Town of Lyons Stormwater Masterplan

ICON Engineering, Inc.

November 2016

Contents

1.0 Introduction

1.1 Authorization

This report was authorized by the Town of Lyons in the Disaster Recovery Services Agreement of February 16, 2016. A fully executed agreement was received by ICON Engineering Inc. on March 28, 2016. This study was supported by the grant funding from the Community Development Block Grant Disaster Recovery program.

1.2 Purpose and Scope

Stormwater Master Plans are commonly used by local and regional governments in a manner similar to land use, parks, or other master plans. These plans become part of the local community's comprehensive and capital improvement plans. Stormwater master plans help community leaders, planners, and engineers work with developers and private land owners. Stormwater drainage is unaffected by administrative or paper boundaries and a stormwater master plan helps all parties understand the natural conditions, constraints, and opportunities to manage stormwater in a safe, compliant, and sustainable manner. Like most master plans, this report provides the Town a starting point for ensuring the public safety and welfare of its citizens, businesses, and visitors.

The purpose of this study is to develop a comprehensive stormwater master plan for the Town of Lyons. The focus of the study is to:

- Quantify stormwater runoff and quantity
- Identify potential flood hazards and problem areas for subbasins tributary to North St. Vrain Creek, South St. Vrain Creek, and St. Vrain Creek, as they flow through the Town
- Identify and prioritize capital improvement projects to reduce flood frequency and flood risk
- Recommended improvement to enhance water quality and meet other sustainable objectives
- Provide a guide for increasing stormwater resilience within the Town of Lyons.

The original drainage master plan for the Town of Lyons was completed by BRW, Inc. in 1998. This study will provide and update to the 1998 plan. Today, the Town has grown beyond the limits of the 1998 study. Furthermore, updates to the means and methods of engineering analysis provide additional information to determine risk and benefits. This Stormwater Master Plan utilizes current topographic, property, and engineering data collected between 2013 and 2016. Like its predecessor, this report is likely to serve the community for many years to come.

This study initially identified and inventoried stormwater infrastructure throughout town. A geospatial database of over 250 features was collected and is being incorporated into the Town's larger GIS inventory. From that point, hydrologic analysis was completed to determine the range of stormwater runoff from each of the Town's drainage basins. A hydraulic analysis used the stormwater runoff values to model how the surface waters drained through town. The existing storm sewer system was evaluated to determine how capture and conveyance systems operated during the various design storms. The resulting flood depth maps were used to identify or confirm problem areas and structures at risk of flood damages. Alternative solutions to mitigate the potential damages were developed. Each alternative was considered for resulting benefits (i.e. averted damages) and costs. A recommended plan was developed to guide the town through future infrastructure, land use, and stormwater management decisions. Additional information was developed for System Maintenance, Storm Water Utility, Adjacent Watersheds, and Water Quality.

The following is a summary of the scope of work completed for the Town of Lyons Storm Drainage Master Planning study:

- Data Collection and Review
- Field inventory of existing stormwater features
- Baseline Hydrology and Hydraulics
  - Document rainfall using NOAA Atlas 14
  - Develop a basin-wide two-dimensional hydrodynamic model to estimate general flow paths within the watershed.
  - Define individual subwatershed boundaries
  - Develop hydrologic models for the 2-, 5-, 10-, 50-, and 100-year return period storms subject to the following guidelines:
    * Use the Colorado Urban Hydrograph Procedure (CUHP) to generate basin runoff hydrographs
    * Use the Environment Protection Agency Storm Water Management Model (EPA SWMM) to route the individual hydrographs
    * Evaluate the performance of existing storm drain infrastructure 24 inches or greater in size

  - Evaluate hydrologic condition for 120% of the 100-year return period
  - Identify residual flood potential within the basin using a two-dimensional hydrodynamic model, such as FLO-2D

- Alternatives Analysis

  - Identify existing and future potential drainage and water quality problems along tributary paths to North St. Vrain Creek, South St. Vrain Creek, and St. Vrain Creek, as they flow through the Town
  - Develop and evaluate alternative plans on an outfall-by-outfall basis to reduce flooding potential on insurable structures and to provide water quality treatment
  - Estimate benefits of flood reduction

- Capital Improvements Plan

  - Development of a recommended approach to stormwater management within the Town Limits
  - Identify a Phasing and Prioritization Plan for improvements

1.3 Mapping and Survey

One foot interval contours were generated from LiDAR project mapping. Project mapping was based on Federal Emergency Management Agency (FEMA) 2013 Post-flood LiDAR mapping with the following attributes and is equivalent to 1-foot contour interval topographic mapping:

Name: 2013 South Platte River Flood Area 1
Collection Date: Fall 2013 – Spring 2014
Vertical Accuracy: 9.25 cm RMSE
Point Spacing: 0.7 m
Vertical Datum: NAVD88
Horizontal Datum: NAD83

Survey data at existing storm drains and sewers were collected by ICON Engineering and associated sub-consultants as part of this contract. All survey was also gathered on NAD83 horizontal datum and the NAVD88 vertical datum.

An inventory of existing storm sewer infrastructure was completed between May and July 2016. A photo, description, condition, and location of each structure was recorded in the field and stored in a geospatial database. The geospatial data has been utilized within the Town's larger GIS database. A link to the online repository for the data is available for review: Appendix K. This online repository link will expire in the near future, but the data is preserved in perpetuity through the Town's GIS database.

1.4 Data Collection

A summary of reports reviewed alongside the preparation of this report are presented below:

Table 1-1: Data Collected

Document Title	Date	Author
Town of Lyons, Boulder County, Colorado, Drainage Master Plan Final Report	April 1998	BRW, Inc.
Zoning District Map of the Town of Lyons, Colorado	January 2009	King Surveyors, Inc.
2010 Lyons Planning Area Map	2010	Civil Resources
Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual		UDFCD

1.5 Data Delivery

This report is produced for the Town in a variety of formats. Hardcopy reports are provided to the Town as interim and final deliverables. A web based version of the entire report and appendices are provided to the Town for integration into the Town web portal. A downloadable PDF is also available from the web link version. And, the supporting map information is provided on a web-based mapping program that can be hosted on the Town's website now and in the future.

GIS data collected during the stormwater inventory was transferred to the town in September 2016 to complement the separate GIS database project undertaken by the town.

2.0 Study Area Description

2.1 Project Area

The project area includes the subbasins tributary to the North Saint Vrain Creek, South Saint Vrain Creek, Red Hill Gulch, and Stone Canyon within the Town of Lyons. The total drainage area studied is approximately 8.6 square miles.

Existing drainage in the Town reflects open channel drainageways in combination with storm sewer conveyance for more urbanized areas. Most of the Town's existing drainage infrastructure is undersized due to the increase in development within the Town during the 1990s. The existing conveyance system has the capacity to convey nuisance flows, but it does not have the capacity to convey even the minor (5-year) storm events.

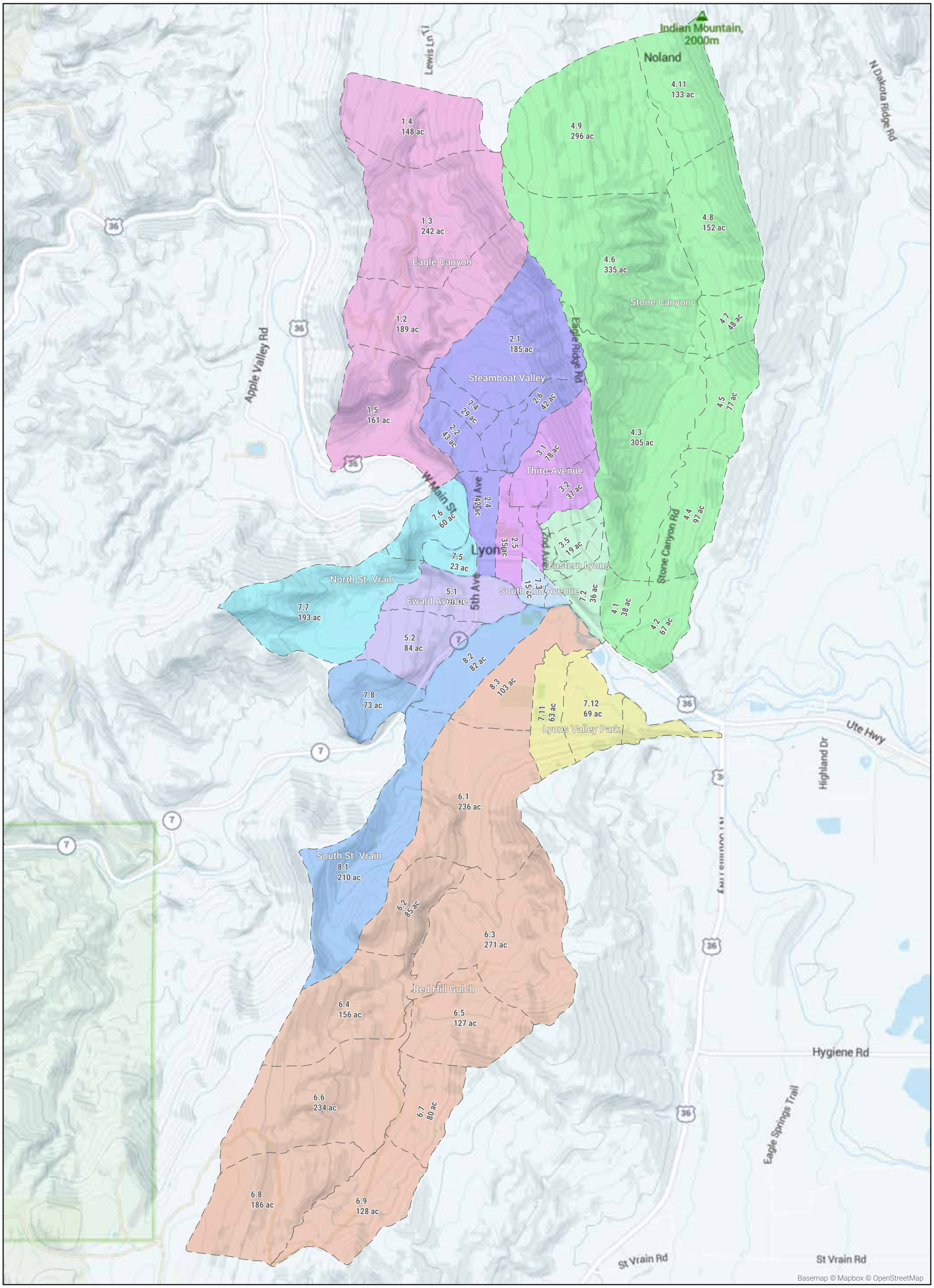
At the time of this report, there are current requests for study and analysis of potential annexation areas adjacent to the current town limits. These areas were identified for study after the completion of the stormwater inventory and hydrologic analysis. However, this study has provided some limited information relative to adjacent areas.

2.2 Land Use

The study area watershed is comprised of a combination of Hydrologic Soil Group (HSG) A, B, C, and D soils as classified by the Natural Resources Conservation Service (NRCS). These soil types are very intermixed with HSG A soils (i.e. soils with increased hydrologic conductivity) covering areas such as downtown locations, and north-south along the eastern basin limits. HSG B soils cover the least area in the watershed, with locations predominately along Saint Vrain Creek, and north and south branches. HSG C soils are represented along a north-south plane, along the easternmost portions of the watershed. Finally, HSG D soils (i.e. soils with the least potential for hydrologic conductivity) represent the greatest are of the watershed and are predominately located towards the northern and western watershed limits, covering rock outcrops and other less permeable sources.

It should be noted that for the study area, the HSG A soils are colluvial land type soil. According to the colluvial land soil description, the depth to restrictive feature is 2 to 60 inches to lithic bedrock. Because of the underlying bedrock, it was assumed that the HSG A soils would have the drainage characteristics of HSG B soils.

Land use was determined by compiling information from the 2009 Zoning District Map, 2010 Lyons Planning Area Map, and by ground-truthing the land cover based on an October 2015 aerial image of the watershed. Each land use category was assigned a percent imperviousness with guidance from Chapter 6 – Runoff of the UDFCD Urban Storm Drainage Criteria Manual. Table 2-1 outlines the land use categories and the corresponding percent imperviousness. In addition to the land use categories found in Table 2-1, Boulder County Open Space land use represented a significant portion of the watershed. Table 2-2 displays the soil types used to calculate imperviousness for the Boulder County Open Space land use category.



Lyons Stormwater Masterplan

Figure 2-1: Watersheds

LYONS COLORADO

ICON ENGINEERING, INC.

Table 2-1: Land Use Description

Land Use Category	UDFCD Equivalent	Imperviousness
Agriculture	Undeveloped: Greenbelts, agricultural	2%
Business	Business: Downtown areas	95%
Park	Parks, cemeteries	10%
Municipal Facilities	Business: Suburban areas	75%
Estate Residential1	Residential: Single Family: 2.5 acres or larger	35%
Low Density Residential1	Residential: Single Family: 0.25-0.75 acres	75%
Medium Density Residential1	Residential: Single Family: 0.75-2.5 acres	85%
Commercial	Business: Downtown areas	95%
Employment Area	Business: Downtown areas	95%
Commercial Entertainment	Business: Downtown areas	95%
Light Industrial	Industrial: Light areas	80%
General Industrial	Industrial: Heavy areas	90%

Table 2-2: Soil Types Found in Boulder County Open Space Land Use Category

Soil Unit	HSG	Soil Type	Drainage Class	Runoff Class	Rock Outcrop	Imperviousness
MdB	A	sandy loam	well	very low		2%
Nh	B	loam	poorly	very low		2%
Cu	A	gravelly sandy loam	excessively	low		5%
NnB	C	sandy clay loam	well	medium		8%
SmF	C	stony loam	well	high	10%	10%
BaF	D	very stony sandy loam	well	very high	10%	10%
PrF	D	very stony loamy fine sand	well	very high	35%	35%
Ro	D	unweathered bedrock	N/A	very high	100%	100%

It should be noted that land use category corresponds to the 2010 Lyons Planning Area Map. However, in some cases, the planning description and corresponding lot size were not representative of what is observed through aerial imagery and field reconnaissance. In these cases, the imperviousness percentages were revised to be more representative of what was observed.

Future imperviousness was determined by comparing the land use in the 2010 Lyons Planning Area Map to current aerial imagery, and noting which areas of the Town could be further developed based on the planning guidance.

2.3 Outfall Descriptions

The study area has been divided into eleven separate outfalls based on their general drainage patterns. A description of each outfall can be found below with an outfall map found in XXX .

2.3.1 Eagle Canyon The Eagle Canyon watershed, with a tributary area of 740 acres, is located west of downtown Lyons. The drainage path for the watershed is a steep mountain channel with an approximate slope between 5% and 35%. The channel flows south turning east near Eagle Canyon Subdivision before draining along the left bank of North St. Vrain Creek. The watershed ranges in elevation from 6670 feet to 5390 feet. The majority of the watershed is undeveloped or large lot residential with the exception of the Eagle Canyon Subdivision. The Eagle Canyon Subdivision drains to the southeast into an existing detention basin before discharging into Eagle Canyon drainage.

2.3.2 Eastern Lyons The Eastern Lyons Watershed is generally bounded by 2nd Avenue to the west and Stone Canyon Watershed to the east. The watershed ranges in elevation from 5850 feet to 5300 feet. The 87 acre watershed conveys flow southwest to the 2nd Avenue and Main Street intersection. An existing storm drain intercepts flow from the new development along

1st Avenue discharging onto the street on 2nd Avenue. Flow within the Eastern Lyons Watershed is conveyed along the east side of 2nd Avenue in a small roadside swale. Any flows exceeding the capacity of this swale that overtop 2nd Avenue have the possibility of spilling into the Third Avenue Watershed. A small, 18-inch, storm drain intercepts minor flows north of Main Street and conveys flow through the shopping center. The storm drain crosses Main Street discharging into an open channel in the South 2nd Avenue Watershed before discharging into St. Vrain Creek.

Eastern Lyons Watershed on First Avenue looking towards downtown

During the course of this study, the Colorado Department of Transportation initiated a roadway and storm drainage improvements along Main Street in the vicinity of 2nd Avenue. The as-built documents were not available at the time of the hydraulic analysis, but an estimated version of the storm drain system in that area was used in the study.

2.3.3 Ewald Ave The Ewald Avenue Watershed originates southwest of the North and South St. Vrain Creek confluence. The 160 acre watershed ranges in elevation from 5875 feet to 5320 feet. Unlike the other major watersheds, the Ewald Avenue Watershed does not have a defined channel flow path. The runoff from this watershed is primarily sheet flow along the steep

hillsides northeast towards the residential developments. The hillside in the upper reaches of the watershed has an approximately slope of 15 percent. In the developed portion of the watershed the slope is approximately six percent. The majority of conveyance is through the residential street with the exception of a 48 inch reinforced concrete storm drain pipe installed along Park Street from 4^{th} Avenue to North St. Vrain Creek.

Ewald Watershed looking east down Prospect Street

2.3.4 Lyons Valley Park Located south of St. Vrain Creek, the Lyons Valley Park Watershed is primarily medium residential lots. The watershed ranges in elevation from 5860 feet to 5260 feet. The runoff from the 210 acre watershed is conveyed northeast through the subdivision to St. Vrain Creek. There is no defined flow path through the watershed as flow is primarily conveyed

down McConnell Drive. There is an 18-inch reinforced concrete storm drain system on Bohn Court, Noland Court, and Estes Court. Curb side combination inlets capture stormwater in these areas. The system is upsized to a 30-inch reinforced concrete pipe at McConnell Drive before the flow is discharged into the St. Vrain Creek.

Lyons Valley Park looking south towards hogback

2.3.5 North St. Vrain The North St. Vrain Creek Watershed is a combination of several subwatersheds that are directly tributary to North St. Vrain Creek. There are both left and right bank tributaries with subwatersheds ranging in size from 20 acres to 190 acres. The watersheds vary in land use including dense residential, commercial, open space, and undeveloped areas.

2.3.6 Red Hill Gulch The Red Hill Gulch Watershed is located on the south side of the St. Vrain Creek ranging in elevation from 6800 feet to 5300 feet. The runoff from this 1560 acre watershed is conveyed in the upper reaches by an open channel with an average slope of 5 to 20 percent. The channel generally follows Red Gulch Road north before flows exit the mountainous terrain and enters a broad alluvial valley. The runoff continues north where flows are intercepted by South Ledge Ditch. Any flows exceeding the capacity of the South Ledge Ditch will overtop the ditch and continue north. Due to the limited capacity of the irrigation ditch, major storm events have the possibility of conveying a large volume of water north into Bohn Park and Lyons Valley Park Subdivision. The average slope of the overflow path downstream of the South Ledge Ditch is approximately two percent.

Headwaters of the Red Hill Gulch Watershed

Red Hill Gulch Watershed exiting the canyons

2.3.7 South St. Vrain The South St. Vrain Creek is a combination of several subwatersheds that are directly tributary to South St. Vrain Creek. These subwatersheds are both left and right bank tributaries to the South St. Vrain Creek ranging in size from 70 acres to 210 acres. The development throughout the watershed varies from undeveloped to large lot residential.

