provides an assessment of the most cost-effective combination of Actions within a sequence to achieve different levels of flow control.

Most Actions are represented in SUSTAIN as a lumped facility at the bottom of each catchment, even though in reality these would likely be implemented as several distributed installations.

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Figure 4. Runoff Routing Schematic Example from GSI Incentive Flow Control Program Fact Sheet.



* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Compost amendment is only applied for lawn surfaces

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Program Implementation Constraints

Only a portion of the drainage areas routed to Actions in the runoff routing schematics (e.g., Figure 4) could realistically be managed due to real-world implementation constraints. To address this, feasibility criteria, and technical and participation constraints, were characterized for the Actions in each flow control Program to represent realistic implementation by land use, surface type, and parcel ownership. These implementation constraints are summarized in the Fact Sheets and detailed in Tables 3 through 7. The methodology used varies by Program, as described below.

GSI Incentive, Roadway Retrofit, and Reforestation Flow Control Programs

For the GSI Incentive, Roadway Retrofit, and Reforestation Flow Control Programs, the total implementation area (as defined in Table 2) will be further refined as follows to define the maximum drainage area:

- "Infeasible Areas" will be eliminated: Infeasible areas that can be readily delineated in GIS (e.g., unsuitable soil conditions, slopes, groundwater protection areas) will be excluded.
- A "Technical Factor" will be applied: This factor represents the estimated fraction of the remaining drainage area that could feasibly be managed based on technical considerations like infiltration restrictions (e.g., high groundwater), space constraints, utility conflicts, existing runoff patterns, and site uses. The Technical Factors range from 5 to 80 percent, depending upon the Action and setting (land use and surface type).
- A "Participation Factor" will be applied: This factor represents the anticipated participation rate in the Program based on an assessment of the benefits, risks, and burdens (e.g., long term maintenance) that could influence participants. The Participation Factors range from 2 to 30 percent, depending upon the Action and setting (land use and surface type).
- The combination of the "Technical Factor" and the "Participation Factor" is called the "Composite Factor". This describes the total influence these factors have on the total implementation area after it's reduced by infeasible areas.

The maximum drainage area managed by each Action in the SUSTAIN model is calculated as follows:

$$\begin{aligned} &= \text{Total Implementation Area (reduced by infeasible areas)} \times \text{"Technical Factor"} \times \text{"Participation Factor"} \\ &= \text{Total Implementation Area (reduced by infeasible areas)} \times \text{"Composite Factor"} \end{aligned}$$

The Composite Factors (i.e., Technical Factor x Participation Factor) range from 0.2 to 24 percent.

An overview of the process for calculating the maximum area managed by each Action is shown in Figure 5. Calculations are based on Program implementation area and applicability listed in Table 2, the drainage areas from the routing schematic (example provided as Figure 4), Action infeasibility criteria (see Tables 3, 4 and 5), and Action Technical and Participation Factors (see Tables 3, 4 and 5).

The Technical and Participation Factors were estimated based on best professional judgment of the County and Consultant teams, who have extensive experience with design and implementation of similar Actions (rationale is provided in Tables 3, 4 and 5). A number of simplifications were made to develop

high-level representative factors. For example, factors are assumed to be the same across all Program basins, while, in actuality, these factors would likely vary spatially (e.g., in urban and rural areas). Additionally, Participation Factors are assumed to be the same for all land uses, while they would likely vary (e.g., in residential versus commercial areas). It is expected that the factors will underestimate implementation rates for some scenarios, overestimate implementation rates for others, and be generally representative at the basin and county scale.

Programs can be modeled with Participation Factors applied to represent a realistic scenario or without Participation Factors applied to provide an upper bound (i.e., a scenario restricted solely based on technical factors). This provides a range of results to represent more optimistic (i.e., 100%) participation rates.

Figure 5. Steps for Calculating Maximum Area Managed by Actions in SUSTAIN Model.

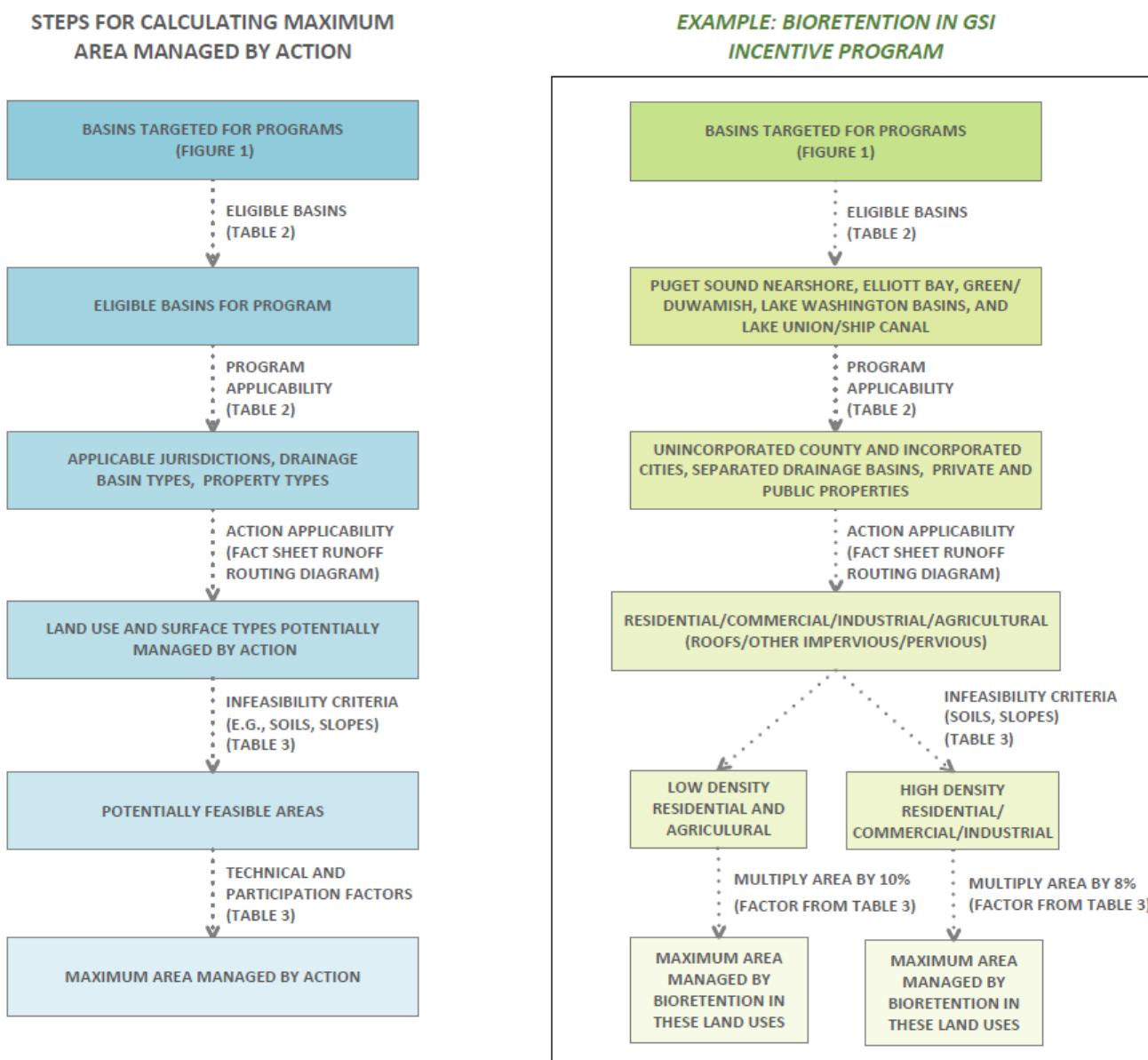


Table 3. GSI Incentive Flow Control Program Implementation Constraints.

GSI Action	Infeasible Areas ^a	Technical Factor ^b								Participation Factor ^c	Composite Factor (Technical x Participation) ^d	Rationale ^f			
		Low Density Residential			High Density Residential, Commercial, and Industrial			Agricultural				Rationale ^f			
		Roof	Other Imp	Perv	Roof	Other Imp	Perv	Roof	Other Imp			Technical Factor ^g	Participation Factor ^h		
Rain garden on till	Outwash soil, slopes > 10%	30%	30%	30%				30%	30%	20%	6.0%	Larger footprint than on outwash soil; needs positive drainage to rain garden and overflow to right of way. Less space available in denser areas.	Vegetated amenity; larger footprint on till soil; popular in RainWise program.		
Rain garden on outwash	Till soil, slopes > 10%	50%	50%	50%				50%	50%	20%	10.0%	Smaller footprint than on till soil; needs positive drainage to facility and overflow to right of way. Less space available in denser areas.	Vegetated amenity; smaller footprint on outwash soil; popular in RainWise program.		
Bioretention on outwash	Till soil, slopes > 10%	50%	50%	50%	40%	40%	40%	50%	50%	20%	8.0% - 10.0 %	Smaller footprint than on till soil; needs positive drainage to facility and overflow to right of way. Less space available in denser areas.	Vegetated amenity; smaller footprint on outwash soil.		
Cisterns	-	50%			50%			50%		25%	12.5%	Small footprint; above ground; needs positive drainage for overflow to right of way.	Small footprint; popular in RainWise program; requires seasonal operation and maintenance.		
Bioretention planter to drywell	Till soil	30%	30%	30%	30%	30%	30%	30%	30%	15%	4.5%	Drywell has small footprint; depth may limit feasibility based on separation from groundwater.	Vegetated amenity; additional maintenance for underdrain/drywell.		
High rate filter to deep UIC well	Outwash soil, gw protection areas				20%	20%	20%			5%	1.0%	Limited opportunities for UIC siting (requires thick, unsaturated deep aquifer).	UIC well would likely reduce participation due to risk and maintenance.		
Depaving	-		20%			10%			20%	5%	0.5% - 1.0%	Site uses often preclude depaving; more opportunities in residential/agricultural setting.	Most paved space is required for site use reducing participation.		
Permeable pavement	Slopes > 3%		30%			30% ^e			10%	2%	0.2% - 0.6%	Site use may preclude permeable pavement; not appropriate where clogging may result from sedimentation/sanding or with pollutant spills risk.	Desire for retrofit likely limited to settings where existing pavement is in poor condition.		
Blue roof					20%					2%	0.4%	Requires flat roof with parapet; structure must be able to support loading of a blue roof without structural upgrades.	Desire for retrofit likely limited to settings where existing roof needs upgrades		
Compost amendment				80%			80%			30%	24%	Few technical constraints for this Action (e.g., soil contamination, steep slopes).	Minor impact (except for establishment period) and does not change or reduce usable lawn area.		

gw- groundwater UIC - Underground injection control

a "Infeasible Areas" are areas where the Action will not be applied.

b "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.

c "Participation Factor" represents for the anticipated participation in the Program.

d "Composite Factor" is the combined factor applied to estimate the maximum implementation area.

e Permeable pavement not applied for industrial land use.

f Technical and participation factors are based on professional judgement. While these factors would vary spatially (e.g., in urban and rural areas), for the purposes of this analysis, factors are assumed to be the same across all Program basins.

g Additional technical consideration for roofs: 1) downspout reconfiguration often required to route roof runoff to Action, and 2) challenge to collect water from internal downspouts on flat roof buildings

h While participation rates would vary by land use, for the purposes of this analysis, a constant participation factor is assumed.

Max Implementation Area = Total Drainage Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

=Total Drainage Area (reduced by infeasible areas) x "Composite Factor"

LEGEND

Action not applied	
High Implementation	≥30%
Medium Implementation	15 to <30%
Low Implementation	≤15%

Table 4. Roadway Retrofit Flow Control Program Implementation Constraints.

Flow Control Action	Infeasible Areas ^a	Technical Factor ^b					Participation Factor ^c	Composite Factor (Technical x Participation) ^d	Rationale ^f		
		Residential, Commercial, Industrial			Agriculture	Highway					
		Local Road in City	Local Road Outside City	Arterial	All Roads	Highway					
Bioretention on outwash	Till soil, slopes > 10%	30%	40%	30%	40%	40%	30%	9% - 12%	Requires positive drainage for inflow to adjacent vegetated strip; linear systems have more siting opportunities along right of way; fewer siting opportunities in denser areas.		
Detention pond					20%	5%	30%	2% - 6%	Larger area required for pond; assume highway siting opportunities limited to offramp areas.		
Detention vault ⁵		40%	40%	40%			30%	12%	Smaller footprint; can install under road or shoulder, increasing opportunities.		
High-rate filter to infiltration vault ⁵	Till soil	30%	30%	30%			30%	9.0%	Can install under road or shoulder, increasing opportunities.		
High-rate filter to infiltration pond	Till soil				20%	5%	30%	2% - 6%	Larger area required for pond; assume highway siting opportunities limited to offramp areas.		
High-rate filter to deep UIC well	Outwash soil, gw protection areas	10%	10%	10%			20%	2%	Limited opportunities for UIC siting (requires thick, unsaturated deep aquifer).		

gw- groundwater

UIC - Underground injection control

^a "Infeasible Areas" are areas where the Action will not be applied.^b "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.^c "Participation Factor" represents for the anticipated participation in the Program.^d "Composite Factor" is the combined factor applied to estimate the maximum implementation area.^e Action not applied for residential land use.^f Technical and participation factors are based on professional judgement. While these factors would vary spatially (e.g., in urban and rural areas), for the purposes of this analysis, factors are assumed to be the same across all Program basins.^g While participation rates would vary by land use and partner agency, for the purposes of this analysis, a constant participation factor is assumed.

Max Implementation Area = Total Drainage Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

=Total Drainage Area (reduced by infeasible areas) x "Composite Factor"

LEGEND

Action not applied
High Implementation ≥30%
Medium Implementation 15 to <30%
Low Implementation ≤15%

Table 5. Reforestation Flow Control Program Implementation Constraints.

Action	Infeasible Areas ¹	Technical Factor ²									Participation Factor ³	Composite Factor (Technical x Participation) ⁴	Rationale ⁵		
		Residential		Commercial			Industrial						Technical Factor		Participation Factor ⁶
		Perv Inside City	Perv Outside City	Roof	Other Imp	Perv	Roof	Other Imp	Perv	2%	-	4%	Primary technical constraint is soil contamination in industrial areas.	Few private parcel owners would be willing to sell.	
Reforest High Density Development on private parcel	Publicly-owned parcel			80%	80%	80%	40%	40%	40%	5%	2%	-	4%	Primary technical constraint is soil contamination in industrial areas.	Few private parcel owners would be willing to sell.
Reforest High Density Development on public parcel	Privately-owned parcel			80%	80%	80%	40%	40%	40%	2%	1%	-	2%	Primary technical constraint is soil contamination in industrial areas.	Most publicly-owned space has an established use.
Reforest Pervious Area on private parcel	Publicly-owned parcel	2%	10%							2%	0.04%	-	0.2%	Requires large pervious area without an established use.	Few private parcel owners would allow easement.

^a "Infeasible Areas" are areas where the action will not be applied.^b "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.^c "Participation Factor" represents the anticipated participation in the Program.^d "Composite Factor" is the combined factor applied to estimate the maximum implementation area. ("Composite Factor" = "Technical Factor" x "Participation Factor").^e Technical and Participation Factors are based on professional judgment. While these factors would vary spatially (e.g., in urban and rural areas, by partnering jurisdiction), for the purposes of this analysis, factors are assumed to be the same across all program basins.^f While participation rates would vary by land use, for the purposes of this analysis, a constant participation factor is assumed.

Max Implementation Area = Total Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

=Total Area (reduced by infeasible areas) x "Composite Factor"

LEGEND

Action not applied	
High Implementation	≥30%
Medium Implementation	15 to <30%
Low Implementation	≤15%

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Regional Facility Flow Control Program

The nature of the Regional Facility Flow Control Program is different than the flow control Programs described above in that the implementation rate will be primarily limited by the available space for regional facilities. Given that, implementation factors were developed to estimate the maximum facility footprint area (rather than the maximum drainage area managed, as described for the other Programs).

To estimate the maximum potential facility footprint area for a regional facility, public and private parcel area in each catchment will be screened in aggregate to estimate the total candidate footprint area where facilities may be feasible. Screening will be conducted in GIS based on the criteria in Table 6. Because not all candidate areas identified in GIS would prove feasible during planning, Technical and Participation Factors will be applied to the candidate footprint area for these facilities in each catchment to estimate a more realistic level of implementation. The rationale for those factors is provided in Table 7.

The maximum footprint area for regional flow control facilities on public or private parcels is calculated as follows:

- = Candidate footprint area (reduced by screening criteria) x "Technical Factor" x "Participation Factor"
- = Candidate footprint area (reduced by screening criteria) x "Composite Factor"

The Composite Factors (i.e., Technical Factor x Participation Factor) for regional flow control facilities is 0.2 percent on private parcels and 6 percent on public parcels.

After applying the Composite Factor, if the total maximum facility footprint area in a catchment is the unit size of a regional facility (defined in the Action Fact Sheets), or larger, regional facilities on public or private parcels will be considered for that specific catchment.

Table 6. Regional Stormwater Treatment Program—Screening Criteria for Candidate Sites for Facilities on Public and Private Parcels.

Criteria Category	Screening Criteria
Parcel Type/Ownership	<ul style="list-style-type: none"> ● For publicly owned parcels: publicly-owned parcels, excluding airports, cemeteries, and trail corridors ● For privately-owned parcels: privately owned parcels
Outside Critical Areas/ Floodplain/ Sloped Areas	Located outside of: <ul style="list-style-type: none"> ● 100-year FEMA floodplain ● Areas with slope exceeding 10% ● Critical areas (steep slopes and buffers, wetlands, etc.)

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Table 7. Regional Facility Flow Control Program Implementation Constraints (for Maximum Footprint Area).

Flow Control Action	Infeasible Areas ^a	Private Parcels			Public Parcels			Rationale ^e
		Technical Factor ^b	Participation Factor ^c	Composite Factor (Technical x Participation) ^d	Technical Factor ^b	Participation Factor ^c	Composite Factor (Technical x Participation) ^d	
Detention pond	See screening criteria	10%	2%	0.2%	20%	30%	6%	Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell.
Detention vault	See screening criteria	10%	2%	0.2%	20%	30%	6%	Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell.
High-rate filter to infiltration vault	See screening criteria, till soil	10%	2%	0.2%	20%	30%	6%	Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell.
High-rate filter to infiltration pond	See screening criteria, till soil	10%	2%	0.2%	20%	30%	6%	Requires site with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell.
Sports Field / Park Detention	See screening criteria, areas other than public sports fields or parks				20%	30%	6%	Requires park or sports field with sufficient upstream drainage area that can be captured on site. Requires sufficient feasible space (e.g., open/unused space outside of critical areas with mild slope) with feasible tie in to downstream drainage system. Not all publicly owned parcels would be willing to partner. Few privately owned parcels would be willing to sell.

^a "Infeasible Areas" are areas where the Action will not be applied.

^b "Technical Factor" represents the estimated fraction of the drainage area that could feasibly be treated based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.

^c "Participation Factor" represents for the anticipated participation in the Program.

^d "Composite Factor" is the combined factor applied to estimate the maximum implementation area.

^e Technical and participation factors are based on professional judgement. While these factors would vary spatially (e.g., in urban and rural areas, by partnering jurisdiction), for the purposes of this analysis, factors are assumed to be the same across all Program basins.

Maximum Footprint Area = Candidate Footprint Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"

= Candidate Footprint Area (reduced by infeasible areas) x "Composite Factor"

LEGEND

Action not applied	
High Implementation	≥30%
Medium Implementation	15 to <30%
Low Implementation	≤15%

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Program Costs

Program Fact Sheets provide lifecycle costs for unit Actions, including initial capital, operations and maintenance, and capital replacement costs over a 30-year lifecycle. In Phase 3, the Action lifecycle costs were refined to reflect a simplified costing approach to better meet the County's needs. Basis of estimate documentation for Action lifecycles costs developed in Phase 3 is provided in HDR and Herrera (2024).

Program administration elements, such as Program development, outreach, application processing, inspections, are listed in the Program Description/Assumptions text box in the Program Fact Sheet. These costs will be developed and applied after Program optimization. Appendix I of Herrera (2024) provides example applications of different Program delivery models for different levels of Program implementation.

SUSTAIN Program Optimization

Program Fact Sheets provide a description of how SUSTAIN will be used to evaluate and optimize the Programs. The Programs will be optimized based on the most cost-effective Actions.

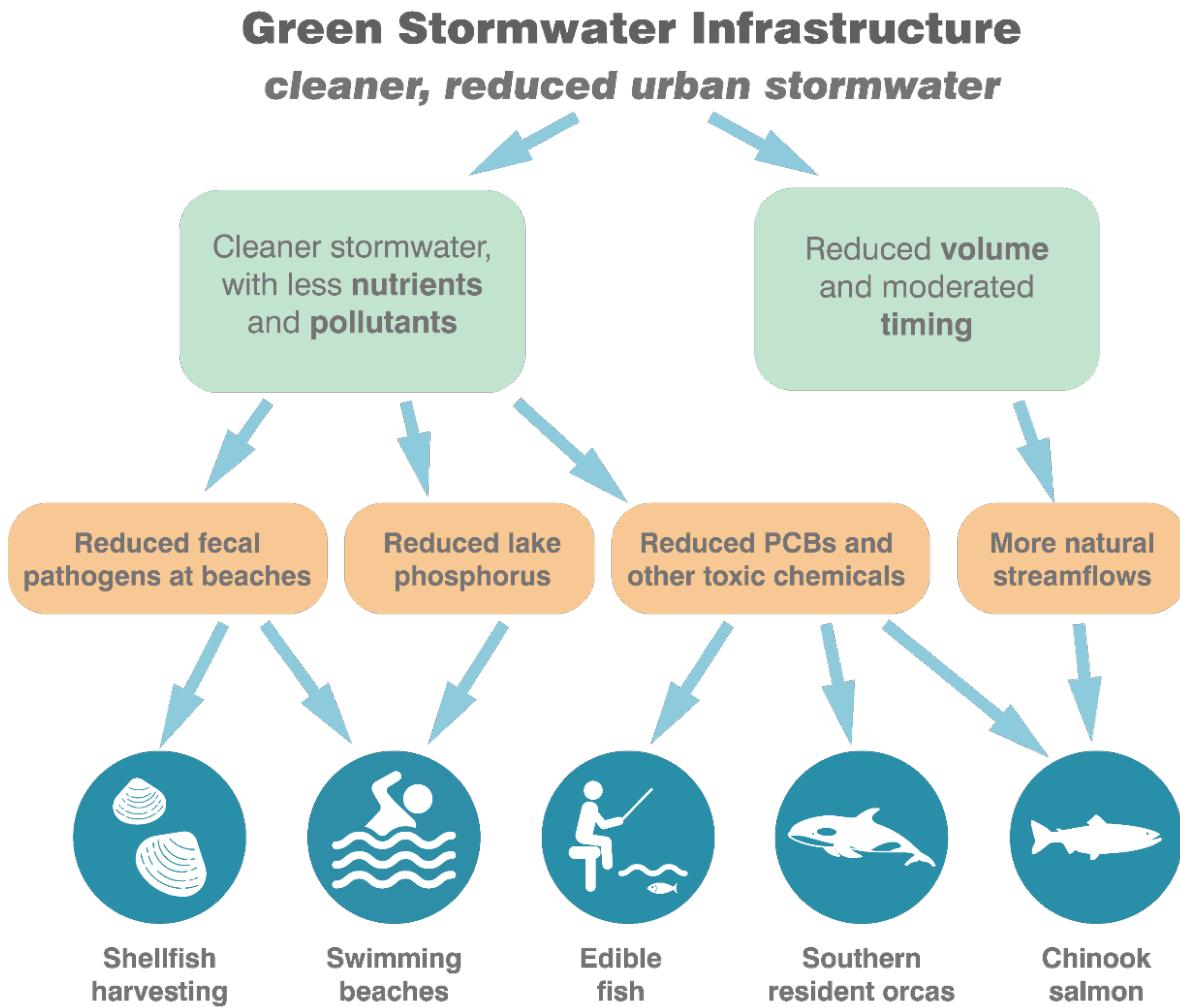
For performance, Actions will be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions will be estimated.

For costs, SUSTAIN optimization will be based on Action 30-year lifecycle costs. Program development and administration costs will be scaled and applied to modeling results.

Causal Model Linkages

Programs can also be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The Fact Sheets provide a narrative and graphic to illustrate the types of factors (e.g., pollutant load reductions) that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. An example graphic is provided as Figure 6.

Figure 6. "Causal Model Linkage" Graphic Example from GSI Incentive Program Fact Sheet.



Key Limitations and Future Considerations

This document provides an overview of the assumptions and technical basis for the Program Fact Sheet content. The following text provides a summary of key limitations in the development of the WQBE Programs and considerations for future Programs.

- Participation and Technical Factors for each Program were developed based on best professional judgment. While these factors would vary spatially, they were applied county-wide for this planning-level analysis to simplify model assumptions. To improve model accuracy, the Participation and Technical Factors could be refined and varied in future modeling efforts to reflect anticipated differences in specific areas of the county (e.g., rural versus urban).
- The maximum facility footprint area for the Regional Facility Flow Control Program will be evaluated using GIS based on high-level screening criteria. These areas will not be evaluated further (e.g., ground-truthed) so additional Technical and Participation Factors were developed to

account for the unknowns on public and private property. Further investigation of site conditions would be necessary to confirm feasibility of any particular site or area.

- While the Programs developed for this phase of modeling focus specifically on flow control, the information compiled for the WQBE toolkit thus far provides a high degree of flexibility for refining or enhancing the existing Programs or developing completely new Programs. Information for new Actions could also be developed in the future to provide even more modeling flexibility within the WQBE toolkit.

References

HDR and Herrera. 2024. Phase 3 Unit Cost Basis for Water Quality Benefits Evaluation (Appendix G to 439-TM1). Technical Memorandum prepared for King County Wastewater Treatment Division by HDR Engineering, Inc. March.

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May.

Herrera. 2023. Proposed Flow Control Actions and Programs Assessment (TM #438-TM1). Prepared for King County Wastewater Treatment Division by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2024. WQBE Phase 3 Action and Program Fact Sheet Development (439-TM1). Prepared for King County Wastewater Treatment Division by Herrera Environmental Consultants, Inc., Seattle, Washington.

Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December.

Appendix G

Phase 3 Action Fact Sheets

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RAIN GARDEN

Water Quality Benefits Evaluation Action Fact Sheet



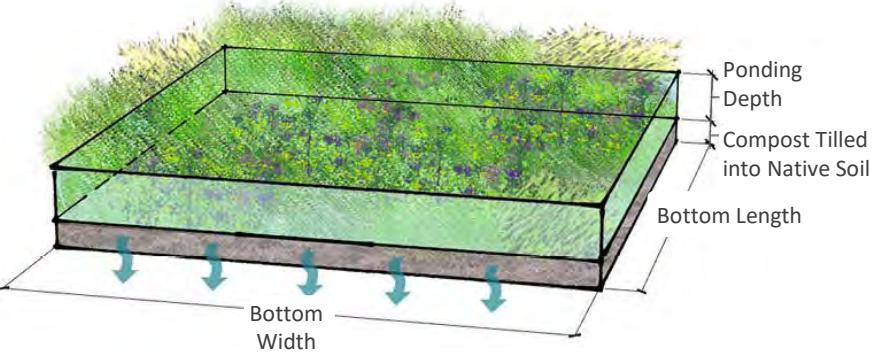
Phase 3

10/1/2024



City of Bellevue 145th Place SE Project
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A shallow, landscaped depression with adapted plants, visually similar to bioretention but with compost-amended native soils and no underdrain. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas and to allow stormwater to pass through the amended soil profile. Provides volume and peak flow reduction and water quality treatment.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	25 SF	25 SF
Unit Drainage Area	806 SF	2,844 SF
Ponding Depth	6 in	6 in
Bottom Length	7.08 ft	7.08 ft
Bottom Width	3.54 ft	3.54 ft
Side Slope	3H : 1V	3H : 1V
Treatment Media Depth ^a	8 in	8 in
Treatment Media Porosity ^a	25%	25%
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

N/A: Not Applicable

- a. The Treatment Media is non-engineered and does not provide Basic Water Quality treatment. Infiltration through the Treatment Media is assumed to occur at the Native Soil Design Infiltration Rate

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

AREAS MANAGED

Land Uses:

- Residential
- Commercial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Roofs
- Lawns
- Driveways
- Sidewalks
- Parking Lots

DESIGN ASSUMPTIONS

- Design is based on the *Seattle Stormwater Manual, "Rain Garden"* (Volume 3 Section 5.4.5).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the *2016 King County Surface Water Design Manual*, this project assumes the Unit Action provides Basic Water Quality Treatment.
- Non-engineered treatment media consists of 3" compost tilled in to an 8-inch finished depth.
- No underdrain included.





SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition
Total Project	\$8,200
Total Direct Construction	\$5,800
Total Indirect Non-Construction	\$2,400
Operation and Maintenance	\$2,100/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

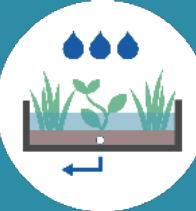
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Maximum drainage areas of 10,000 square feet of impervious surface to an individual facility.
- Meet local jurisdiction utility separation requirements.
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation.
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas.
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the *2016 King County Surface Water Design Manual*.

BIORETENTION HPBSM PLANTER

Water Quality Benefits Evaluation Action Fact Sheet



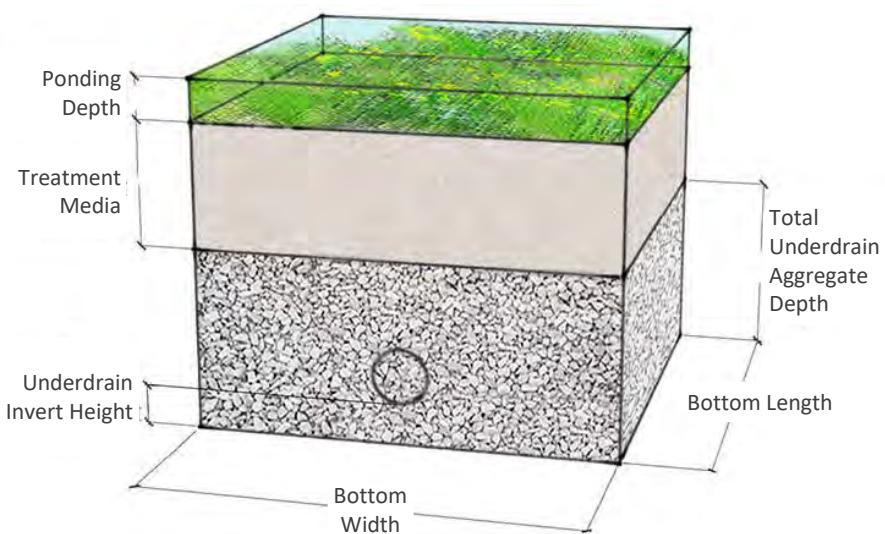
Phase 3

10/1/2024



Photo courtesy of Paradigm

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Similar to bioretention, this Action includes a designed high-performance bioretention soil media (HPBSM) and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants. This Action varies from bioretention in that the sides are vertically contained by walls constructed from formed concrete. These designs are often used in highly-urbanized settings. Provides water quality treatment and peak flow reduction. For this analysis, the Action is assumed to have an underdrain and closed bottom.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	25 SF
Unit Drainage Area	2,357 SF
Ponding Depth	6 in
Bottom Length	8.7 ft
Bottom Width	2.9 ft
Side Slope	Vertical
Treatment Media Depth	18 in
Treatment Media Porosity	30%
Treatment Media Design Infiltration Rate	6 in/hr
Total Underdrain Aggregate Depth	26 in
Underdrain Invert Height	6 in
Underdrain Diameter	8 in
Underdrain Aggregate Porosity	40%
Native Soil Design Infiltration Rate ^a	N/A

N/A: Not Applicable

a. Incidental infiltration to native soils neglected.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Driveways
- Parking Lots
- Sidewalks
- Plazas
- Local Roads
- Arterial Roads

DESIGN ASSUMPTIONS

- Design is based on the *Seattle Stormwater Manual*, "Non-infiltrating Bioretention" (Volume 3 Section 5.8.2).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- Underdrain layer includes 12" cover, 8" underdrain pipe, and 6" bedding.
- Vertical sides.



BIORETENTION HPBSM PLANTER

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	25 th Percentile Effluent Concentration ^a
Total Copper	62.3%	7.1 µg/L
Dissolved Copper	57.6%	4.6 µg/L
Total Zinc	91.0%	5.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L ^b
Total Phosphorus	54.9%	0.024 mg/L
Total Nitrogen	51.3%	1.2 mg/L
Total Suspended Solids	78.0%	13.5 mg/L
Total PCBs	78.0% ^c	358 pg/L ^c
Total PBDEs	67.1% ^c	0.034 ng/L ^c
Total PAHs	95.1%	<0.01 µg/L ^b
Bis(2-ethylhexyl)phthalate	63.2% ^c	0.044 µg/L ^c
Fecal Coliform	61.5 %	31.5 CFU/100 mL

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash

b. Method detection limit.

c. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition	In Right of Way
Total Project	\$26,500	\$36,500
Total Direct Construction	\$18,700	\$25,800
Total Indirect Non-Construction	\$7,800	\$10,700
Operation and Maintenance	\$2,800	\$2,800

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

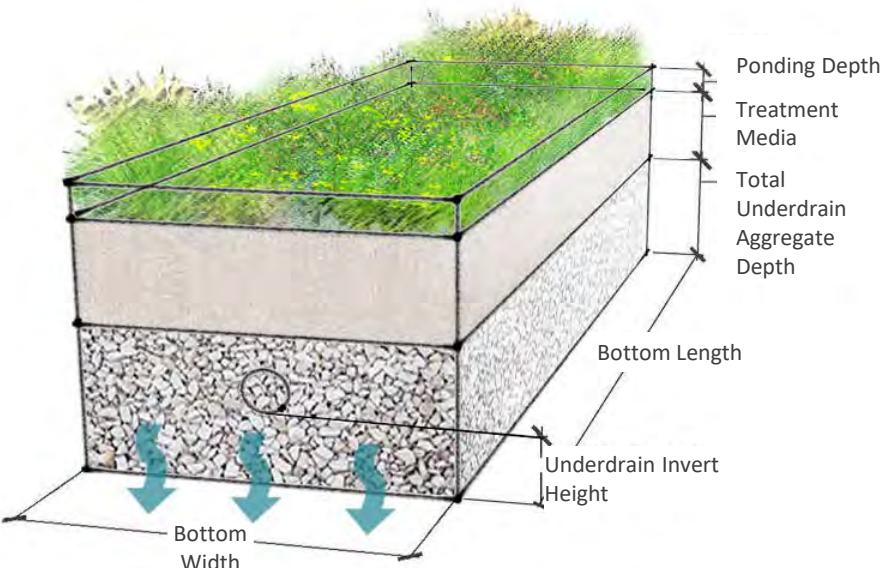
PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Because non-infiltrating bioretention facilities do not infiltrate water to surrounding soils (water discharges via an underdrain and surface overflow), these Actions are not subject to infiltration facility requirements.
- Non-infiltrating bioretention is not permitted if the under-drained water would be routed to a nutrient-critical receiving water.
- Public Right-of-Way installation for urban areas only.



City of Redmond Overlake Village LID Retrofit Project
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Shallow earthen depressions with a designed high-performance bioretention soil media (HPBSM) and plants adapted to the local climate and soil moisture conditions. Stormwater is stored as surface ponding before it filters through the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil or, in soils with lower infiltration rates, collected by an underdrain and discharged to the drainage system. Provides volume and peak flow reduction and water quality treatment.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	85 SF	85 SF
Unit Drainage Area	12,148 SF	9,570 SF
Ponding Depth	6 in	6 in
Bottom Length	16 ft	16 ft
Bottom Width	5.33 ft	5.33 ft
Side Slope	3H : 1V	3H : 1V
Treatment Media Depth	18 in	18 in
Treatment Media Porosity	30%	30%
Treatment Media Infiltration Rate	6 in/hr	6 in/hr
Total Underdrain Aggregate Depth	26 in	N/A
Underdrain Invert Height	12 in	N/A
Underdrain Diameter	8 in	N/A
Underdrain Aggregate Porosity	40%	N/A
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

N/A: Not Applicable

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

Visit kingcounty.gov/WQBE for more information.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- | | |
|----------------|------------------|
| • Roofs | • Local Roads |
| • Lawns | • Arterial Roads |
| • Driveways | • Highways |
| • Parking Lots | |
| • Sidewalk | |
| • Plazas | |

DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual (KCSWDM)* Section C.2.6.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Although not listed in the Basic or Enhanced Water Quality Treatment Menu in the KCSWDM, this project assumes the Action, including the HPBSM, provides Enhanced Water Quality Treatment.
- The HPBSM is a low phosphorus media composed of 70% sand, 20% coir and 10% high carbon wood ash (biochar). No polishing layer is included.
- For bioretention installed in till soils, an elevated underdrain promotes infiltration. Design includes 6" cover, 8" underdrain pipe, and 12" bedding.
- For bioretention installed on outwash soils, no underdrain is included.



BIORETENTION HPBSM

Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, underdrain flow, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that infiltrates is lost to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	25 th Percentile Effluent Concentration ^a
Total Copper	62.3%	7.1 µg/L
Dissolved Copper	57.6%	4.6 µg/L
Total Zinc	91.0%	5.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L ^b
Total Phosphorus	54.9%	0.024 mg/L
Total Nitrogen	51.3%	1.2 mg/L
Total Suspended Solids	78.0%	13.5 mg/L
Total PCBs	78.0% ^c	358 pg/L ^c
Total PBDEs	67.1% ^c	0.034 ng/L ^c
Total PAHs	95.1%	<0.01 µg/L ^b
Bis(2-ethylhexyl)phthalate	63.2% ^c	0.044 µg/L ^c
Fecal Coliform	61.5 %	31.5 CFU/100 mL

a. Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash

b. Method detection limit

c. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

UNIT ACTION COSTS

Costs/Unit Action ^{a,b}	With Underdrain		No Underdrain	
	On Property without Acquisition	In Right of Way/ Highway	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$50,100	\$90,300	\$46,500	\$90,000
Total Direct Construction	\$35,400	\$63,900	\$32,800	\$63,700
Total Indirect Non-Construction	\$14,700	\$26,400	\$13,700	\$26,300
Operation and Maintenance	\$3,100/year	\$3,100/year	\$3,100/year	\$3,100/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

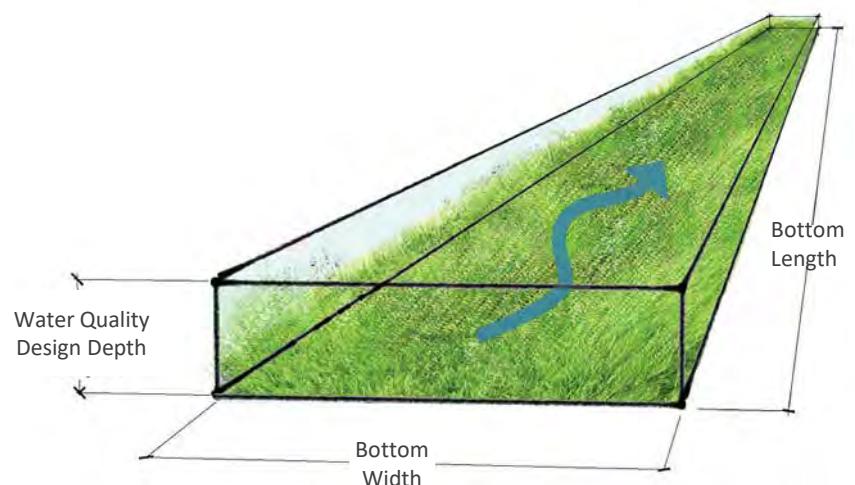
- Site must have sufficient space (e.g., right-of-way applications typically require minimum planter width of 12 feet)
- Locate away from traveled areas on individual lots to prevent soil compaction and damage to vegetation
- No discharge towards existing basements, erosion hazard areas, or landslide hazard areas
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields
- See comprehensive list of infeasibility criteria in Section C.2.6 of the 2016 King County Surface Water Design Manual



ACTION DESCRIPTION

An open, gently sloped, vegetated channel designed for treatment of stormwater. Grass is most common vegetation, but wetland vegetation can be used if soil is saturated. Provides water quality treatment, peak flow reduction, and conveyance. These are designed to “filter” water as it is conveyed through a vegetated swale. While this Action may provide incidental infiltration, that is not the primary treatment mechanism.

UNIT ACTION SCHEMATIC



DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	200 SF
Unit Drainage Area	27,878 SF
Bottom Length	100 ft
Bottom Width	2 ft
Side Slope	3H : 1V
Water Quality Design Depth	1.4 in
Native Soil Design Infiltration Rate ^a	N/A
Water Quality Design Flow Rate (Off-line)	0.052 cfs

N/A: Not Applicable

a. Incidental infiltration to native soils neglected.

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Parking Lots
- Arterial Roads
- Local Roads
- Highways

DESIGN ASSUMPTIONS

- Design is based on the *2016 King County Surface Water Design Manual, "Basic Bioswales"*, Section 6.3.1.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
- Non-engineered soil media consists of 2" compost tilled into 6" native soil.
- Water flows relatively evenly across the entire width of a densely-vegetated area.
- No infiltration to native soils.





SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that flows through the bioswale (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	33.9%	4.8 µg/L
Dissolved Copper	8.99%	3.6 µg/L
Total Zinc	33.3%	20.0 µg/L
Dissolved Zinc	29.0%	15.0 µg/L
Total Phosphorus	-37.2%	0.100 mg/L
Total Nitrogen	-7.63%	0.562 mg/L
Total Suspended Solids	27.9%	10.0 mg/L
Total PCBs	27.9% ^a	265 pg/L ^a
Total PBDEs	24.0% ^a	0.025 ng/L ^a
Total PAHs	27.9% ^a	0.0012 µg/L ^a
Bis(2-ethylhexyl)phthalate	23.0% ^a	0.033 µg/L ^a
Fecal Coliform	6.25%	1775 CFU/100 mL

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$16,200	\$29,000
Total Direct Construction	\$11,400	\$20,500
Total Indirect Non-Construction	\$4,800	\$8,500
Operation and Maintenance	\$2,600/year	\$2,600/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

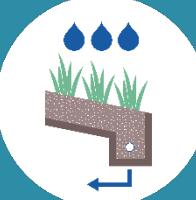
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Generally appropriate when there is less than 5 acres of contributing impervious surface.
- Site in areas with a minimum of 6 hours of sunlight daily throughout the year.
- Do not site in high-use areas without oil control, as required in Section 6.6 in the *King County Surface Water Design Manual*.

MEDIA FILTER DRAIN (MFD)

Water Quality Benefits Evaluation Action Fact Sheet



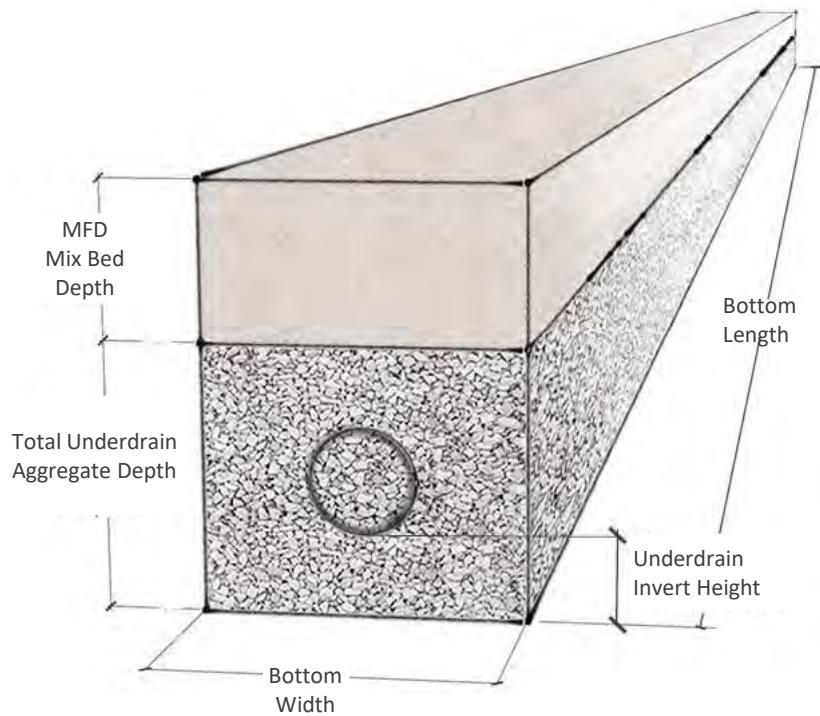
Phase 3

10/1/2024



Photo accessed on 7/2/2020 from
<https://www.wsdot.wa.gov/design/roadsides/stormwater-management>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A linear flow-through stormwater treatment device that can be sited along roadway side slopes (conventional design) and medians, borrow ditches, or other linear depressions. Cut-slope applications may also be considered. MFDs have four basic components: a gravel no-vegetation zone, a vegetated filter strip, the MFD mix bed, and an optional gravel-filled underdrain trench or layer of crushed surfacing base course. Treated water is either infiltrated into the underlying soil or collected by an underdrain and discharged to the drainage system.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	200 SF	200 SF
Unit Drainage Area	2,000 SF	2,000 SF
Lateral Slope	3H : 1V	3H : 1V
Ponding Depth	0 in	0 in
Bottom Length	100 ft	100 ft
Bottom Width	2 ft	2 ft
MFD Mix Bed Depth	12 in	12 in
MFD Mix Porosity	40%	40%
MFD Mix Media Infiltration Rate	10 in/hr	10 in/hr
Total Underdrain Aggregate Depth	20 in	N/A
Underdrain Invert Height	6 in	N/A
Underdrain Diameter	8 in	N/A
Underdrain Aggregate Porosity	40%	N/A
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

N/A: Not Applicable

AREAS MANAGED

Land Uses:

- Highway
- Agricultural

Property Types:

- Public Right-of-Way

Surface Types:

- Arterial Roads
- Local Roads
- Highway

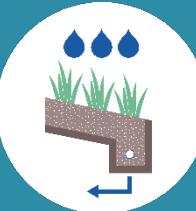
DESIGN ASSUMPTIONS

- Design is based on the *2019 Washington State Department of Ecology Stormwater Management Manual for Western WA (SWMMWW)*, Best Management Practice (BMP) T8.40.
- Sizing is based on the SWMMWW Table V-6.5.
- The MFD mix consists crushed rock, dolomite, gypsum, and perlite.
- No underdrain included for MFDs installed on outwash soils.
- Treatment steps include:
 - Stormwater runoff enters the media filter drain and is conveyed via sheet flow over a vegetation-free gravel zone for sheet dispersion and to provide some pollutant trapping
 - A grass strip is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system
 - Runoff is then filtered through the treatment media bed and treated water is drained to an approved discharge location



MEDIA FILTER DRAIN (MFD)

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, filtration, underdrain flow, and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	86.2%	9.45 µg/L
Dissolved Copper	40.8%	6.25 µg/L
Total Zinc	85.1%	22.0 µg/L
Dissolved Zinc	80.8%	16.0 µg/L
Total Phosphorus	85.7%	0.033 mg/L
Total Nitrogen	NF	NF
Total Suspended Solids	94.1%	2.8 mg/L
Total PCBs	94.1% ^a	74.3 pg/L ^a
Total PBDEs	80.9% ^a	0.007 ng/L ^a
Total PAHs	94.1% ^a	0.00035 µg/L ^a
Bis(2-ethylhexyl)phthalate	76.2% ^a	0.0091 µg/L ^a
Fecal Coliform	NF	NF

NF: No data found. Assigned a value of 0 in SUSTAIN since no data was found.

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	Rural Roadway/Highway	
	With Underdrain	No Underdrain
Total Project	\$35,800	\$32,600
Total Direct Construction	\$25,300	\$23,100
Total Indirect Non-Construction	\$10,500	\$9,500
Operation and Maintenance	\$2,400/year	\$2,400/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Avoid construction on longitudinal slopes steeper than 5%.
- For narrow roadway shoulders, ensure sufficient space available for parking.
- Do not construct in wetlands and wetland buffers.
- Install above the site mean high water table levels to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow ground water.
- Do not site in areas of seasonal ground water inundation or basement flooding.
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields

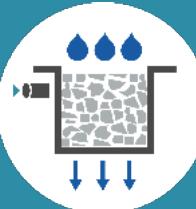
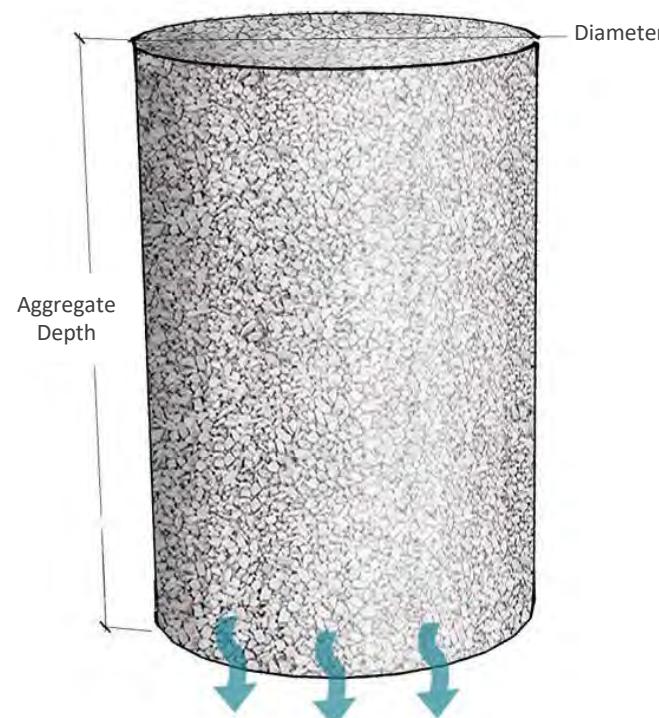


Photo accessed on 7/2/2020 from
<https://www.thisoldhouse.com/>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A gravel filled hole that conveys stormwater runoff into the soil matrix. Provides volume and peak flow reduction.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	13 SF	13 SF
Unit Drainage Area	261 SF	780 SF
Ponding Depth	N/A	N/A
Diameter	4 ft	4 ft
Aggregate Depth	6 ft	6 ft
Aggregate Porosity	40%	40%
Native Soil Design Infiltration Rate ^a	0.3 in/hr	2.5 in/hr

a. Lateral infiltration assumed to occur through half of the sidewall depth.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Agricultural

Property Types:

- Private Parcel
- Public Parcel

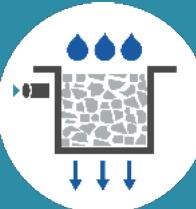
Surface Types:

- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Lawns

DESIGN ASSUMPTIONS

- Design is based on the *2017 Seattle Stormwater Manual*, "Drywells" (Volume 3 Section 5.4.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet a Modified Level 1 Flow Control Standard, in which peak discharge rates were matched to the pre-developed (forested) peak discharge rates for the 2- and 10-year return intervals.
- Pre-treatment via upstream treatment Action will be provided.
- Infiltration to native soil assumes infiltration through the bottom surface and half of the sidewall surface area.
- The installed Action must be registered with Ecology as an Underground Injection Control (UIC).





SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents storage, infiltration and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

Visit kingcounty.gov/WQBE for more information.

UNIT ACTION COSTS

Costs/Unit Action ^{a,b}	On Property without Acquisition
Total Project	\$19,800
Total Direct Construction	\$14,000
Total Indirect Non-Construction	\$5,800
Operation and Maintenance	\$1,000/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Minimum spacing between drywells is 10 feet.
- Setback is at least 15 feet from buildings with crawl space or basement elevations that are below the overflow point of the drywell.
- Can be placed under a pervious or impervious surface cover to conserve space.
- A minimum 5' setback shall be maintained between any part of the action and any structure or property line.
- Locate downgradient of the primary and secondary reserve drainfield areas.
- Locate away from sensitive area buffers.
- Do not direct overflows toward a slope steeper than 15%.
- Meet infiltration siting restrictions, including setbacks:
 - 50 feet away from top of slopes > 20% and over 10 feet of vertical relief
 - 100 feet away from closed or active landfill, drinking water well, or spring used for drinking water supply
 - 100 feet away from proposed or existing septic system drainfields

DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL

Water Quality Benefits Evaluation Action Fact Sheet



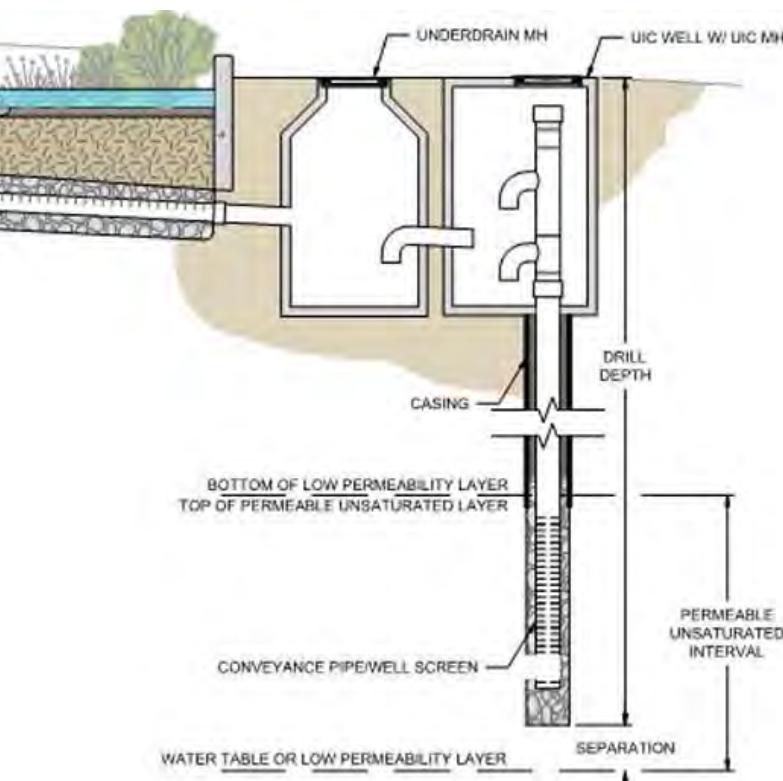
Phase 3

10/1/2024



Seattle Public Utilities Delridge Natural Drainage System
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A well that extends below an upper confining layer and discharges into the underlying vadose zone. This includes drywells where drilling extends through a surficial till layer into the vadose zone below. This analysis assumes a water-well style UIC downstream of a pre-treatment Action. Provides volume and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Assumed Maximum Flow Rate	0.111 cfs
Unit Footprint Area	42 SF
Unit Drainage Area ^a	N/A

N/A: Not Applicable

a. Unit Drainage Area based on drainage area of pre-treatment Action.

AREAS MANAGED

Land Uses:

- Residential
- Commercial

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Sidewalks
- Lawns
- Local Roads
- Arterial Roads

DESIGN ASSUMPTIONS

- Design and sizing based on *King County Wastewater Treatment Division's Barton Basin Combined Sewer Overflow Control Project with Green Stormwater Infrastructure* (Barton).
- Maximum flow rate assumed to be 50 gallons per minute (0.111 cubic feet per second) based on average results presented in the Barton Drainage Report, Section 6.4.
- Well includes the following configuration:
 - Drilling and casing of 12-inch diameter borehole
 - 20-foot long 8-inch diameter pipe-sized well screen with filter pack
 - 5-foot deep stainless-steel well sump containing energy-dissipation rock, allowing water to drain out of well
 - Sand filter pack around well screen and sump, extending 8 feet above the top of the well screen
 - Maintenance hole over wellhead to convey treated stormwater into the well
 - Maximum well depth of 100 feet to accommodate future removal of sediment by vactor equipment
 - Underdrain manhole to provide for additional sediment removal
- Pre-treatment via upstream treatment Action will be provided.
- Includes a surface seal in the final completion of a deep UIC.