2.3.8 South 2nd Avenue The South 2nd Avenue Watershed is bounded by 3rd Avenue to the west, Main Street to the north and east and the St. Vrain Creek to the south. The approximately 20 acre watershed drains southeast ranging in elevation from 5360 feet to 5310 feet. A combination 24-inch storm drain and open channel system conveys flow along the south side of Main Street discharging into St. Vrain Creek. An 18-inch storm drain conveys flow south from the Park Street and 2nd Avenue intersection into St. Vrain Creek.

2.3.9 Steamboat Valley The Steamboat Valley watershed is located directly north of downtown, bounded by the Eagle Canyon Watershed to the west and to the east by the Third Avenue and Stone Canyon Watersheds. The majority of the 370 acre watershed converges just upstream of downtown and is conveyed between 4th and 5th Avenue. In the upper reaches, the watershed consists of

large lot residential and undeveloped properties. The lower third of the watershed is fully developed consisting of residential and commercial lots. In the lower downtown area the watershed is bounded by 4th Avenue to the east and North St. Vrain Creek to the west. The watershed ranges in elevation from 6520 feet to 5335 feet.

Steamboat Valley upstream of Vasquez Road

The flow concentrates in the upper reaches in an open channel with an approximate slope of 16 percent. The flow continues south into a private inadvertent storage area on the Russell property upstream of the old railroad embankment. Downstream of the railroad embankment the drainageway is confined in a small open channel that conveys flow

through backyards of private property. There are several roadway crossings within this reach including Vasquez Road, McCall Alley, Reese Avenue, Steward Avenue, and Stickney Avenue. A reportedly historic stone box culvert intercepts flow and conveys flow underneath downtown until the outfall location into North St. Vrain Creek. The slope is approximately four percent downstream of the railroad embankment.

Steamboat Valley downstream of Vasquez Road

An 18-inch reinforced concrete storm drain pipe collects flow along 5th Street south of Main Street to Park Drive. This pipe increases in size just downstream of Park Drive to a 28-inch by 16-inch reinforced concrete elliptical pipe before discharging to North

St. Vrain Creek.

Along 4th Avenue an 18-inch reinforced concrete storm drain pipe intercepts flow at Stickney Avenue and conveys the flow south to Railroad Avenue. At Railroad Avenue the storm drain increases in size to a 24-inch reinforced concrete storm drain pipe continuing south to the outfall location into North St. Vrain Creek.

Steamboat Valley downstream of Seward Avenue

2.3.10 Stone Canyon The Stone Canyon Watershed is located east of the Third Avenue and Eastern Lyons Watersheds. In the upper reaches, the 1550 acre watershed is dominated by large residential and undeveloped properties. The open channel which conveys the majority of the runoff for the Stone Canyon watershed has an average slope of approximately four percent. The

watershed ranges in elevation from 6580 feet to 5294 feet.

Stone Canyon upstream of Stone Canyon Road

The open channel drainageway passes through multiple roadway crossings within Boulder County. Within the Town of Lyons, Stone Canyon is conveyed underneath Stone Canyon Road through a 13 foot by 8 foot reinforced concrete box culvert. The drainage path continues south where flow is conveyed underneath Ute Highway through an 8 foot by 4 foot reinforced concrete box culvert into St. Vrain Creek.

2.3.11 Third Avenue The Third Avenue watershed, approximately 170 acres, conveys flow southwest into the downtown area along Third Avenue. The watershed is undeveloped upstream of the downtown area bounded by Steamboat Valley to the west and Eastern Lyons and Stone Canyon. The watershed ranges in elevation from 6260 feet to 5320 feet. Development within the lower

portions of the watershed is dominated by residential and commercial development. The watershed discharges flow into North St. Vrain Creek just upstream of the confluence with South St. Vrain Creek.

Third Avenue downstream towards Main Street

An existing 5 foot x 4 foot elliptical pipe conveys flow underneath Main Street at Third Avenue into the South 2nd Avenue Watershed.

3.0 Hydrologic Analysis

3.1 Overview

For this study, a new hydrologic model was prepared for the Town of Lyons. This purpose of this model was to develop updated hydrology for the 2-, 5-, 10-, 50-, and 100-year storm frequencies for both existing and future imperviousness. Similar to the 1998 BRW study, the UDFCD's Colorado Urban Hydrograph Procedure (CUHP) was used to develop runoff hydrographs for each sub-basin in the study. However, with the recent release of CUHP v2.0 by the UDFCD, and that Lyons is located outside of the UDFCD boundary, further investigations were made to confirm the applicability of the new CUHP software in comparison to other hydrologic methods. The selection of the hydrologic model is discussed below.

A full copy of the Hydrologic study is provided in *Appendix B.*

3.2 Hydrologic Model

To evaluate the latest version of CUHP (and other hydrologic methods) and to determine the appropriate model inputs, a peak flow sensitivity analysis was conducted for a typical undeveloped sub-basin near the Town, using various hydrologic techniques. The following lists the hydrologic methods that were reviewed in the sensitivity analysis:

- United States Geologic Survey (USGS) Regional Regression Equations.
- Rational Method.
- CUHP 2005 Version 1.4.4 – This is the more recent model used by UDFCD (prior to the recent update) and has been used for over 40 years to estimate peak flows in the Denver metropolitan area and front range.
- CUHP Version 2.0 – Recently the UDFCD has determined that peak flows developed in recent hydrologic studies using CUHP 2005 version 1.4.4 deviated from statistical stream gage analysis across the District and created uncertainty with CUHP model results for some studies. Additionally, CUHP 2005 version 1.4.4 has not been calibrated with gage data since its inception in the 1970s with adjustments made in the 1980s. Therefore, UDFCD has recalibrated CUHP with updated rainfall and runoff with results tested against stream gage frequency analysis. However, it should be noted that during the recalibration of CUHP, there were no watersheds with an imperviousness less than 20 percent. Therefore, for sub-basins with imperviousness below 20 percent, the peak flows are estimated using similar methodology used in CUHP 2005 version 1.4.4.
- HEC-HMS Model - using Curve Number method.
- UDFCD Allowable Release Rates – The UDFCD Urban Storm Drainage Criteria Manual, Volume 2, Storage chapter provides predevelopment peak unit discharge rates for watersheds of various

slopes and Hydrologic Soil Groups (HSGs) that are utilized to determine the maximum allowable 100-year release rates for a full spectrum detention facility.

Based on the results of the undeveloped sub-basin peak flow sensitivity analysis, CUHP version 2.0 was recommended for the hydrologic modeling for the Lyons storm drainage master plan. The unit rates of runoff from CUHP version 2.0 were generally in the same range as those generated using the Rational Method, in addition to the UDFCD allowable release rates. The unit rates of runoff generated using CUHP 2005 version 1.4.4 were higher than any of the other hydrologic methods which potentially would overestimate the peak flows for the Town. The regional regression equations significantly underestimated the unit rates of runoff when compared to the other hydrologic model methods. Further documentation on the hydrologic model recommendations can be found in Appendix B.

3.3 Design Rainfall

The design rainfall for the project was derived using the one-hour precipitation depths from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. One-hour point precipitation depths were based on the centroid of the entire project area and were recorded for the 2-, 5-, 10-, 50-, and 100-year recurrence intervals. Point precipitation depths for varying elevation within the project area were identified, but point precipitation depth adjustments due to elevation were not necessary since the difference in the one-hour precipitation depths by elevation was less than 0.1 inches. Using the one-hour precipitation depth, CUHP calculates the incremental depth for each time increment from 5 to 120 minutes. Due to the smaller sizes of sub-basins, precipitation depth-area reduction factors were not utilized. Table 3-1 summarizes the design rainfall depths for various recurrence intervals.

Table 3-1: 1-hr Rainfall Depth

Return Period	1-Hr Rainfall Depth (in)
2-yr	0.77
5-yr	1.05
10-yr	1.33
50-yr	2.23
100-yr	2.71

3.4 Sub-basin Characteristics

Sub-basin characteristics for each basin are further described below and can be found in *Appendix A*.

3.4.1 Sub-basin Delineation Sub-basins were delineated using the 2011 LIDAR and associated 1-ft contours. There is a total of 44 sub-basins within the project area. The undeveloped sub-basins located higher up in the watersheds are larger in size than the sub-basins within the urbanized Town. Sub-basin sizes range from 17 acres to 335 acres. *Appendix A* provides an overview of the sub-basins.

3.4.2 Length, Centroid Distance, Slope CUHP parameters such as sub-basin length, distance to centroid, and slopes were derived for each sub-basin using topographic data. Slopes were computed using the length-weighted, corrected average slope from UDFCD's Urban Storm Drainage Criteria Manual (USDCM), including corrections for stream and vegetated channels.

3.4.3 Depression Losses The maximum pervious depression storage was set to the recommended value of 0.4 inches for wooded areas and open fields. The maximum impervious depression storage was set to the recommended value of 0.1 inches. No adjustments were made to these recommended values.

3.4.4 Infiltration Soils data was obtained from USDA NRCS Soil Survey Geographic Database for the project area which classified the soils into Hydrologic Soils Groups (HSGs). Additional soils mapping was obtained from the USDA NRCS Web Soil Survey. This information is provided in Appendix B.

The initial rate, final rate, and decay coefficient for the Horton's infiltration parameters were based on the recommended values in the USDCM. The Horton's infiltration parameters were weighted based on the percentage of each soil type within each sub-basin. Table 3-2 summarizes the Horton's infiltration parameters utilized in the analysis.

3.4.5 CUHP Output The hydrologic analysis was conducted for both existing conditions and future conditions land use. The 100-year peak discharges from CUHP v2.0 for both conditions are presented in Table 3-3. CUHP output for other recurrence intervals is provided in Appendix B.

Although this hydrologic analysis did not calibrate peak flows to the previous Town of Lyons Drainage Master Plan Final Report prepared by BRW, the CUHP unit rates of runoff were compared with

Table 3-2: 1-hr Rainfall Depth

Hydrologic Soil Group	Infiltration (inches per hour) Initial - fi	Final - fo	Decay Coefficient
A/B	4.5	0.6	0.0018
C	3.0	0.5	0.0018
D	3.0	0.5	0.0018

the previous study unit rates of runoff for sub-basins that were similarly delineated. In some cases, the unit rates of runoff are similar, but there are cases where the unit rates of runoff differ. These differences are primarily due to physical differences in input assumptions (imperviousness, HSGs, etc.).

3.5 Hydrograph Routing

A hydrograph routing network was developed based on field reconnaissance, survey of the existing storm sewer network within Town, and the BRW, Inc. drainage master plan using EPA SWMM. The routing network in EPA SWMM includes: nodes (junctions and dividers), conduits (including overflow or diverted links), storage units, storage outlets, and outfalls. The model input parameters for nodes include: node identifier, invert elevation, maximum node depth, and overflow or diverted link identifier. Input parameters for conduits include: conduit identifier, upstream and downstream node identifiers, shape (e.g. trapezoidal, circular, rectangular, etc.), length, bottom width, side slopes, roughness coefficient, number of barrels, and inlet/outlet offset depths. Input parameters for storage units include: storage unit identifier, invert elevation, maximum depth, and a stage-area relationship. Input parameters for storage outlets include: outlet identifier, upstream and downstream node identifiers, and a stage-discharge relationship. Input parameters for outfalls include the outfall identifier and invert elevation. Input parameters for the SWMM model are provided in Appendix B.

3.5.1 SWMM Node Input Parameters Node identifiers in SWMM are synonymous with the sub-basin IDs. Invert elevations were determined using the 2011 LIDAR data. In some instances, a divider was used to allow the flow to be routed through the existing storm sewer system but when the capacity of the storm sewer is exceeded, the water overflows into the street (along 2nd Avenue south of E. Main Street and near the intersection of Main Street and E. Main Street).

Table 3-3: CUHP Output, 100-Year

Subbasin	Existing Conditions 100-Year Peak Discharge (cfs)	Existing Conditions Unit Rate of Runoff (cfs/ac)	Future Conditions 100-Year Peak Discharge (cfs)	Future Conditions Unit Rate of Runoff (cfs/ac)
1.2	408	2.16	408	2.16
1.3	534	2.21	534	2.21
1.4	403	2.72	403	2.72
1.5	449	2.79	449	2.79
2.1	306	1.65	306	1.65
2.2	97	2.27	97	2.27
2.3	59	2.55	59	2.55
2.4	116	2.61	116	2.61
2.5	102	2.89	102	2.89
2.6	54	1.29	54	1.29
3.1	142	1.83	167	2.15
3.2	92	2.49	92	2.49
3.3	21	3.68	21	3.68
3.4	52	3.05	52	3.05
3.5	32	1.64	32	1.64
3.6	20	1.34	20	1.34
3.7	12	4.55	12	4.55
3.8	31	2.18	31	2.18
4.1	102	2.66	128	3.32
4.1	183	1.38	183	1.38
4.2	113	1.69	114	1.70
4.3	386	1.27	386	1.27
4.4	128	1.32	128	1.32
4.5	117	1.52	117	1.52
4.6	526	1.57	526	1.57
4.7	70	1.47	70	1.47
4.8	227	1.49	227	1.49
4.9	575	1.94	575	1.94
5.1	171	2.19	208	2.67
5.2	194	2.33	194	2.33
6.1	387	1.64	393	1.67
6.2	187	2.18	187	2.19
6.3	370	1.37	370	1.37
6.4	186	1.19	186	1.19
6.5	213	1.68	213	1.68
6.6	233	1.00	233	1.00
6.7	176	2.21	176	2.21
6.8	252	1.35	252	1.35
6.9	216	1.69	216	1.69
7.1	25	0.97	28	1.09
7.1	161	2.55	161	2.55
7.1	199	2.86	234	3.37
7.2	70	1.94	70	1.94
7.3	50	3.29	50	3.29
7.4	69	2.37	69	2.37
7.5	26	1.16	26	1.16
7.6	134	2.25	134	2.25
7.7	359	1.86	359	1.86
7.8	144	1.97	145	1.99
7.9	24	3.66	24	3.66
8.1	315	1.50	315	1.50
8.2	93	1.13	93	1.13
8.3	136	1.32	136	1.32

3.5.2 SWMM Conduit Input Parameters For the drainage basins located outside of Town, transects of the drainage channels were generated using the 2011 LIDAR and a representative channel cross-section was input into the SWMM model. The manning's roughness coefficient for these undeveloped drainage basins was estimated to be 0.035 to represent channels with some weeds and stones.

Within the developed areas, characteristics of the drainage facilities were based on survey of the existing storm sewer system, field reconnaissance, and sizing the channels so that the flow could adequately be conveyed to the outfall. Between 5th Avenue and 4th Avenue, there is an existing drainage ditch that varies in width and depth but is enclosed downstream to accommodate development over the ditch. For the purposes of the SWMM model, it was assumed to have a uniform width and depth. There is a small roadside swale with intermittent driveway and roadway culverts along the west side of 3rd Avenue. However, the swale and culverts have such limited capacity and during large storm events, the water would flow down 3rd Avenue. At 3rd Avenue and Main Street there is a 30" reinforced concrete pipe that diverts flow from 3rd Avenue to the southeast along E. Main Street. During large storm events, the flow continues down within E. Main Street, which was modeled as an open channel, until it discharges into the St. Vrain Creek. South of E. Main Street along 2nd Avenue there is a storm sewer system consisting of 18-inch, 12-inch, and 15-inch corrugated metal pipe which discharges into the St. Vrain Creek. This storm sewer system was modeled as a 12-inch pipe in the SWMM model.

There are many sub-basins which are direct flow areas into the North St. Vrain Creek, South St. Vrain Creek, or St. Vrain Creek. Therefore, the conduits for these sub-basins were modeled as "dummy" conduits.

3.5.3 SWMM Storage Input Parameters An existing detention pond is located within Sub-basin 1.5. The stage-area relationship was taken directly from the BRW, Inc. drainage master plan, as well as the stage-discharge relationship for the outlet. No additional detention ponds were modeled for the existing conditions, although inadvertent storage and/or privately owned detention may elsewhere within the project area.

3.5.4 SWMM Output The SWMM routing was conducted for both existing conditions and future conditions. The 100-year peak discharges at all of the outfalls from the SWMM model for both conditions are presented in Table 3-4. SWMM output for other recurrence intervals is provided in *Appendix J.*

Table 3-4: SWMM Output, 100-Year

SWMM Outfall Name	Routed Sub-basins	Receiving Water	Existing Conditions 100-Year Peak Discharge (cfs)	Future Conditions 100-Year Peak Discharge (cfs)
StoneCanyonSt.VrainOUT	4.9, 4.11, 4.6, 4.8, 4.7, 4.3, 4.5, 4.4, 4.1, 4.2	St. Vrain Creek	2356	2361
EagleCanyonN.St.VrainOUT	1.4, 1.3, 1.2, 1.5	North St. Vrain Creek	1716	1716
RedHillGulchS.St.VrainOUT	6.8, 6.9, 6.6, 6.7, 6.4, 6.5, 6.2, 6.3, 6.1	South St. Vrain Creek	2198	2203
Sub2.4N.St.VrainOUT	2.1, 2.2, 7.4, 2.3, 2.4	North St. Vrain Creek	682	682
Sub7.2St.VrainOUT	3.1, 3.2, 2.5, 3.4, 3.3, 7.2	St. Vrain Creek	581	611
Sub7.3St.VrainOUT	7.3	St. Vrain Creek	50	50
Sub7.7N.St.VrainOUT	7.7	North St. Vrain Creek	359	359
Sub7.8S.St.VrainOUT	7.8	South St.Vrain Creek	144	145
Sub5.1N.St.VrainOUT	5.1	North St. Vrain Creek	171	208
Sub7.5N.St.VrainOUT	7.5	North St. Vrain Creek	26	26
Sub8.2St.VrainOUT	8.2	St. Vrain Creek	407	407
Sub7.1St.VrainOUT	7.1	St. Vrain Creek	378	414
Sub7.6N.St.VrainOUT	7.6	North St. Vrain Creek	134	134

Figure 3.1: SWMM Hydrographs

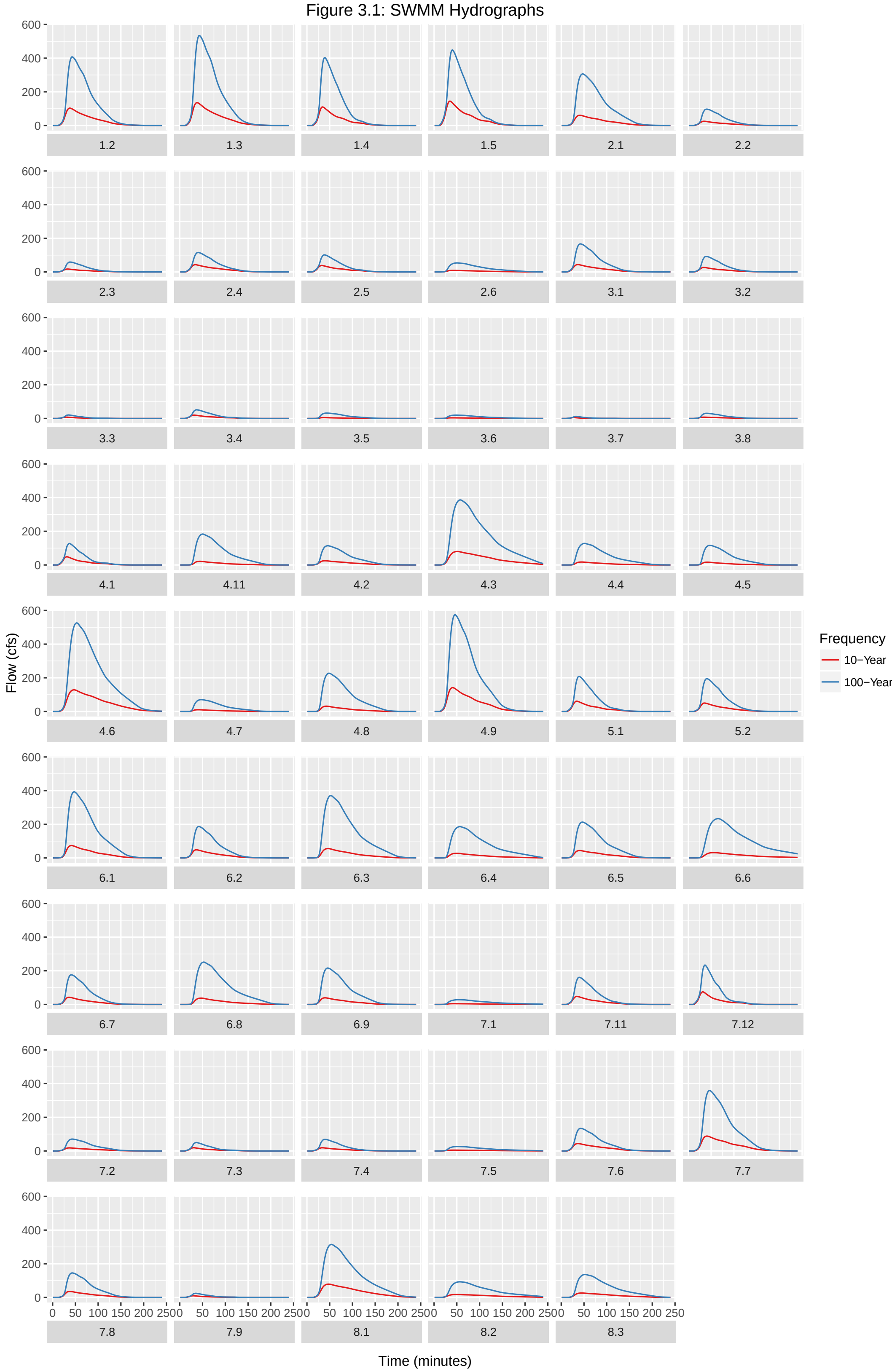


Table 3-5: SWMM Output, Outfalls

Outfall	Design Flow Location	2-yr	5-yr	10-yr	50-yr	100-yr
Eagle Canyon						
	Outfall into North St. Vrain Creek	160	261	433	1268	1716
North St. Vrain						
	Subwatershed 7.7	34	54	88	265	359
	Subwatershed 7.6	21	32	44	104	134
	Subwatershed 7.5	2	3	5	19	26
Ewald Avenue						
	Subwatershed 5.1	27	41	61	157	208
	Subwatershed 5.2	19	30	50	145	194
South St. Vrain						
	Subwatershed 7.8	13	20	36	108	145
	Subwatershed 8.1	29	46	79	232	315
	Subwatershed 8.2	6	11	17	66	93
Steamboat Valley						
	Vasquez Road	20	33	60	221	306
	Old Railroad Embankment	48	78	126	418	573
	Main Street	69	108	165	503	682
	Outfall into North St. Vrain Creek	69	108	165	503	682
Third Avenue						
	East of Cemetary	18	29	44	125	167
	Stickney Avenue	12	18	27	70	92
	Stickney Ave. and 3rd Ave.	30	47	70	194	258
	Main Street	50	75	108	272	358
	Outfall into North St. Vrain Creek	83	125	179	461	611
Eastern Lyons						
	Second Avenue at Stickney Alley	3	5	8	23	31
	First Avenue	1	2	5	23	32
	Kelling Drive	1	2	4	14	20
	Main Street	9	14	23	73	100
South 2nd Avenue						
	West of Second Avenue	10	15	19	39	50
	East of Second Avenue	5	8	10	19	24
Red Hill Gulch						
	Upstream end of Red Gulch Road	66	122	286	1213	1726
	South Ledge Ditch	80	148	341	1447	2078
	Bohn Park	86	160	361	1533	2204
Lyons Valley						
	West of McConnell Dr	21	32	48	122	161
	East of McConnell Dr	35	52	75	178	234
	East of Lyons Valley Park	1	2	4	20	28
Stone Canyon						
	Stone Canyon Subdivision	129	219	432	1566	2183
.	Ute Highway	146	246	474	1694	2361

Table 3-6: SWMM Output, Existing Structures

Outfall	Structure	Size	Approximate Capacity (cfs)	Approximate Return Period
Steamboat Valley				
	5th Ave.: Main St. to Park Dr.	18-inch	15	< 2-yr
	5th Ave.: Park Dr. to N St. Vrain Creek	28-inch x 16-inch	37	< 10-yr
	4th Ave.: Stickney Ave. to Railroad Ave.	18-inch	17	< 2-yr
	4th Ave.: Railroad Ave. to N St. Vrain Creek	24-inch	38	< 10-yr
	Vasquez Rd.	(2) 48-inch	330	> 100-yr
	McCall Alley	42-inch	183	< 50-yr
	Reese Ave.	36-inch	105	< 10-yr
	Seward St. Alley	60-inch x 36-inch	154	< 50-yr
	5th Ave.: Main St.	24-inch	32	< 10-yr
Third Avenue				
	Main Street	60-inch x 48-inch	303	> 100-yr
	Evans St. to Park St.	18-inch	15	< 2-yr
	Park St. to N St. Vrain Creek	36-inch x 24-inch	97	< 100-yr
South 2nd Avenue				
	South of Main St.	24-inch	45	< 2-yr
	3rd Ave.: Railroad Ave.	24-inch	30	< 2-yr
	2nd Ave.: Park St.to St. Vrain Creek	18-inch	15	< 2-yr
Ewald Avenue				
	Park St.	48-inch	261	< 50-yr
Lyons Valley				
	Raymond Ct.	24-inch	41	< 2-yr
	McConnel Drive	30-inch	75	< 5-yr
	McConnel Drive: Outfall	30-inch	75	< 5-yr
	McConnel Dr.: McConnel Dr.	24-inch	41	< 2-yr
Eastern Lyons				
	1st Ave.: 2nd Ave.	30-inch	104	< 100-yr
Stone Canyon				
	Stone Canyon Rd.: Stone Canyon Rd.	13 ft. x 8 ft. box	4361	> 100-yr
.	Ute Highway: Stone Canyon Road	8 ft. x 4 ft. box	920	< 50-yr

4.0 Hydraulic Analysis

4.1 Previous Analysis and Events

The information provided in the previous 1998 Drainage Master Plan study was used to help identify flood hazards throughout the Town of Lyons. The previous report identifies several key areas as having potential for flooding hazards. A few key events are highlighted for reference.

In the August 1994 flood the Ewald Avenue subwatershed was observed to produce enough runoff to carry debris off the hillside onto the residential streets.

Steamboat Valley was identified as having the greatest impact to flooding throughout the Town of Lyons. The report indicated the Steamboat Valley Watershed was the hardest hit area during the 1994 storm. The existing storm drain system between 4^{th} and 5^{th} Avenue was estimated to be an approximate 5-year storm capacity. The storage behind the old railroad embankment was identified as an issue of major concern. The properties downstream of the railroad embankment have grown reliant on this detention and removal of this detention would have negative impacts to downstream property owners. Several properties behind the railroad embankment were noted to be at risk of flooding when the detention area was full.

The conveyance of Red Hill Gulch stormwater runoff in South Ledge Ditch was identified as a possible flooding hazard. The report noted the possibility of the ditch embankment to become compromised and the bank to be breached with the conveyance of storm water runoff. It should be noted that Lyons Valley Subdivision was not constructed at the time of the previous report.

The 2013 flood event had a well-documented impact on the Town of Lyons. The confluence of the north and south St. Vrain Rivers was the center of flood damages during the 2013 floods. Several reports provide further documentation of the flood event. Numerous post-flood studies on the floodplain and restoration projects are also available.

A 2015 flood event was notable because of the hail associated with the storm. The resulting hail-laden runoff clogged surface conveyance (streets, gutters) as well as capture systems (inlets, outlet structures).

4.2 Evaluation of Existing Facilities

Existing storm drain infrastructure was evaluated to determine the approximate design storm frequency. A summary of existing infrastructure is provided in the GIS data provided in *Appendix K*.

FLO-2D software is a two-dimensional flood routing model that was used to identify residual flood potential with the watershed. FLO-2D simulates channel flow, unconfined overland flow and street flow over complex topology. The model uses the full dynamic wave momentum equation and a central finite difference routing scheme with eight potential flow directions to predict the progression of a floodwave over a system of square grid elements. The development of the FLO-2D model is further discussed below.

4.2.1 Flo-2D Model Development 10-foot by 10-foot grid cells were used to maximize the precision in identifying flooding potential throughout the watershed. Elevations for each grid cell were computed through FLO-2D by interpolating the project LiDAR data. Building obstructions were incorporated into the FLO-2D model based on building footprint data that was generated as part of this study.

Individual subwatershed hydrographs were taken from the hydrology model (CUHP) and applied to the FLO-2D surface. Each hydrograph was applied at a single FLO-2D grid cell where the majority of discharges were expected to converge for each subwatershed. Existing storm drain systems 24-inch and larger were included in the FLO-2D model.

Separate FLO-2D models were used to distinguish the flooding potential for the study area for each of the design storms.

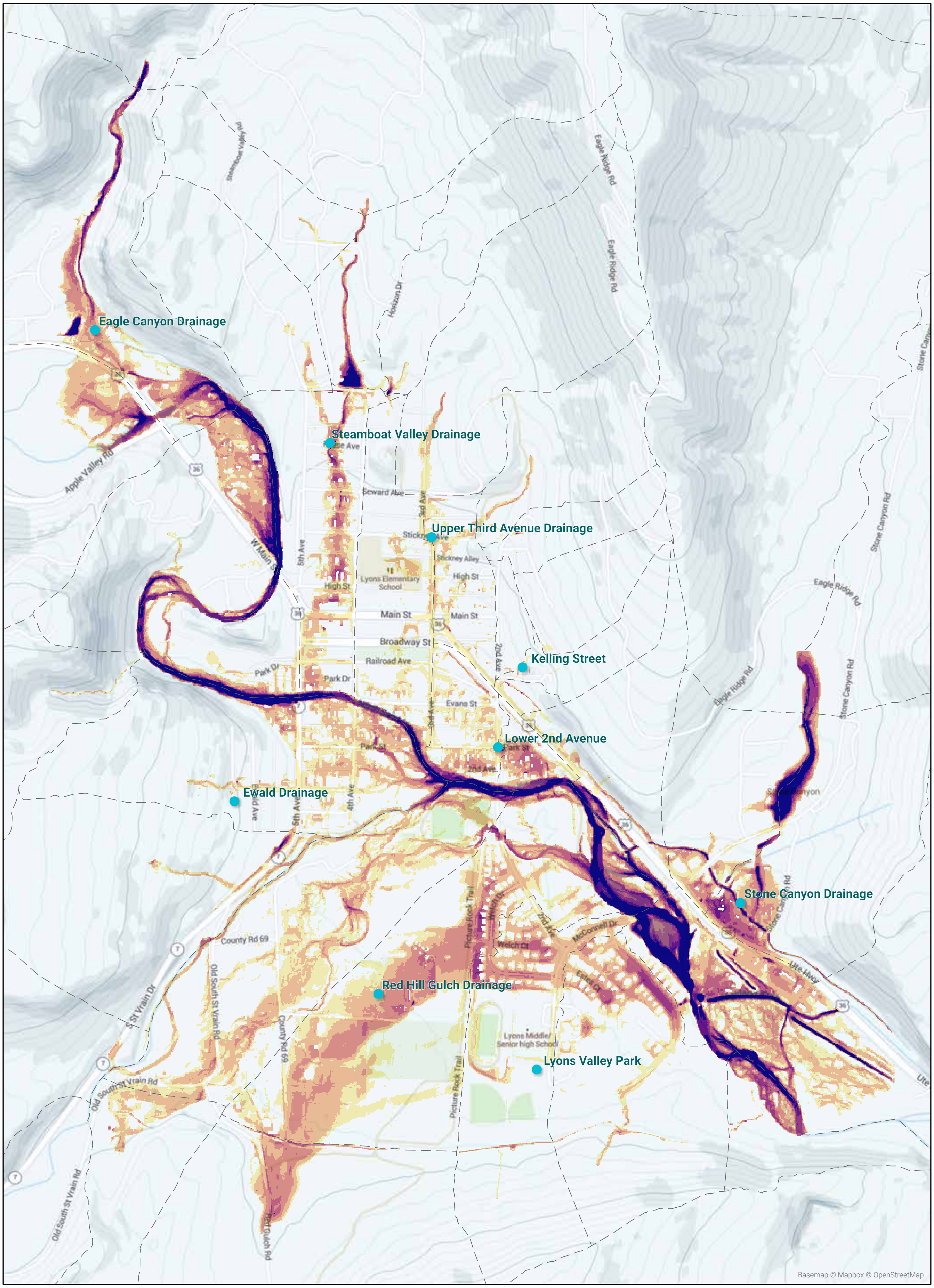
The results of these models are provided in *Appendix D*.[1]

[1] Results are also available on the project's interactive webmap at `https://iconengineering.github.io/lyons-stormwater-masterplan/map`

4.3 Flood Hazards

FLO-2D uses the full dynamic wave momentum equation when computing flow depth at each cell in the study area. This computational methodology accounts for floodplain storage at each sump location in the watershed attenuating flows as they traverse the watershed downstream. This floodplain storage is not accounted for in the SWMM model which is computed using a kinematic wave approach. This difference in modeling approach leads to discrepancies when comparing design peak flows from the SWMM model and the inundation limits shown in the hydraulic analysis. Existing capacity for each outfall system was estimated from normal depth calculations given each pipe slope. The existing storm drain infrastructure generally lacks the capacity to adequately convey the 5-year storm event.

This is not unusual for a town the age and size of the Town of Lyons. Land use regulations and stormwater management policies were not common to smaller towns along the Front Range of Colorado until sometime after the 1965 flood on the South Platte River ravaged metro Denver. By the time development regulation and stormwater infrastructure recommendations expanded to include smaller towns along the Front Range, a lot of Lyons' roadways and private development had encroached on the natural drainageways.



Lyons Stormwater Masterplan

Figure 4-1: Problem Identification

100-year Max Flow Depth (ft)

.5 1 2 3 4 5 6+

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4.3.1 Eagle Canyon The most significant flooding hazard in the Eagle Canyon Watershed is just upstream of the confluence with North St. Vrain Creek. Development immediately upstream of the confluence has limited the capacity of the channel. By limiting the ability of the channel to convey water to North St. Vrain, the discharge overtops Main Street and spills to the south.

4.3.2 Eastern Lyons The small swale and private roadway culverts along the east side of 2nd Avenue limit the capacity to convey the basin runoff downstream. With no storm drain or curb and gutter system installed along 2nd Avenue, all basin runoff will flow along 2nd Avenue on the street. As mentioned previously, during major events runoff from the Eastern Lyons watershed any flow overtopping 2nd Avenue will flow west and contribute flow to the Third Avenue Watershed.

In the lower reaches of Eastern Lyons Watershed the businesses along Main Street and residences along Kelling Drive have experienced flooding in the past. The only storm drain intercepting flow near the businesses is an 18-inch storm drain. This system can capture less than the 5-year design flow in ideal, free flow, no debris conditions.

4.3.3 Ewald Ave As noted in the previous study, the steep slopes of the Ewald Ave Watershed pose a flooding hazard to the residential development in the lower portions of the watershed. The steep slopes in the upper portion of the watershed result in high velocities of runoff eroding the hillside and carrying debris into the residential development.

The Boulder County open space borders these properties and constrains the range of solutions for intercepting or diverting these flows. However, the lower end of this basin drains well into the confluence area of North and South St. Vrain rivers.

4.3.4 Lyons Valley Park Flooding hazards in the Lyons Valley Park Watershed are a result of development within the basin without adequate storm drain conveyance. The 18-inch storm drain throughout the upper reaches of the development was not designed to convey major storm events.

A significant flooding hazard for the Lyons Valley Park Watershed is overflow from the Red Hill Gulch Watershed. The overflow drainage path from Red Hill Gulch is discussed in further detail below.

An overflow path from the hillside south of the High School, Ledge Ditch sub-basin, is an interesting problem. The modeling scenarios do not account for the irrigation ditch that traverses the hillside near the toe of slope. This is a common hydraulic modeling assumption to account for a runoff event during a ditch full scenario. However, in a practical sense the irrigation ditch catches most minor storm events and effectively protects the adjacent residential structures. At a minimum, the ditch should be monitored for stability to ensure overflows and spills from stormwater are handled safely. Additional planning for a time when the ditch is no longer operational or maintained should be considered. Finally, protection or enhancement of the minor swale along the rear lot lines of the neighborhood should be considered to ensure sheet flows are passed around the structures.

4.3.5 North St. Vrain Flooding hazards in the North St. Vrain Watershed are limited to the lower end of the basin. Generally flows in this basin concentrate in natural valleys and are conveyed overland towards the St. Vrain River. Land use changes in this area have limited the flood risk significantly.

4.3.6 Red Hill Gulch The most significant flooding hazard in the Red Hill Gulch Watershed is flow overtopping the South Ledge Ditch and flow continuing north into Bohn Park and Lyons Valley Subdivision. As noted above, utilizing the ditch for intercepting and conveying stormwater runoff creates a significant hazard for downstream properties. These comingled flows

Flows exceeding the capacity of the South Ledge Ditch continue north in an unconfined flow path

exceed the design capacity of the canal jeopardizing the structural integrity of the ditch. Flows overtopping the ditch create an uncontrolled overflow impacting Bohn Park and homes in the Lyons Valley Subdivision.

The surface flows from Red Hill Gulch follow an ancient alluvial fan pattern starting at the intersection of Red Hill Gulch Road and Jasper Drive and extending north towards the South St. Vrain. The surface flows generally follow Red Hill Gulch Road north until it turns west, the surface flows continue north east of a high point on County Road 69. This is an interesting key point in the surface drainage conditions of Red Hill Gulch because the surface flows are so close to the South St. Vrain, but instead follow a natural topographic low point east-northeast. This ultimately leads to a flow path intersecting with Lyons Valley subdivision and the newly planned Bohn Park.

4.3.7 South St. Vrain Flooding hazards in the South St. Vrain Watershed are generally created by the lack of a formal drainage conveyance system. The topography within these watersheds conveys the runoff in separate flow paths to South St. Vrain Creek. The flow paths are generally shallow native grass and rock swales with minimal impact to private property or public infrastructure.