DEEP UNDERGROUND INJECTION CONTROL (UIC) WELL

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents infiltration and overflow

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition	In Right of Way
Total Project	\$57,200	\$81,900
Total Direct Construction	\$40,400	\$58,000
Total Indirect Non-Construction	\$16,800	\$23,900
Operation and Maintenance	\$900/year	\$900/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

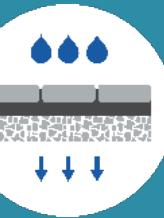
b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Locate away from wellhead protection area, Critical Aquifer Recharge Area, or a Sole Source Aquifer.
- Submittal of a State Waste Discharge Permit application required and will be determined on a site-by-site basis following the evaluation of the UIC permit application.

PERMEABLE PAVEMENT

Water Quality Benefits Evaluation Action Fact Sheet



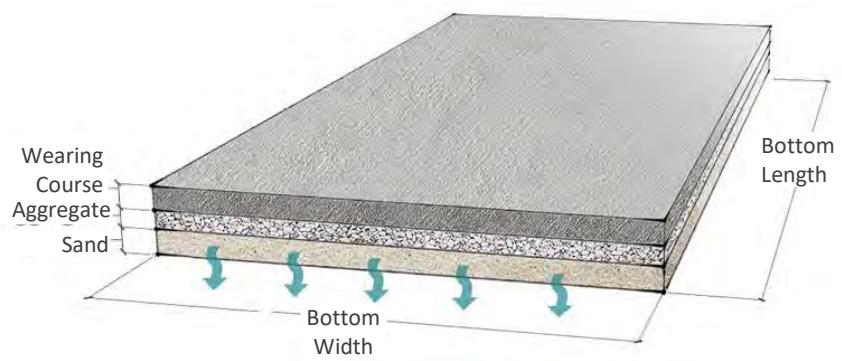
Phase 3

10/1/2024



City of Puyallup 9th St NW Porous Asphalt Roadway and Driveway Aprons
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Includes pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material. Intended to allow passage of water through pavement. Provides volume and peak flow reduction. Provides water quality treatment when sand treatment layer is provided.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	200 SF	200 SF
Unit Drainage Area	200 SF	200 SF
Ponding Depth	0 in	0 in
Bottom Length	20 ft	20 ft
Bottom Width	10 ft	10 ft
Treatment Media Depth ^a	6 in	6 in
Treatment Media Porosity	35%	35%
Aggregate Depth	3 in	3 in
Aggregate Porosity	40%	40%
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

a. Sand treatment layer provided for pollution-generating hard surfaces (i.e., low volume residential driveways) only.

AREAS MANAGED

Land Uses:

- Residential
- Commercial

Property Types:

- Private Parcel
- Public Parcel

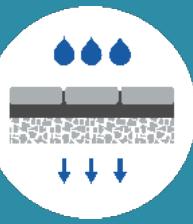
Surface Types:

- Low Volume Residential Driveways
- Sidewalks
- Plazas
- Trails
- Pedestrian and bike paths
- Parking Lots

DESIGN ASSUMPTIONS

- Design and sizing based on the *2016 King County Surface Water Design Manual*, "Permeable Pavement", Appendix C, Section C.2.7.
- Section consists of 5" wearing course (pervious concrete or porous asphalt) over 3" aggregate. For low volume residential driveways, the section is underlain by 6" sand treatment layer
- Subsurface ponding assumed to include:
 - Ponding in aggregate layer: 3" x 40% porosity = 1.2"
 - Ponding in sand layer: 6" x 35% porosity = 2.1"
 - Storage in wearing course neglected
- The aggregate base contains less than 5% fines (material passing the #200 sieve) based on the fraction passing the #4 sieve.
- No run-on from other areas. The permeable pavement surface manages stormwater runoff from its own footprint only.
- Installation is on flat grades (e.g., <5% slope). No subsurface check dams required.





PERMEABLE PAVEMENT

Water Quality Benefits Evaluation Action Fact Sheet

Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents subsurface ponding, infiltration, and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	Permeable Paver Plaza (no sand layer)	Pervious Concrete Sidewalk (no sand layer)	Permeable Paver Driveway (with sand layer)	Porous Asphalt Driveway (with sand layer)
Total Project	\$9,500	\$15,800	\$11,000	\$8,300
Total Direct Construction	\$6,700	\$11,200	\$7,800	\$5,900
Total Indirect Non-Construction	\$2,800	\$4,600	\$3,200	\$2,400
Operation and Maintenance	\$2,300/year	\$2,300/year	\$2,300/year	\$2,300/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Limit to sites with 5% or less grade.
- Do not locate in high traffic or heavy load applications such as arterial roads, highways, and industrial/commercial loading areas.
- Do not locate in areas where King County's Permeable Pavement Infeasibility Criteria (see Section C.2.7 in the *2016 King County Surface Water Design Manual*) apply, such as (but not limited to) the following areas:
 - Where ground water drains into an erosion hazard or landslide hazard area
 - Where nearby basements that may be impacted
 - Where seasonal high groundwater or an underlying impermeable/low permeable layer lies within 1 foot of the bottom of the installation
 - Downslope of steep, erosion prone areas that are likely to deliver sediment
 - Within 50 feet from the top of slopes greater than 20%
 - Within 100 feet of a closed or active landfill
 - Within 100 feet of a drinking water well, or a spring used for drinking water supply, for pollution-generating surfaces (e.g., driveways)

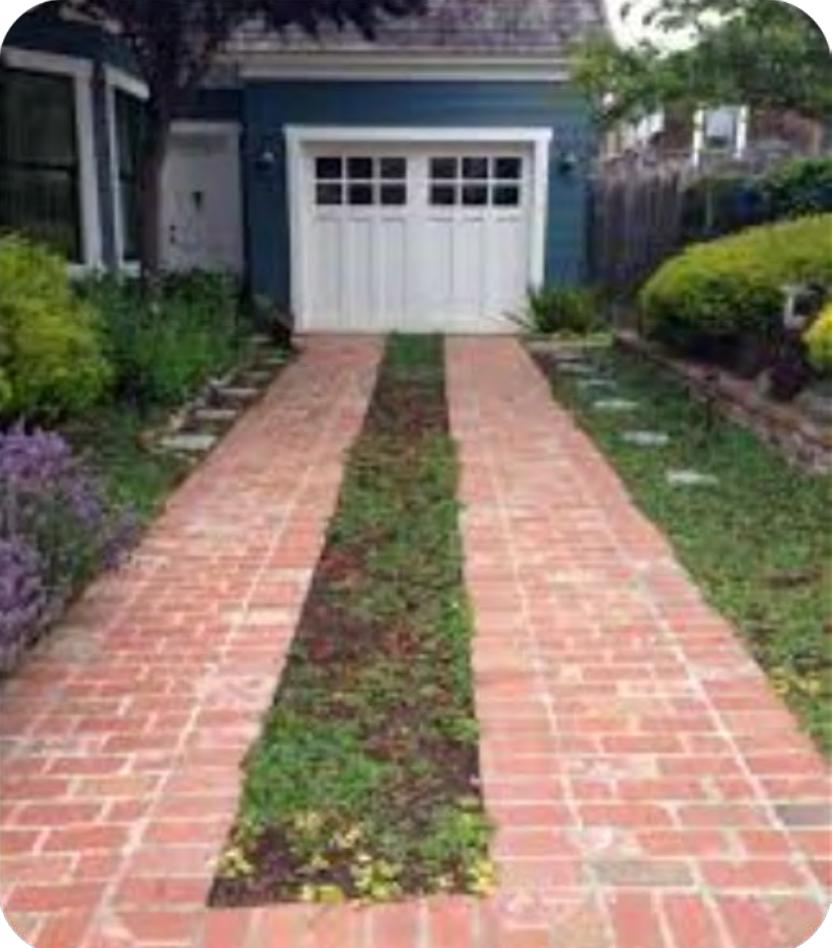
DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024



Wheel strips replacing fully impervious driveway

Photo accessed on 7/2/2020 from <https://www.cityofpacificgrove.org/>

ACTION DESCRIPTION

Depaving, or removal of impervious surfaces down to bare soil. The area is amended with compost and planted with low lying ground cover. To allow continued site use, the area may be retrofit with an alternative treatment (e.g., wheel strip driveways) per King County Surface Water Design Manual, "Reduced Impervious Surface Credit". Provides volume and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	100 SF
Existing Surface ^a	Impervious
New Surface ^a	Pervious

a. This Action will be modeled in SUSTAIN by converting the depaved area from an impervious to pervious surface.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Driveways
- Sidewalks
- Parking Lots

DESIGN ASSUMPTIONS

- Designs based on the *2016 King County Surface Water Design Manual*, "Reduced Impervious Surface Credit" (Appendix C, Section C.2.9).
- For wheel strip driveways, assume 10-foot-wide by 10-foot-long driveway converted to two (2) concrete pavement strips, each 2-feet-wide by 10-feet-long, for a total of 40 square feet impervious area (60% impervious area reduction).
- Restored pervious areas amended with 4 inches of well-rotted compost tilled into the upper 8 inches of the soil.



DEPAVING (REMOVAL OF IMPERVIOUS SURFACES)

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Convert the surface type from existing impervious cover to a pervious surface type of the same land use.

Treatment:

- While no treatment is provided, pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	Driveway Depaving with Wheel Strips	Driveway Depaving without Alternative Surface
Total Project	\$2,600	\$2,000
Total Direct Construction	\$1,800	\$1,400
Total Indirect Non-Construction	\$800	\$600
Operation and Maintenance	\$700/year	\$700/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- The area credited as mitigated must be no more than 10,000 square feet on any one site/lot unless the surface is served by a flow control facility designed by a civil engineer in accordance with Section 1.2.3 of the *2016 King County Surface Water Design Manual*.
- Any runoff from the area credited as mitigated must be directed to vegetated pervious areas on the site/lot or discharged through a perforated pipe connection per Section C.2.11 of the *2016 King County Surface Water Design Manual*.
- Any portion of the area credited as mitigated that is pollution-generating impervious surface must be less than 5,000 square feet on any one site/lot unless the surface is served by a water quality treatment facility designed by a civil engineer in accordance with Section 1.2.8 of the *2016 King County Surface Water Design Manual*.

STORMWATER TREATMENT WETLAND

Water Quality Benefits Evaluation Action Fact Sheet



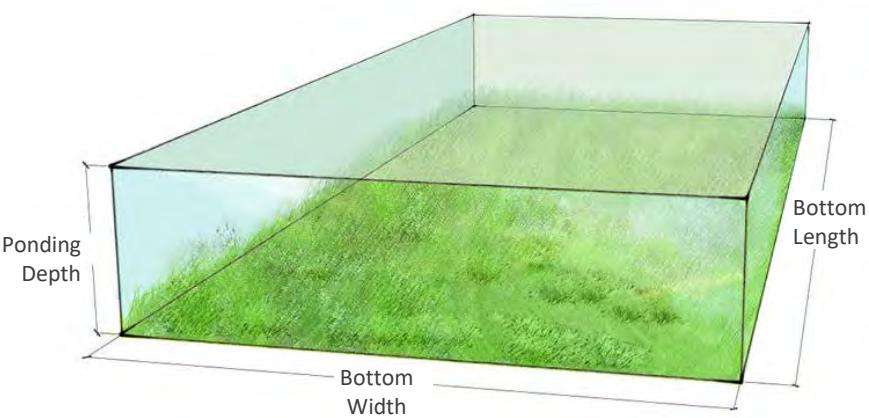
Phase 3

10/1/2024



Photo accessed on 7/2/2020 from
<https://www.portseattle.org/projects/wetlands-and-habitat-restoration>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Similar to a wet pond but also provides a shallow marsh area to allow the establishment of emergent wetland aquatic plants, which improves pollutant removal. Provides water quality treatment and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	503 SF
Unit Drainage Area	62,988 SF
Ponding Depth	48 in
Bottom Length	31.5 ft
Bottom Width	16 ft
Side Slope	3H : 1V
Water Quality Design Flow Rate (Off-line)	0.118 cfs
Native Soil Design Infiltration Rate ^a	N/A

a. Not Applicable, incidental infiltration to native soils neglected.

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- | | |
|----------------|------------------|
| • Roofs | • Local Roads |
| • Lawns | • Arterial Roads |
| • Sidewalks | • Highways |
| • Driveway | |
| • Parking Lots | |

DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.3 "Stormwater Wetlands".
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Sized and designed as a Basic facility.
- Two-cell facility includes:
 - Pre-settling cell with volume equal to one-third the volume of the entire facility and minimum sediment storage depth of 1 foot
 - 1-foot freeboard over entire surface area
 - Dividing berm submerged 1 foot below the WQ design water surface
- No infiltration to native soil.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.



STORMWATER TREATMENT WETLAND

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	25.0%	3.0 µg/L
Dissolved Copper	0.0%	2.0 µg/L
Total Zinc	45.9%	12.0 µg/L
Dissolved Zinc	0.0%	10.0 µg/L
Total Phosphorus	24.2%	0.071 mg/L
Total Nitrogen	5.81%	0.932 mg/L
Total Suspended Solids	52.4%	6.81 mg/L
Total PCBs	78.1%	165 pg/L
Total PBDEs	45.1% ^a	0.017 ng/L ^a
Total PAHs	85.6%	0.024 µg/L
Bis(2-ethylhexyl)phthalate	42.4% ^a	0.022 µg/L ^a
Fecal Coliform	19.1%	425 CFU/100 mL

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property/Highway without Acquisition
Total Project	\$1,537,200	\$815,000
Total Direct Construction	\$463,100	\$463,100
Total Indirect Non-Construction	\$1,074,100	\$351,900
Operation and Maintenance	\$2,500/year	\$2,500/year
Property Acquisition ^c	\$555,554	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Areas with high winter groundwater levels are ideal for wetland siting.
- Potential site evapotranspiration must be considered as sufficient water must be retained in facility to supply adequate water for aquatic vegetation.
- The pre-settling cell must retain a permanent pool of water throughout the wet season, and the second cell must retain water for at least 10 months of the year.
- Setback required from tract line is 5-feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetland inlet and outlet structures.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 6.2.3 and Section 6.4.2.

DETENTION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



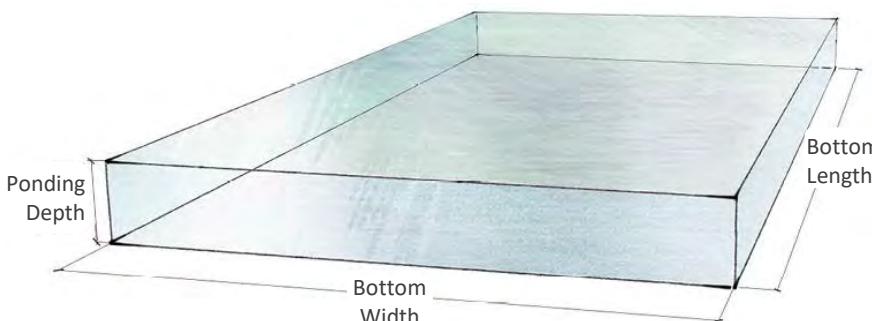
Phase 3

10/1/2024



Photo accessed on 7/2/2020 from
<https://csengineermag.com/>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A box-shaped underground facility that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate. Provides peak flow reduction.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	2,592 SF
Unit Drainage Area	28,658 SF
Ponding Depth	72 in
Bottom Length	54 ft
Bottom Width	48 ft
Side Slope	Vertical
Orifice Diameter	1.16 in
Orifice Height	0 ft
Notch Width	0.37 in
Notch Height	2.40 ft

DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual*, "Detention Vaults" (Chapter 5, Section 5.1.3).
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step. The unit Action was sized to meet the Level 2 Flow Control standard with pre-developed forest condition.
- The invert elevation of the outlet is elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom.
- The outlet is also elevated a minimum of 2 feet above the orifice to retain oil within the vault.
- Access is provided by a 5-foot by 10-foot removable, locking panel.
- Internal height of 7 feet.



DETENTION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.

Treatment:

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	26.2% ^b	4.2 µg/L ^b
Dissolved Copper	3.23% ^b	3.0 µg/L ^b
Total Zinc	44.0% ^b	18.0 µg/L ^b
Dissolved Zinc	13.6% ^b	16.1 µg/L ^b
Total Phosphorus	17.7% ^b	0.113 mg/L ^b
Total Nitrogen	7.80% ^b	0.674 mg/L ^b
Total Suspended Solids	57.6% ^b	12.9 mg/L ^b
Total PCBs	57.6% ^a	342 pg/L ^a
Total PBDEs	56.9%	93.5 ng/L
Total PAHs	52.1%	0.228 µg/L
Bis(2-ethylhexyl)phthalate	46.7% ^a	0.042 µg/L ^a
Fecal Coliform	31.5% ^b	500 CFU/100 mL ^b

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

b. Performance based on detention pond performance which provide similar unit processes for pollutant removal.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$6,324,900	\$5,775,500	\$6,302,400
Total Direct Construction	\$3,281,800	\$3,281,800	\$3,638,400
Total Indirect Non-Construction	\$3,043,100	\$2,493,700	\$2,664,000
Operation and Maintenance	\$5,200/year	\$5,200/year	\$5,200/year
Property Acquisition ^c	\$422,603	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Setbacks to tract/easement lines for vaults shall be 5 feet; adjacent building setback lines shall be 10 feet.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.

DETENTION POND

Water Quality Benefits Evaluation Action Fact Sheet



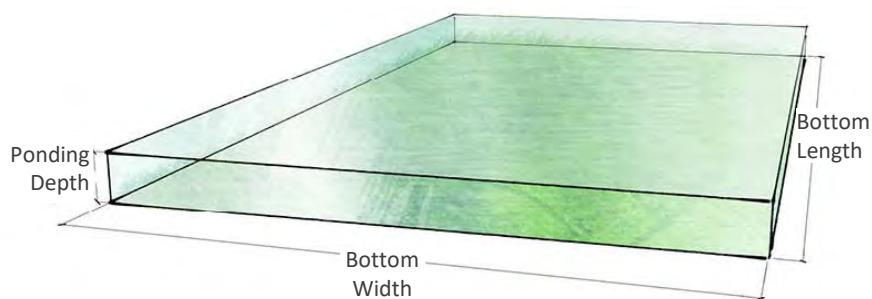
Phase 3

10/1/2024



Photo courtesy of Paradigm

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A surface basin that provides temporary storage of stormwater runoff. The stored stormwater runoff is then released through a control structure at an attenuated rate, allowing the basin to dry out between storm events. Provides peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	4,500 SF
Unit Drainage Area	36,569 SF
Ponding Depth	48 in
Bottom Length	95 ft
Bottom Width	47.4 ft
Side Slope	3H : 1V
Orifice Diameter	1.41 in
Orifice Elevation	0 ft
Notch Width	0.87 in
Notch Height	1.44 ft

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design is based on *2016 King County Surface Water Design Manual*, Chapter 5, Section 5.1.1 “Detention Ponds”.
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.



DETENTION POND

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Design Parameters were modified to accurately represent the Unit Action's performance in SUSTAIN.

Treatment:

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	26.2%	4.2 µg/L
Dissolved Copper	3.23%	3.0 µg/L
Total Zinc	44.0%	18.0 µg/L
Dissolved Zinc	13.6%	16.1 µg/L
Total Phosphorus	17.7%	0.113 mg/L
Total Nitrogen	7.80%	0.674 mg/L
Total Suspended Solids	57.6%	12.9 mg/L
Total PCBs	57.6% ^a	342 pg/L ^a
Total PBDEs	56.9% ^b	93.5 ng/L ^b
Total PAHs	52.1% ^b	0.228 µg/L ^b
Bis(2-ethylhexyl)phthalate	46.7% ^a	0.042 µg/L ^a
Fecal Coliform	31.5%	500 CFU/100 mL

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

b. Performance based on detention vault performance which provide similar unit processes for pollutant removal.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property/Highway without Acquisition
Total Project	\$2,709,600	\$1,222,400
Total Direct Construction	\$694,200	\$694,600
Total Indirect Non-Construction	\$2,015,400	\$527,800
Operation and Maintenance	\$10,000/year	\$10,000/year
Property Acquisition ^c	\$1,144,543	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

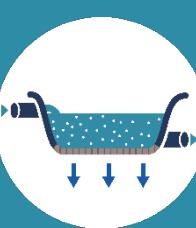
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Do not locate in dedicated public road right-of-way.
- Must meet the following setbacks:
 - Tract or property line must be setback 5 feet from the emergency overflow water surface
 - The water surface at the pond outlet invert elevation must be setback 100 feet from proposed or existing septic system drainfields
 - Design water surface must be a minimum of 200 feet from any steep slope hazard area or landslide hazard area
 - Design water surface must be setback a minimum distance from top of slope equal to the total vertical height of a slope area that is steeper than 15%
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.1.

INFILTRATION POND

Water Quality Benefits Evaluation Action Fact Sheet



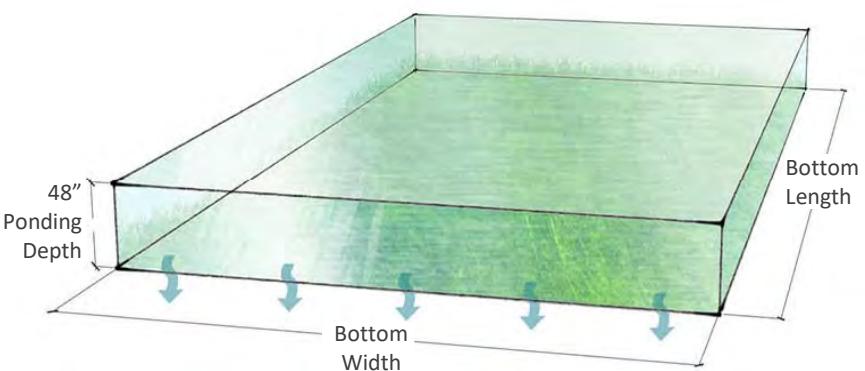
Phase 3

10/1/2024



Photo accessed on 7/2/2020 from
<https://www.stormwater.pca.state.mn.us>

UNIT ACTION SCHEMATIC



DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	2,785 SF	1,479 SF
Unit Drainage Area	36,595 SF	46,396 SF
Ponding Depth	48 in	48 in
Bottom Length	74.6 ft	54.4 ft
Bottom Width	37.3 ft	27.2 ft
Side Slope	3H : 1V	3H : 1V
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

ACTION DESCRIPTION

A surface basin that temporarily stores stormwater runoff similar to a detention pond, but also provides infiltration. Provides volume and peak flow reduction.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

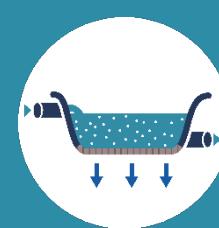
DESIGN ASSUMPTIONS

- Design based on *2016 King County Surface Water Design Manual* Chapter 5, Section 5.2.2 "Infiltration Ponds"
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Length-to-width ratio assumed to be 2:1
- Pre-treatment via upstream treatment Action will be provided
- Maintenance access roads must be provided to the control structure and other drainage structures associated with the pond
- An overflow structure and emergency spillway shall be provided



INFILTRATION POND

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition		On Property/Highway without Acquisition	
	In Till Soil	In Outwash Soil	In Till Soil	In Outwash Soil
Total Project	\$2,039,300	\$1,947,300	\$880,800	\$788,800
Total Direct Construction	\$500,500	\$448,200	\$500,500	\$448,200
Total Indirect Non-Construction	\$1,538,800	\$1,499,100	\$380,300	\$340,600
Operation and Maintenance	\$5,900/year	\$3,700/year	\$5,900/year	\$3,700/year
Property Acquisition ^c	\$891,189	\$891,189	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
 - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
 - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
 - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
 - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.2.2.

INFILTRATION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

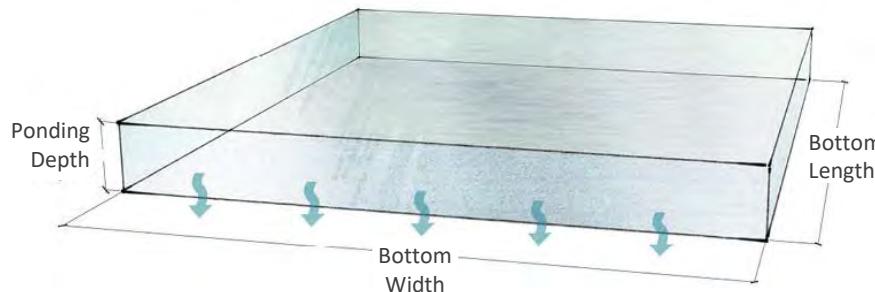
10/1/2024



City of Redmond Overlake Village Infiltration Vault
Photo accessed on 7/2/2020 from

<https://content.govdelivery.com/accounts/WAREDMOND/bulletins/1e5d116>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

An open bottomed, box-shaped underground facility that stores stormwater runoff similar to detention vaults, but also provides infiltration via an open bottom. Provides volume reduction and peak flow reduction.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	1,836 SF	1,156 SF
Unit Drainage Area	28,719 SF	39,365 SF
Ponding Depth	72 in	72 in
Bottom Length	51 ft	34 ft
Bottom Width	36 ft	34 ft
Side Slope	Vertical	Vertical
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design based on *2016 King County Surface Water Design Manual* Chapter 5, Section 5.2.4 "Infiltration Vaults".
- Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region precipitation time series with a 15-minute model time step. The Unit Action was sized to meet the Level 2 Flow Control standard with a pre-developed forest condition.
- Pre-treatment via upstream treatment Action will be provided.
- Designs include a solid bottom riser (with clean-out gate) and outflow system for safely discharging overflows to the downstream conveyance system or acceptable discharge point.
- Energy dissipation at the inlet is required to prevent scour and will be accomplished by using the detail for the sand filter vault (see Figure 6.5.3.A in the 2016 King County Surface Water Design Manual).
- Access roads are required to the vault access panel.

INFILTRATION VAULT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, infiltration, and overflow.

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition		On Property without Acquisition		In Right of Way/ Highway	
	In Till Soil	In Outwash Soil	In Till Soil	In Outwash Soil	In Till Soil	In Outwash Soil
Total Project	\$4,423,500	\$3,733,400	\$3,981,300	\$3,291,300	\$4,821,100	\$3,956,300
Total Direct Construction	\$2,262,300	\$1,870,200	\$2,262,300	\$1,870,200	\$2,782,300	\$2,282,500
Total Indirect Non-Construction	\$2,161,200	\$1,863,200	\$1,719,000	\$1,421,100	\$2,038,800	\$1,673,800
Operation and Maintenance	\$4,800/year	\$4,800/year	\$4,800/year	\$4,800/year	\$4,800/year	\$4,800/year
Property Acquisition ^c	\$340,082	\$340,082	\$0	\$0	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

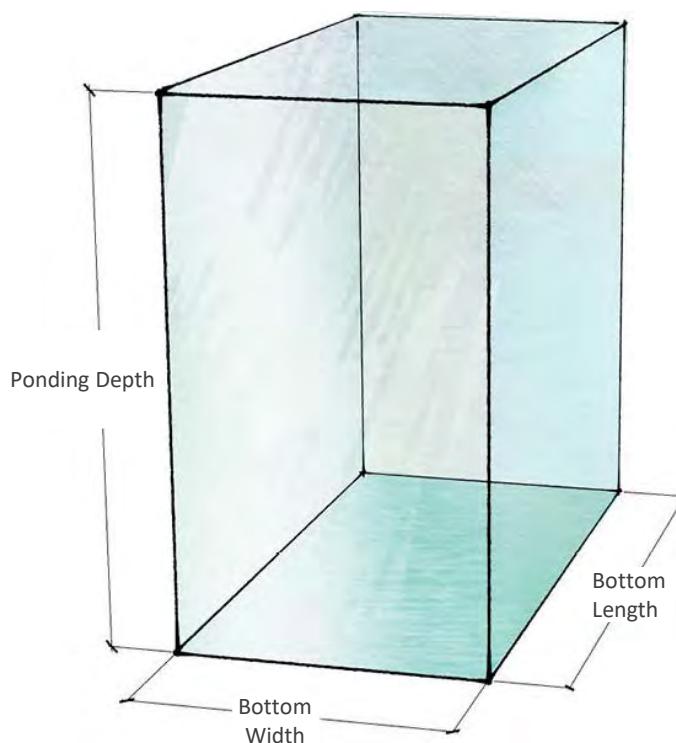
PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- The proposed vault bottom shall be at least 3 feet above the seasonal high groundwater level and have at least 3 feet of permeable soil beneath the bottom.
- Not allowed on slopes greater than 25% (4H:1V).
- Must meet infiltration siting restrictions, including setbacks:
 - The tract, easement or property line must be set back 5 feet from the emergency overflow water surface
 - Design water surface must be set back 100 feet from proposed or existing septic system drainfields
 - Design water surface must be minimum 200 feet from any steep slope hazard area or landslide hazard area
 - Design water surface must be set back 20 feet from external tract, easement or property lines
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.2.4.



Freeland RainCatchers
Photo courtesy of RKI

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A tank designed to provide temporary storage and slow release of rooftop stormwater runoff. Provides peak flow reduction.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Roofs

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	18 SF
Unit Drainage Area	1,300 SF
Ponding Depth	60 in
Bottom Length	6 ft
Bottom Width	3 ft
Orifice Diameter	0.25 in
Orifice Elevation	4 in

DESIGN ASSUMPTIONS

- Design is based on *2017 Seattle SW Manual*, Volume 3 Section 5.5.2 “Single Family Residential (SFR) Cisterns”.
- Sizing is based on sizing factors for the On-site Performance Standard from the *2017 Seattle Stormwater Manual* Section 5.5.2.6.
- Flow control orifice assumed to be 0.25-inch-diameter at 4-inch-elevation.
- Designs include a filter screen or other debris barrier to prevent insects, leaves, and other larger debris from entering the system.
- Overflow conveyance to an approved discharge or another Action (e.g., bioretention installation, etc.) provided by gravity flow pipe.





SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, orifice flow, and overflow.

Treatment:

- Model will assume no treatment provided unless Program includes manual operation of orifice valve by property owner.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition
Total Project	\$30,600
Total Direct Construction	\$21,600
Total Indirect Non-Construction	\$9,000
Operation and Maintenance	\$700/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	--	--
Dissolved Copper	--	--
Total Zinc	--	--
Dissolved Zinc	--	--
Total Phosphorus	--	--
Total Nitrogen	--	--
Total Suspended Solids	--	--
Total PCBs	--	--
Total PBDEs	--	--
Total PAHs	--	--
Bis(2-ethylhexyl)phthalate	--	--
Fecal Coliform	--	--

* Action provides negligible water quality benefit

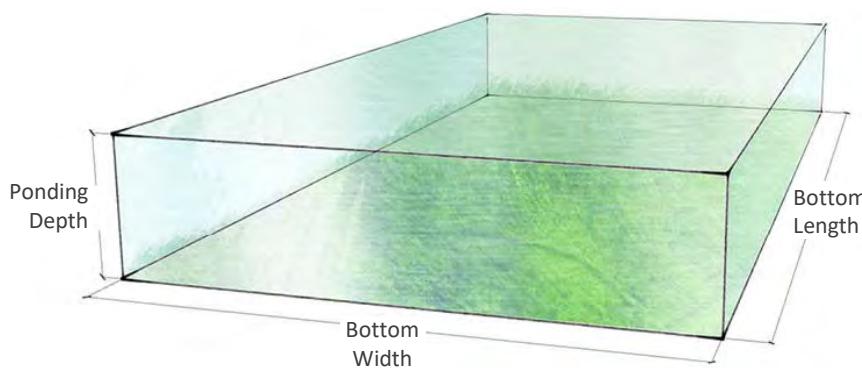
PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Contributing drainage areas must not be pollution-generating.
- Cisterns are subject to local code requirements, such as Seattle Municipal Code Title 23 – Land Use Code due to height in excess of 4.5 feet.
- Rainwater shall be used for outdoor irrigation uses only.
- Additional feasibility and siting considerations can be found in the *2017 Seattle Stormwater Manual* Volume 3 Section 5.5.2 and Appendix C.



Photo accessed on 7/2/2020 from
<https://www.redmond.gov/487/Stormwater-Ponds>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A constructed stormwater pond that retains a permanent pool of water ("wetpool"), at least during the wet season, for settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	553 SF
Unit Drainage Area	63,075 SF
Ponding Depth	48 in
Bottom Length	33.3 ft
Bottom Width	16.6 ft
Side Slope	3H : 1V
Water Quality Design Flow Rate (Off-line)	0.118 cfs

Note: For Actions with side slopes, see SUSTAIN representation in 439-TM1 Appendix B.

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Driveway
- Parking Lots
- Local Roads
- Arterial Roads
- Highways

DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.1 "Wetponds".
- Sized as Basic facility.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality Design Flow Rate to the Action.
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Two-celled facility:
 - Pre-settling cell requires minimum sediment storage depth of 1-foot
 - Diving berm is submerged 1-foot below the Water Quality design water surface
- No infiltration to native soil.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.





SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.
- Design Parameters were modified in SUSTAIN to account for model side slope limitations. See SUSTAIN model documentation for additional details.

Treatment:

- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	45.0%	3.0 µg/L
Dissolved Copper	22.7%	3.0 µg/L
Total Zinc	62.5%	13.0 µg/L
Dissolved Zinc	36.8%	10.0 µg/L
Total Phosphorus	49.5%	0.071 mg-P/L
Total Nitrogen	27.6%	0.904 mg/L
Total Suspended Solids	76.2%	7.5 mg/L
Total PCBs	76.2% ^a	199 pg/L ^a
Total PBDEs	65.5% ^a	0.019 ng/L ^a
Total PAHs	76.2% ^a	0.00093 µg/L ^a
Bis(2-ethylhexyl)phthalate	61.7% ^a	0.025 µg/L ^a
Fecal Coliform	60.0%	85.5 CFU/100 mL

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property/Highway without Acquisition
Total Project	\$1,669,300	\$869,200
Total Direct Construction	\$493,900	\$493,900
Total Indirect Non-Construction	\$1,175,400	\$375,300
Operation and Maintenance	\$2,200/year	\$2,200/year
Property Acquisition ^c	\$615,475	\$0

- a. All costs are per unit of Action. See Unit Action Design Parameters table.
- b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.
- c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

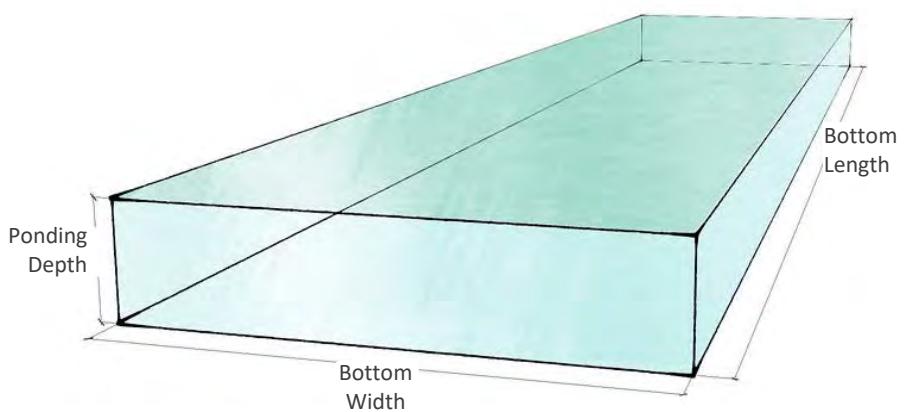
PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Both cells of the wetpond must retain a permanent pool of water throughout the wet season.
- Setback is required from tract line is 5 feet from emergency overflow water surface.
- Access and maintenance roads are required and must extend to both the wetpond inlet and outlet structures.
- See comprehensive list of infeasibility criteria in Section 6.2.3 and Section 6.4.1.2 of the *2016 King County Surface Water Design Manual*.



Photo accessed on 7/2/2020 from:
<http://romtecutilities.com/wet-dry-panel-vault-installation>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

An underground structure similar to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. Provides water quality treatment and peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	1,615 SF
Unit Drainage Area	63,010 SF
Ponding Depth	48 in
Bottom Length	80 ft
Bottom Width	20.2 ft
Side Slope	Vertical
Water Quality Design Flow Rate (Off-line)	0.118 cfs

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- | | |
|----------------|------------------|
| • Roofs | • Local Roads |
| • Lawns | • Arterial Roads |
| • Sidewalks | • Highways |
| • Driveways | |
| • Parking Lots | |
| • Plazas | |

DESIGN ASSUMPTIONS

- Design and sizing are based on *2016 King County Surface Water Design Manual* Section 6.4.2 "Basic Wetvaults".
- Off-line Water Quality Design Flow Rate is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Off-line design assumes flow splitter will be used to divert flows up to the Water Quality (WQ) Design Flow Rate to the Action
- Additional minimum sediment storage of 6 inches required.
- Two-celled facility with cells separated by baffle wall.
- Lockable grates instead of solid manhole covers included in design to increase air contact with the wetpool.
- 12-inch-diameter outlet pipe back-sloped and extended 1 foot below the WQ design water surface.
- 8-inch-diameter gravity drain controlled by a valve.



WETVAULT

Water Quality Benefits Evaluation Action Fact Sheet

Phase 3



10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding and overflow.

Treatment:

- Water that flows through the Action (up to the water quality design flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	45.0% ^b	3.0 µg/L ^b
Dissolved Copper	22.7% ^b	3.0 µg/L ^b
Total Zinc	62.5% ^b	13.0 µg/L ^b
Dissolved Zinc	36.8% ^b	10.0 µg/L ^b
Total Phosphorus	49.5% ^b	0.071 mg/L ^b
Total Nitrogen	27.6% ^b	0.904 mg/L ^b
Total Suspended Solids	76.2% ^b	7.5 mg/L ^b
Total PCBs	76.2% ^a	199 pg/L ^a
Total PBDEs	65.5% ^a	0.019 ng/L ^a
Total PAHs	76.2% ^a	0.00093 µg/L ^a
Bis(2-ethylhexyl)phthalate	61.7% ^a	0.025 µg/L ^a
Fecal Coliform	60.0% ^b	85.5 CFU/100 mL ^b

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

b. Performance based on wet pond performance which provide similar unit processes for pollutant removal.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition	In Right of Way/ Highway
Total Project	\$5,698,800	\$5,246,700	\$5,790,300
Total Direct Construction	\$2,981,300	\$2,981,300	\$3,342,400
Total Indirect Non-Construction	\$2,717,500	\$2,265,400	\$2,447,900
Operation and Maintenance	\$3,100/year	\$3,100/year	\$3,100/year
Property Acquisition ^c	\$347,803	\$0	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

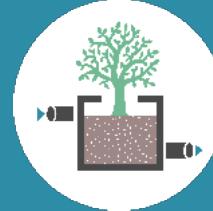
c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Relatively small catchments (less than 10 acres of impervious surface) with high land values typically most practical because vaults are relatively expensive.
- Must have a flow length-to-width ratio greater than 3:1 minimum.
- 5-foot setback to tract/easement lines required.
- 10-foot setback for buildings adjacent to the vault required.
- For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.3 and Section 6.4.

HIGH RATE UNDERGROUND FILTER SYSTEM

Water Quality Benefits Evaluation Action Fact Sheet



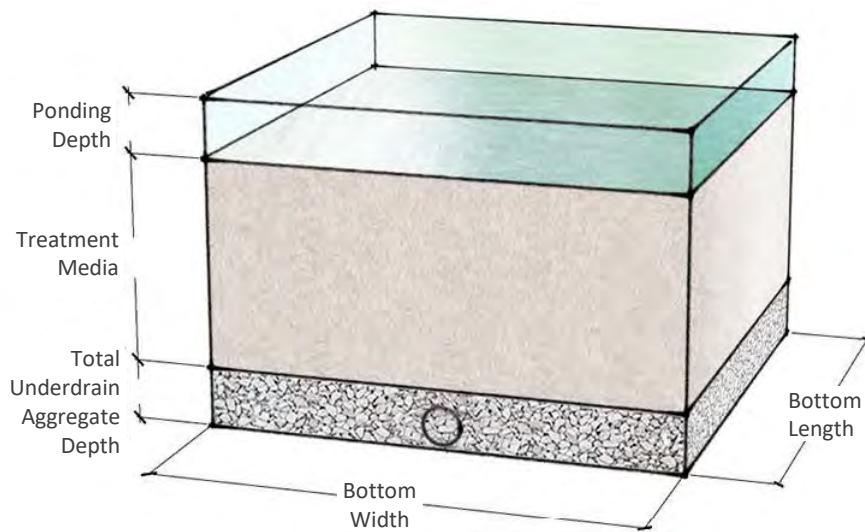
Phase 3

10/1/2024



Filterra® Bioretention System
Photo accessed on 7/2/2020 from
www.conteches.com

UNIT ACTION SCHEMATIC



N/A: Not Applicable

a. Liner prevents infiltration to native soil

ACTION DESCRIPTION

An underground stormwater treatment device comprised of one or more structures that house rechargeable, media-filled cartridges that trap particulates and adsorb pollutants from stormwater runoff. These devices are often used in highly urbanized settings and may be proprietary. Provides water quality treatment.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	16 SF
Unit Drainage Area	34,956 SF
Ponding Depth	2 in
Bottom Length	4 ft
Bottom Width	4 ft
Side Slope	Vertical
Treatment Media Depth	21 in
Treatment Media Porosity	40%
Treatment Media Design Infiltration Rate	175 in/hr
Total Underdrain Aggregate Depth	6 in
Underdrain Invert Height	0 in
Underdrain Diameter	4 in
Underdrain Aggregate Porosity	40%
Native Soil Design Infiltration Rate ^a	N/A
Water Quality Design Flow Rate (Off-line)	0.081 cfs

AREAS MANAGED

Land Uses:

- Commercial
- Industrial
- Highway

Property Types:

- Private Parcel
- Public Parcel
- Public Right-of-Way

Surface Types:

- Roofs
- Sidewalks
- Driveways
- Parking Lots
- Plazas
- Local Roads
- Arterial Roads

DESIGN ASSUMPTIONS

- Design is based on standards for Contech® Filterra® Bioscape External Bypass configuration.
- Sizing is based on Washington Department of Ecology (Ecology) General Use Level Designation (GULD) approved infiltration rate of 175 inches/hour for Enhanced Water Quality Treatment.
- Off-line Water Quality Design Flow Rate based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.
- Proprietary Filterra® engineered media assumed. Other proprietary media and facilities may be used. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) for a full list of GULD approved media for Enhanced Water Quality Treatment.
- No infiltration to native soil.





Phase 3

10/1/2024

HIGH RATE UNDERGROUND FILTER SYSTEM

Water Quality Benefits Evaluation Action Fact Sheet

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	25 th Percentile Effluent Concentration ^a
Total Copper	51.6%	3.1 µg/L
Dissolved Copper	34.2%	2.0 µg/L
Total Zinc	56.4%	20.1 µg/L
Dissolved Zinc	53.4%	26.0 µg/L
Total Phosphorus	42.4%	0.034 mg/L
Total Nitrogen	45.8%	0.422 mg/L
Total Suspended Solids	86.4%	2.5 mg/L
Total PCBs	84.1%	414 pg/L
Total PBDEs	74.3% ^b	0.0061 ng/L ^b
Total PAHs	86.4% ^b	0.00031 µg/L ^b
Bis(2-ethylhexyl)phthalate	70.0% ^b	0.008 µg/L ^b
Fecal Coliform	NF ^c	NF ^c

NF: No data found

a. Performance based on proprietary Filterra® engineered media.

b. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

c. Assigned a value of 0 in SUSTAIN since no data was found.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	Public Right of Way with Portland Cement Concrete Pavements		Public Right of Way with Hot Mix Asphalts	
	Urban ROW	Highway ROW	Urban ROW	Highway ROW
Total Project	\$208,300	\$153,300	\$149,700	\$135,700
Total Direct Construction	\$147,500	\$108,500	\$106,000	\$96,100
Total Indirect Non-Construction	\$60,800	\$44,800	\$43,700	\$39,600
Operation and Maintenance	\$2,500/year	\$2,500/year	\$2,500/year	\$2,500/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the *2016 King County Surface Water Design Manual* Section 5.1.3 and Section 6.7.



STORMWATER PARK (WATER QUALITY TREATMENT)

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

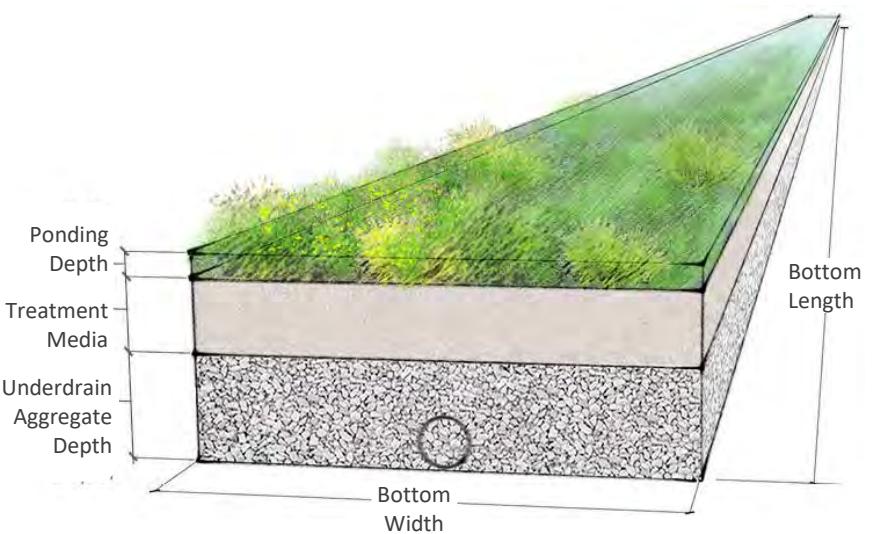
10/1/2024



Manchester Stormwater Park
Photo accessed on 7/2/2020 from

<http://nwcascade.com/projects/manchester-stormwater-park/>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

A large-scale vegetated media filtration facility designed to treat stormwater runoff from a large drainage area. Provides water quality treatment.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	5,940 SF
Unit Drainage Area	17,249,760 SF
Ponding Depth	8.4 in
Bottom Length	84.9 ft
Bottom Width	70 ft
Treatment Media Depth	21.6 in
Treatment Media Porosity	40%
Treatment Media Design Infiltration Rate	175 in/hr
Total Underdrain Aggregate Depth	18 in
Underdrain Invert Height	0 in
Underdrain Diameter	12 in
Underdrain Aggregate Porosity	40%
Native Soil Design Infiltration Rate ^a	N/A

N/A: Not Applicable

a. Liner prevents infiltration to native soil

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural
- Forest

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- | | |
|----------------|------------------|
| • Roofs | • Local Roads |
| • Lawns | • Arterial Roads |
| • Sidewalks | • Highways |
| • Driveways | |
| • Parking Lots | |
| • Plazas | |

DESIGN ASSUMPTIONS

- Design based on *Kitsap County Manchester Stormwater Retrofit Drainage Report, April 2014* (Manchester).
- Manchester design used proprietary Filterra® treatment media. Refer to Ecology's Emerging stormwater treatment technologies (TAPE) website for additional media types that are General Use Level Designation (GULD) approved for Enhanced Water Quality Treatment.
- Unit Footprint Area matches Manchester design bottom footprint area.
- Unit Drainage Area based on Manchester contributing drainage area, scaled as follows:
 - Scaled up by factor of approximately 7 based on the ratio of Ecology's currently approved GULD infiltration rate for Filterra® media for Enhanced Water Quality Treatment of 175 inches/hour to the infiltration rate of 24.8 inches/hour used for Manchester design
 - Scaled down by factor of safety of 1.3 to account for commercial and transportation areas within the Manchester contributing drainage area
- No infiltration to native soil (Manchester facility is concrete-lined).



STORMWATER PARK

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, underdrain flow, and overflow.

Treatment:

- Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal ^a	25 th Percentile Effluent Concentration ^a
Total Copper	51.6%	3.1 µg/L
Dissolved Copper	34.2%	2.0 µg/L
Total Zinc	56.4%	20.1 µg/L
Dissolved Zinc	53.4%	26.0 µg/L
Total Phosphorus	42.4%	0.034 mg/L
Total Nitrogen	45.8%	0.422 mg/L
Total Suspended Solids	86.4%	2.5 mg/L
Total PCBs	84.1%	414 pg/L
Total PBDEs	74.3% ^b	0.0061 ng/L ^b
Total PAHs	86.4% ^b	0.00031 µg/L ^b
Bis(2-ethylhexyl)phthalate	70.0% ^b	0.008 µg/L ^b
Fecal Coliform	NF ^c	NF ^c

NF: No data found

a. Performance based on proprietary Filterra® engineered media.

b. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

c. Assigned a value of 0 in SUSTAIN since no data was found.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition
Total Project	\$8,452,600	\$7,694,000
Total Direct Construction	\$4,021,600	\$4,021,600
Total Indirect Non-Construction	\$4,431,000	\$3,672,400
Operation and Maintenance	\$11,300/year	\$11,300/year
Property Acquisition ^c	\$583,580	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Must be designed, assembled, installed, operated and maintained according to the manufacturer's manuals, documents, and Ecology GULD approval.
- The distance from the point of entry of water to the most distant point on the surface of the treatment media shall not exceed 12-feet.
- 5-foot setback to tract/easement lines.
- 10-foot setback for buildings adjacent to stormwater facility.
- Additional feasibility and siting considerations can be found in the 2016 King County Surface Water Design Manual Section 6.7.



SPORTS FIELD AND PARK DETENTION

Water Quality Benefits Evaluation Action Fact Sheet



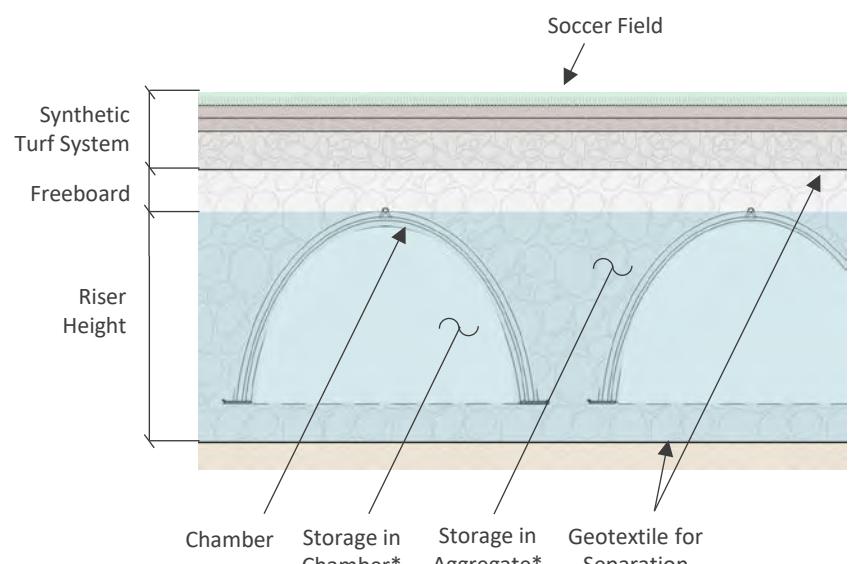
Phase 3

10/1/2024



Photo accessed on 10/11/23 from
<https://milford-global.com/>

UNIT ACTION SCHEMATIC



* Storage capacity varies by stage. Design represented in SUSTAIN using an FTABLE.

ACTION DESCRIPTION

Subsurface storage at existing sport field or park to provide flow control while preserving recreational site use. An underground chamber array will detain the water draining from the overlying area and offsite contributing drainage area. The stored stormwater runoff is released through a control structure at an attenuated rate. Provides peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area (1/2 soccer field)	29,600 SF
Unit Drainage Area (incl. overlying field)	103,800 SF
Chamber Height / Width	2.5 ft / 4.25 ft
Chamber Row Spacing	0.5 ft
Chamber Rows / Total Chamber Length	38 / ~5,700 ft
Aggregate Depth Below/Above Chambers	0.5 ft / 0.5 ft
Aggregate Porosity	0.4
Orifice Diameter	0.84 in
Orifice Elevation	0 ft
Notch Width	0.33 in
Notch Height	14.4 in
Riser Height	3 ft
Native Soil Design Infiltration Rate ^a	N/A

N/A: Not Applicable

a. Liner prevents infiltration to native soil

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial
- Highway
- Agricultural
- Forest

Surface Types:

- Roofs
- Lawns
- Sidewalks
- Arterial Roads
- Highways
- Driveways
- Parking Lots
- Plazas

Property Types:

- Private Parcel
- Public Parcel

DESIGN ASSUMPTIONS

- Representative Action assumes an array of subsurface storage chambers under one half of a standard soccer field to detain water draining from the overlying area and offsite contributing drainage area. Implementation includes:
 - ADS StormTech Chambers (SC-740)
 - Field restoration with artificial turf and paint
 - Conveyance from upstream drainage area and to downstream drainage system
- No infiltration to underlying soil
- No additional site improvements (e.g., lighting, seating) are included
- No property acquisition
- The unit Action was sized to meet the Level 2 Flow Control standard with pre-developed forest condition. Sizing is based on modeling in MGSFlood using Puget East 40-inch Mean Annual Precipitation Climate Region with a 15-minute model time step.

SPORTS FIELD AND PARK DETENTION

Water Quality Benefits Evaluation Action Fact Sheet

Phase 3



10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Stage-storage-discharge routing (FTABLE).

Treatment:

- Water that flows through the orifice will be assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. While not designed for treatment, there will be some pollutant removal via sedimentation (see Performance Parameters table below).
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	26.2% ^c	4.2 µg/L ^c
Dissolved Copper	3.23% ^c	3.0 µg/L ^c
Total Zinc	44.0% ^c	18.0 µg/L ^c
Dissolved Zinc	13.6% ^c	16.1 µg/L ^c
Total Phosphorus	17.7% ^c	0.113 mg/L ^c
Total Nitrogen	7.80% ^c	0.674 mg/L ^c
Total Suspended Solids	57.6% ^c	12.9 mg/L ^c
Total PCBs	57.6% ^a	342 pg/L ^a
Total PBDEs	56.9% ^b	93.5 ng/L ^b
Total PAHs	52.1% ^b	0.228 µg/L ^b
Bis(2-ethylhexyl)phthalate	46.7% ^a	0.042 µg/L ^a
Fecal Coliform	31.5% ^c	500 CFU/100 mL ^c

a. Values derived from TSS translator equations. See methods section of 439-TM1 Appendix D.

b. Performance based on detention vault performance which provide similar unit processes for pollutant removal.

c. Performance based on detention pond performance which provide similar unit processes for pollutant removal.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition
Total Project	\$17,993,900
Total Direct Construction	\$10,224,600
Total Indirect Non-Construction	\$7,769,300
Operation and Maintenance	\$33,300 /year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

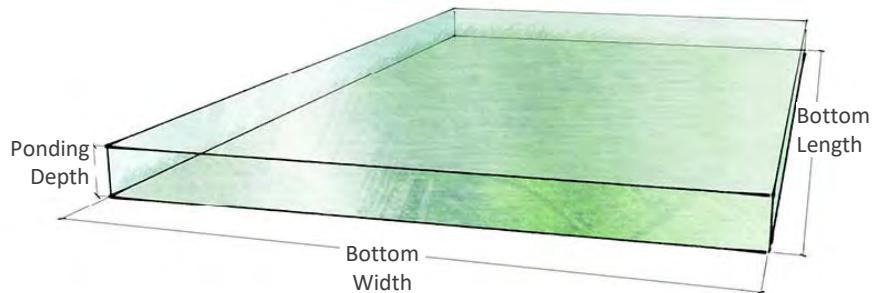
- May be difficult to find willing partners for publicly-owned parcels or willing sellers for privately-owned parcels
- Requires sufficient upstream drainage area that can be captured on site; sufficient feasible space outside of critical areas with mild slope; sufficient clearance to groundwater; and feasible downstream tie-in to drainage infrastructure. Note: design assumes relatively shallow depth of ~ 5.3 feet to mitigate some of these limitations.
- More likely to find willing partners where sports field or park requires upgrade (e.g., poor drainage, interest in artificial turf). Note: Costs assume that artificial turf will be installed (or similar improvements provided) to increase participation.
- Does not change or reduce useable field or park area
- Because this action assumes no infiltration to underlying soils, infiltration-related restrictions do not apply





Photo accessed on 01/22/24 from
<https://water.phila.gov/gsi/tools/blue-roof/>

UNIT ACTION SCHEMATIC



ACTION DESCRIPTION

Rooftop detention designed to provide temporary storage and slow release of stormwater runoff. This technique is most commonly used in dense urban areas where other methods of stormwater detention are impractical. Provides peak flow reduction.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	1,000 SF
Unit Drainage Area	1,000 SF
Ponding Depth	4 in
Bottom Length	40 ft
Bottom Width	25 ft
Orifice Diameter	0.25 in
Orifice Elevation	0 in

AREAS MANAGED

Land Uses:

- Commercial
- Industrial

Surface Types:

- Roofs

Property Types:

- Private Parcel
- Public Parcel

DESIGN ASSUMPTIONS

- Representative Action^a assumes retrofitting an existing flat roof (with parapet) to provide up to 4 inches of storage. Implementation includes:
 - Waterproof lining installed
 - Roof drainage reconfigured to direct runoff from 1,000 sf to control structure at roof drain
 - HVAC/utilities on roof raised 6 inches
 - Control structure has 0.25-inch orifice and redundant overflow with protective screening (e.g., sand filter to protect orifice from clogging)
- Building does not require structural upgrades
- No property acquisition

^a Other blue roof configurations can include check dams across the roofs deck, modular tray systems, hybrid green/blue roofs, and water harvesting for reuse.



SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Model explicitly represents ponding, orifice flow, and overflow.

Treatment:

- Model will assume no treatment provided.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	--	--
Dissolved Copper	--	--
Total Zinc	--	--
Dissolved Zinc	--	--
Total Phosphorus	--	--
Total Nitrogen	--	--
Total Suspended Solids	--	--
Total PCBs	--	--
Total PBDEs	--	--
Total PAHs	--	--
Bis(2-ethylhexyl)phthalate	--	--
Fecal Coliform	--	--

* Action provides negligible water quality benefit

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition
Total Project	\$116,500
Total Direct Construction	\$82,300
Total Indirect Non-Construction	\$34,200
Operation and Maintenance	\$2,600/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Project sites will be limited to King County-owned buildings and buildings owned by willing partners/property owner partners
- Requires flat, or nearly flat, roof with parapet of at least 6 inches
- Assumes that the structure can readily support the loading of a blue roof and no structural upgrades are required
- Note: Costs assume that the roof will be waterproofed to increase uptake.

COMPOST AMENDMENT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

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Photo accessed from Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13"

ACTION DESCRIPTION

Amend soil under existing lawn surfaces with compost to increase water holding capacity and infiltration. Amended area is revegetated with turf. Reduces runoff volume and peak flows.

DESIGN PARAMETERS

Parameter	Soil Type	
	Till	Outwash
Unit Footprint Area	500 SF	500 SF
Treatment Media Depth ^a	8 in	8 in
Treatment Media Porosity ^a	25%	25%
Native Soil Design Infiltration Rate	0.3 in/hr	2.5 in/hr

N/A: Not Applicable

- a. The Treatment Media is non-engineered and does not provide Basic Water Quality treatment. Infiltration through the Treatment Media is assumed to occur at the Native Soil Design Infiltration Rate

AREAS MANAGED

Land Uses:

- Residential
- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Lawns

DESIGN ASSUMPTIONS

- Representative Action assumes amending soil under existing lawn and revegetating with turf. implementation includes:
 - Remove lawn vegetation and scarify (loosen) subgrade to 8 inches depth
 - Place 1.75 inches of compost and rototill into 6.25 inches of soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches)
 - Scarify (loosen) subsoil 4 inches below the amended layer to produce a 12-inch depth of uncompacted soil
 - Water or roll to compact to 85% of maximum dry density
 - Rake to level and remove surface woody debris and rocks larger than 1 inch diameter
 - Revegetate with turf lawn (not seeded)
- Design is based on Washington State Department of Ecology's "Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13" Option 2 (amending existing site soil or subsoil).

COMPOST AMENDMENT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

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SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Convert the surface type from existing lawn to pasture (to represent the runoff characteristics of compost amended lawn as described in 2019 *Washington State Department of Ecology Stormwater Management Manual for Western WA (SWMMWW)*).

Treatment:

- All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100% removed from the surface water model.
- Bypass water is assumed to receive no treatment and retains the influent pollutant concentrations.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property without Acquisition
Total Project	\$5,900
Total Direct Construction	\$4,200
Total Indirect Non-Construction	\$1,700
Operation and Maintenance	\$300/year

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Project sites will be limited to King County-owned land and sites owned by willing property owners
- Few other technical constraints apply (e.g., soil contamination may prohibit, very steep slopes may be infeasible)
- Does not change or reduce lawn area (expect for establishment period)

REFOREST HIGH DENSITY DEVELOPMENT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

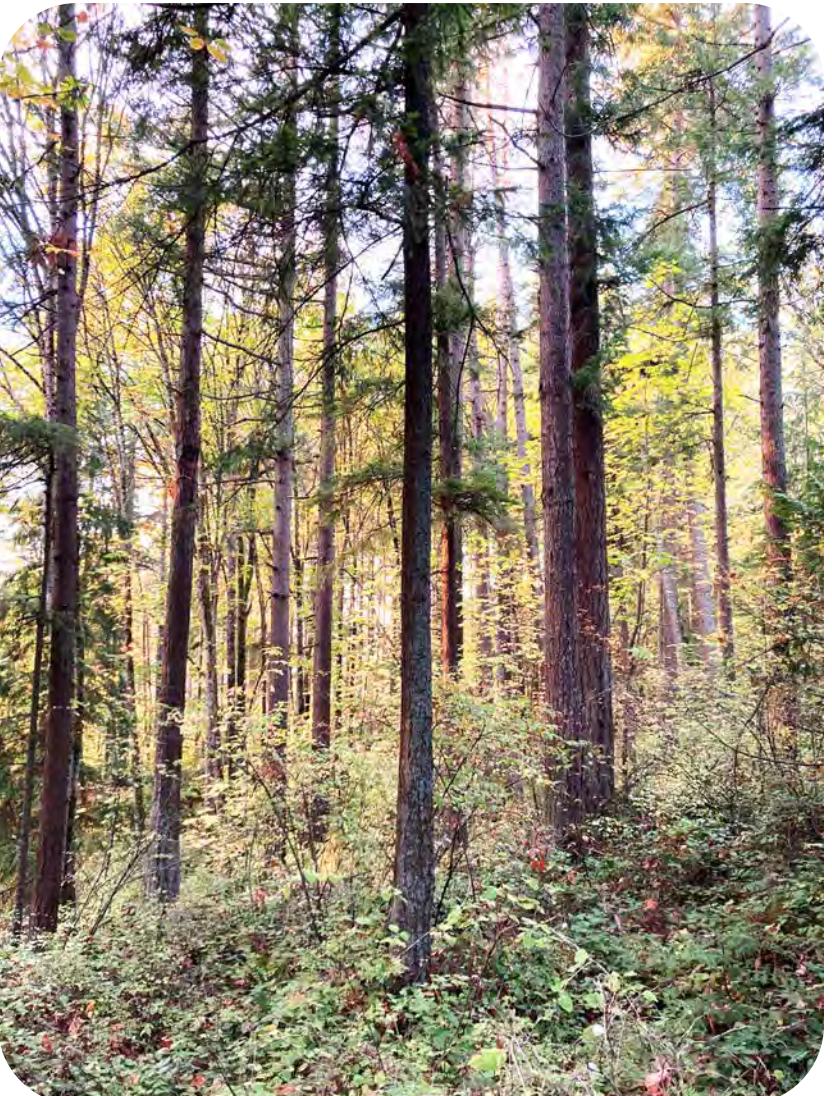


Photo courtesy of Herrera

ACTION DESCRIPTION

Convert existing impervious surface and buildings to forest by uncompacting/ amending soil and planting trees and understory vegetation. While the benefits of this Action would increase over time as the trees and vegetation become established, the performance is represented as a mature forest. Reduces runoff volume and peak flows.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	43,560 SF
Existing Surface ^a	Impervious
New Surface ^a	Forest

- a. This Action will be modeled in SUSTAIN by converting the reforested area from an impervious to forested surface.

AREAS MANAGED

Land Uses:

- Commercial
- Industrial

Property Types:

- Private Parcel
- Public Parcel

Surface Types:

- Parking lots
- Walkways
- Driveways
- Buildings
- Lawn

DESIGN ASSUMPTIONS

- Representative Action assumes replacing a typical strip mall building and parking lot with forest. Implementation includes:
 - Property acquisition, if on private property
 - Demolish/remove structure and parking lot surface
 - Scarify subsoil to 6" depth and place 18 inches of topsoil type A
 - Plant multi-layer native plant communities and trees
 - Build simple trail through forested area and install signage
 - Maintain plants during 2-year plant establishment period
- Assumes one acre parcel coverage is 60% parking and 40% structure
- Benefits of mature forest are modeled

REFOREST HIGH DENSITY DEVELOPMENT

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Convert the land surface type from existing impervious surfaces (building and parking lot) to forest over underlying soil type (till or outwash). Action is modeled as a mature forest.

Treatment:

- While no treatment is provided, pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition
Total Project	\$24,045,100	\$19,490,500
Total Direct Construction	\$11,075,000	\$11,075,000
Total Indirect Non-Construction	\$12,970,100	\$8,415,500
Operation and Maintenance	\$3,300/year	\$3,300/year
Property Acquisition ^c	\$3,503,531	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- May be difficult to find willing partners for publicly-owned parcels (with unprogrammed space that can be forested) or willing sellers for privately-owned parcels
- Other technical constraints include soil contamination may prohibit and very steep slopes may be infeasible.

REFOREST PERVIOUS AREA

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

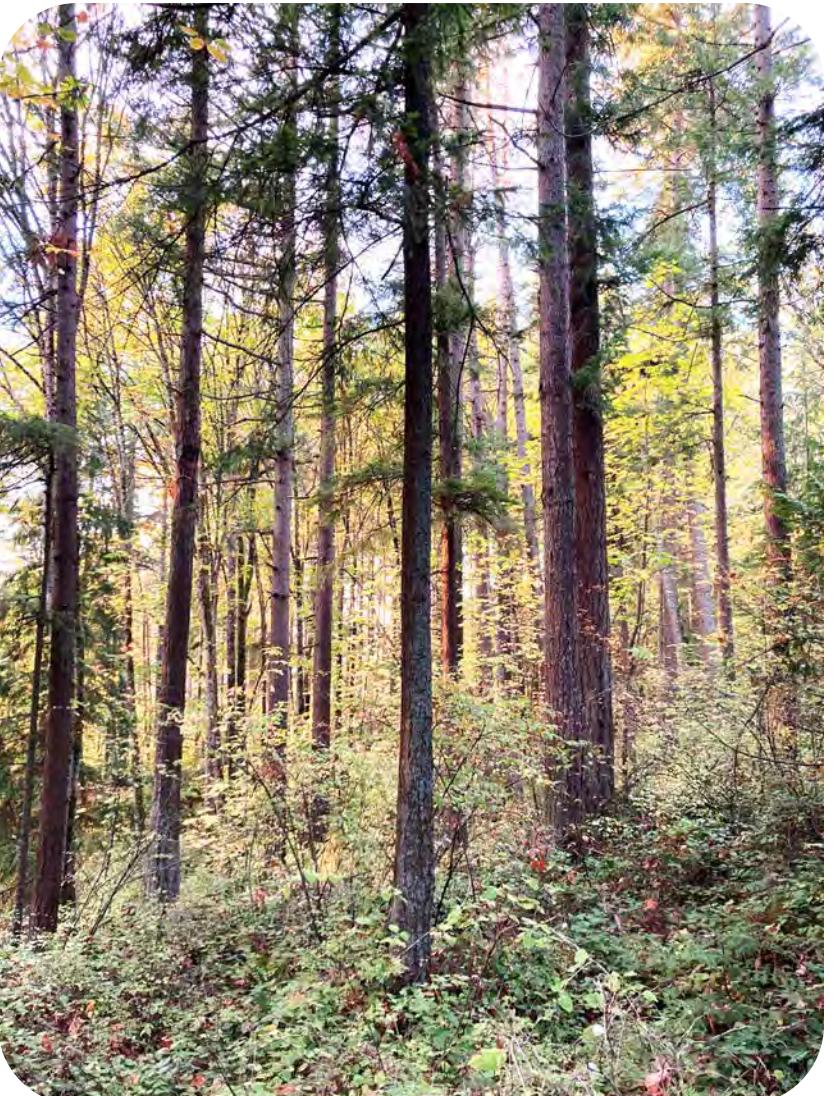


Photo courtesy of Herrera

ACTION DESCRIPTION

Convert existing pervious surface to forest by uncompacting/amending soil and planting trees and understory vegetation. While the benefits of this Action would increase over time as the trees and vegetation become established, the performance is represented as a mature forest. Reduces runoff volume and peak flows.

DESIGN PARAMETERS

Parameter	Value
Unit Footprint Area	43,560 SF
Existing Surface ^a	Pervious
New Surface ^a	Forest

- a. This Action will be modeled in SUSTAIN by converting the reforested area from a pervious to forested surface.

AREAS MANAGED

Land Uses:

- Residential

Property Types:

- Private Parcel

Surface Types:

- Lawn

DESIGN ASSUMPTIONS

- Representative Action assumes replacing a pervious area with forest. Implementation includes:
 - $\frac{1}{2}$ of the area will require scarification and topsoil application. Scarify subsoil to 6" depth and place 12 inches of topsoil type A.
 - Plant multi-layer native plant communities and trees
 - Maintain plants during 1-year plant establishment period
- Benefits of mature forest are modeled

REFOREST PERVIOUS AREA

Water Quality Benefits Evaluation Action Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODEL REPRESENTATION

Hydrologic:

- Convert the land surface type from existing pervious surfaces to forest over underlying soil type (till or outwash). Action is modeled as a mature forest.

Treatment:

- While no treatment is provided, pollutant loads will be reduced due to the differences in pollutant concentrations and runoff volumes from the change in surface type.

TREATMENT PERFORMANCE PARAMETERS

Target Pollutants	Median Percent Removal	25 th Percentile Effluent Concentration
Total Copper	N/A	N/A
Dissolved Copper	N/A	N/A
Total Zinc	N/A	N/A
Dissolved Zinc	N/A	N/A
Total Phosphorus	N/A	N/A
Total Nitrogen	N/A	N/A
Total Suspended Solids	N/A	N/A
Total PCBs	N/A	N/A
Total PBDEs	N/A	N/A
Total PAHs	N/A	N/A
Bis(2-ethylhexyl)phthalate	N/A	N/A
Fecal Coliform	N/A	N/A

N/A: Not applicable. See model representation treatment section.

UNIT ACTION COSTS

Costs/Unit Action ^{a, b}	On Property with Acquisition	On Property without Acquisition
Total Project	\$6,302,000	\$1,747,400
Total Direct Construction	\$992,900	\$992,900
Total Indirect Non-Construction	\$5,309,100	\$754,500
Operation and Maintenance	\$0/year	\$0/year
Property Acquisition ^c	\$3,503,531	\$0

a. All costs are per unit of Action. See Unit Action Design Parameters table.

b. Costs are presented in 2023 dollars. Life cycle costs can vary by Program. See Program Fact Sheets.

c. Property acquisition costs are included in total indirect non-construction costs. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table shows medium acquisition costs. See 439-TM1 for low and high property acquisition costs.

PROGRAMMATIC FEASIBILITY/SITING CONSIDERATIONS

- Project sites will be limited to those owned by willing property owners.
- Other technical constraints include soil contamination may prohibit and very steep slopes may be infeasible.

Appendix H

Phase 3 Program Fact Sheets

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GSI INCENTIVE FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM OVERVIEW

The GSI Incentive Flow Control Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide grants, rebates, or other financial incentives to eligible property owners for installing and maintaining GSI on their properties.

The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

The Program could include the GSI practices (“Actions”) listed below. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

The following pages include key assumptions and an overview the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

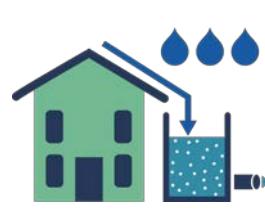
ACTIONS INCLUDED IN PROGRAM



RAIN GARDEN



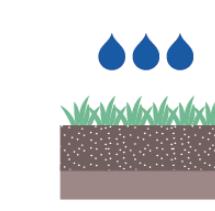
BIORETENTION *



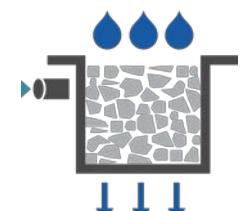
CISTERN



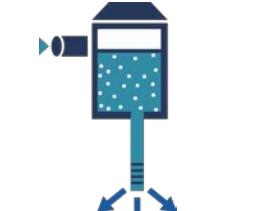
DEPAVING



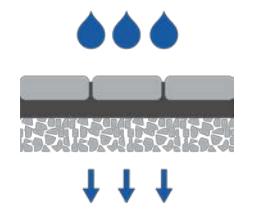
COMPOST AMENDMENT



DRYWELL



DEEP UIC WELL ***



PERMEABLE PAVEMENT



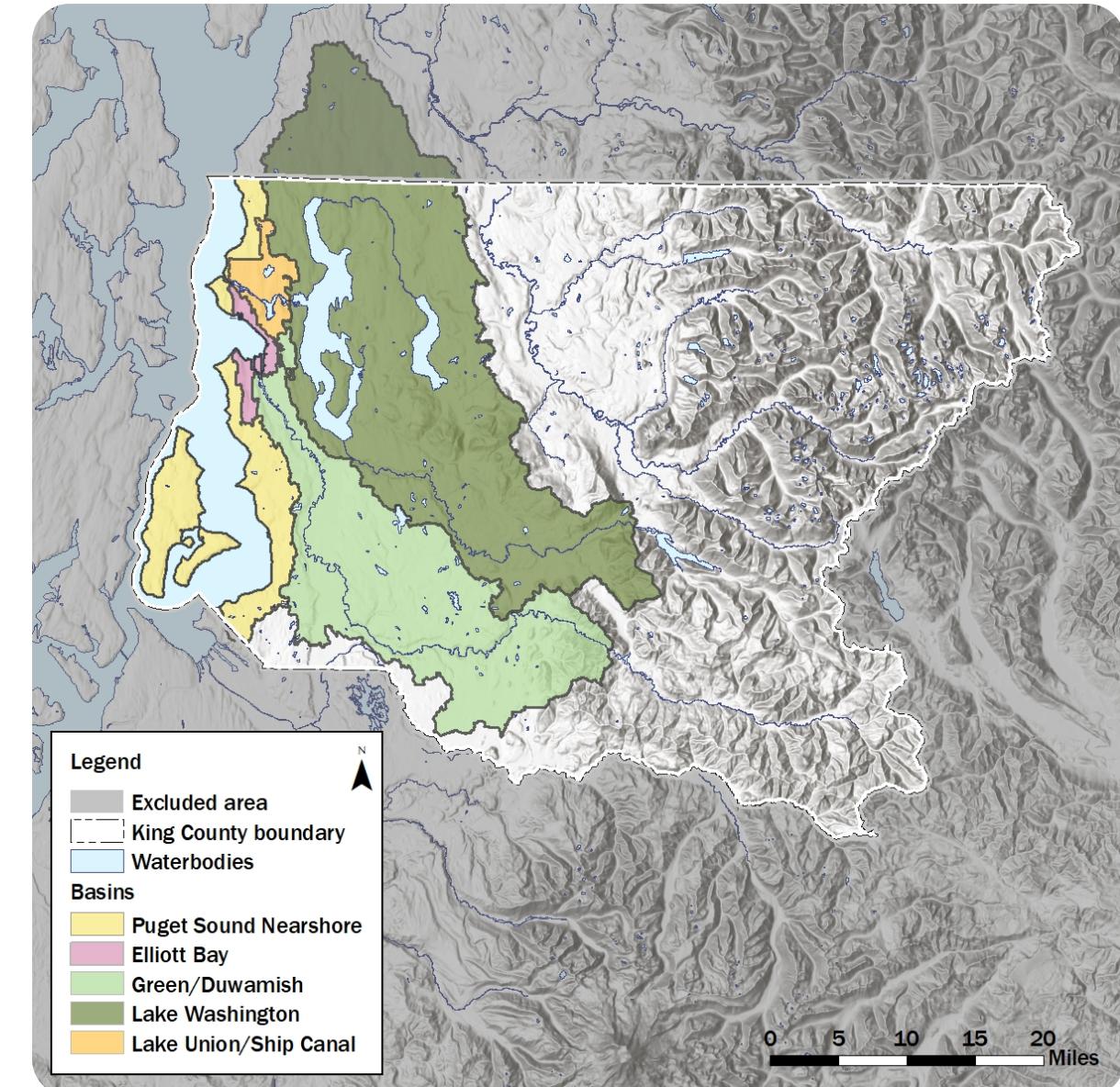
BLUE ROOF

* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Paired with upstream bioretention planter for pre-treatment

*** Paired with upstream high-rate filter for pre-treatment

PROGRAM IMPLEMENTATION AREA



PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial land uses
- Private and public parcels

GSI INCENTIVE FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODELING APPROACH

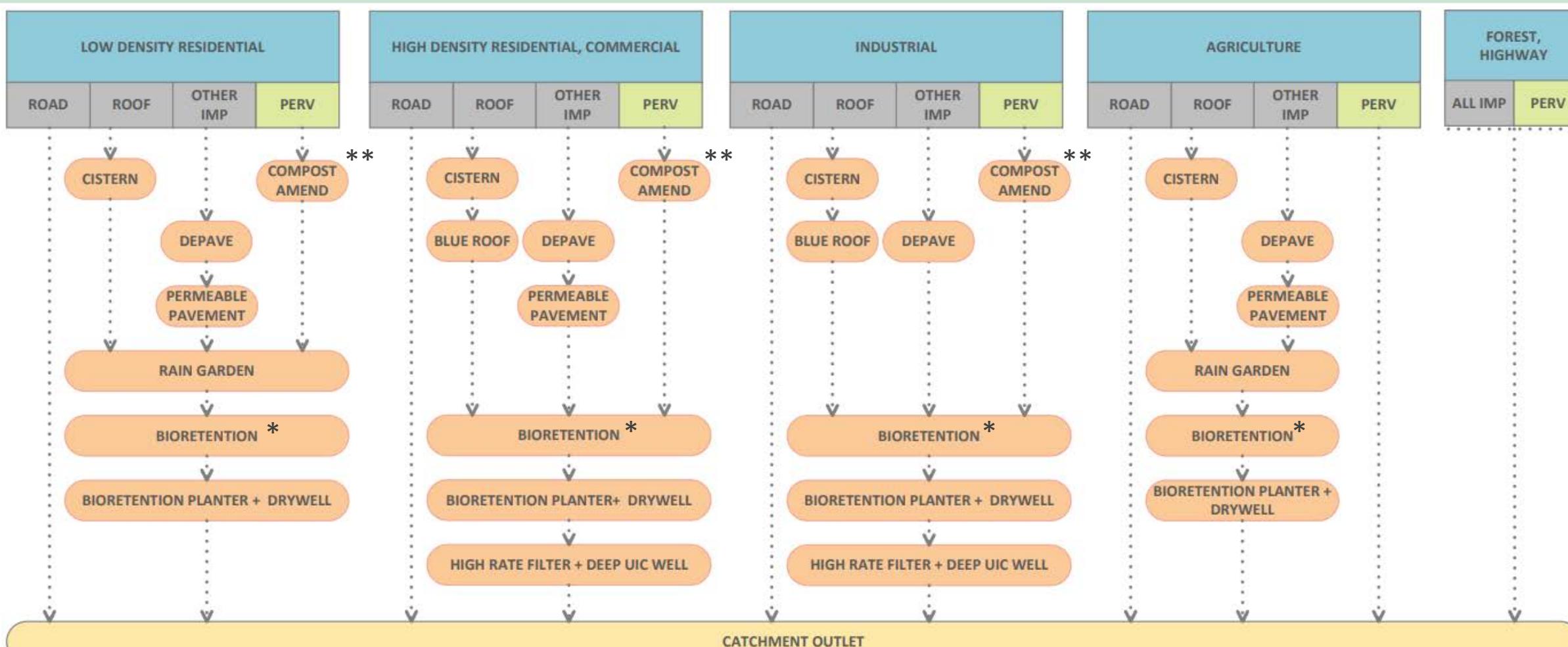
Runoff routing:

This diagram shows how stormwater runoff is routed through GSI Actions in the SUSTAIN model. The arrows characterize the routing of runoff from each land use and surface type to the Actions or Action treatment trains. The compost amendment and depave Actions are represented in the model by converting the modeled surface type. Some Actions are only applied to certain soil and slope conditions (see the Implementation Constraints Table on page 3). Overflow from the Actions and unmanaged runoff is routed to the catchment outlet. SUSTAIN provides an assessment of the most cost-effective combination of Actions within a treatment train to achieve different levels of flow control.

SUSTAIN Program optimization:

SUSTAIN could be used to evaluate and optimize the most cost-effective Actions for this Program.

- For performance, Actions can be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions can be estimated.
- For costs, optimization can be based on Action lifecycle costs. Program development and implementation costs can be scaled and applied to modeling results.
- SUSTAIN models these Actions as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN are assumed to be distributed throughout the defined drainage area.



* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Compost amendment is only applied for lawn surfaces

GSI INCENTIVE FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM DESCRIPTION/ASSUMPTIONS

Program description:

- The GSI Flow Control Incentive Program would provide financial incentives in the form of rebates, grants, or other forms of funding to property owners to install GSI practices (Actions) to provide flow control for currently unmanaged stormwater runoff from roofs and other impervious surfaces, such as parking lots and driveways.
- The Program would be applicable to private parcels in residential, commercial, and industrial, agricultural areas with separated drainage systems. Eligible areas would include unincorporated King County and cities in the implementation area. GSI Actions would be implemented across the eligible areas based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies.
- Program elements would include:
 - Public outreach
 - Website with eligibility maps, design tools, and incentive calculator
 - Application processing and site/construction inspection
 - Contractor recruitment/trainings
 - Annual inspections and maintenance
- Modeling will determine full costs of design, construction, maintenance and replacement. A separate evaluation will determine rebates/grants for incentivizing participation. Costs of Program development and administration, would be borne by the County, or potentially shared with other partners.

Key assumptions:

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained).

Key risks and challenges:

- Relies, in part, on cooperation between King County and partners
- Relies on interested property owners
- Requires alignment with varied local codes
- Requires development of qualified contractor base
- Requires ongoing maintenance efforts and costs

PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
 = Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

GSI Action	Infeasible Areas ¹	Technical Factor ²								Participation Factor ³	Composite Factor (Technical x Participation) ⁴		
		Low Density Residential			High Density Residential, Commercial, and Industrial			Agricultural					
		Roof	Other Imp	Perv	Roof	Other Imp	Perv	Roof	Other Imp				
Rain garden on till	Outwash soil, slopes > 10%	30%	30%	30%				30%	30%	20%	6.0%		
Rain garden on outwash	Till soil, slopes > 10%	50%	50%	50%				50%	50%	20%	10.0%		
Bioretention on outwash	Till soil, slopes > 10%	50%	50%	50%	40%	40%	40%	50%	50%	20%	8.0% - 10.0%		
Cisterns	--	50%			50%			50%		25%	12.5%		
Bioretention planter to drywell	Till soil	30%	30%	30%	30%	30%	30%	30%	30%	15%	4.5%		
High rate filter to deep UIC well	Outwash soil, gw protection areas				20%	20%	20%			5%	1.0%		
Depaving	--		20%			10%			20%	5%	0.5% - 1.0%		
Permeable pavement	Slopes > 3%		30%			30% ⁵			10%	2%	0.2% - 0.6%		
Blue roof					20%					2%	0.4%		
Compost amendment				80%			80%			30%	24%		

- "Infeasible Areas" are areas where the Action will not be applied.
- "Technical Factor" represents the estimated fraction of the implementation area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.
- "Participation Factor" represents the anticipated participation in the Program.
- "Composite Factor" is the combined factor applied to estimate the maximum drainage area.
- Not applied to industrial land use.