4.3.8 South 2nd Avenue Flood hazards within the South 2nd Avenue Watershed are caused by contributing flow from other watersheds, lack of local runoff storm drain conveyance, and proximity to St. Vrain Creek. The elliptical pipe underneath Main Street conveys runoff from the Third Avenue Watershed to the South 2nd Avenue Watershed. The pipe discharges flow into an undersized open channel that conveys flow southeast towards 2nd Avenue. Any flow that is not intercepted by the 24-inch storm drain at 2nd Avenue spills to the south impacting properties. The 18-inch storm drain at 2nd Avenue and Park Street intercepts approximately the XX design flow for the subwatershed, impacting more properties.

4.3.9 Steamboat Valley The most significant flood hazard impacting downtown Lyons is runoff from Steamboat Valley. The runoff from the upper watershed concentrates behind the old railroad embankment. The area behind the old railroad embankment poses a significant flood hazard to downstream properties. Close observation on the stability and maintenance of this embankment is

important to managing the risk of a breach or other failure during a storm event. This will require coordination with several private property owners. Downstream of the railroad embankment development within the natural drainage path has confined the runoff to an undersized open channel through private property. The lack of conveyance capacity of this channel and culvert roadway crossings between 4th Avenue and 5th Avenue creates a flooding hazard damaging private property. Any flow that is not intercepted by the historic stone culvert continues on the surface flowing through backyards with additional impact to private property and structures.

Existing Steamboat Valley channel lacks conveyance capacity

Steamboat Valley at Reese Street between 4th and 5th Avenue

The existing conveyance within Steamboat Valley does not have the hydraulic capacity to convey storms greater than the 5-year return period. More importantly, the materials (stone and open channel) and alignment (erratic with several sharp bends and constrictions) subjects the adjacent properties to additional risk from debris clogging.

4.3.10 Stone Canyon The steep natural drainageway in the Stone Canyon Watershed conveys the runoff into the open space of the Stone Canyon Subdivision without significant flood hazards. The roadway crossing at Stone Canyon Road conveys the flow downstream without impacting a significant number of residences within the subdivision. Development downstream of Stone Canyon Road has eliminated the conveyance capacity of the channel to convey runoff without impacting properties. The water backs up against Ute Highway as water is conveyed underneath the roadway through the box culvert.

There have been reports of soil subsidence in the open space areas adjacent to the channel. This study did not include detailed geotechnical analysis to determine a cause or effect of the reported soil movement. More formal identification of the problem areas, formal and regular monitoring of those sites, and geotechnical analysis would be required to properly evaluate the risk of those soils relative to flood hazards (i.e. bank failure reducing channel capacity), private, or public property.

4.3.11 Third Avenue Runoff from the undeveloped upper watershed enters the downtown in two distinct locations. East of the cemetery flow drains south into the developed area of the watershed along Third Avenue. Flow from the eastern portion of the watershed flows into the downtown area west along Stickney Avenue before turning south on Third Avenue. The runoff from the watershed continues south along Third Avenue where the majority of the flow is conveyed in the street. The elliptical pipe at Main Street conveys flow underneath Main Street into the South 2nd Avenue Watershed. Flows exceeding the capacity of the elliptical pipe split with some flow continuing southeast north of Main Street while some flow overtops Main Street and continues flowing down Third Street.

5.0 Flood Hazard Area Mapping

5.1 Approach

Two dimensional floodplain analysis.

5.2 Assumptions

The flood hazard area maps are non-regulatory, but identify structures at risk of flood damage based on surface flow depths. The flooding depicted on this map is a uniform storm event across all watersheds at the same period of time and same duration.

Free flow. These depths do not account for debris or hail or other impediments in storm water conveyance systems. Debris flow modeling is possible, but is beyond the scope of this master plan study.

Storm sewer systems. Small diameter storm sewer systems were not accounted for in the hydraulic modeling and resulting floodplain mapping for this master plan study. The impact of a 4 or 8-inch or even 18-inch culvert on flood depths is limited when considering storm events beyond the 2 year recurrence interval. As a sensitivity analysis, the 18-inch storm sewer pipes and inlets were accounted for in the Lyons Village area. The resulting flood depths were unchanged for all but the 2 year recurrence interval. In the 2 year recurrence interval storm, the flood depths were reduced by approximately 3 inches. The floodplain mapping is drawn as a quilt of interlocking 10 foot squares with depth averaged across that area. There were less than 40 squares (4,000 square feet) removed from flooding when accounting for the 18-inch storm sewer.

It is important to note, this is not a referendum on the existing 18-inch storm sewer system. Clearly, an 18-inch storm sewer conveys water and a has a beneficial impact on the flood risk in the neighborhood. This is a clear indication of the limitations of master plan level, town wide, flood risk mapping. The uncertainty variables at the master plan level results in floodplain maps depicting general, conservative areas of risk. When areas such as developed neighborhoods with existing storm sewer systems show up on the master plan flood maps attention should be given to determine if a higher level of study is necessary. In the case of Lyons Valley, the storm is functional and clearly benefits the properties more than the master plan flood hazard maps indicate. However, when combined with anecdotal stories about spring and summer street flooding from overwhelmed inlets, this may be an area to consider for additional detailed field survey and hydraulic analysis.

5.3 Regulatory Floodplains

Conversion of these flood hazard areas to regulatory floodplains is a complicated, long, but well documented process. At this time, the master plan makes no specific recommendation for submitting these floodplain delineations to FEMA for formal adoption. As flood recovery projects are completed and budgets are set for priority capital improvements, a more formal Flood Insurance Study can be considered to accurately map the flood hazards to FEMA specifications.

6.0 Alternative Analysis

6.1 Alternative Development Process

An Alternative Analysis was completed to develop flood mitigation solutions for the problem areas identified in the previous section. Goals for mitigation focused a minimum condition to provide storm drainage capacity meeting currently defined drainage criteria for the Town of Lyons and solutions to reducing flooding on insurable structures. Consideration was also given to reducing infrastructure sizing and costs by incorporating detention.

Alternatives were considered first for open channel and then for piped systems. Open channels are more cost effective, provide additional ecological benefits, mimic or sometimes restore the natural environment, but require additional stabilization and maintenance to provide long term benefits. Piped systems are far more hydraulically efficient and allow for more flexible land uses in and around the system, but do not benefit the natural environment and can be significantly more costly to install, particularly in underlying rock soils.

For example, the development of downtown Lyons over the historic drainageway has limited the ability to convey the major storm events through an open channel system. Since an open channel system is not feasible, large storm drain infrastructure is needed to reduce the flood hazards throughout the study area. The storm drain infrastructure must limit the amount of flow in the street to provide emergency vehicles access during storm events.

The analysis aimed to develop stormwater solutions first within the Town of Lyons. When those alternatives were exhausted as cost prohibitive or unfeasible, then the project team considered alternatives outside of the Town limits. The cost of land acquisition, land use regulations, and extra-territorial jurisdiction can add significant costs to stormwater projects outside of the Town limits. Conversely, knowing about potential out of town solutions to in-town risks can be prudent to future planning exercises in annexation, development referrals, and multi-agency coordination.

6.2 Criteria and Constraints

As noted above, goals for the baseline alternative plan was to provide storm drainage capacity to meeting currently defined drainage criteria set forth in the Town of Lyons Storm Drainage System Criteria. The minor storm frequency for the Town of Lyons is the 2-yr design storm with the 100-yr design storm classified as the major storm frequency.

6.3 Evaluation of Detention

6.3.1 Detention Detention is a common approach to reduce peak flows, optimize pipe size, and save on downstream infrastructure costs. Review of the previous master plan confirmed that previously master planned detention facilities were drafted to meet this goal. If detention is installed in the upper watersheds of the Town, there is a significant cost savings to downstream stormwater infrastructure.

However, upon closer examination of the previous master plan assumptions, field inspection of the proposed detention sites, and conceptual pond grading and layout there were additional constraints on the detention pond locations.

6.3.2 Steep Topography The steep slopes on the north end of Steamboat drainage require significant grading operations to achieve a functional detention volume even approaching 0.5 acre feet. This fact alone may still be a viable alternative since excavation is generally less expensive than long lengths of large storm sewer pipe material, utility crossings, and installation. However, given the geology of the upper Steamboat drainage the depth to bedrock is known to be very shallow in many locations. Rock excavation for a detention facility is prohibitively expensive. Excavation of the rock in a quarry scenario would be one economically viable means of providing sufficient detention volume at a reasonable cost for Steamboat drainage.

6.3.3 Multiple Hillside Ponds Staged detention facilities staggered in stair-step fashion up the steep slopes is another alternative to achieve the benefits of detention without significant excavation. However, the extensive footprint of disturbance for multiple embankments, overflow spillway design, and permanent impact on property makes

6.3.4 Property Acquisition The natural valleys between 4th and 5th Streets and 3rd and 4th Streets could provide suitable detention facilities if several existing constraints are mitigated. First, the private homes in the adjacent parcels would be impacted by detention depths of more than approximately 5 feet. Purchase and demolition of homes affected by a proposed detention facility would be required to achieve a useful detention volume. Second, the existing embankments between 4th and 5th Street should be reconstructed to replace the rock and native soils that were used to build what is reported to be an old railroad embankment. Until the compaction and stability of that embankment can be verified, it should not be relied upon to safely detain stormwater. It is unclear what the overflow path may be should the outlet under the embankment fail, collapse or clog. However it is likely the overflow could lead to additional erosion and scour of the embankment flanks and expedite complete failure of the embankment. Third, the valleys near the cemetery are also candidates for detention, but the steep slopes make each valley individually difficult to achieve a reasonable volume. However, purchase of a uniquely shaped parcel of land slicing between the valleys could allow an embankment to be constructed that joins the two valleys and creates a reasonable detention volume.

6.4 Alternative Categories

For each outfall system, multiple alternatives were evaluated in the initial screening process including:

- Improve storm drain infrastructure to convey minor storm runoff
- Improve storm drain infrastructure to the initial storm, and provide detention facilities to reduce infrastructure costs where applicable
- Improve storm drain infrastructure to the major storm runoff.
- Improve storm drain infrastructure to the major storm, and provide detention facilities to reduce infrastructure costs where applicable

6.5 Alternative Hydraulics

Each alternative was modeled using SWMM to determine the pipe sizes necessary to meet the desired alternative criteria. The reduction in flooding potential throughout the basin was evaluated for the minor and major design storm frequencies using FLO-2D.

6.6 Alternative Costs

Alternative cost estimates were developed using UDFCD's master planning cost estimating spreadsheet UD-MP COST, version 2.2. 2012 unit cost values were adjusted to present value using the Colorado Construction Cost Index 2016 Second Quarter Report. A rolling four-quarter inflation rate of 1.2673 was used to adjust unit costs.

Operation and Maintenance was also included within the UD MP Cost worksheet. Manhole and inlet maintenance was assumed to occur once every five years. Maintenance on detention basins and water quality facilities was assumed to occur every other year.

Inlet quantities were calculated assuming an inlet interception capacity of 1 cfs / foot of inlet.

Dewatering, Traffic Control and Utility Coordination / Relocation were assigned based on the following percentages of capital costs: Dewatering (1%), Traffic Control (5%), Utility Coordination / Relocation (10%).

Special items that were added to the UD-MP COST spreadsheet include:

- Asphalt Repaving: $40 / S.Y.
- Curb and Gutter: $30 / L.F.

No alterations were made to default values calculated as a percent of Capital Improvement Costs, such as Engineering, Legal / Administrative, Contract Administration / Construction Management, and Contingency.

6.7 Alternative Plans

A - Red Hill Gulch Overflow Channel East Any flow that exceeds the capacity of the South Ledge Ditch poses a flooding hazard to Lyons Valley Subdivision and Bohn Park. This uncontrolled spill flow risks the structural integrity of the ditch and poses a hazard to homes along the west side of Lyons Valley Park. The Red Hill Gulch Overflow Channel would intercept flows along the east

side of Bohn Park preventing these flows from diverting into the Lyons Valley Park Subdivision. The grading associated with the overflow channel would change the surface conditions of the east side of the park but still allow for parking and multi-purpose uses. The multiple uses of this eastern side of the park require the channel to be wider and flatter that typical conveyance channels in order to maintain the function of the space for parking and exhibitions.

Red Hill Gulch Overflow Channel East would intercept flows before diverting runoff into Lyons Valley Park Subdivision

In general, this option intercepts and conveys large storm events from Red Hill Gulch before those flows encroach on private property. The alignment utilizes existing town property and requires no additional easements or property acquisition.

However, this alternative compromises existing functions of the park land and assumes upstream development will not have an impact on the drainage conditions. In other words, solving the Red Hill Gulch drainage this far down in the watershed costs a lot when compared to what upstream alternatives may do to reduce stormwater impacts.

B - Red Hill Gulch Overflow Channel West An alternative to the east channel at the downstream end of the watershed is a western channel. When the Western Corridor is annexed into the Town of Lyons the overflow channel alignment should be evaluated to intercept the flows upstream of Bohn Park eliminating any disturbance to the park. The flows would be conveyed west of Bohn Park and discharged into South St. Vrain Creek. This is a smaller channel used for a singular stormwater purpose – it does not have to share uses with a park or parking lot. The western alignment also conveys water around Bohn Park and Lyons Valley subdivision.

However, the channel would require an easement or land acquisition from the adjoining land owners. And, because of the smaller footprint, the hydraulics of the channel require drop structures to control erosive velocities.

C - Red Hill Gulch Cut-Off Channel Outside of the Town, there is another problem area and option for managing Red Hill Gulch stormwater runoff.

A third alternative for Red Hill Gulch drainage intercepts the gulch flows at the Picture Rock Trailhead and diverts those flows west into the South St. Vrain. This alternative has the advantage of working a stormwater solution upstream of existing development and mitigating flood risk as high up in the watershed as feasible. This is the most hydraulically efficient alternative in that the diversion distance to the South St. Vrain is short and the diversion volume is reduced when compared to downstream alternatives.

However, the constraints on this alternative are compounded by the need for easement or land acquisition on both public and county open space property. The details of a diversion in this location will require careful design and analysis. The surface flows are spread over a large area, but the right grading could allow just enough water to drain north through the park area and intercept the remainder to safely divert it west to the South St. Vrain. Easements and reconstruction of Red Gulch Road would be required. Existing irrigation ditches in the area compound problems rerouting surface flows. Any diversion would still have to cross Ledge Ditch and Meadow Ditch.

There are several roadside ditches and ditch crossings that should be investigated further. The stormwater flows into Ledge and Meadow ditches complicate the flow paths for this drainage. Upstream and downstream of the irrigation ditches, the roadside swales are an important part of conveying stormwater but need to be maintained to ensure positive drainage away from the roadway.

D - Steamboat Drainage Culvert Replacement To reduce flooding within the Steamboat Valley Watershed, the existing historic box culvert could be upsized to convey the design discharge. Upsizing the existing historic box culvert along the current alignment between 4th and 5th Avenue would encourage the runoff from the watershed to follow the historic drainage path. However, implementing this alternative would require extensive easements as the historic culvert runs through the downtown area underneath development on private properties.

E - Steamboat Drainage Interceptors Downstream of the private railroad embankment an interceptor system could be installed to collect flow at the McCall Alley roadway crossing. Flows in excess of the existing channel and roadway crossings would be intercepted and conveyed west to 5th Avenue. The storm drain system would continue south to North St. Vrain Creek. Intercepting the flow at McCall Alley would alleviate the flooding on properties downstream by limiting the flow to the existing infrastructure capacity.

For further protection, an additional lateral could be installed up 5th Avenue to the drainage roadway crossing at Vasquez Road. The lateral up to Vasquez Road would intercept flows upstream of the private detention area, reducing the risk on downstream properties if the embankment was to fail.

A storm drain system could be installed in 4th Avenue in the lower portions of the Steamboat Valley Watershed to intercept local runoff and convey the discharge to the North St. Vrain Creek. This additional storm drain system would alleviate some of the existing flooding hazard on properties in the downtown area.

F - Third Avenue Inlets and Storm Drain To mitigate flood hazards associated with the Third Avenue Watershed, a storm drain is proposed from the upper reaches from Third Avenue east of the cemetery downstream to the North St. Vrain Creek. A lateral along Stickney Avenue would intercept the flows from the undeveloped northeast portion of the watershed that drains southwest into the downtown area. Continuing the storm drain system south of Main Street would alleviate some of the burden of the South 2nd Avenue Watershed. Any flows in excess of the existing storm drain in the Third Avenue Watershed currently spill in the South 2nd Avenue Watershed.

However, it is important to note that excavation in the northern end of the Third Avenue basin is likely to encounter rock and other earthwork complications. Depth of inlets and storm sewers will be limited by excavation cost, which limits the hydraulic head and increases pipe size. As pipe size increases, depth to cover the pipe must increase and become a costly design loop to determine a feasible storm sewer alignment.

G - Lower 3rd Avenue Inlet Excess surface flows on 3rd Avenue could be conveyed to a large storm sewer inlet at the existing storm sewers on the southeast corner of 3rd and Broadway. The existing grated inlets on the west flowline of 3rd Avenue at Main Street could be improved, but flows exceeding the capacity of those inlets will continue south on 3rd Avenue. The proposed lower 3rd Avenue inlets would capture flows from both gutter flowlines to maintain safe street capacity on the south end of 3rd Avenue during storm events.

The west flowline is also one of the locations where surface flows could be routed through a minor storm weir into a small volume water quality pond in the east end of Sandstone Park. The pond would treat 'first flush' or the initial runoff volume with larger flows continuing south.

H - Third Avenue Drainage Interceptors Similar to the Steamboat drainage alternative, the surface conveyance on Third Avenue could be improved instead of excavation and installation of inlets and pipes. The surface conveyance improvement contains flows within the Town ROW, gutters, and directs flow south to the river. This reduces many of the overflows into private property that exceed the existing roadway swales or smaller curbs. This alternative also reduces surface flows intercepted at cross street intersections that drain water into private property and complicate street flows entering Steamboat drainage.

This alternative does not resolve major storm overflows. The minor storms are handled with the interceptor gutters and cross pans. However, when those conveyance paths are at capacity, the overflow will continue down the natural topography. An inlet and pipe system could be sized to convey a much larger portion of the major storm event. But, as a relatively low cost alternative, the benefits are tangible.

I - Eastern Lyons - Second Avenue Gutter Interceptor Recent development within the Eastern Lyons watershed has increased the runoff from the hillside causing local flooding problems. For larger events the existing roadway conveyance and roadside swale along 2nd Avenue does not adequately convey the runoff south along 2nd Avenue instead diverting flow to the west into the Third Avenue Watershed. Formalizing the street conveyance by installing curb and gutters and cross pans in 2nd Avenue would encourage runoff from this watershed to continue south along 2nd Avenue and not impact properties the Third Avenue Watershed.

J - Eastern Lyons - Second Avenue Inlets and Storm Sewer To ensure no runoff diverts from the Eastern Lyons Watershed, inlets and a storm drain pipe can be installed along 2nd Avenue. The storm drain inlets and pipe in combination with curb and gutter would intercept the flow and convey the flow south to Main Street.