LEGEND

Action not applied	
High Implementation	≥30%
Medium Implementation	15 to <30%
Low Implementation	≤15%

GSI INCENTIVE FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on private property (see table below).
- Upfront Program development costs (develop website, standards, requirements)
- Average annual Program administration costs (outreach, application processing, construction inspections, maintenance education, annual inspections)

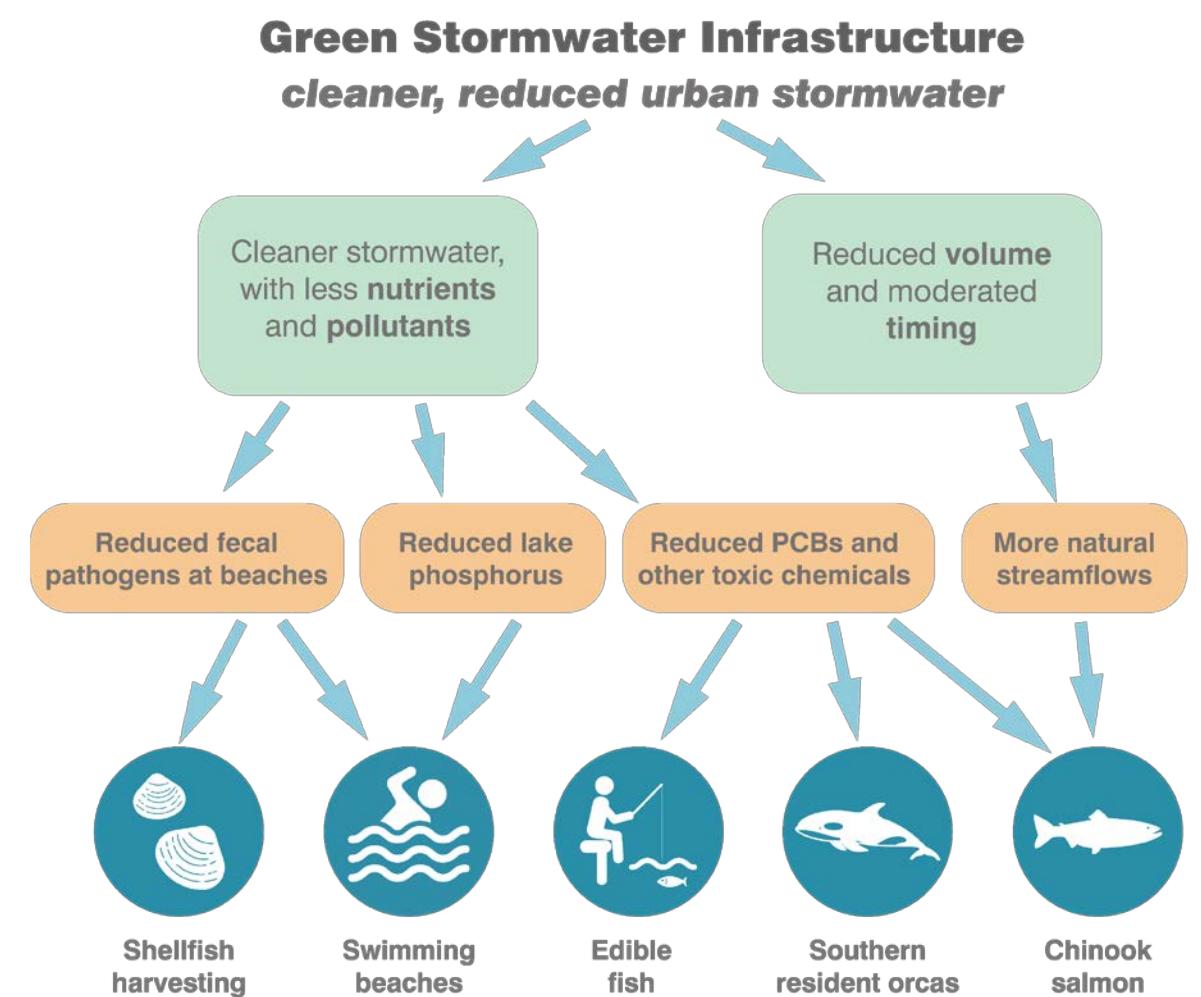
Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

Unit Action	Lifecycle Cost/Unit Action ^{1,2,3}
Rain garden	\$56,700
Bioretention without underdrain	\$117,900
Cisterns	\$46,100
Bioretention planter to drywell	\$76,000
High-rate filter to deep UIC well	\$250,000
Depaving ⁴	\$16,800
Permeable pavement ⁵	\$68,400
Blue roof	\$170,900
Compost amendment	\$13,400

1. All costs are per unit of Action installed on private property without property acquisition.
2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.
4. Costs based on driveway depaving with wheel strips
5. Costs based on permeable paver driveway with sand layer.

LINKAGES TO CAUSAL MODELS

The GSI Incentive Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



ROADWAY RETROFIT FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM OVERVIEW

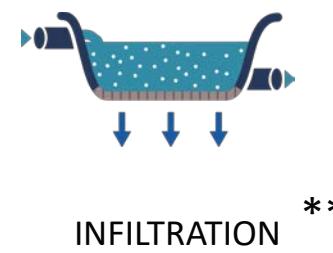
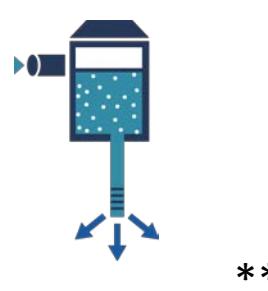
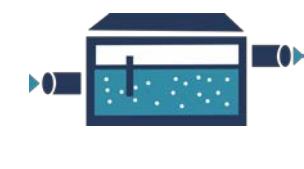
The Roadway Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct flow control practices to manage runoff from roads and highways in King County. The Program would be administered by King County in partnership with Washington State Department of Transportation (WSDOT), other jurisdictions and nongovernmental agencies.

The objective of the Program would be to provide flow control for roadway stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in the Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

The Program could include the flow control practices (“Actions”) listed below. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

The following pages include key assumptions and an overview of the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

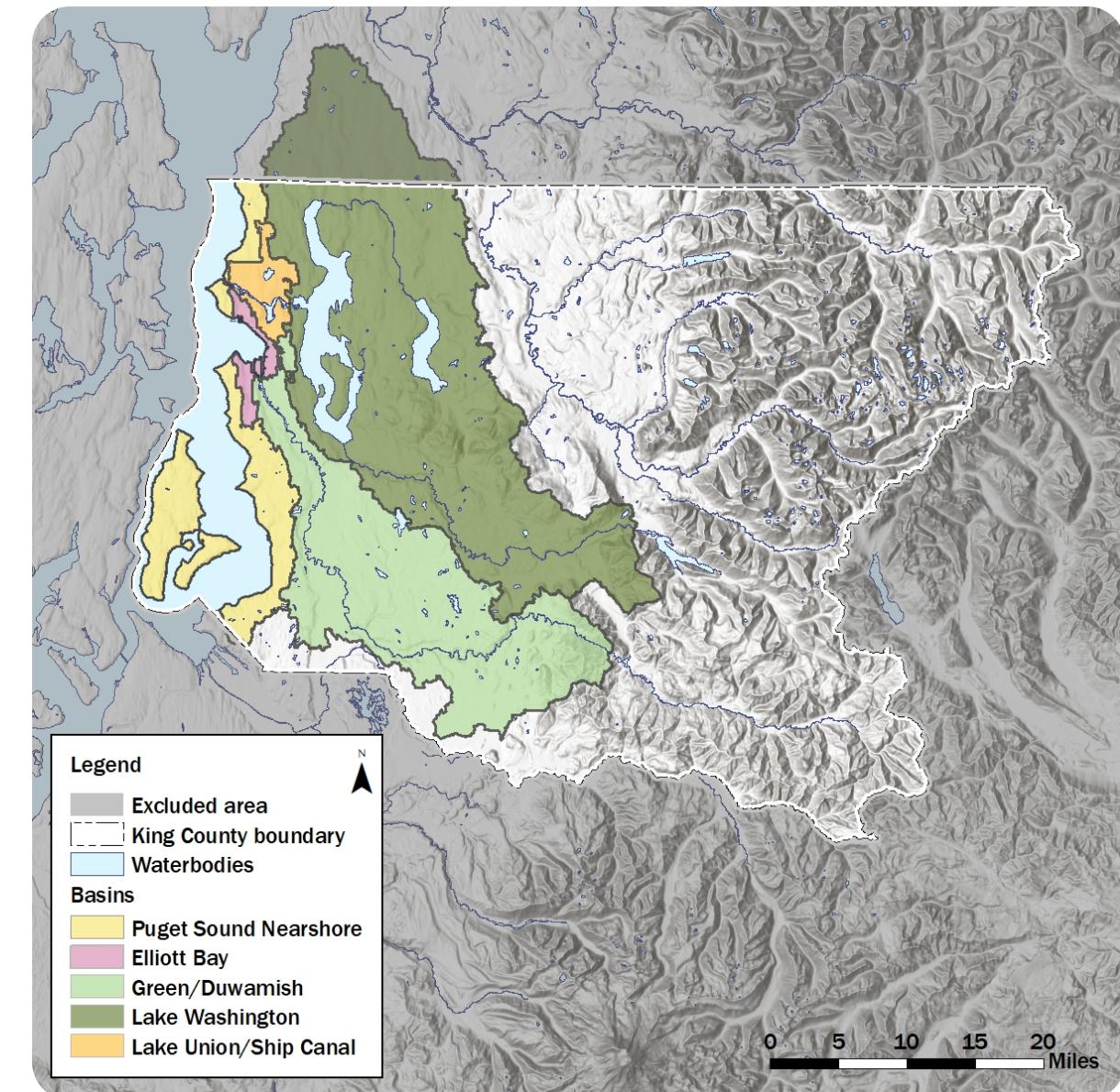
ACTIONS INCLUDED IN PROGRAM



* Not including bioretention facilities with underdrains on till soil due to minimal flow control benefits

** Paired with upstream high-rate filter for pre-treatment

PROGRAM IMPLEMENTATION AREA



PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial, agricultural, highway land uses
- Public right-of-way (local roads, arterial/collector roads, and highways)

ROADWAY RETROFIT FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

SUSTAIN MODELING APPROACH

Runoff routing:

This diagram shows how stormwater runoff is routed through flow control Actions in the SUSTAIN model. The arrows characterize the routing of runoff from each land use and surface type to the Actions or Action treatment trains. Some Actions are only applied to certain soil and slope conditions (see the Implementation Constraints Table on page 3). Overflow from the Actions and unmanaged runoff is routed to the catchment outlet. SUSTAIN provides an assessment of the most cost-effective combination of Actions within a treatment train to achieve different levels of flow control.

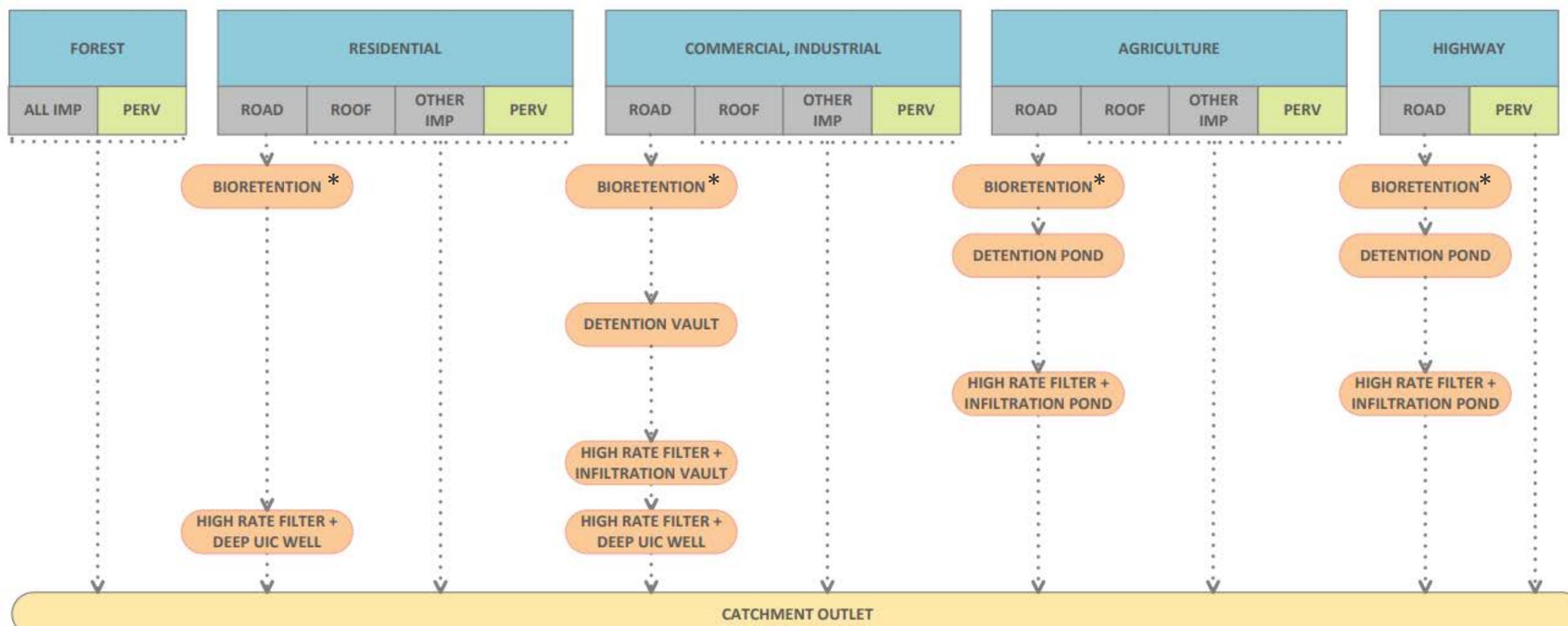
SUSTAIN Program optimization:

SUSTAIN could be used to evaluate and optimize the most cost-effective Actions for this Program.

- For performance, Actions can be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions can be estimated.
- For costs, optimization can be based on Action lifecycle costs. Program development and implementation costs can be scaled and applied to modeling results.
- SUSTAIN models these Actions as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN are assumed to be distributed throughout the catchment.

LEGEND

	HIGHWAY Land use
	Impervious surface
	Pervious surface
	BIORETENTION Action
	SUSTAIN will select best option in box
.....>	Runoff routing



ROADWAY RETROFIT FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM DESCRIPTION/ASSUMPTIONS

Program description:

- The Roadway Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct Actions to provide flow control for currently unmanaged stormwater runoff from roads and highways in King County.
- The Program would be applicable to highways, and local, collector, and arterial roads in residential, commercial and agricultural areas with separated drainage systems. Eligible areas would include unincorporated King County and cities in the implementation area.
- Actions would be implemented across the eligible areas based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County in partnership with Washington State Department of Transportation (WSDOT), other jurisdictions and nongovernmental agencies.
- Program elements would include:
 - Outreach to WSDOT, other jurisdictions and nongovernmental agencies
 - Interagency agreements for implementation and maintenance
 - County-wide planning effort to identify and prioritize best retrofit opportunities
 - Capital improvement project planning, design, and construction
 - Ongoing project inspections and maintenance
- King County would be responsible for the cost of Action design and construction, as well as the costs of Program development and administration.
- Long-term Action maintenance and replacement costs would be borne by the site jurisdiction (King County, city or state).

Key assumptions:

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Actions would be sited in County or partner agency right of way and property acquisition would not be required.
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained).

Key risks and challenges:

- Relies, in part, on cooperation between King County and other entities to agree on project priorities, locations, details, funding, and implementation strategies
- Requires ongoing maintenance efforts and costs, which would be borne, at least in part, by the County

PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
= Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

Flow Control Action	Infeasible Areas ¹	Technical Factor ²					Participation Factor ³	Composite Factor (Technical x Participation) ⁴
		Residential, Commercial, Industrial			Agriculture	Highway		
		Local Road in City	Local Road Outside City	Arterial	All Roads	Highway		
Bioretention on outwash	Till soil, slopes > 10%	30%	40%	30%	40%	40%	30%	9% - 12%
Detention pond					20%	5%	30%	2% - 6%
Detention vault ⁵		40%	40%	40%			30%	12%
High-rate filter to infiltration vault ⁵	Till soil	30%	30%	30%			30%	9%
High-rate filter to infiltration pond	Till soil				20%	5%	30%	2% - 6%
High-rate filter to deep UIC well	Outwash soil, gw protection areas	10%	10%	10%			20%	2%

- "Infeasible Areas" are areas where the Action will not be applied.
- "Technical Factor" represents the estimated fraction of the implementation area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.
- "Participation Factor" represents the anticipated participation in the Program.
- "Composite Factor" is the combined factor applied to estimate the maximum drainage area.
- Action not applied for residential land use.

LEGEND

Action not applied	
High Implementation	≥30%
Medium Implementation	15 to <30%
Low Implementation	≤15%

ROADWAY RETROFIT FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited in the public right of way (see table below). While lifecycle costs include maintenance, some maintenance costs could be borne by partnering jurisdictions, nongovernmental agencies and WSDOT.
- Upfront Program development costs (outreach, interagency agreements, planning study)
- Average annual Program administration costs (partner coordination, project oversight, maintenance)

Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

Unit Action	Lifecycle Cost/Unit Action ^{1,2,3}
Bioretention without underdrain (outwash, in right-of-way/highway)	\$161,400
Detention pond (in right of way/highway)	\$1,444,200
Detention vault (in right of way)	\$6,432,100
High-rate filter to infiltration pond (outwash, in right of way/highway)	\$1,082,700
High-rate filter to infiltration vault (outwash, in right of way)	\$3,992,400
High-rate filter to deep UIC well (till, in right of way)	\$274,000

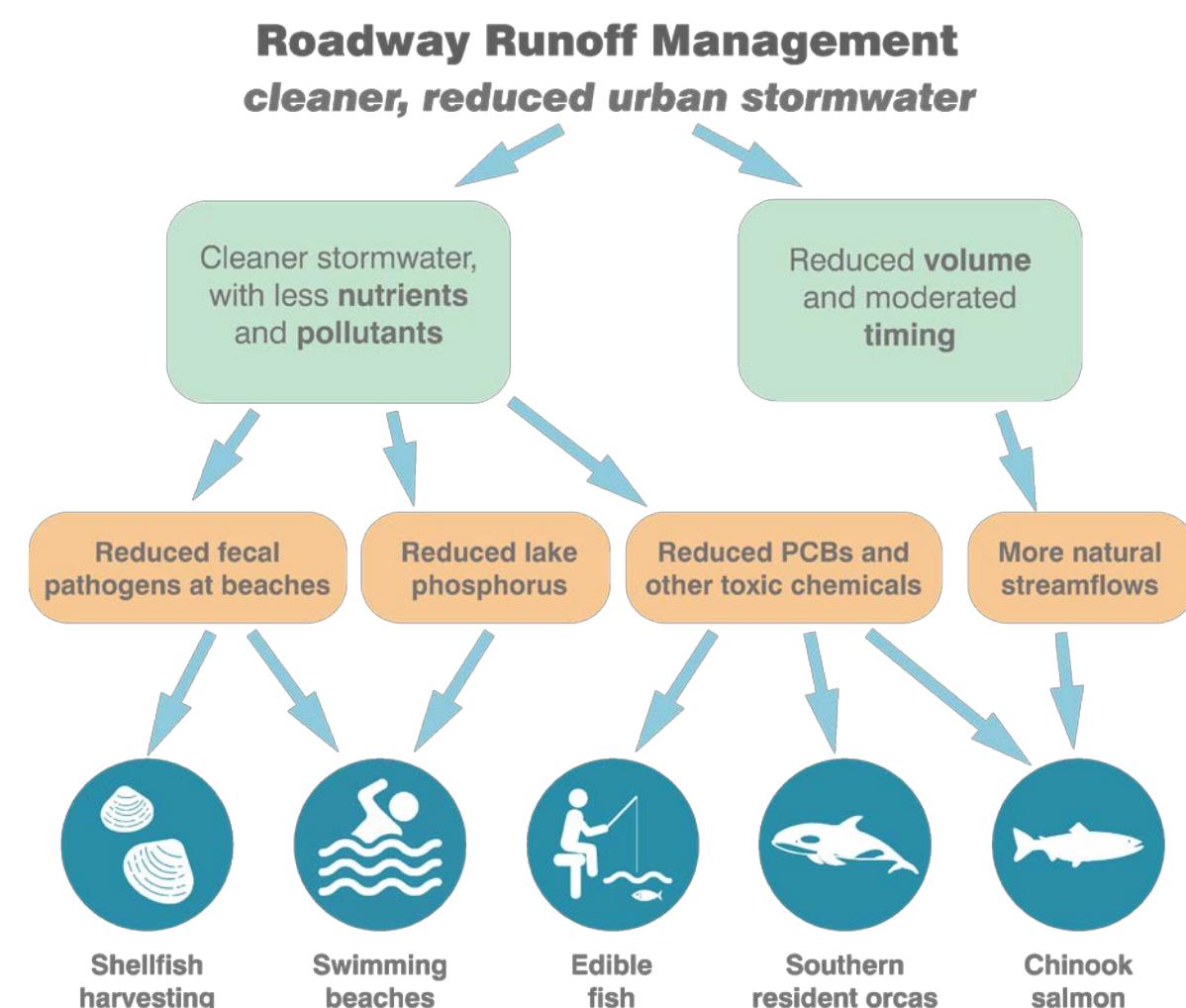
1. All costs are per unit of Action. Costs do not include property acquisition.

2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.

3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.

LINKAGES TO CAUSAL MODELS

The Roadway Retrofit Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



REGIONAL FACILITY FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM OVERVIEW

The Regional Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct regional stormwater flow control facilities to manage runoff from large subbasins. The Program would be administered by King County in partnership with other jurisdictions and nongovernmental agencies.

The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in the Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

The Program could include the flow control practices (“Actions”) listed below on publicly- and privately owned parcels. The most cost-effective combinations of Actions for this Program could be identified using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in companion Action Fact Sheets.

The following pages include key assumptions and an overview of the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

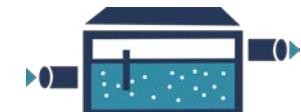
ACTIONS INCLUDED IN PROGRAM



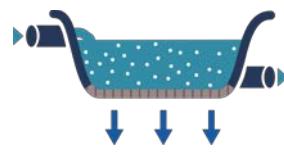
SPORTS FIELD AND PARK DETENTION



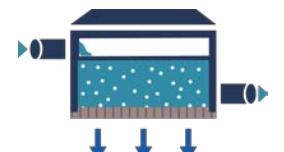
DETENTION POND



DETENTION VAULT



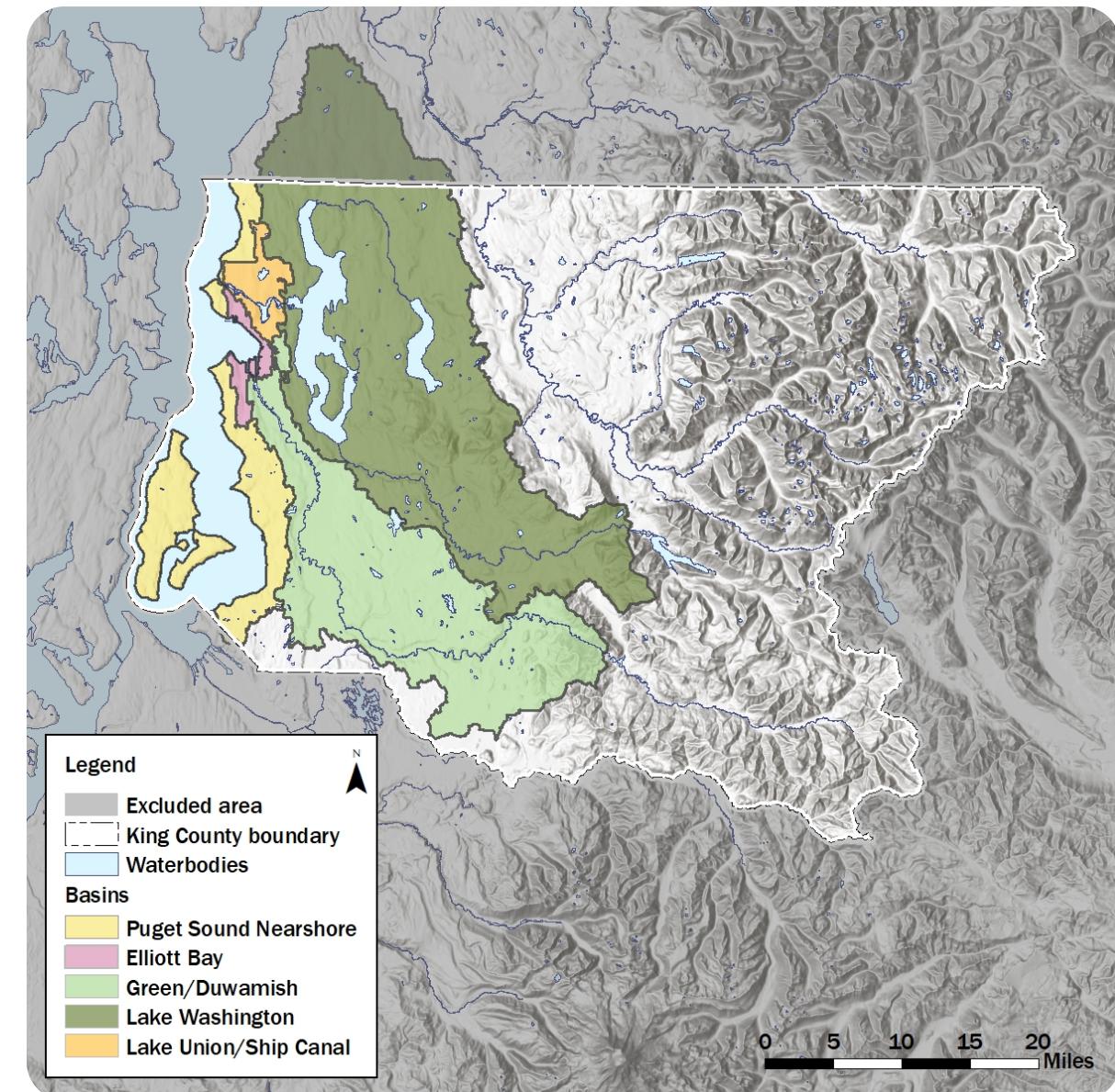
INFILTRATION *
POND



INFILTRATION *
VAULT

* Paired with upstream high-rate underground filter for pre-treatment

PROGRAM IMPLEMENTATION AREA



PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Residential, commercial, industrial, agricultural, highway land uses
- All surface types

REGIONAL FACILITY FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

Phase 3



10/1/2024

SUSTAIN MODELING APPROACH

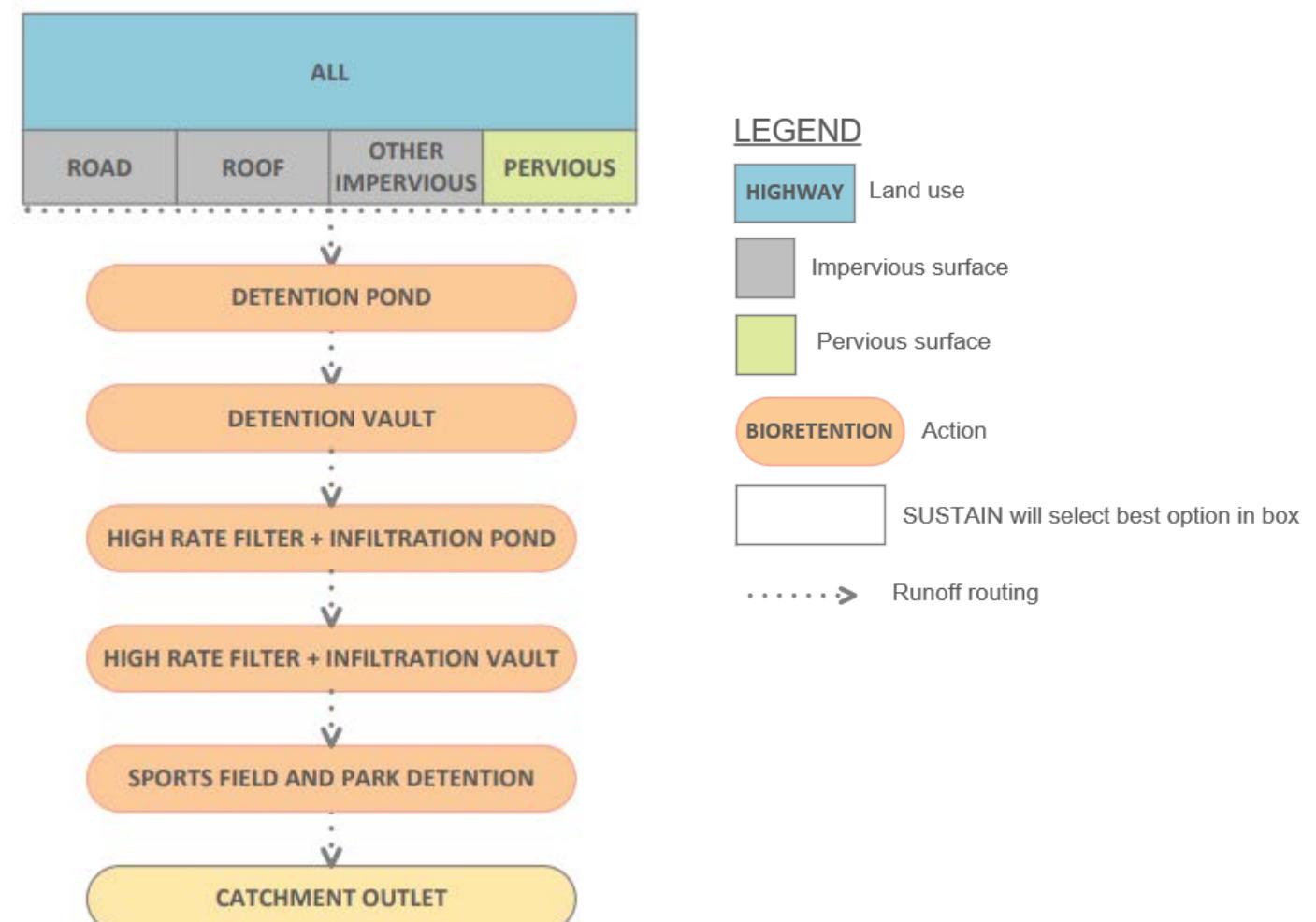
Runoff routing:

This diagram shows how stormwater runoff is routed in the SUSTAIN model. The arrows characterize the routing of stormwater runoff from each land use and surface type in the drainage area upstream of a potential regional facility on public parcels or private parcels. Overflow from the regional facilities and unmanaged runoff is routed to the catchment outlet.