K - Lyons Valley Inlet Improvements Runoff from the upper portions of the subwatershed sheet flows in a general northeast direction through the subdivision to St. Vrain Creek. The storm drain infrastructure installed with the development of Lyons Valley Park Subdivision is a minor drainage system and lacks capacity to convey major storm events.

L - Lyons Valley South Ditch Improvements The South Ledge Ditch located south of Lyons Valley Park Subdivision intercepts runoff from the subwatershed. Formalizing the ditch to convey stormwater east towards St. Vrain Creek would reduce the tributary area contributing to the flooding hazards of Lyons Valley Park Subdivision. If comingling of stormwater and irrigation flows is not desired an overflow conveyance system intercepting the runoff from the upper portions of the watershed could be built just downstream of South Ledge Ditch. This conveyance system could be included as Lyons Valley Park becomes fully developed.

This alternative should be developed in coordination with the future development of Lyons Valley. A drainage feature around the south end of the currently platted lots would benefit the new construction as well as the existing homes in the neighborhood.

The greatest limitation of this alternative is the operation and maintenance of the irrigation ditch and the coordination with any future development. Breaches and overtopping of the existing ditch are likely to continue to occur given the earthern embankment construction of the ditch. As the platted future development moves into the final plan approval process, careful coordination should identify the benefits to both existing and future homes in the area. And, when the cost of perimeter surface water conveyance (i.e. swale) is compared to sizing interior storm inlets and pipes sized to safely capture and convey the offsite flows, the cost-benefit should resolve any further limitations of the concept.

M - Lyons Valley McConnel Drive Culvert The impervious area of the school campus leads to nuisance drainage issues along McConnel Drive. It is unclear how the stormwater runoff is treated within the school campus, but the roof drains and parking along the east side of the campus are direct discharge to the west gutter of McConnel Drive. On-site water quality and detention facilities, perhaps conversion of part of the irrigated turf areas, would collect, treat, and attenuate on-site discharges. A pond near the northeast corner of the site could connect to a new underground storm sewer tied into the Type R inlets at 2nd Avenue. This would move surface flow, particularly nuisance flows dribbling winter melt water that freezes overnight, into the on-site pond and underground, safely conveyed in a pipe system.

N - Ewald Ave - Corona Hill Diversion Ditch As witnessed in the 1994 event, the Ewald Avenue Watershed poses a significant flooding hazard to downstream properties within the watershed. High velocity runoff flow off Corona Hill can carry debris into the residential neighborhood. Intercepting the flow upstream of the development and conveying the flow to the south would prevent debris flow from impacting private properties. The diversion channel south of the development would require significant energy dissipation to prevent the discharge from reaching high velocities and eroding the hillside south of the development. The steep slopes along the hillside would make construction of any diversion channel difficult.

O - Ewald Ave - Corona Hill Street Inlets An alternative to intercepting flows upstream of the residential development is formalizing street conveyance and installing storm drain infrastructure along Prospect Road. The storm drain infrastructure in combination with curb and gutter improvements would confine the runoff from Corona Hill to the street limiting the impact to private properties. Installing additional inlets and laterals along the Prospect Street storm drain alignment would encourage more water to be conveyed in the pipe as this system is currently limited by the two inlets near 4th Avenue.

P - 2nd Avenue – Kelling Drive Private Improvements There are past stormwater runoff events that have led to private property damages (fencing, landscaping, and structural flooding). Magnitude of the damages has not be investigated as part of this study. The subject properties, residential structures on the north side of Kelling Drive and commercial structures on the south side of Kelling Drive, are near the bottom of a steep southwestern facing slope. Runoff from the upstream property impervious area is controlled through downspouts, gutters, landscape swales, street gutters, and storm sewer systems.

The northern properties appear to have all or most of their foundations above adjacent grade, positive drainage away from the structure. However, additional property line swales could convey surface flows around the structures. The southern properties appear to have adverse drainage slopes near the building and could benefit from more formalized drain pans along top or toe of the retaining walls on the north side of the property. An existing grated inlet in the north flowline of Kelling Drive could be improved to increase surface water capture, but only reduces surface flows already in the street.

Support from the Town in terms of permitting, review, and easement terminology could resolve drainage issues in the vicinity of Kelling Drive. The installation of swales, inlets, pipes, moving existing outbuildings, and re-landscaping perimeter swales on each of the affected lots can be highly effective private improvements that mitigate the flood risks in this area. However, the work would be on private property and therefore require special agreements (easements, cost-sharing, access requirements, or code updates, etc.) for the Town to participate in design, construction, operation, maintenance, or financing. Therefore, the town's assistance could come in the form of coordinating the private efforts to ensure a comprehensive solution is achieved.

Q - 2nd Avenue – Kelling Drive Interceptor Curbs Similar to Steamboat and 3rd Avenue ... not a full spectrum fix, but can make a difference in small storm runoff events.

R - Stone Canyon Outfall Improvements An existing outfall under the highway is smaller than the outfall pipe upstream. Upsizing the outfall pipe to match the 13'x8' reinforced concrete box culvert would help convey stormwater flows under the highway with less upstream head on the system.

Table 6-1: Cost Summary

Alt ID	Description	Capital	Easement / ROW	Engineering	Legal / Admin	Contract Admin / CM	Contingency	Total Capital Cost	Annual O-M Cost	50-Year O-M Cost
A	Red Hill Gulch East	$435,644	$-	$65,347	$21,782	$43,564	$108,911	$675,248	$2,580	$81,073
B	Red Hill Gulch West	$1,434,809	$200,328	$215,221	$71,740	$143,481	$358,702	$2,424,281	$16,752	$526,408
C	Red Hill Gulch Cut-Off	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA
D	Steamboat Drainage Culvert Replacement	$2,994,801	$2,825,346	$449,220	$149,740	$299,480	$748,700	$7,467,287	$1,638	$51,472
E	Steamboat Drainage Interceptors	$3,268,309	$-	$490,246	$163,415	$326,831	$817,077	$5,065,878	$914	$28,721
F	Third Avenue Inlets and Storm Drain	$1,977,609	$-	$296,641	$98,880	$197,761	$494,402	$3,065,293	$1,638	$51,472
G	Lower Third Avenue Inlet	$963,061	$-	$144,459	$48,153	$96,306	$240,765	$1,492,744	$1,512	$47,512
H	Third Avenue Drainage Interceptors	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA
I	Eastern Lyons Second Avenue Gutter Interceptor	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA
J	Eastern Lyons Second Avenue Inlets and Storm Drain	$1,187,423	$-	$178,113	$59,371	$118,742	$296,856	$1,840,505	$2,583	$81,167
K	Lyons Valley Inlet Improvements	$1,568,145	$-	$235,222	$78,407	$156,815	$392,036	$2,430,625	$3,213	$100,964
L	Lyons Valley South Ditch Improvements	$742,627	$-	$111,394	$37,131	$74,263	$185,657	$1,151,072	$1,400	$43,993
M	Lyons Valley McConnell Drive	$921,110	$-	$138,167	$46,056	$92,111	$230,278	$1,427,722	$2,268	$71,269
N	Ewald Ave Corona Hill Diversion Ditch	$537,491	$-	$80,624	$26,875	$53,749	$134,373	$833,112	$290	$9,113
O	Ewald Ave Corona Hill Street Inlets	$811,845	$-	$121,777	$40,592	$81,185	$202,961	$1,258,360	$1,386	$43,553
P	2nd Avenue Kelling Drive Private Improvements	#NA	#NA	$4,250	$250	$500	$-	$5,000	$-	$-
Q	2nd Avenue Kelling Drive Interceptor Curbs	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA	#NA
R	Stone Canyon Outfall Improvements	$848,829	$-	$127,324	$42,441	$84,883	$212,207	$1,315,684	$150	$4,714

7.0 Water Quality Improvements

Comprehensive stormwater management includes a wide variety of rainfall scenarios from exceedingly rare peak flow events to statistically average events to brief afternoon rain showers. The best plans acknowledge all phases of stormwater management and provide benefits throughout the watershed and throughout the range of recurrence intervals.

Constraints to this approach are clearly financial, the major capital improvement projects are expensive and the minor water quality BMPs can become costly pieces of infrastructure to maintain in working order. However, there are localized water quality improvements that can be implemented in certain watersheds in specific communities. These smaller scale projects fit within smaller towns well because a reasonable implementation density (i.e. participation percentage) is within reach of public-private partnerships.

Other larger scale water quality projects are just as important to the overall stream health. Larger ponds integrated into public spaces are a typical method of capturing a large water quality volume. Ordinances that require water quality implementation for new and redevelopment can be equally important. (See Appendix X for examples.)

7.1 Small Scale Water Quality Improvements

7.1.1 Tree Wells The downtown area could benefit from design of landscape and streetscape improvements that incorporate water quality treatment. One example of this multi-purpose streetscape is a tree-well water quality installation. Additional information is provided by the EPA's "Stormwater to Street Trees" informational guide.[2]

[2] http://www.davey.com/media/183712/stormwater_to_street_trees.pdf

The tree wells have an advantage of water quality treatment in the highly impervious main street area, but also have application in side street and park areas. In any case, the tree wells treat for water quality, but from a volumetric standpoint are a small scale solution.

7.1.2 Rain Gardens Another small scale option for targeted water quality is installation of rain gardens. Generally accepted as a means of treating roof top runoff from private property downspouts, there are applications for rain gardens in commercial and municipal applications. A commercial property or municipal building could route downspouts to a street side rain garden, with proper consideration for saturation of soils resulting impact on roadways, sidewalks, icing, and maintenance. A cul-de-sac or small parking area could be routed to an infiltration basin or rain garden for additional water quality treatment. Additional design and maintenance information is provided by UDFCD.[3]

[3] http://udfcd.org/wp-content/uploads/2014/07/T-03-Bioretention.pdf

7.1.3 Rainwater Harvesting Recent changes in state law (HB 1005) allow for private properties to harvest a small amount of rainwater from their rooftop for allowable uses (irrigation) on their property. Typically, a 55 gallon barrel or cistern is connected to roof downspouts to collect rainfall and snowmelt. Although rooftop runoff is not the largest source of stormwater pollution, it can still have a beneficial impact on urban water quality. The dust and wind blown litter that reaches rooftops can be captured in rain water harvesting systems. More importantly, the peak runoff events from the impervious surfaces are attenuated, or delayed, from entering the municipal stormwater system. This reduces the volume of stormwater treated by downstream systems.[4]

[4] http://extension.colostate.edu/topic-areas/natural-resources/rainwater-collection-colorado-6-707/

7.2 Large Scale Water Quality Improvements

7.2.1 Confluence Area Water Quality Pond At the time of this report, the ongoing confluence area and St. Vrain restoration projects are making improvements in and around the rivers. One area that could have an advantageous siting for a water quality pond is the east end of Prospect in the confluence area. If other project designs allow for a pond to be constructed in this area, the outlet could be configured to treat a water quality capture volume for the confluence area basin.

There are other water quality pond locations, but the confluence area was identified as the largest potential pond with urbanized runoff. The existing pond at Eagle Canyon could be studied for reconfiguration, but the impervious area is relatively low in that overall basin. Large water quality ponds along the northern side of Town near the river would treat the most urbanized stormwater runoff. However, a property and topographic review of the area could not identify areas large enough to capture a full water quality capture volume. Sandstone Park was the largest open space parcel, but would require significant grading and storm sewer installation that would significantly limit the park uses. Other upstream areas are available, but generally treat only the undeveloped portions of town.

7.2.2 Streambank Wetlands There are several good locations for water quality treatment along the St. Vrain, particularly downstream of Lyons Valley stormwater outlet structures. The side channels north and south of McConnell Drive as well as the Bohn Park outfall east of 2nd Avenue can treat stormwater runoff upstream of the St. Vrain main channel. Wetland plantings in a specifically designed low velocity channel can absorb pollutants conveyed through nuisance and first flush stormwater events, while allowing larger runoff events to pass through the channel. The streambank wetlands are similar to the St. Vrain restoration work upstream, but designed and managed on a smaller scale to adapt to the side tributary flows.

7.2.3 Pervious Pavers The reduction of impervious area is a direct means of increasing infiltration and interrupting the transmission of water borne pollutants in the urbanized watershed. For the Main Street and downtown areas, the addition of pervious pavers can be a good way to reduce impervious area. There are several candidate locations in parking areas, sidewalks, plaza areas that could infiltrate runoff before it reaches the curb and gutter system. However, there are also many lessons learned on maintenance of pervious pavement surfaces, specifically related to the winter environment and non-infiltrating soils of Colorado. The impact of a snow plow on pavers, expansion of clay soils creating ponding in pervious asphalt, or the freeze thaw action on pervious concrete surfaces are all documented issues. Ultimately, pervious pavement surfaces work well when combined with traditional pavement surfaces for high traffic, heavy load, and high maintenance pathways. The UDFCD has a good worksheet[5] describing the opportunities and limitations of pervious surfaces.

[5] http://udfcd.org/wp-content/uploads/2014/07/T-10-Permeable-Pavements.pdf

7.3 Outfall Water Quality

There is a separate category of water quality treatment that is particularly suited to the Town of Lyons – outfall water quality. Given the limitations on property, soils, and age of the infrastructure in Lyons the outfall pipes discharge directly into the rivers. In many ways, the outfall is the last option for water quality treatment in a particular watershed. Other communities along Front Range have investigated these same challenges and found a few specific treatment options that have unique water quality advantages. It takes a very unique topographic condition with a small tributary basin for these elements to meet a full water quality capture volume. But, in all cases, the advantage of intercepting even the 'urban drool' nuisance flows in a small, maintainable, vegetated basin improves even the perception of a standard metal culvert dribbling directly into the river.

A list of outfall water quality options are detailed in the appendix. Each option is suited for different outfall locations and uses. The infiltration basin concepts are essentially miniaturized infiltration basins with a design suitable for curbside maintenance. Whereas the level spreaders are more complicated structures diverting low flows into hillside infiltration laterals that can irrigate and help sustain native vegetation on the stream banks. These concepts require additional design based on site specific conditions, but can be a starting point for high visual impact outfall improvement projects.

8.0 Capital Improvements Plan

A Capital Improvements Plan (CIP) in its most basic sense includes a budget and a list of capital improvement projects. From those elements, the CIP is aligned with priorities of the governing agency, permitting, and construction logistics. This undoubtedly includes discussion relative to other master plans, comprehensive plans, current events, future plans, and historical performance. With priority projects identified, the budget and requisite financing discussions move forward. Internal and external funding sources are aligned with candidate projects, perhaps influencing the relative priorities. Finally, the plan is ratified and set forth in terms of planning, timing, and contracting.

This stormwater master plan prepares one element of a full Capital Improvements Plan – the list of projects and anticipated costs. All alternatives were evaluated during the master plan process, and cost estimates for each alternative were part of that evaluation. An engineer's recommendation highlights the alternatives that have the highest likelihood of implementation and therefore highest priority within the comprehensive list of alternatives. The Town can take the recommended alternatives and associated costs into further deliberations with the Town staff, consultants, and advisors to determine the best course of action. Essentially, this storm water master plan completes the first phase of a stormwater CIP. But from this solid starting point, the Town will be able to further evaluate the priority of stormwater improvements relative to other municipal projects. And, then determine how the essential stormwater needs can be funded and completed to increase the resilience of the entire community to flood hazard damages.

Cost estimates for the alternatives described in Section 6 were completed using the Urban Drainage and Flood Control District cost estimating spreadsheets. These spreadsheets are routinely used to evaluate the life cycle costs of stormwater infrastructure projects. The cost estimates are comprehensive estimates including design, construction and maintenance.

The appendix provides all supporting information for cost estimates and rankings of selected alternatives. In summary, the recommended stormwater improvements have a total life-cycle cost of $750M for the Town of Lyons.

9.0 System Maintenance

There are three primary components to system maintenance that can maximize the capacity and function of the existing, and proposed, storm sewer systems. Schedule, equipment, and monitoring are three of the key elements to operation and maintenance of a stormwater system.

The schedule of maintenance operations is a function of unpredictable storm events and routine dry-weather maintenance activities. A standard operating procedure for municipal work crews will include a schedule identifying which storm sewer systems get maintained at which time. At a minimum, every storm sewer inlet and outfall within Town right-of-way or open space property should be cleaned, patched, sealed, or otherwise maintained once a year. Although sediment and debris removal is the most common maintenance activity, patching of exposed reinforcing steel, clearing inlet grate frames to ease removal, mastic sealing joints at asphalt/concrete, sealing pipe joints, or tightening clamps holding flared end sections can all be effective, routine maintenance activities.

The equipment used in maintenance operations can be a significant initial cost, but ultimately reduce manpower requirements. Given the Town's variety of storm sewer inlet grates, pipe sizes, and culvert dimensions the equipment must be flexible and manage a variety of debris conditions. Fortunately, most of the Town's stormwater infrastructure is accessible from Town right-of-way. Therefore, a vacuum truck is a likely candidate for use in maintenance operations. Whether the truck is owned, leased, or rented for the year, month, or days of stormwater infrastructure maintenance is a decision for budgeting and policy. However, the ability to lift a grate, insert a flexible nozzle of varying size, and hydro-excavate the debris and sediment from the system is an effective means of clearing the system, increasing capacity, and extending the life of the components. The material is captured in an on-board tank and disposed at an in-town stockpile for processing or an offsite dump. Other equipment can be either too large to effectively clear the inlets and pipes (i.e. backhoe, skidsteer); or too small to complete the job in an efficient manner (i.e. handheld shovels and picks).

Monitoring the system becomes a preventative maintenance activity. Observation of the storm sewer system during small rain events, fire hydrant testing, or snow melt events can identify blockages or pipe failures before large spring storms cause bigger problems. Observation of the inlet systems can become part of a staff or consultant responsibility or become a down-time task for maintenance staff. The existing system inventory completed for this master plan includes photos of every element of the system as of the Summer of 2016. The database of photos can be helpful in determining the rate of deterioration, sedimentation, or failure since that benchmark time.

Other activities can be important to a System Maintenance program, but schedule, equipment, and monitoring cover the key aspects of sustaining the existing storm sewer system. A good maintenance program increases the overall resilience of the system through knowledge of the system limitations and tendencies. When large spring storm events clog the system with hail and leaf debris, maintenance staff with experience maintaining the system over time can quickly clear choke points with effective equipment and understand the impact on the system.

10.0 Storm Water Utility

This study evaluated the existing stormwater infrastructure and proposed new stormwater infrastructure to mitigate flood risk. To improve resiliency of the Town to flood disasters, there is an infrastructure solution but that requires a significant capital investment. Grants, joint projects, cost shares, and other large scale funding mechanisms will be useful for making those improvements. But a regular funding source for stormwater improvements is equally valuable. A stormwater fee can offset the routine costs of operation and maintenance of stormwater facilities that may otherwise be overlooked in the regular municipal budgeting process. The fee is as much a reminder for proper care of the existing infrastructure as it is a financial support to critical public facilities.

Stormwater fees can be controversial. A stormwater fee supported by defensible cost projections and allocated on a reasonable and controlled metric can be less controversial than broad based uniform fees. Details of a storm water utility implementation are beyond the scope of this master plan. However, additional information is provided here to start the conversation about implementing a mechanism to fund routine stormwater maintenance and projects.