SUSTAIN Program optimization:

Regional stormwater flow control facilities on publicly- and privately owned parcels could be evaluated by the SUSTAIN model to optimize the most cost-effective facilities for this Program.

- For performance, Actions can be optimized for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the optimized Actions can be estimated.
- For costs, optimization can be based on Action lifecycle costs. Program development and implementation costs can be scaled and applied to modeling results.
- Maximum potential footprint areas for regional facilities were calculated for each catchment based on screening criteria described on page 3. SUSTAIN models these facilities as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN could be distributed throughout the catchment.



REGIONAL FACILITY FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM DESCRIPTION/ASSUMPTIONS

Program description:

- The Regional Stormwater Flow Control Program would fund, plan, and implement capital improvement projects to construct regional stormwater facilities to manage stormwater runoff from large subbasins.
- Eligible areas for regional facilities include private and public parcels in separated drainage systems in unincorporated King County and partnering cities.
- The Program would be administered by King County.
- Program elements would include:
 - Outreach to other jurisdictions and nongovernmental agencies to form partnerships
 - Interagency agreements for implementation and maintenance
 - County-wide planning effort to identify and prioritize best regional stormwater flow control opportunities
 - Recruit private parcel owners in highly feasible, beneficial locations
 - Property acquisition (for privately-owned parcels)
 - Capital improvement project planning, design, and construction
 - Ongoing project inspections and maintenance
- King County would be responsible for the cost of Action design, construction, maintenance and replacement, as well as the costs of Program development and administration. There is a potential for cost sharing with the site jurisdiction.

Key assumptions:

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas
- Because this is a retrofit Program, Action sizing is not based on redevelopment requirements (i.e., contributing drainage area to each unit Action is not constrained)
- Facilities considered on County or partnering city property would not require property acquisition
- Facilities considered on private property would require property acquisition

Key risks and challenges:

- Relies, in part, on cooperation between County and partners to agree on project priorities, locations, details, funding, and implementation strategies
- Requires ongoing maintenance efforts and costs, which would be borne, at least in part, by the County
- Acquiring land for facilities on private parcels relies on willing sellers

SCREENING CRITERIA FOR MAXIMUM FOOTPRINT AREA

Potential feasible footprint area for regional stormwater flow control facilities would be identified in GIS based on the following screening criteria:

Criteria Category	Screening Criteria
Parcel Type/Ownership	<ul style="list-style-type: none">For publicly owned parcels: publicly-owned parcels, excluding airports, cemeteries, and trail corridorsFor privately-owned parcels: privately owned parcels
Outside Critical Areas/ Floodplain/ Sloped Areas	<p>Located outside of:</p> <ul style="list-style-type: none">100-year FEMA floodplainAreas with slope exceeding 10%Critical areas (steep slopes and buffers, wetlands, etc.)

LEGEND

Action not applied	
High Implementation	≥30%
Medium Implementation	15 to <30%
Low Implementation	≤15%

PROGRAM IMPLEMENTATION CONSTRAINTS

Max Footprint Area = Candidate Footprint Area (reduced by screening criteria) x "Technical Factor" x "Participation Factor"
= Candidate Footprint Area (reduced by screening criteria x "Composite Factor")

Flow Control Action	Infeasible Areas ¹	Private Parcels			Public Parcels		
		Technical Factor ²	Participation Factor ³	Composite Factor (Technical x Participation) ⁴	Technical Factor ²	Participation Factor ³	Composite Factor (Technical x Participation) ⁴
Detention pond	See screening criteria	10%	2%	0.2%	20%	30%	6%
Detention vault	See screening criteria	10%	2%	0.2%	20%	30%	6%
High-rate filter to infiltration vault	See screening criteria, till soil	10%	2%	0.2%	20%	30%	6%
High-rate filter to infiltration pond	See screening criteria, till soil	10%	2%	0.2%	20%	30%	6%
Sports Field / Park Detention	See screening criteria, areas other than public sports fields or parks				20%	30%	6%

1. "Infeasible Areas" are Areas where the Action will not be applied.

2. "Technical Factor" represents the estimated fraction of the sites that would prove to be feasible during planning

3. "Participation Factor" represents the anticipated participation in the Program.

4. "Composite Factor" is the combined factor applied to estimate the maximum number of sites where regional facilities could be implemented.

REGIONAL FACILITY FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet



Phase 3

10/1/2024

PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on public property and private property (see table below). While lifecycle costs include maintenance, some maintenance costs could be borne by partnering jurisdictions and nongovernmental agencies.
- Upfront Program development costs (outreach, interagency agreements, planning study)
- Average annual Program administration costs (partner coordination, project oversight, maintenance)

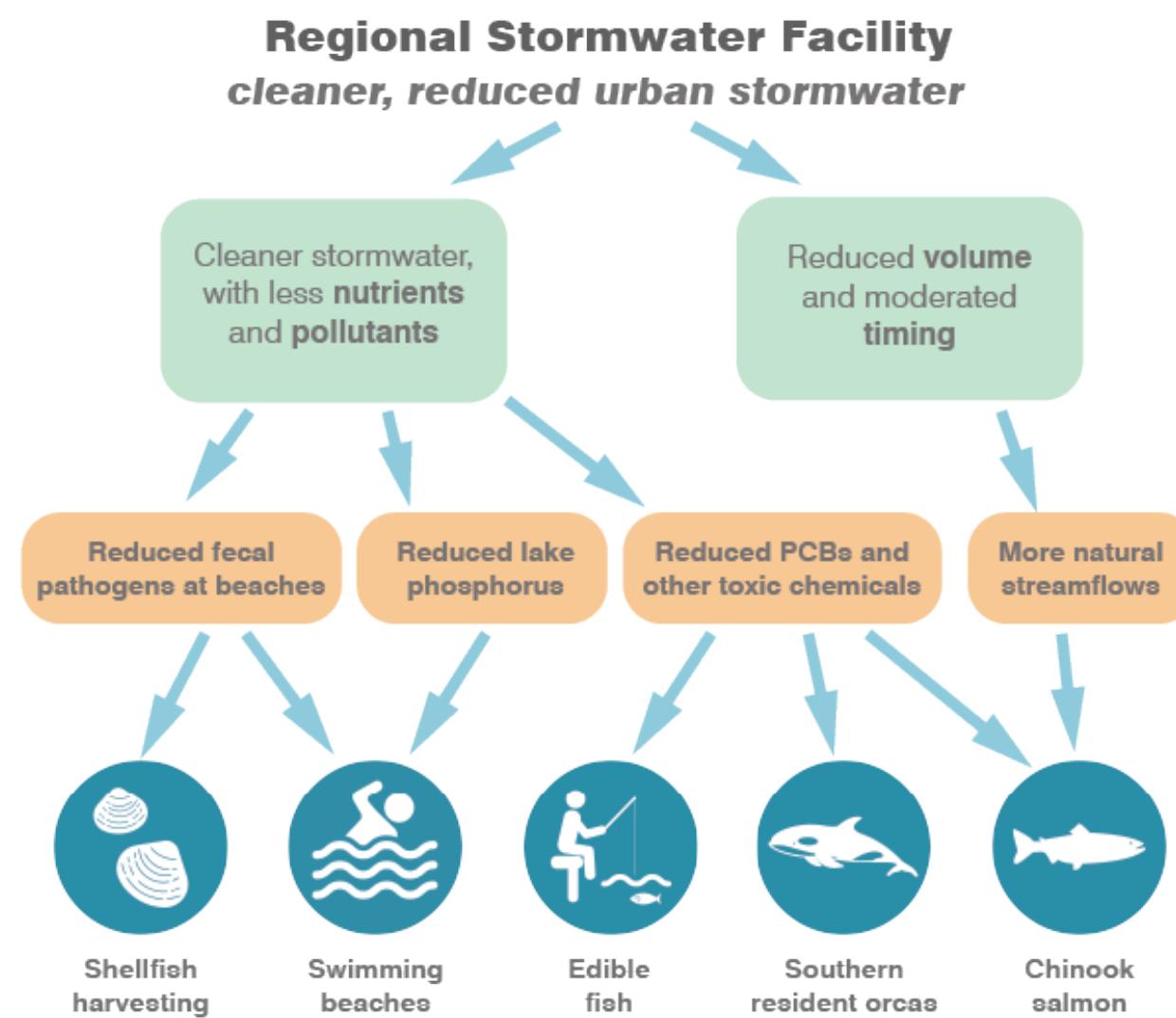
Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

Unit Action	Lifecycle Cost/Unit Action ^{1,2,3}
Detention pond on public parcel	\$1,444,200
Detention pond on private parcel	\$2,931,400
Detention vault on public parcel	\$5,905,200
Detention vault on private parcel	\$6,454,600
High-rate filter to infiltration vault on public parcel	\$3,930,800
High-rate filter to infiltration vault on private parcel	\$4,375,400
High-rate filter to infiltration pond on public parcel	\$1,082,700
High-rate filter to infiltration pond on private parcel	\$2,243,700
Sports field / park detention on public parcel	\$18,700,900

1. All costs are per unit of Action. Lifecycle costs for Actions sited on public property do not include land acquisition costs, while Actions sited on private property include an added cost for land acquisition. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table includes medium acquisition costs. See 439-TM1 Appendix E for low and high property acquisition costs.
2. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
3. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.

LINKAGES TO CAUSAL MODELS

The Regional Flow Control Facility Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



REFORESTATION FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

Phase 3



10/1/2024

PROGRAM OVERVIEW

The Reforestation Flow Control Program would fund, plan, and implement reforestation projects on public lands and acquired private parcels in King County. The Program would be administered by King County, potentially in partnership with other jurisdictions and nongovernmental agencies.

The objective of the Program would be to provide flow control for stormwater runoff in separated drainage basins to more closely mimic predeveloped hydrology for receiving waterbodies in the Puget Sound Nearshore, Elliott Bay, Green/Duwamish, Lake Union/Ship Canal, and Lake Washington basins. The Program could be adapted for combined drainage basins with the objective to reduce combined sewer overflows.

The Program could include reforestation of high density development and pervious areas ("Actions") shown below. The cost-effectiveness of the Program could be evaluated using the SUSTAIN model. Modeling inputs for the Actions, including design, performance, and cost assumptions, are provided in a companion Action Fact Sheets.

The following pages include key assumptions and an overview of the Program. See 439-TM1 Appendix F for more detailed information regarding the methods used.

ACTIONS INCLUDED IN PROGRAM

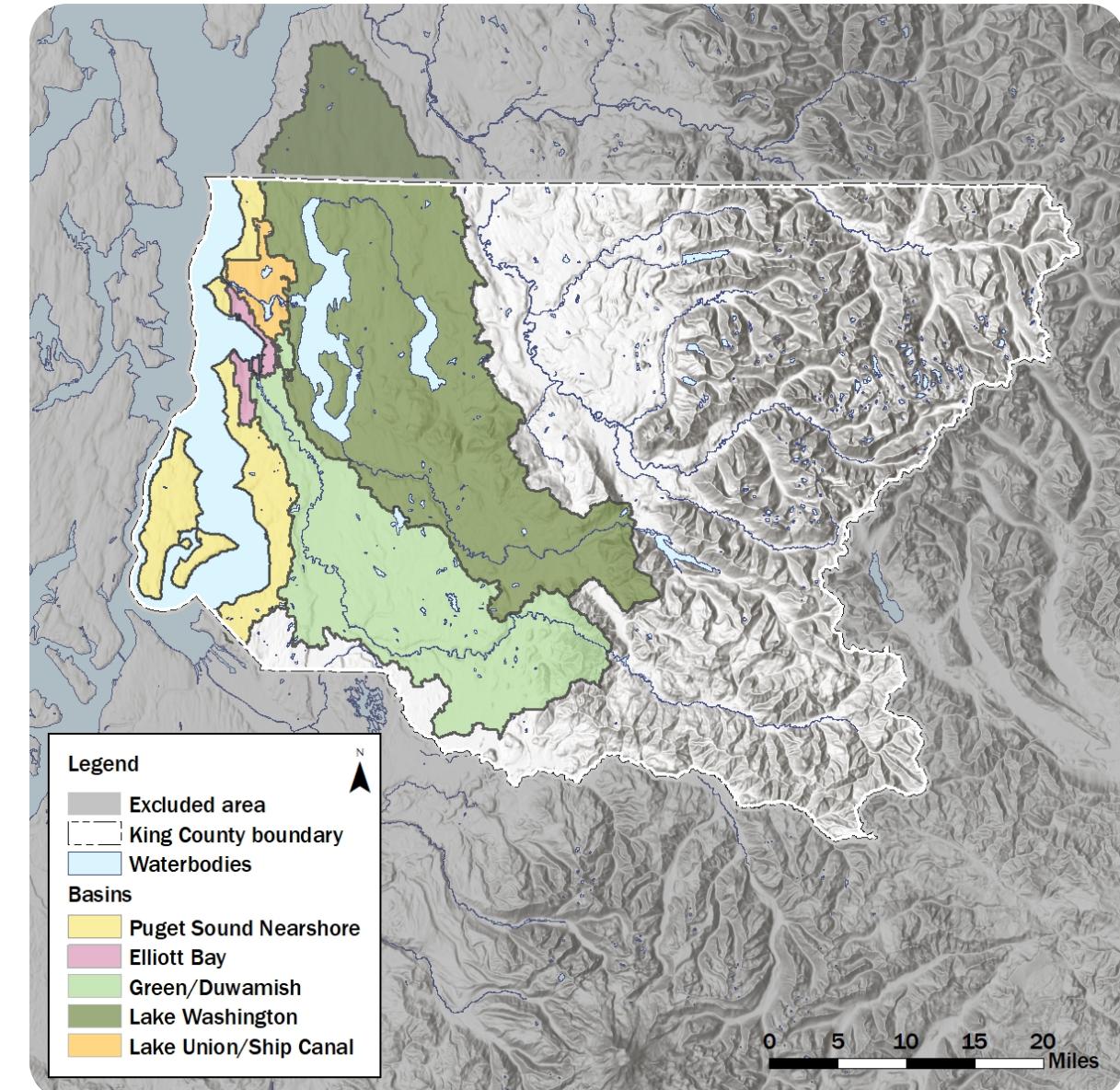


REFOREST HIGH
DENSITY
DEVELOPMENT



REFOREST
PERVIOUS AREA

PROGRAM IMPLEMENTATION AREA



PROGRAM APPLICABILITY

- Basins in implementation area (see map above)
- Unincorporated King County and cities
- Separated drainage basins
- Commercial and industrial land uses
- Private and public parcels

REFORESTATION FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

Phase 3



10/1/2024

SUSTAIN MODELING APPROACH

Runoff routing/land conversion:

This diagram shows how runoff characteristics are changed by converting some land use and surface type combinations to forest in the SUSTAIN model. Flows from the forest and unmanaged runoff is routed to the catchment outlet.

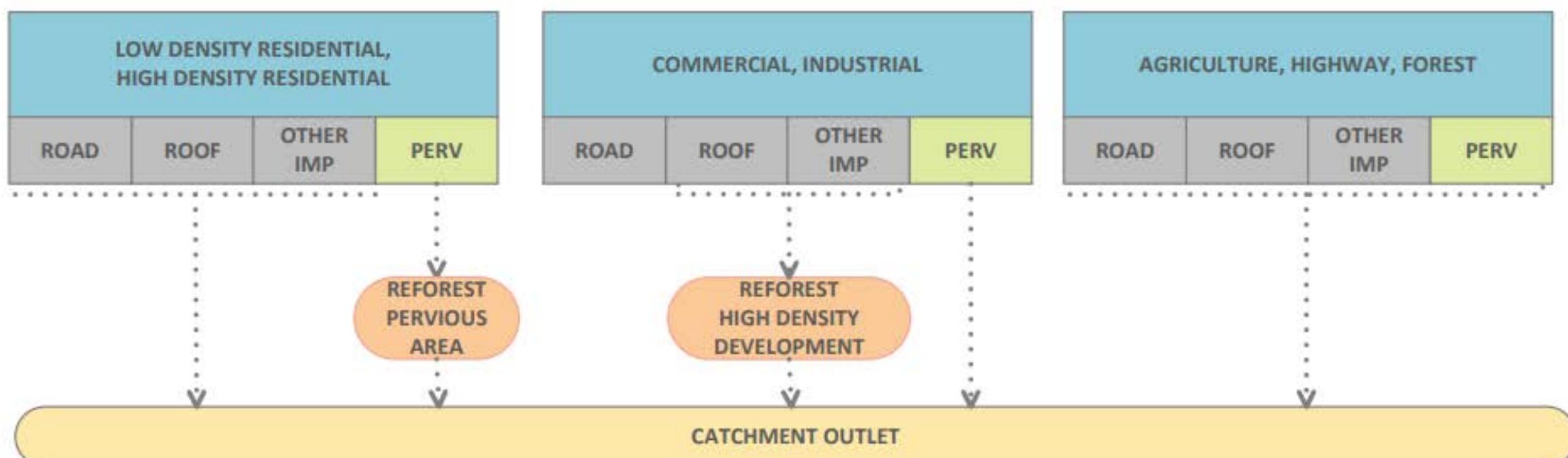
SUSTAIN Program optimization:

SUSTAIN could be used to evaluate the cost-effectiveness of the Actions in this Program.

- For performance, the Actions can be evaluated for runoff volume reduction on days in the timeseries where runoff exceeds a threshold that represents an unnatural hydrograph. The associated pollutant load reduction provided by the Actions can be estimated.
- For costs, evaluation can be based on Action lifecycle cost. Program development and implementation costs can be scaled and applied to modeling results.
- SUSTAIN models this Action as a lumped representation at the bottom of each catchment. The cost-effective Actions identified by SUSTAIN are assumed to be distributed throughout the catchment.

LEGEND

	HIGHWAY Land use
	Impervious surface
	Pervious surface
	BIORETENTION Action
	SUSTAIN will select best option in box
.....>	Runoff routing



REFORESTATION FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

Phase 3



10/1/2024

PROGRAM DESCRIPTION/ASSUMPTIONS

Program description:

- The Reforestation Flow Control Program would fund, plan, and implement reforestation projects on public lands and acquired private parcels in commercial, industrial and residential areas of King County.
- Reforestation would be implemented based on the assumed technical and participation factors shown in the table to the right.
- The Program would be administered by King County.
- Program elements would include:
 - Outreach to other jurisdictions and nongovernmental agencies to form partnerships
 - County-wide planning effort to identify and prioritize best reforestation opportunities on public lands and private land for sale
 - Property acquisition (for privately-owned parcels)
 - Design and implement reforestation project (e.g., remove structures, depave, scarify and amend soil, plant trees and understory, and install simple recreational trail)
 - Maintain vegetation during 3-year establishment period and annual thereafter
- King County would be responsible for the cost of Action design, construction, and maintenance, as well as the costs of Program development and administration. There is a potential for cost sharing with the site jurisdiction.

Key assumptions:

- Factors influencing technical feasibility and participation are based on professional judgement and assumed to be the same across all eligible areas.
- Reforestation projects on private property would require property acquisition.

Key risks and challenges:

- Requires ongoing maintenance efforts and costs, which would be borne, at least in part, by the County.
- Acquiring land for reforestation of private parcels relies on willing sellers.

PROGRAM IMPLEMENTATION CONSTRAINTS

Max Drainage Area = Total Implementation Area (reduced by infeasible areas) x "Technical Factor" x "Participation Factor"
= Total Implementation Area (reduced by infeasible areas) x "Composite Factor"

Action	Infeasible Areas ¹	Technical Factor ²								Participation Factor ³	Composite Factor (Technical x Participation) ⁴		
		Residential		Commercial			Industrial						
		Perv Inside City	Perv Outside City	Roof	Other Imp	Perv	Roof	Other Imp	Perv				
Reforest High Density Development on private parcel	Publicly-owned parcel			80%	80%	80%	40%	40%	40%	2%	1% - 2%		
Reforest High Density Development on public parcel	Privately-owned parcel			80%	80%	80%	40%	40%	40%	5%	2% - 4%		
Reforest Previous Area on private parcel	Publicly-owned parcel	2%	10%							2%	0.04% - 0.2%		

- "Infeasible Areas" are areas where the Action will not be applied.
- "Technical Factor" represents the estimated fraction of the implementation area that could feasibly be managed based on technical considerations like space constraints, utility conflicts, existing runoff patterns, and site uses.
- "Participation Factor" represents the anticipated participation in the Program.
- "Composite Factor" is the combined factor applied to estimate the maximum drainage area.

LEGEND

Action not applied	
High Implementation	≥30%
Medium Implementation	15 to <30%
Low Implementation	≤15%

REFORESTATION FLOW CONTROL PROGRAM

Water Quality Benefits Evaluation Program Fact Sheet

Phase 3



10/1/2024

PROGRAM COSTS

Program costs include:

- Lifecycle costs for Actions sited on public property and private property (see table below). While lifecycle costs include maintenance, some maintenance costs could be borne by partnering jurisdictions and nongovernmental agencies.
- Upfront Program development costs (partnering, planning study)
- Average annual Program administration costs (partner coordination, project design, maintenance)

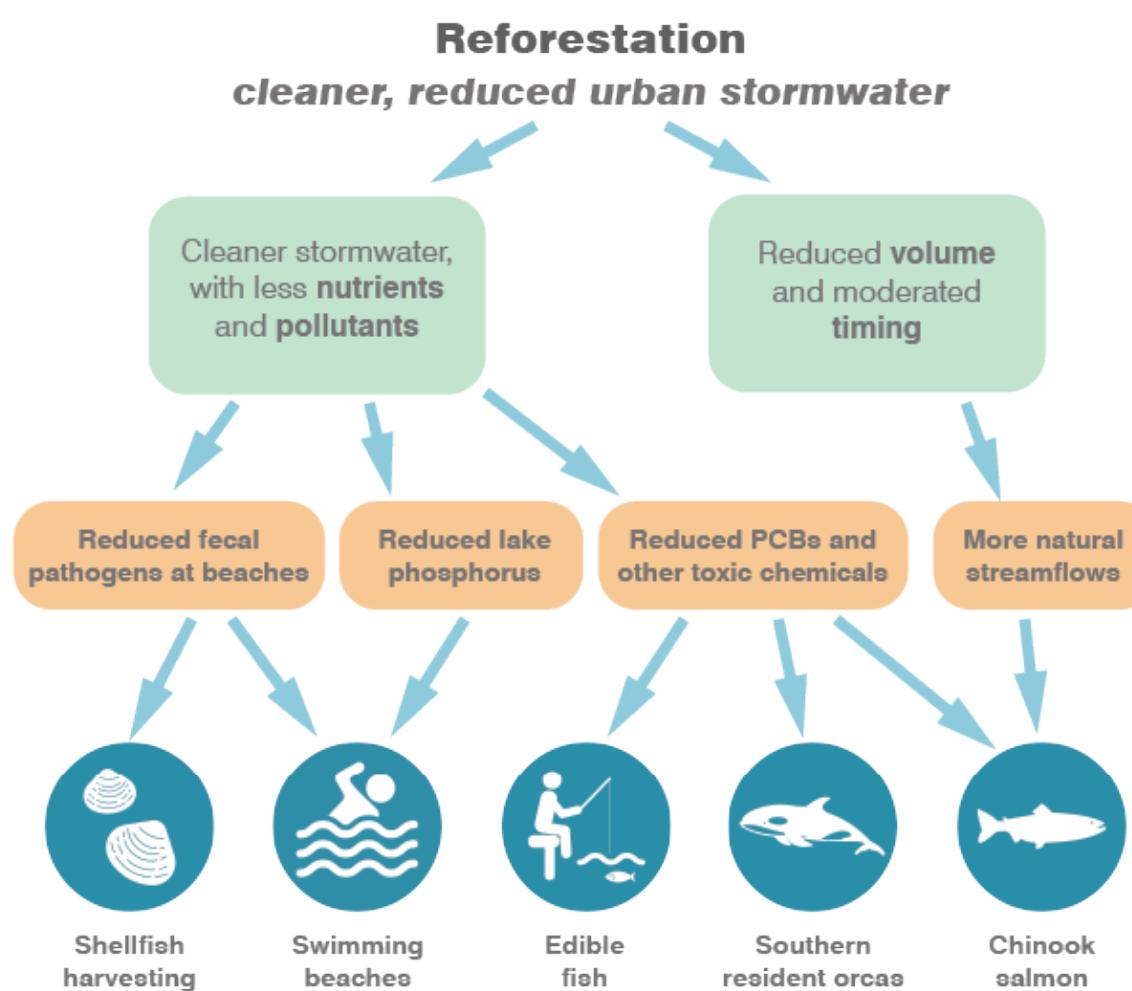
Program development and administration costs are not included in the table and can be applied separately. See 439-TM1 Appendix I for examples.

Unit Action	Lifecycle Cost/Unit Action ^{1,2}
Reforest High Density Development on private parcel ³	\$24,131,700
Reforest High Density Development on public parcel ³	\$19,577,100
Reforest Pervious Area on private parcel ⁴	\$1,747,400

1. All costs are per unit of Action. Costs are presented in 2023 dollars. Life-cycle include initial capital, operations and maintenance, and capital replacement costs over a 30-year life-cycle.
2. Annual O&M costs are included in the life-cycle costs with periodic replacements. For details on the total project costs and O&M cost development, see 439-TM1 Appendix E.
3. Lifecycle costs for Actions sited on public property do not include land acquisition costs, while Actions sited on private property include an added cost for land acquisition. Low, medium and high property acquisition costs were calculated to represent the range of costs across King County. The table includes medium acquisition costs. See 439-TM1 Appendix E for low and high property acquisition costs.
4. Costs assume willing property owners and do not include property acquisition.

LINKAGES TO CAUSAL MODELS

The Reforestation Flow Control Program could be evaluated using causal models to assess benefits to a suite of human and ecological health endpoints. The graphic below illustrates the types of factors that might be influenced by a Program and how changes in those factors might improve outcomes for shellfish harvest, swimming beaches, edible fish, Chinook salmon, and Southern Resident orcas. Causal model inputs for the evaluation would be based on the factors shown here. A detailed list of potential causal model inputs are included as an appendix to technical memorandum #420-TM1.