Stormwater fees exist in many communities along Colorado's front range, some have been around for decades and others are more recently adopted.

10.1 What is a Stormwater Utility

The basic concept of a stormwater utility is to charge property owners for the amount of impervious area on their property in return for providing construction and maintenance of a stormwater system. Impervious area consists of manmade surfaces, which prevent the infiltration of rainfall and snowmelt into the ground, and include; buildings, driveways, parking lots, patios, commercial and industrial roads, private roads, and other "hard" surfaces. It can be estimated that runoff from these impervious surfaces increases 2 to 3 times from what the runoff was when the parcel was undeveloped. In addition, the water quality of the stormwater is worse than it was when the parcel was undeveloped.

Most stormwater utilities therefore have a fee based on the amount of impervious area on each parcel. This type of fee, if developed correctly, has been upheld in the courts of Colorado as a legal fee. Under the Tax Payers Bill of Rights (TABOR), a utility is termed an enterprise and is allowed if its meets the TABOR definition of an enterprise. Under this definition, an enterprise is a government owned business (similar to a water or sewer utility), which derives 90% or more of its revenue from non-governmental sources.

10.2 Stormwater Utility Fee Study Outline

Phase A - Feasibility Study. A data collection and litmus test for feasibility of the stormwater fee. This introduces the concept and builds the project team of consultants, staff, legal representatives, and engineers. This study results in a budget level estimate of fees that could be generated from several alternative mechanisms. (i.e. impervious area, rooftop area, lot size, etc.) The billing options are usually a key driving factor in the decision for how the fee is implemented. A town with existing billing systems for water and sewer may be able to easily add on a stormwater fee to the existing invoicing and collections systems. However, depending on billing systems or operational constraints, a separate invoice may need to be developed with its own schedule. These initial research results will then be compared to adjacent communities and discussed amongst the project team to determine a preferred approach. It is at this point the scope of the fee will be identified and limitations on how the funds can be spent will be drafted. This work should take between 3 and 4 months and not require any legislative action.

Phase B – Preliminary Plan. The initial preferences are formalized into a preliminary plan that can be presented to staff, councils, and the general public for review and comment. A municipal and public process can revise and adjust the fees, structure, and invoicing to fit the needs of the administration and general public. This preliminary plan will provide a more accurate estimate of impervious area or other metrics selected to quantify the fee across various properties. A selection of a rate structure and any classifications of properties (i.e. private, public, non-profit, etc.) can be made at this stage. Billing options will be finalized. And inherent to the more defined rate structure will be a discussion on potential credits to the fee (i.e. installation of rain barrels saves 10% of the fee per year, etc.). An implementation cost for new software, systems, adjustment of existing systems, or migration of existing processes can be estimated. This work could take as long as 6 months and may require public hearings or other administrative processes to document the public process.

Phase C – Implementation. This process finalizes the preliminary plan and results in the delivery of the first stormwater fee invoices to the community. Consequently, additional public outreach is necessary. Rate classes are finalized for single family, multi family, commercial, public, non-profit and other criteria. A financial outlook projecting revenues and expenditures should be developed to support the final adoption of the fee. Public works staff and consultants can be utilized to prioritize stormwater utility routine tasks, annual procedures, emergency operation allowances, and qualified special projects. A budget for routine tasks may involve a monthly allocation for 12 hours of vac truck time for stormwater inlet cleaning. An annual procedure may be an inventory of outfall conditions town-wide. Emergency operation allowances can be an agreement that specifies how much of the annual stormwater fee budget is reserved for emergency repairs and operations. A list of qualifications for special projects that can use the stormwater fee can be developed to provide guidance for staff and consultants to use when calls on the stormwater fee are made for repair, rehabilitation or improvement of stormwater infrastructure. Before presentation of the fee to the legislative process, a trial run of the billing, time keeping, and tracking systems should be run. In some cases, this can be a staged implementation where the fee is instituted for public facilities at a trial rate of $1 per parcel. When those systems are functional, the whole project can be presented to council for adoption.

10.3 Use of Funds

There can be specific study of how the funds are used. How the funds are transferred within the Town's accounting system is important and includes how the Town staff records their expenses related to stormwater. The funds from a stormwater utility should be used primarily for projects benefitting existing development because the existing property owners pay the fees. New developers are expected to pay their share of major drainage projects serving new development, because they are responsible for the excess stormwater their development creates. New developments are responsible for the minor drainage infrastructure within their development such as street drainage systems, and minor system pipes and channels conveying water to the major drainage facilities.

10.4 Range of Nearby Stormwater Utility Fees

The existing stormwater utilities in nearby communities can provide a rough estimate for what a fee may be in Lyons. The range is from less than $1 to more than $11. Berthoud has a fee of approximately $2.50 per single family residential unit. Greeley, a much larger community, has a fee of just over $5 per single family unit. Loveland has a fee over $11 and has been in existence since the early 1980s. In general, the average around the front range of Colorado is about $5 per single family residential unit. However, the average can be misleading as the variables for how the fee is paid, used, and allocated changes for every community, land use, and sometimes by year.

11.0 Conclusion

There are several key concepts developed through the master plan study of local stormwater in the Town of Lyons.

11.1 Hydrology

Since the 2013 Floods, there has been a number of studies on the hydrology of major watersheds within the State and in particular along the Front Range of Colorado. This study utilized the latest software and methods to evaluate the basins immediately affecting the Town of Lyons. Evaluations of the minor (2 year), intermediate, and major (100 year) storms were completed. Analysis of the basins included a scenario for wild fire, with consideration for the vegetation density and impact of charred earth on stormwater runoff. This hydrologic analysis can be a useful starting point for public and private studies of future stormwater detention, capture, conveyance, as well as redevelopment of Town of Lyons watersheds.

11.2 Land Use

The land use assumptions for this study determined the land use within the 2016 Town boundary is effectively built out. In other words, when comparing the existing impervious area with the impervious areas assumed by the future land use maps, the increase is less than 10% of the impervious area. Therefore, this study utilized the future land use impervious area for hydrologic and hydraulic computations. This is a unique, but not atypical, condition for a smaller front range community with the topographic constraints of Lyons.

Consequently, development or redevelopment within the Town limits will not immediately invalidate the conclusions of this master plan.

11.3 Detention

Detention is a valuable means of slowing down stormwater, storing it for a short period of time, and releasing it in a controlled manner. However, the steep slopes and land use constraints in the Town have limited the feasibility of detention. Further evaluation of the detention facilities contemplated in the previous (1998) master plan identified several costly and complicated factors in the grading, stability, and available storage volume. Consequently, this master plan does not recommend significant benefit from detention facilities. However, if the Town expands into the upper elevations on the north side of Town development of new detention facilities should be recommended and carefully designed.

11.4 Water Quality

Stormwater master plans are quick to identify the major storm water risks and highlight the capital projects that can alleviate those risks. The nature of benefit-cost financing decisions forces communities to consider damages averted as a major element of the process. However, there are incremental damages that are more difficult to quantify with current technologies – water quality impairments for example. Therefore, it is prudent to consider the means and methods by which a community can improve water quality in the larger watersheds in which the community resides. This master plan has identified a number of smaller, achievable water quality improvements for the Town. The macro scale water quality ponds that can record an official water quality capture volume are as difficult to construct as the detention facilities on steep slopes in essentially built-out communities. Therefore, this master plan considers the greatest benefit to water quality will come through private, small-scale water quality installations throughout an engaged and caring community.

11.5 Public Outreach

This master plan was scoped to focus on engineering analysis to investigate the localized flood risk areas and evaluate mitigation alternatives. The public process was coordinated with Town staff and consultants and included presentations at the Utility and Engineering Board, Board of Trustees, and meetings with concerned citizens and neighbors. The public input to the process is essential in validating the assumptions used to model the flood risks throughout areas of complicated terrain, infrastructure, and changing ground conditions due to flood recovery and construction projects. Given the dynamic nature of flood recovery projects and the current economic environment, the public outreach for this particular master plan must continue through at least the planned completion of flood recovery projects in March 2018. At that time, the regional projects and plans on the North and South St. Vrain Rivers will be substantially completed. Evaluation and future implementation of the stormwater master plan will be influenced by completion of the major river projects. The online version of the master includes a 'click-to-comment' function that allows users to add stormwater master plan comments that get stored in a single database. This commenting function, as well as the Town's ongoing attention to stormwater related matters, ensures this stormwater master plan has a long shelf life.

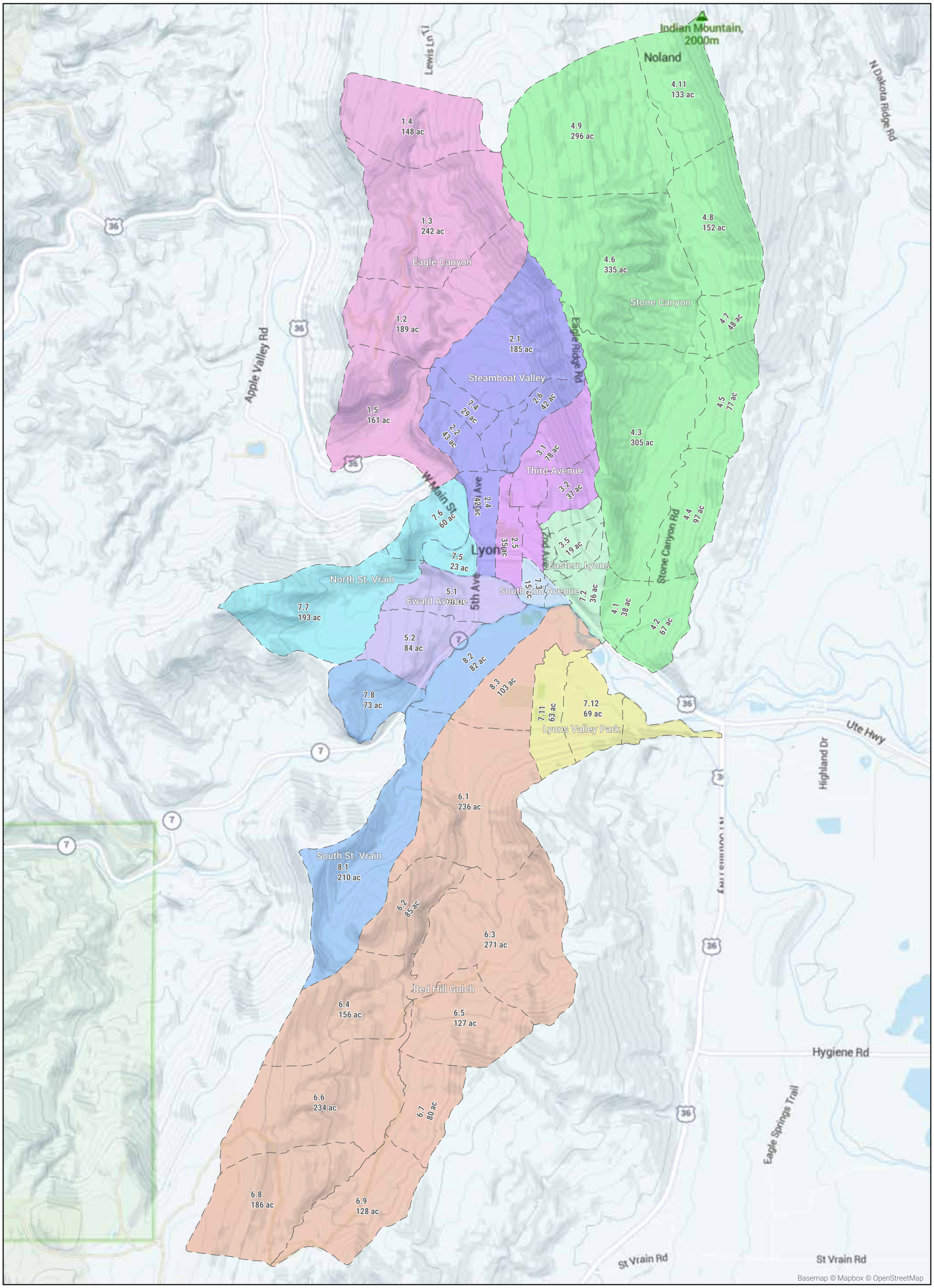
11.6 Operation and Maintenance

Operation and maintenance is always a key element to any stormwater plan. When the CIP projects reach nearly impossible budget figures, or when the priorities for other municipal infrastructure out rank surface drainage improvements, or when the best projects don't get built for another 10 years, the operation and maintenance of the existing system continues. The Town's existing stormwater system is functional despite limited capacity and generally disconnected conveyance systems. Therefore, resilience to flood risks can still improve even if it is only maintenance activities on the existing system. Trash removal, debris clean up, sediment removal, pipe maintenance, inlet cleaning, gutter pan replacements, and other routine tasks are the preeminent recommendation of the stormwater master plan.

11.7 Next Steps

The next steps for the Town of Lyons stormwater master plan include a frequent and routine review of the projects, priorities, and plans set forth in this document. This document in and of itself cannot solve a stormwater problem, avert flood risk, or increase resilience in the community. But, when this plan is paired with other planning efforts, included in development discussions, use of the technical appendices in evaluation of future projects, or other citations this plan can add value and clarity to stormwater management discussions in the Town of Lyons for many years to come.

Appendix A



Lyons Stormwater Masterplan

Figure A-1: Watersheds

LYONS COLORADO

ICON ENGINEERING, INC.

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1.0 INTRODUCTION

This introduction provides basic information including purpose and scope, mapping sources, and data collection. The remainder of this report represents the hydrologic analysis conducted on subbasins which are tributary to North St. Vrain Creek, South St. Vrain Creek, and St. Vrain Creek near the Town of Lyons, Colorado (Town).

1.1 Purpose and Scope

The intent of this report is to document the hydrologic analysis conducted by Wright Water Engineers, Inc. (WWE) to provide updated peak discharges for the 2-, 5-, 10-, 50-, and 100-year storm events for subbasins which are tributary to North St. Vrain Creek, South St. Vrain Creek, and St. Vrain Creek as they flow through the Town. This hydrologic analysis focused on the existing and future drainage conditions of the watershed that can be used to develop alternative drainageway planning concepts and prepare a preliminary design of improvements.

1.2 Mapping

Mapping used in the hydrologic analysis was based on 2011 LIDAR topography with 1-ft contour intervals provided by ICON Engineering, Inc. As a result of the September 2013 flood, there were significant changes in channels due to avulsion, scour, and deposition. However, these changes primarily affected channel and floodplain areas rather than upland areas that comprise the vast majority of subbasin drainage areas. The 2011 LIDAR data was found to be suitable for subbasin delineation and parameterization. Aerial mapping from Google Earth dated October 2015 was used to determine existing land use conditions and calculate subbasin imperviousness.

1.3 Data Collection

The following summarizes the information that was used as a reference for this hydrologic analysis:

- Town of Lyons, Boulder County, Colorado, Drainage Master Plan Final report, BRW, Inc., April 1998.

- Zoning District Map of the Town of Lyons, Colorado, King Surveyors, Inc., Readopted January 2009.

- 2010 Lyons Planning Area Map, Civil Resources, 2010.
- Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual.

2.0 HYDROLOGIC ANALYSIS

This section of the report provides an overview of the hydrologic characteristics, calculations, and modeling used to develop the hydrology for the project area, as well as detailed descriptions of the design rainfall, subbasin characteristics, model input, model results, results, and comparisons with previous studies.

2.1 Project Area Description

The project area includes the subbasins tributary to the North Saint Vrain Creek, South Saint Vrain Creek, Red Hill Gulch, and Stone Canyon within the Town. The total drainage area studied is approximately 8.6 square miles.

Existing drainage in the area consists of mostly open channels with some storm sewers in urbanized areas in Town. Most of the Town's existing drainage infrastructure is undersized due to the increase in development within the Town during the 1990s. The existing conveyance system has the capacity to convey the nuisance flows, but it does not have the capacity to convey even the minor (5-year) storm events.

2.2 Previous Studies

Hydrology of watersheds running through the Town was previously studied by BRW, Inc. for the *Town of Lyons Drainage Master Plan Final Report* dated April 1998. This drainage master plan utilized the Colorado Urban Hydrograph Procedure (CUHP) and the Urban Drainage Storm Water Management Model (SWMM) to simulate developed stormwater runoff rates and volumes to identify problem areas. Additionally, the drainage master plan formulated a strategy to cost effectively upgrade the Town's flood control facilities and provided feasibility-level cost analyses to enable subsequent capital budgeting.

The hydrologic analysis conducted for the Town as a part of this effort was not "calibrated" to the hydrology defined in the BRW, Inc. drainage master plan. Comparisons were made to the unit rates of runoff from the BRW, Inc. drainage master plan, but the hydrologic analysis described in this report was conducted independently using the CUHP version 2.0. Both hydrologic studies utilized CUHP so differences between the BRW and WWE model results can be explained by physical factors (i.e. differences in subbasin imperviousness and the use of updated NOAA Atlas 14 precipitation data).

2.3 Hydrologic Model

To evaluate the latest version of CUHP (and other methods) and to determine the appropriate model inputs, WWE conducted a peak flow sensitivity analysis for a typical undeveloped subbasin near the Town using various hydrologic methods. This sensitivity analysis was conducted to determine which hydrologic method should be utilized for the Lyons stormwater master plan since Lyons is located outside of the UDFCD boundary and the hydrologic method to be used to estimate peak discharges is not limited to CUHP. The following lists the hydrologic methods that were utilized in this sensitivity analysis:

- United States Geologic Survey (USGS) Regional Regression Equations.
- Rational Method.
- CUHP 2005 Version 1.4.4 -- This is the current model used by UDFCD and has been used for over 40 years to estimate peak flows in the Denver metropolitan area.
- CUHP Version 2.0 -- Recently the UDFCD has determined that peak flows developed in recent hydrologic studies using CUHP 2005 version 1.4.4 deviated from statistical stream gage analysis across the District and created uncertainty with CUHP model results for some studies. Additionally, CUHP 2005 version 1.4.4 has not been calibrated with gage data since its inception in the 1970s with adjustments made in the 1980s. Therefore, UDFCD has recalibrated CUHP with updated rainfall and runoff with results tested against stream gage frequency analysis. However, it should be noted that during the recalibration of CUHP, there were no watersheds with an imperviousness less than 20 percent. Therefore, for subbasins with imperviousness below 20 percent, the peak flows are estimated using similar methodology used in CUHP 2005 version 1.4.4.

- HEC-HMS Model -- using Curve Number method.

- UDFCD Allowable Release Rates -- The UDFCD *Urban Storm Drainage Criteria Manual, Volume 2, Storage* chapter provides pre-development peak unit discharge rates for watersheds of various slopes and Hydrologic Soil Groups (HSGs) that are utilized to determine the maximum allowable 100-year release rates for a full spectrum detention facility.

Based on the results of the undeveloped subbasin peak flow sensitivity analysis, WWE recommended using CUHP version 2.0 for the hydrologic modeling for the Lyons stomwater master plan. The unit rates of runoff from CUHP version 2.0 were in the same range as those generated using the Rational Method and the UDFCD allowable release rates. The unit rates of runoff generated using CUHP 2005 version 1.4.4 were higher than any of the other hydrologic methods which may overestimate the peak flows for the Town. The regional regression equations significantly underestimate the unit rates of runoff when compared to the other hydrologic model methods.