Appendix I

Program Implementation Costs

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TECHNICAL MEMORANDUM

Date: October 4, 2024
To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division
From: Rebecca Dugopolski, PE, Herrera Environmental Consultants, Inc
Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc
Subject: WQBE Program Implementation Cost Development (Appendix I to 439-TM1)

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Table 4. Regional Stormwater Treatment Program.....	17

Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for "Actions" composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or "unit Actions") that are aggregated and combined to develop "Programs," or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or "Packages", for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- **Phase 1 (2020):** Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- **Phase 2 (2021-2022):** Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).
- **Phase 3 (2023-2024):** An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

The SUSTAIN model develops cost-effectiveness curves for each Program based on 30-year lifecycle costs for individual Actions. The lifecycle costs include the cost to design and construct the Actions within a Program as well as maintain and replace the Actions over a 30-year period. Additionally, property acquisition was included in the lifecycle costs when acquisition was required to implement an Action (i.e., regional facilities on private property). These costs were included in the SUSTAIN model to reflect the total cost incurred by all parties rather than solely King County.

However, the overarching implementation costs for the Program are generally not captured in these 30-year lifecycle costs. Therefore, it is anticipated that Program implementation costs would be developed outside of the SUSTAIN model. Ideally, these Program implementation costs would reflect potential "economies of scale" or shifts to more efficient implementation models depending on the size and complexity of the Package that is selected for a particular Program.

Program implementation approach and costs will vary based on the type of Program and the size of the selected Package from the SUSTAIN model results. Given this consideration, this memorandum provides example Program implementation assumptions and planning level costs for the following three Programs based on Packages selected from the Phase 2 SUSTAIN modeling:

- Green Stormwater Infrastructure (GSI) Incentive Program
- Roadway Stormwater Treatment Program
- Regional Stormwater Treatment Program

Methodology

To develop example implementation assumptions and planning costs, the following information was compiled and/or estimated for each of the three Programs identified above:

- Program implementation elements and cost components
- Scales of program implementation (Small and Large)
- Applicable program delivery models
- Planning level cost estimate for program development for each program delivery model
- Planning level cost estimate for ongoing program implementation for each program delivery model

The three Programs developed in Phase 2 were modeled in SUSTAIN using the 30-year life cycle costs to identify the most cost-effective Actions that achieve different levels of water quality improvement at different costs (Paradigm and Herrera 2022). Two program scales (small and large) were evaluated using results from the SUSTAIN modeling:

- **Small:** \$200M Package from SUSTAIN results reflecting 30-year life cycle costs
- **Large:** Package representing the "knee" of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

The SUSTAIN lifecycle costs do not include costs required for implementing the Programs. Therefore, planning level program implementation costs were developed outside of the SUSTAIN model for initial program development and ongoing program implementation for each of the two program scales. The programmatic costs are predominately focused on County staff (with support from consultants as the program scale increases in size), with additional funding allotted to supplies and materials needed for implementing the program.

Program implementation costs for the Small program scale with the smaller number of Actions were estimated and then scaled up for the Large program scale which had larger numbers of Actions. In the process, economies of scale were considered in connection with this scaling. These planning level costs were estimated based on a review of program implementation costs from similar existing programs in the region and best professional judgement. Costs were also adjusted based on the applicable program delivery models that were selected for each Program. The delivery models identified in Table 1 were specifically considered in this evaluation.

Table 1. Delivery Models used for Developing Program Implementation Costs.

Model	Applicable Program Delivery Models
1. Capital Program	1.1: County led
	1.2: County led with consultant support
2. Incentive Program	2.1: County led rebate/reimbursement program
	2.2: County led rebate/reimbursement program with consultant support
3. Public-Private Partnership	3.1: County led, design-build by landowner
	3.2: Community Based Public-Private Partnership (CBP3)

For each of the Programs, the following sections provide the Program description, the Program implementation elements not included in the SUSTAIN lifecycle costs, and the potential delivery models for implementing the Programs.

Program Delivery Cost Estimates

GSI Incentive Program

The GSI Incentive Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide rebates, reimbursements, or other financial incentives to eligible property owners for designing, constructing, and maintaining GSI on their properties.

Program Development Components

The program development planning level cost estimate for the GSI Incentive Program includes direct labor and overhead and material costs for staff to develop:

- Program web page with eligibility maps
- Design tools
- Incentive calculator
- Education and outreach materials
- Contractor training materials

Ongoing Program Implementation Components

The ongoing program implementation planning level cost estimate for the GSI Incentive Program includes direct labor and overhead and material costs for staff to:

Advertise the program to eligible property owners/contractors

- Process applications
- Provide contractor training for GSI installation

SUSTAIN Lifecycle Cost Elements

The following lifecycle cost considerations have already been developed as part of the SUSTAIN modeling:

- Design GSI BMPs
- Construct GSI BMPs
- Maintain GSI BMPs
- Replace GSI BMPs

The GSI Incentive Program is intended to provide a rebate or reimbursement to cover a portion of the design, construction, and/or maintenance costs to incentivize property owners for implementing Actions on their property. This technical memorandum does not identify the amount needed to incentivize property owners, but this would be evaluated as part of the program development.

Program Size

For the planning level cost evaluation, our team evaluated two program sizes for the GSI Incentive Program:

- **Small:** \$200M Package from SUSTAIN results reflecting 30-year life cycle costs
- **Large:** \$683M Package representing the “knee” of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

Applicable Program Delivery Models

The following program delivery models were selected for evaluation for the GSI Incentive Program:

Model 2: Incentive Program

- Model 2.1: County led rebate/reimbursement program
- Model 2.2: County led rebate/reimbursement program with consultant support

Table 2 provides a summary of the GSI Incentive Program description, the numbers and types of Actions included in the small and large scale programs, and the planning level cost estimates for different Program delivery models.

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Table 2. GSI Incentive Program.

Program Description and Cost Components	Short Program Description			Program Cost Components					SUSTAIN Lifecycle Cost Components		Combined Program and SUSTAIN Lifecycle Cost Components		
				Program Development		Ongoing Program Implementation			Ongoing BMP Implementation				
	The GSI Incentive Program would provide incentives for property owners to install small scale green stormwater infrastructure (GSI) practices to help manage the rain that falls on their roofs and other impervious surfaces, such as parking lots and driveways. The Program would provide rebates, reimbursements, or other financial incentives to eligible property owners for designing, installing, and/or maintaining GSI on their properties.	Direct labor and overhead and material costs for staff to develop:	Direct labor and overhead and material costs for staff to: <ul style="list-style-type: none">Advertise the program to eligible property owners/contractorsProcess applicationsProvide contractor training for GSI installation					Direct labor and overhead and material costs for staff to: <ul style="list-style-type: none">Design GSI BMPsConstruct GSI BMPsMaintain GSI BMPsReplace GSI BMPsProvide rebate/reimbursement (towards GSI BMP construction cost and ~1-2 yrs maintenance)	Includes Program Development, Ongoing Program Implementation, and Ongoing BMP Implementation				
Program Delivery Model and Planning Level Program Implementation Costs	Scale	Description of Actions Included ^a	Model	Applicable Program Delivery Models	Program Development	Ongoing Program Implementation			Ongoing BMP Implementation	Program + SUSTAIN			
					Initial Cost (including staff) ^b	County Staff	Approx. Annual Cost (including staff) ^c	Approx. Program Cost per BMP	Total 30-Year Cost (including staff) ^d	County Staff	Approximate Annual Cost ^c	Total 30-Year Lifecycle Cost ^e	Total 30-Year Lifecycle Cost ^d
	Small	2,544 bioretention units	2. Incentive Program	2.1: County led rebate/reimbursement program	\$300,000	2 FTE	\$540,000	\$6,368	\$11M	2 FTE	\$6.7M	\$200M	\$211M
				2.2: County led rebate/reimbursement program with consultant support (25%)	\$308,000	1.5 FTE	\$548,000	\$6,462	\$12M	1.5 FTE			\$212M
	Large	7,530 bioretention units 410 rain gardens 405 bioretention planters 264 cisterns 12 bioretention planter to deep UIC wells	2. Incentive Program	2.1: County led rebate/reimbursement program	\$900,000	6 FTE	\$1,620,000	\$5,637	\$34M	6 FTE	\$23M	\$683M	\$717M
				2.2: County led rebate/reimbursement program with consultant support (75%)	\$966,000	1.5 FTE	\$1,686,000	\$5,867	\$36M	1.5 FTE			\$719M

^a The following BMPs were removed from the SUSTAIN results to simplify implementation of the Small Program: 1 bioretention planter, 1 bioretention planter drywell, and 1 permeable pavement area

The following BMPs were removed from the SUSTAIN results to simplify implementation of the Large Program: 2 bioretention planter drywells and 1 permeable pavement area

^b Initial cost is based on 2023 dollars.^c The 30-year lifecycle cost was divided evenly among 30 years. Actual costs may be higher or lower each year than what is presented here for the initial planning level cost estimates.^d Total 30-year cost is based on 2023 dollars. A 3% labor cost escalation and 5.25% discount rate was incorporated into these initial planning level cost estimates.^e Small Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington \$200M Package.

Large Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington Package selected to represent the "knee" of the cost-effectiveness curve (\$683M).

BMP = best management practice

FTE = full-time equivalent

GSI = green stormwater infrastructure

UIC = underground injection control

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Roadway Stormwater Treatment Program

The Roadway Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct treatment practices (Actions) to treat runoff from roads and highways in King County. The Program would be administered by King County in partnership with cities and the Washington State Department of Transportation (WSDOT).

Program Development Components

The program development planning level cost estimate for the Roadway Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Implement a County-wide planning effort to identify and prioritize best retrofit opportunities
- Conduct outreach to cities and WSDOT to form partnerships
- Develop interagency agreements for implementation and maintenance

Ongoing Program Implementation Components

The ongoing program implementation planning level cost estimate for the Roadway Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Continue to identify and prioritize best retrofit opportunities
- Coordinate with cities and WSDOT
- Continue to develop interagency agreements for implementation and maintenance

SUSTAIN Lifecycle Cost Elements

The following lifecycle cost elements have already been developed as part of the SUSTAIN modeling:

- Design capital improvement projects
- Construct capital improvement projects
- Maintain capital improvement projects
- Replace capital improvement projects

Program Size

For the planning level cost evaluation, our team evaluated two program sizes for the Roadway Stormwater Treatment Program:

- **Small:** \$200M Package from SUSTAIN results reflecting 30-year life cycle costs

- **Large:** \$731M Package representing the “knee” of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

Applicable Program Delivery Models

The following program delivery models were selected for evaluation for the Roadway Stormwater Treatment Program:

Model 1: Capital Program

- Model 1.1: County led
- Model 1.2: County led with consultant support

Table 3 provides a summary of the Roadway Stormwater Treatment Program description, the numbers and types of Actions included in the small and large scale programs, and the planning level cost estimates for different Program delivery models.

Table 3. Roadway Stormwater Treatment Program.

Program Description and Cost Components	Short Program Description			Program Cost Components					SUSTAIN Lifecycle Cost Components	Combined Program and SUSTAIN Lifecycle Cost Components		
				Program Development		Ongoing Program Implementation			Ongoing BMP Implementation			
	The Roadway Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct treatment practices (Actions) to treat runoff from roads and highways in King County. The Program would be administered by King County in partnership with cities and the Washington State Department of Transportation (WSDOT).	Direct labor and overhead and material costs for staff to:	● Implement a County-wide planning effort to identify and prioritize best retrofit opportunities ● Coordinate with cities and WSDOT ● Continue to develop interagency agreements for implementation and maintenance	Direct labor and overhead and material costs for staff to:	● Continue to identify and prioritize best retrofit opportunities ● Coordinate with cities and WSDOT ● Continue to develop interagency agreements for implementation and maintenance	Direct labor and overhead and material costs for staff to:	● Design capital improvement projects ● Construct capital improvement projects ● Maintain capital improvement projects ● Replace capital improvement projects	Includes Program Development, Ongoing Program Implementation, and Ongoing BMP Implementation				
Program Delivery Model and Planning Level Program Implementation Costs	Scale	Description of Actions Included ^a	Model	Applicable Program Delivery Models	Program Development		Ongoing Program Implementation	Ongoing BMP Implementation	Program + SUSTAIN			
					Initial Cost (including staff) ^b	County Staff	Approx. Annual Cost (including staff) ^c	Approx. Program Cost per BMP	Total 30-Year Cost (including staff) ^d	County Staff	Approximate Annual Cost ^e	Total 30-Year Lifecycle Cost ^d
	Small	795 media filter drains 411 bioretention units 248 high-rate underground filters 34 high-rate filter deep UIC wells 17 biofiltration swales	1. Capital Program	1.1: County led	\$300,000	2 FTE	\$150,000	\$2,990	\$3M	1 FTE	\$6.6M	\$200M
				1.2: County led with consultant support (25%)	\$308,000	1.5 FTE	\$154,500	\$3,080	\$3M	0.8 FTE		
	Large	2,993 bioretention units 2,331 media filter drains 469 high-rate underground filters 282 bioretention planters 34 high-rate filter deep UIC wells	1. Capital Program	1.1: County led	\$600,000	4 FTE	\$300,000	\$2,888	\$6M	2 FTE	\$24M	\$731M
				1.2: County led with consultant support (75%)	\$644,000	1 FTE	\$322,000	\$3,100	\$7M	0.5 FTE		

^a The following BMPs were removed from the SUSTAIN results to simplify implementation of the Small Program: 2 bioretention planters
The following BMPs were removed from the SUSTAIN results to simplify implementation of the Large Program: 1 biofiltration swale

^b Initial cost is based on 2023 dollars.

^c The 30-year lifecycle cost was divided evenly among 30 years. Actual costs may be higher or lower each year than what is presented here for the initial planning level cost estimates.

^d Total 30-year cost is based on 2023 dollars. A 3% labor cost escalation and 5.25% discount rate was incorporated into these initial planning level cost estimates.

^e Small Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington \$200M Package.

Large Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington Package selected to represent the "knee" of the cost-effectiveness curve (\$731M).

BMP = best management practice

FTE = full-time equivalent

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Regional Stormwater Treatment Program

The Regional Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct regional stormwater treatment facilities for treating stormwater runoff from large drainage areas that may include multiple types of land uses. The Program would be administered by King County in partnership with cities.

Program Development Components

The program development planning level cost estimate for the Regional Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Implement a County-wide planning effort to identify and prioritize best retrofit opportunities
- Conduct outreach to cities and WSDOT to form partnerships
- Develop interagency agreements for implementation and maintenance
- Develop outreach materials for private parcel owners

Ongoing Program Implementation Components

The ongoing program implementation planning level cost estimate for the Regional Stormwater Treatment Program includes direct labor and overhead and material costs for staff to:

- Continue to identify and prioritize best regional stormwater treatment opportunities
- Coordinate with cities and WSDOT
- Continue to develop interagency agreements for implementation and maintenance
- Conduct outreach to private parcel owners

SUSTAIN Lifecycle Cost Elements

The following lifecycle cost elements have already been developed as part of the SUSTAIN modeling:

- Design capital improvement projects
- Construct capital improvement projects
- Maintain capital improvement projects
- Replace capital improvement projects
- Acquire privately-owned parcels

Program Size

For the planning level cost evaluation, our team evaluated two program sizes for the Regional Stormwater Treatment Program:

- **Small:** \$200M Package from SUSTAIN results reflecting 30-year life cycle costs
- **Large:** \$1.8B Package representing the “knee” of the cost-effectiveness curve from SUSTAIN results reflecting 30-year life cycle costs

Applicable Program Delivery Models

The following program delivery models were selected for evaluation for the Roadway Stormwater Treatment Program:

Model 1: Capital Program

- Model 1.1: County led
- Model 1.2: County led with consultant support

Model 3: Public-Private Partnership

- Model 3.1: County led; design-build by landowner (medium-large scale; often multiple project sites)
- Model 3.2: Community Based Public-Private Partnership (CBP3)

Table 4 provides a summary of the Regional Stormwater Treatment Program description, the numbers and types of Actions included in the small and large scale programs, and the planning level cost estimates for different Program delivery models.

Table 4. Regional Stormwater Treatment Program.												
Program Description and Cost Components	Short Program Description			Program Cost Components					SUSTAIN Lifecycle Cost Components		Combined Program and SUSTAIN Lifecycle Cost Components	
				Program Development		Ongoing Program Implementation			Ongoing BMP Implementation			
	The Regional Stormwater Treatment Program would fund, plan, and implement capital improvement projects to construct regional stormwater treatment facilities to treat stormwater runoff from large subbasins. The Program would be administered by King County in partnership with cities and the Washington State Department of Transportation (WSDOT).	Direct labor and overhead and material costs for staff to:	● Implement a County-wide planning effort to identify and prioritize best retrofit opportunities ● Conduct outreach to cities and WSDOT to form partnerships ● Develop interagency agreements for implementation and maintenance ● Develop outreach materials for private parcel owners	Direct labor and overhead and material costs for staff to:	● Continue to identify and prioritize best retrofit opportunities ● Coordinate with cities and WSDOT ● Continue to develop interagency agreements for implementation and maintenance ● Conduct outreach to private parcel owners	Direct labor and overhead and material costs for staff to:	● Design capital improvement projects ● Construct capital improvement projects ● Maintain capital improvement projects ● Replace capital improvement projects ● Acquire privately-owned parcels	Includes Program Development, Ongoing Program Implementation, and Ongoing BMP Implementation				
Program Delivery Model and Planning Level Program Implementation Costs	Scale	Description of Actions Included	Model	Applicable Program Delivery Models	Program Development		Ongoing Program Implementation			Ongoing BMP Implementation	Program + SUSTAIN	
					Initial Cost (including staff) ^a	County Staff	Initial Cost (including staff) ^a	County Staff	County Staff	Approximate Annual Cost ^b	Total 30-Year Lifecycle Cost ^d	
	Small	26 regional facilities: 3.05 acres of private regional 0.238 acres of small public regional 0.232 acres of private regional draining to small public regional	1. Capital Program	7.1: County led	\$300,000	2 FTE	\$160,000	\$184,615	\$3M	1 FTE	\$6.7M	\$203M
				7.2: County led with consultant support (25%)	\$308,000	1.5 FTE	\$164,500	\$189,808	\$3M	0.8 FTE		\$203M
	Large	238 regional facilities: 25.68 acres of private regional 2.88 acres of large public regional 2.33 acres of small public regional 1.53 acres of private regional draining to small public regional	1. Capital Program	7.1: County led	\$450,000	3 FTE	\$320,000	\$40,336	\$7M	2 FTE	\$59.8M	\$1.8B
				7.2: County led with consultant support (75%)	\$461,500	2.3 FTE	\$328,000	\$41,345	\$7M	1.5 FTE		\$1.9B
		3. Public-Private Partnership	3.1: County led, design-build by landowner	\$450,000	3 FTE	\$210,000	\$26,471	\$4M	0.5 FTE			\$1.8B
			3.2: Community Based Public-Private Partnership (CBP3)	\$450,000	3 FTE	\$187,500	\$23,634	\$4M	0.5 FTE			\$1.8B

^a Initial cost is based on 2023 dollars.^b The 30-year lifecycle cost was divided evenly among 30 years. Actual costs may be higher or lower each year than what is presented here for the initial planning level cost estimates.^c Total 30-year cost is based on 2023 dollars. A 3% labor cost escalation and 5.25% discount rate was incorporated into these initial planning level cost estimates.^d Small Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington \$200M Package.

Large Program was defined as the SUSTAIN 30-year lifecycle cost for a GSI realistic, sediment optimization, Lake Washington Package selected to represent the "knee" of the cost-effectiveness curve (\$1.8B).

BMP = best management practice

CBP3 = Community Based Public-Private Partnership

FTE = full-time equivalent

UIC = underground injection control

WSDOT = Washington State Department of Transportation

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Summary

This document provides example Program implementation assumptions and planning level costs for three Programs modeled with the WQBE Toolkit. The examples provided assume a program length of 30 years and that the costs are evenly distributed over the 30-year period. When implementing a Program, there may be higher costs initially to get the program started that taper to a lower amount as program maintenance. It should also be noted the 30-year lifecycle costs from SUSTAIN for the Regional Stormwater Treatment Program might be lower than estimated due to expected efficiencies from the Public-Private Partnership implementation model for facility construction and long-term operations and maintenance. These efficiencies should be further explored once information is available from regional implementation of this model (e.g., Seattle's RainCity Partnership Program and Washington Department of Ecology's Stormwater Community-Based Public-Private Partnership Program). Attachment A summarizes the QAQC completed for the estimated costs.

References

Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 Action and Program Factsheet Development (431-TM1). Prepared for King County Water and Land Resources Division by Herrera Environmental Consultants. May 2.

Paradigm and Herrera. 2022. Water Quality Benefits Evaluation – Phase 2 SUSTAIN Model Development (821-TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. December 22.

Attachment A

QAQC Form

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FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

PROJECT INFORMATION	
Project Name:	King County Water Quality Benefits Evaluation (WQBE)
Project #:	1136613
Subtask:	Subtask 439 - Flow Control Action and Program Development
Contact:	Carly Greyell (carly.greyell@kingcounty.gov)

DOCUMENT INFORMATION		
Title:	WQBE_Program_Costs_DRAFT_v3_20240119	
Created by:	Herrera	
Contact:	Rebecca Dugopolski (rdugopolski@herrerainc.com)	
Type:	Spreadsheet	
Date:	2/16/2024	
Purpose:	<p>Estimate total agency costs to launch and administer a GSI Incentive Program at different scales (small, medium, large), including agency time, potential state/federal grant funding, consultant time, and dollars allocated for project implementation.</p> <p>The point of comparison for the WQBE GSI Incentive Program was the SFPUC GI Grant Program, which was launched in 2018 with first awards (max \$2M/project) in 2019.</p>	
REVIEWERS	Reviewer #1	Reviewer #2
Name:	Robert Dusenbury (RD)	
Company:	Lotus Water	
Title:	Senior QA/QC Reviewer	
Review Date:	2/2/2024	
Email:	rdusenbury@lotuswater.com	

Comment Type Category:
G - General
T - Technical
E - Editorial
C - Coordination

RESPONDER	
Name:	Olivia Wright
Company/Agency:	Herrera
Title:	Senior Engineer
Response Date:	6/7/2024
Email:	owright@herrerainc.com

Response Code:
1 - Accepted - Will comply
2 - Accepted - Action completed
3 - Discussion or clarification required
4 - Unacceptable for reasons given

Comment Status Code:
1 - Resolved
2 - Resolution pending
3 - Unresolved
4 - Rolled over to next submittal

Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
1	RD	G	Agency costs are in the same ballpark as those seen by SFPUC for their GI Grant Program, although WQBE estimates are a bit higher nominally. This is mainly because PUC has seen a ramp-up period over the first 5 years where the # of active projects takes some time to reach its plateau. SFPUC costs are estimated as a step function with ~\$100K/yr to run the program + \$20K/project for technical assistance.	OW	1	Noted with no action required.	JL	1

FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

PROJECT INFORMATION	
Project Name:	King County Water Quality Benefits Evaluation (WQBE)
Project #:	1136613
Subtask:	Subtask 439 - Flow Control Action and Program Development
Contact:	Carly Greyell (carly.greyell@kingcounty.gov)

DOCUMENT INFORMATION	
Title:	WQBE_Program_Costs_DRAFT_v3_20240119
Created by:	Herrera
Contact:	Rebecca Dugopolski (rdugopolski@herrerainc.com)
Type:	Spreadsheet
Date:	2/16/2024
Purpose:	Estimate total agency costs to launch and administer a GSI Incentive Program at different scales (small, medium, large), including agency time, potential state/federal grant funding, consultant time, and dollars allocated for project implementation. The point of comparison for the WQBE GSI Incentive Program was the SFPUC GI Grant Program, which was launched in 2018 with first awards (max \$2M/project) in 2019.

REVIEWERS	Reviewer #1	Reviewer #2
Name:	Robert Dusenbury (RD)	
Company:	Lotus Water	
Title:	Senior QA/QC Reviewer	
Review Date:	2/2/2024	
Email:	rdusenbury@lotuswater.com	

Comment Type Category:
G - General
T - Technical
E - Editorial
C - Coordination

RESPONDER	
Name:	Olivia Wright
Company/Agency:	Herrera
Title:	Senior Engineer
Response Date:	6/7/2024
Email:	owright@herrerainc.com

Response Code:
1 - Accepted - Will comply
2 - Accepted - Action completed
3 - Discussion or clarification required
4 - Unacceptable for reasons given

Comment Status Code:
1 - Resolved
2 - Resolution pending
3 - Unresolved
4 - Rolled over to next submittal

Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
2	RD	G	SFPUC's LOE to develop and launch their program was closer to 1 annual FTE (I don't think they captured legal costs). Ongoing costs to manage the program have been ~1 FTE, plus a consultant for technical program support. Consultant support appears to be leveling around 1 FTE as the program matures and more projects are active. Contactor training for GSI was done separately. So, a total of 2 FTE for small program seems right.	OW	1	Noted with no action required.	JL	1
3	RD	G	Over the past 4 years, SFPUC's total implementation costs have been 15% of total program cost (~\$250/yr), but that percentage has been dropping and is targeted for ~half of that (~7.5% right there with WQBE projections) as more projects become eligible for reimbursement of construction costs (i.e., payments to grantees go up a lot while internal costs increase marginally).	OW	1	Noted with no action required.	JL	1

FORM WQBE QC-1: TECHNICAL REVIEW COMMENTS

PROJECT INFORMATION	
Project Name:	King County Water Quality Benefits Evaluation (WQBE)
Project #:	1136613
Subtask:	Subtask 439 - Flow Control Action and Program Development
Contact:	Carly Greyell (carly.greyell@kingcounty.gov)

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Title:	WQBE_Program_Costs_DRAFT_v3_20240119	
Created by:	Herrera	
Contact:	Rebecca Dugopolski (rdugopolski@herrerainc.com)	
Type:	Spreadsheet	
Date:	2/16/2024	
Purpose:	<p>Estimate total agency costs to launch and administer a GSI Incentive Program at different scales (small, medium, large), including agency time, potential state/federal grant funding, consultant time, and dollars allocated for project implementation.</p> <p>The point of comparison for the WQBE GSI Incentive Program was the SFPUC GI Grant Program, which was launched in 2018 with first awards (max \$2M/project) in 2019.</p>	
REVIEWERS	Reviewer #1	Reviewer #2
Name:	Robert Dusenbury (RD)	
Company:	Lotus Water	
Title:	Senior QA/QC Reviewer	
Review Date:	2/2/2024	
Email:	rdusenbury@lotuswater.com	

Comment Type Category:
G - General
T - Technical
E - Editorial
C - Coordination

RESPONDER	
Name:	Olivia Wright
Company/Agency:	Herrera
Title:	Senior Engineer
Response Date:	6/7/2024
Email:	owright@herrerainc.com

Response Code:
1 - Accepted - Will comply
2 - Accepted - Action completed
3 - Discussion or clarification required
4 - Unacceptable for reasons given

Comment Status Code:
1 - Resolved
2 - Resolution pending
3 - Unresolved
4 - Rolled over to next submittal

Comment No.	Reviewer	Comment Type	Review Comment	Responder	Response Code	Response Comment	Verifier	Comment Status Code
4	RD	G	Agency costs vary depending on how they roll out their programs (e.g., how much technical support they offer, # of facility inspections).	OW	1	Noted with no action required.	JL	1
5	RD	G	Recommend accounting for a 5-yr horizon from launch to maturity. During this time, agency costs may rise incrementally with the # of active projects, but the \$\$ given to projects may increase several fold.	OW	4	Costs are planning level estimates and reflect an initial Program development cost followed by annual ongoing Program implementation costs. It is recommended that the County consider reviewer comment when developing Programs in the future.	JL	1
6	RD	G	Recommend lowering Implementation costs for the Large program to ~6.5% of overall program costs. The only real oddity I see in the spreadsheet is in comparing implementation costs as a % of overall program costs across the 3 scales. You would expect that to drop from Small to Medium to Large. It does drop from Small to Medium, but then increases from Medium to Large.	OW	1	The large program (package with max reduction) was removed from the analysis based on input from County. The medium program is renamed to the large program.	JL	1

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