2.4 Subbasin Delineation

Subbasins were delineated using the 2011 LIDAR and associated 1-ft contours. There is a total of 44 subbasins within the project area. The undeveloped subbasins located higher up in the watersheds are larger in size than the subbains within the urbanized Town. Subbasin sizes range from 17 acres to 335 acres. Figure 1 provides an overview of the subbasins.

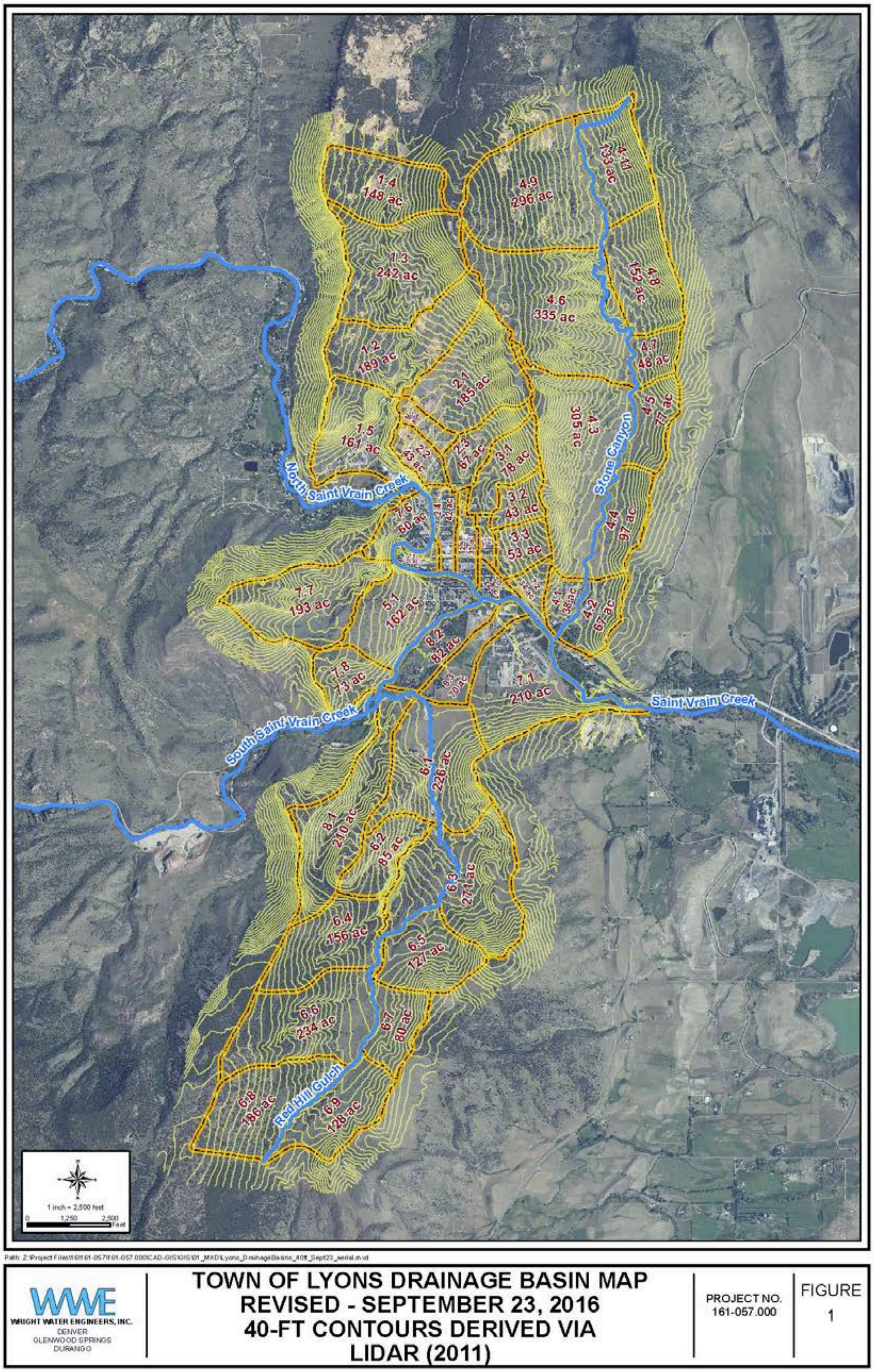

Figure 1. Subbasin Overview Map

2.5 Design Rainfall

The design rainfall for the project was derived using the one-hour precipitation depths from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. One-hour point precipitation depths were based on the centroid of the entire project area and were recorded for the 2-, 5-, 10-, 50-, and 100-year recurrence intervals. Point precipitation depths for varying elevation within the project area were identified, but point precipitation depth adjustments due to elevation were not necessary since the difference in the one-hour precipitation depths by elevation was less than 0.1 inches. Using the one-hour precipitation depth, CUHP calculates the incremental depth for each time increment from 5 to 120 minutes. Due to the smaller sizes of subbasins, precipitation depth-area reduction factors were not utilized. Table 1 summarizes the design rainfall depths for various recurrence intervals.

Table 1. Design Rainfall Depths (inches) for Recurrence Intervals

Storm Duration	2-Year	5-Year	10-Year	50-Year	100-Year
One-Hour	0.77	1.05	1.33	2.23	2.71

2.6 CUHP Input Parameters

The following summarizes the input parameters utilized in CUHP version 2.0. Using GIS, subbasin characteristics were calculated and input into CUHP. The summary of CUHP input parameters for existing conditions and future conditions for the 2-, 5-, 10-, 50-, and 100-year recurrence intervals is provided in Appendix A.

2.6.1 Length to Centroid

The length to centroid is calculated as the distance from the design point of the subbasin along the main drainageway path to the subbasin's centroid. Figure 2 provides an overview of the longest flow paths. The subbasin centroids are identified on the figure with the red and white dots. The length to the centroid was measured from the downstream design point of the subbasin to the centroid along the flow path.

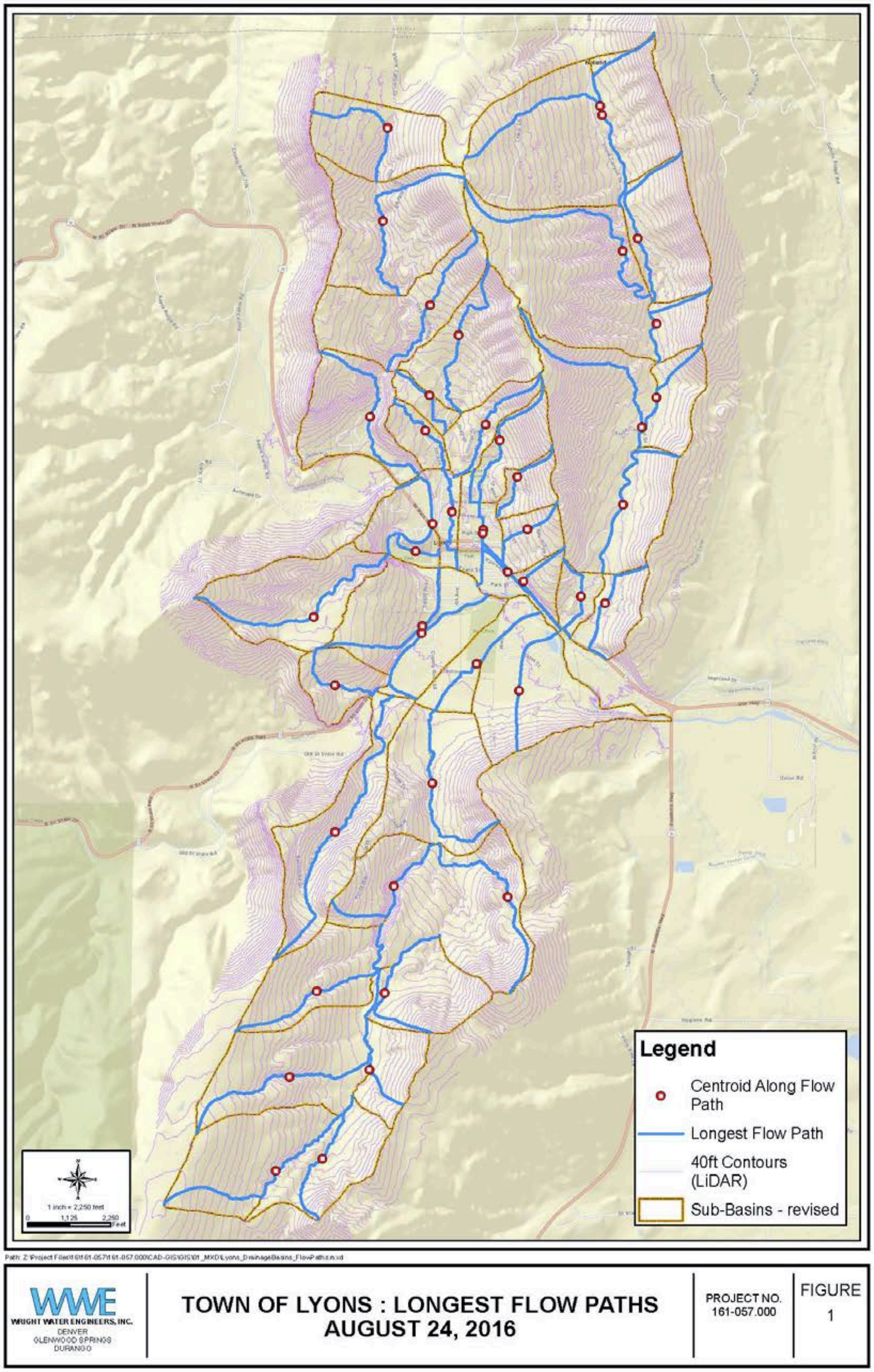

Figure 2. Subbasin Longest Flow Paths

2.6.2 Length

The length is the distance from the downstream design point of the subbasin along the main drainageway path to the furthest point on the subbasin boundary. The length was calculated based on the longest flow path (blue line) shown in Figure 2.

2.6.3 Slope

The slope is the length-weighted, corrected average slope of the subbasin in feet per foot. Per the UDFCD *Urban Storm Drainage Criteria Manual, Volume 1, Chapter 6 Runoff*, there are natural processes at work that limit the time to peak of a unit hydrograph as a natural stream or vegetated channel becomes steeper. To account for this phenomenon, it is recommended that the slope used in CUHP for stream and vegetated channels be adjusted. Table 2 provides a summary of the measured subbasin slopes compared to the adjusted slope for use in CUHP per Figure 6-4 of the UDFCD *Urban Storm Drainage Criteria Manual*.

Table 2. CUHP Subbasin Slope Adjustment

Subbasin	Measured Slope (ft/ft)	Adjusted Slope for use in CUHP (ft/ft)
1.2	0.19	0.06
1.3	0.15	0.06
1.4	0.12	0.06
1.5	0.11	0.06
2.1	0.20	0.06
2.2	0.10	0.06
2.3	0.20	0.06
2.4	0.03	0.03
2.5	0.04	0.04
3.1	0.19	0.06
3.2	0.22	0.06
3.3	0.18	0.06
3.4	0.04	0.04
4.1	0.10	0.06
4.11	0.10	0.06
4.2	0.09	0.06
4.3	0.10	0.06
4.4	0.09	0.06
4.5	0.15	0.06
4.6	0.11	0.06
4.7	0.16	0.06
4.8	0.16	0.06
4.9	0.12	0.06
5.1	0.10	0.06
6.1	0.11	0.06
6.2	0.17	0.06
6.3	0.15	0.06
6.4	0.14	0.06
6.5	0.16	0.06
6.6	0.10	0.06
6.7	0.10	0.06
6.8	0.12	0.06
6.9	0.13	0.06
7.1	0.13	0.06
7.2	0.10	0.06
7.3	0.02	0.02
7.4	0.09	0.06
7.5	0.003	0.003
7.6	0.02	0.02
7.7	0.17	0.06
7.8	0.14	0.06
8.1	0.11	0.06
8.2	0.01	0.01
8.3	0.02	0.01

2.6.4 Percent Imperviousness

The percent imperviousness model input was determined based on land use and soil types found in each subbasin. Land use was determined by compiling information from the 2009 Zoning

District Map, 2010 Lyons Planning Area Map, and by ground-truthing the land cover based on an October 2015 aerial image from Google Earth. Each land use category was assigned a percent imperviousness with guidance from Chapter 6 – Runoff of the UDFCD *Urban Storm Drainage Criteria Manual*. Table 3 outlines the land use categories and the corresponding percent imperviousness. In addition to the land use categories found in Table 3, Boulder County Open Space land use category represented a large amount of many subbasins. Soil types mapped using the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey were assigned a percent imperviousness based on drainage and runoff class and area weighted within each subbasin. (See Appendix B for detailed soil descriptions). Table 4 displays the soil types used to calculate imperviousness for the Boulder County Open Space land use category.

Table 3. Land Use Categories and Corresponding Percent Imperviousness

Land Use Category	UDFCD Vol. 1 Table 6-3 Equivalent	Lyons Percentage Imperviousness
Agriculture	Undeveloped - Greenbelts, agricultural	0.20
Business	Business - Downtown areas	0.95
Park	Parks, cemeteries	0.10
Municipal Facilities	Business - Suburban areas	0.75
Estate Residential[1]	Residential - Single Family: 2.5 acres or larger	0.35
Low Density Residential[1]	Residential - Single Family: 0.25-0.75 acres	0.75
Medium Density Residential[1]	Residential - Single Family: 0.75-2.5 acres	0.85
Commercial	Business - Downtown areas	0.95
Employment Area	Business - Downtown areas	0.95
Commercial Entertainment	Business - Downtown areas	0.95
Light Industrial	Industrial - Light areas	0.80
General Industrial	Industrial - Heavy areas	0.90

[1] Land use category corresponds to the 2010 Lyons Planning Area Map, although the description and corresponding lot size is not representative of what is observed in aerial imagery. WWE revised the percent imperviousness to be more representative of what is observed through imagery and on the ground.

Table 4. Soil Types Found in Boulder County Open Space Land Use Category

Soil Unit	HSG	Soil Type	Drainage Class	Runoff Class	Percent Rock Outcrop	Percent Imperviousness
MdB	A	sandy loam	well	very low		2
Nh	B	loam	poorly	very low		2
Cu	A	gravelly sandy loam	excessively	low		5
NnB	C	sandy clay loam	well	medium		8
SmF	C	stony loam	well	high	10	10
BaF	D	very stony sandy loam	well	very high	10	10
PrF	D	very stony loamy fine sand	well	very high	35	35
Ro	D	unweathered bedrock	N/A	very high	100	100

Future imperviousness was determined by comparing the land use in the 2010 Lyons Planning Area Map to a 2015 Google Earth image and noting which areas of the Town reflected current zoning and which areas may be further developed based on the planning map. The directly connected impervious area was set at level zero to represent “standard practice,” meaning impervious surfaces are not designed to drain over grass buffer strips or other pervious surfaces before reaching a stormwater conveyance system.

2.6.5 Maximum Depression Storage

The maximum pervious depression storage was set to the recommended value of 0.4 inches for wooded areas and open fields. The maximum impervious depression storage was set to the recommended value of 0.1 inches. No adjustments were made to these recommended values.

2.6.6 Horton’s Infiltration Parameters

Soils data was obtained from USDA NRCS Soil Survey Geographic Database for the project area which classified the soils into HSGs. Figure 3 shows an overview of the HSGs for each of the subbasins. Additional soils mapping was obtained from the USDA NRCS Web Soil Survey which is provided in Appendix B.

The HSG A soils are colluvial land type soil. According to the colluvial land soil description, the depth to restrictive feature is 2 to 60 inches to lithic bedrock. Because of the underlying bedrock, it was assumed that the HSG A soils would have the drainage characteristics of HSG B soils.

The initial rate, final rate, and decay coefficient for the Horton's infiltration parameters were based on the recommended values in CUHP. The Horton's infiltration parameters were weighted based on the percentage of each soil type within each subbasin. Table 5 summarizes the Horton's infiltration parameters utilized in the analysis.

Table 5. Horton's Infiltration Parameters

Hydrologic Soil Group	Infiltration (inches per hour)		Decay Coefficient
	Initial - f_i	Final – f_o	
A/B	4.5	0.6	0.0018
C	3.0	0.5	0.0018
D	3.0	0.5	0.0018

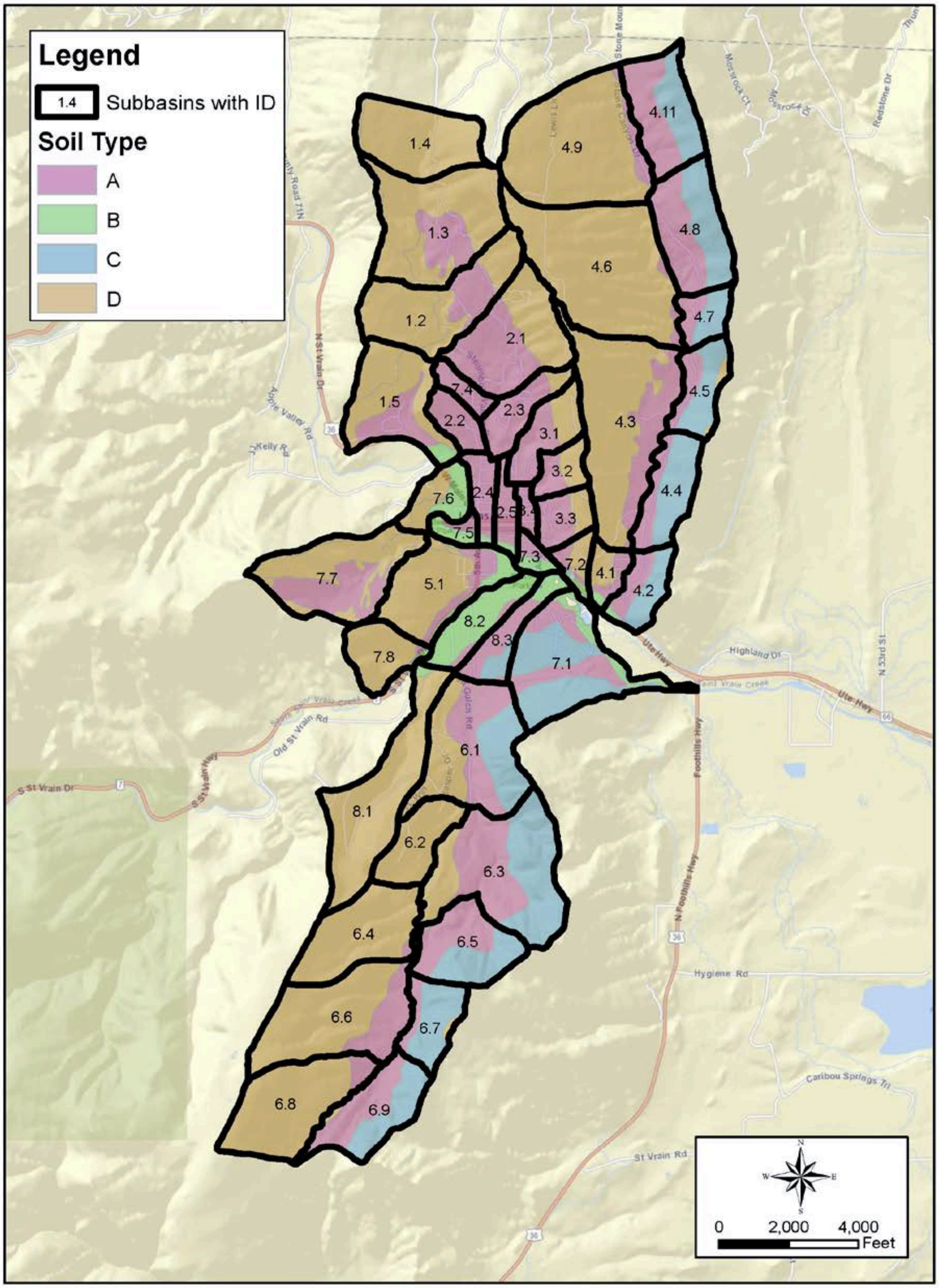

Figure 3. Soils Data

2.7 CUHP Output

The hydrologic analysis was conducted for both existing conditions and future conditions. The 100-year peak discharges from CUHP version 2.0 for both conditions are presented in Table 6. CUHP output for other recurrence intervals is provided in Appendix A.

Although this hydrologic analysis did not calibrate peak flows to the previous Town of Lyons Drainage Master Plan Final Report prepared by BRW, the CUHP unit rates of runoff were compared with the previous study unit rates of runoff for subbasins that were similarly delineated. In some cases, the unit rates of runoff are similar, but there are cases where the unit rates of runoff differ. These differences are primarily due to physical differences in input assumptions (imperviousness, HSGs, etc.).

Table 6. CUHP Output, 100-Year

Subbasin	Existing Conditions 100-Year Peak Discharge (cfs)	Existing Conditions Unit Rate of Runoff (cfs/ac)	Future Conditions 100-Year Peak Discharge (cfs)	Future Conditions Unit Rate of Runoff (cfs/ac)
1.2	408	2.16	408	2.16
1.3	534	2.21	534	2.21
1.4	403	2.72	403	2.72
1.5	449	2.79	401	2.49
2.1	306	1.65	306	1.65
2.2	97	2.27	97	2.27
2.3	130	1.95	130	1.95
2.4	109	2.57	109	2.57
2.5	102	2.89	102	2.89
3.1	142	1.83	167	2.15
3.2	111	2.55	111	2.55
3.3	114	2.16	114	2.16
3.4	51	3.04	51	3.04
4.1	102	2.66	128	3.33
4.11	183	1.38	183	1.38
4.2	113	1.68	114	1.70
4.3	387	1.27	387	1.27
4.4	128	1.33	128	1.33
4.5	117	1.52	117	1.52
4.6	526	1.57	526	1.57
4.7	70	1.47	70	1.47
4.8	227	1.49	227	1.49
4.9	575	1.94	575	1.94
5.1	375	2.32	386	2.39
6.1	367	1.62	373	1.65
6.2	187	2.18	187	2.19
6.3	370	1.37	370	1.37
6.4	186	1.19	186	1.19
6.5	213	1.68	213	1.68
6.6	233	1.00	233	1.00
6.7	176	2.21	176	2.21
6.8	252	1.35	252	1.35
6.9	216	1.69	216	1.69
7.1	531	2.52	599	2.84
7.2	65	1.92	65	1.92
7.3	73	3.35	73	3.35
7.4	68	2.37	68	2.37
7.5	33	1.43	33	1.43
7.6	134	2.25	134	2.25
7.7	360	1.87	360	1.87
7.8	143	1.96	145	1.98
8.1	313	1.49	313	1.49
8.2	93	1.13	93	1.13
8.3	75	1.07	75	1.07

2.8 Hydrograph Routing

WWE developed the hydrograph routing network based on field reconnaissance, survey of the existing storm sewer network within Town, and the BRW, Inc. drainage master plan using EPA SWMM. The routing network in EPA SWMM includes: nodes (junctions and dividers), conduits (including overflow or diverted links), storage units, storage outlets, and outfalls. The model input parameters for nodes include: node identifier, invert elevation, maximum node depth, and overflow or diverted link identifier. Input parameters for conduits include: conduit identifier, upstream and downstream node identifiers, shape (e.g. trapezoidal, circular, rectangular, etc.), length, bottom width, side slopes, roughness coefficient, number of barrels, and inlet/outlet offset depths. Input parameters for storage units include: storage unit identifier, invert elevation, maximum depth, and a stage-area relationship. Input parameters for storage outlets include: outlet identifier, upstream and downstream node identifiers, and a stage-discharge relationship. Input parameters for outfalls include the outfall identifier and invert elevation. Input parameters for the SWMM model are provided in Appendix C.

2.8.1 SWMM Node Input Parameters

Node identifiers in SWMM are synonymous with the subbasin IDs. Invert elevations were determined using the 2011 LIDAR data. In some instances, a divider was used to allow the flow to be routed through the existing storm sewer system but when the capacity of the storm sewer is exceeded, the water overflows into the street (along 2nd Avenue south of E. Main Street and near the intersection of Main Street and E. Main Street).

2.8.2 SWMM Conduit Input Parameters

For the drainage basins located outside of Town, transects of the drainage channels were generated using the 2011 LIDAR and a representative channel cross-section was input into the SWMM model. The manning's roughness coefficient for these undeveloped drainage basins was estimated to be 0.035 to represent channels with some weeds and stones.

Within the developed areas, characteristics of the drainage facilities were based on survey of the existing storm sewer system, field reconnaissance, and sizing the channels so that the flow could adequately be conveyed to the outfall. Between 5th Avenue and 4th Avenue, there is an existing drainage ditch that varies in width and depth but is enclosed downstream to accommodate development over the ditch. For the purposes of the SWMM model, it was assumed to have a uniform width and depth. There is a small roadside swale with intermittent driveway and roadway culverts along the west side of 3rd Avenue. However, the swale and culverts have such limited capacity and during large storm events, the water would flow down 3rd Avenue. At 3rd Avenue and Main Street there is a 30” reinforced concrete pipe that diverts flow from 3rd Avenue to the southeast along E. Main Street. During large storm events, the flow continues down within E. Main Street, which was modeled as an open channel, until it discharges into the St. Vrain Creek. South of E. Main Street along 2nd Avenue there is a storm sewer system consisting of 18-inch, 12-inch, and 15-inch corrugated metal pipe which discharges into the St. Vrain Creek. This storm sewer system was modeled as a 12-inch pipe in the SWMM model.

There are many subbasins which are direct flow areas into the North St. Vrain Creek, South St. Vrain Creek, or St. Vrain Creek. Therefore, the conduits for these subbasins were modeled as “dummy” conduits.

2.8.3 SWMM Storage Input Parameters

There is an existing detention pond located within Subbasin 1.5. The stage-area relationship was taken from the BRW, Inc. drainage master plan, as well as the stage-discharge relationship for the outlet. Although there may be inadvertent storage and/or privately owned detention elsewhere within the project area, no additional detention ponds were modeled for the existing conditions.

2.8.4 SWMM Output

The SWMM routing was conducted for both existing conditions and future conditions. The 100-year peak discharges at all of the outfalls from SWMM for both conditions are presented in Table 7. SWMM output for other recurrence intervals is provided in Appendix C.

Table 7. SWMM Output, 100-Year

SWMM Outfall Name	Routed Subbasins	Receiving Water	Existing Conditions 100-Year Peak Discharge (cfs)	Future Conditions 100-Year Peak Discharge (cfs)
StoneCanyonSt.VrainOUT	4.9, 4.11, 4.6, 4.8, 4.7, 4.3, 4.5, 4.4, 4.1, 4.2	St. Vrain Creek	2,357	2,361
EagleCanyonN.St.VrainOUT	1.4, 1.3, 1.2, 1.5	North St. Vrain Creek	1,362	1,362
RedHillGulchS.St.VrainOUT	6.8, 6.9, 6.6, 6.7, 6.4, 6.5, 6.2, 6.3, 6.1	South St. Vrain Creek	2,357	2,361
Sub2.4N.St.VrainOUT	2.1, 2.2, 7.4, 2.3, 2.4	North St. Vrain Creek	695	695
Sub7.2St.VrainOUT	3.1, 3.2, 2.5, 3.4, 3.3, 7.2	St. Vrain Creek	577	610
Sub7.3St.VrainOUT	7.3	St. Vrain Creek	73	73
Sub7.7N.St.VrainOUT	7.7	North St. Vrain Creek	360	360
Sub7.8S.St.VrainOUT	7.8	South St.Vrain Creek	143	145
Sub5.1N.St.VrainOUT	5.1	North St. Vrain Creek	375	386
Sub7.5N.St.VrainOUT	7.5	North St. Vrain Creek	33	33
Sub8.2St.VrainOUT	8.2	St. Vrain Creek	93	93
Sub8.3St.VrainOUT	8.3	St. Vrain Creek	75	75
Sub7.1St.VrainOUT	7.1	St. Vrain Creek	531	599
Sub7.6N.St.VrainOUT	7.6	North St. Vrain Creek	134	134

3.0 WILDFIRE ANALYSIS

Post-wildfire flooding was evaluated for the subbasins tributary to the North St. Vrain Creek, South St. Vrain Creek, and St. Vrain Creek near the Town based on forest coverage determined from aerial imagery inspection. Beetle kill mapping from an aerial detection survey performed by the U.S. Forest Service was reviewed; however, the trees in this area do not exhibit signs of beetle kill. The purpose of this modeling exercise was to illustrate how peak discharges could potentially temporarily increase following a wildfire. This analysis is intended to provide the Town of Lyons with an order of magnitude approximation of potential wildfire effects on hydrology. Post-wildfire hydrology is typically analyzed using the Curve Number (CN) method (USDA, 2016). For this post-wildfire flood scenario, the watershed was assumed to experience moderate burn severity since the forest coverage in these watersheds is not extremely dense. The CN WWE assigned to a moderate burn severity was an 89, which is consistent with the CN developed by WWE in other post-wildfire hydrology assessments, including the Boulder County Fourmile wildfire in 2010, and the newly released Hydrology Technical Note No. 4, Hydrologic Analyses of Post-Wildfire Conditions, issued by the NRCS in August 2016.

Three representative subbasins, each with different watershed slopes, were modeled in HEC-HMS using existing condition (pre-wildfire) curve numbers as well as post-wildfire curve numbers. These modeling scenarios provide a relative increase in the unit rate of runoff for post-wildfire conditions. Table 8 provides the average factors of increase of the unit rates of runoff for existing, pre-wildfire conditions to post-wildfire conditions.

Table 8. Average Factor of Increase in Unit Rate of Runoff from Existing, Pre-Wildfire Conditions to Post-Wildfire Conditions

Recurrence Interval	Average Factor of Increase
2-yr	11
5-yr	5
10-yr	3
50-yr	2
100-yr	2

Each subbasin was evaluated for forest cover and assigned an approximate percent coverage found in Table 2. Subbasins that are not displayed in Table 9 were either in town, and therefore have minimal potential to experience wildfire, or do not have notable forest coverage. The peak discharge resulting from a wildfire burned subbasin is dependent on the forest coverage in each basin. In other words, the 2-year event may only increase the peak discharge in a subbasin with 20 percent forest coverage by approximately a 2.2 factor of increase (or about two times the existing condition peak discharge).

Table 9. Approximate Percent Coverage of Forest for Forested Subbasins

Subbasin with Forest Coverage	Percent Cover
1.2	20
1.3	30
1.4	80
4.3	10
4.6	20
4.9	50
6.1	20
6.2	70
6.3	20
6.4	90
6.6	80
6.8	70
6.9	10
8.1	50

The results in this evaluation provide useful information on the potential magnitude of hydrologic effects of burn areas in this watershed. The unit rate of runoff average factors of increase can be applied to the existing, pre-wildfire unit rates of runoff generated from the CUHP modeling to determine the potential increase in runoff after a wildfire. Changes in hydrology due to wildfires are temporary in nature and decrease back to pre-burn levels over periods of time ranging from 5 to 10 years or more; however, changes in runoff and volumes in the years immediately following a wildfire can be extreme.

Mud and debris flows can be triggered by as little as 0.25 inches of rain in 30 minutes on steep, burned slopes (WWE, 2011). Mud and debris flows are most common in smaller tributaries, but some “bulking” would be expected even on the main stems due to ash, sediment, and debris. In addition, debris damming and subsequent breaching (which are not accounted for in the modeling) can significantly increase peak discharges in post-wildfire floods. WWE did not account for sediment bulking in this hydrologic analysis, and additional analysis would be needed to determine approximate bulking factors for different reaches. Debris damming and breaching also was not evaluated as a part of this study. If there are high risk locations that could be affected by this phenomenon in Town, additional analysis using dam break routines could be used to estimate potential peak discharges.

This post-wildfire flooding analysis is just a representative scenario. Additional studies could be performed to evaluate different burn area scenarios based on factors including locations of key infrastructure in the watershed, applying USGS debris flow regression equations to specific subbasins, varying burn area size and severity, and other considerations discussed above.

4.0 CONCLUSIONS

This effort to develop updated hydrology for subbasins tributary to the North Saint Vrain Creek, South Saint Vrain Creek, Red Hill Gulch, and Stone Canyon within the Town utilizes an updated hydrologic model than the model that was utilized in the previous hydrologic study. Results of this hydrologic analysis provide reasonable estimates of peak discharges that can be used to develop alternative drainageway planning concepts and prepare a preliminary design of improvements.

5.0 REFERENCES & SOURCES OF DATA

BRW, Inc., April 1998, Town of Lyons, Boulder County, Colorado Drainage Master Plan Final Report.

Civil Resources, 2010, 2010 Lyons Planning Area Map.

King Surveyors, Inc., January 2009, Zoning District Map of the Town of Lyons, Colorado.

National Oceanic and Atmospheric Administration, 2013, Precipitation-Frequency Atlas of the United States, Midwestern States, Volume 8.

United States Department of Agriculture, Natural Resources Conservation Service, Soil Survey Geographic Database (current).

United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey.

United States Department of Agriculture, Natural Resources Conservation Service, August 2016, Hydrology Technical Note No. 4: Hydrologic Analyses of Post-Wildfire Conditions.

Urban Drainage and Flood Control District, January 2016, Urban Storm Drainage Criteria Manual: Volume 1, Management, Hydrology, and Hydraulics, Chapter 6 Runoff.

Urban Drainage and Flood Control District, January 2016, Urban Storm Drainage Criteria Manual: Volume 2, Structures, Storage, and Recreation, Chapter 12 Storage.

U.S. Forest Service and Forest Health Protection, February 2016, Aerial Detection Survey, online at http://www.fs.usda.gov/detail/r2/forest-grasslandhealth/?cid=fsbdev3_041629

Wright Water Engineers, Inc., February 2011, Final Summary of Findings – Fourmile Canyon Post-Fire Hydrology and discussion of Conceptual Mitigation Measures.

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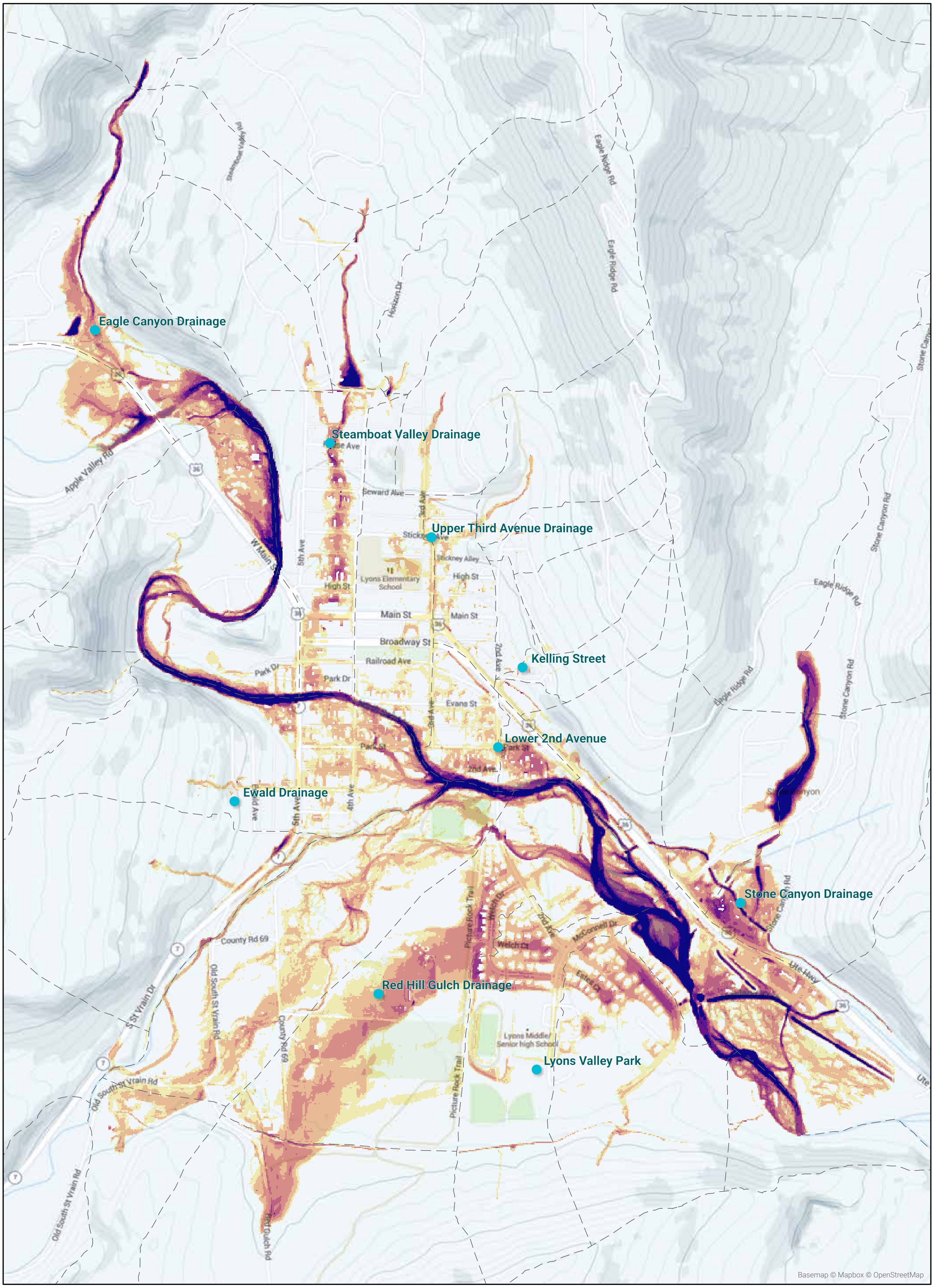
Appendix C



Lyons Stormwater Masterplan

Figure C-1: Problem Identification

100-year Max Flow Depth (ft)

.5 1 2 3 4 5 6+

LYONS COLORADO

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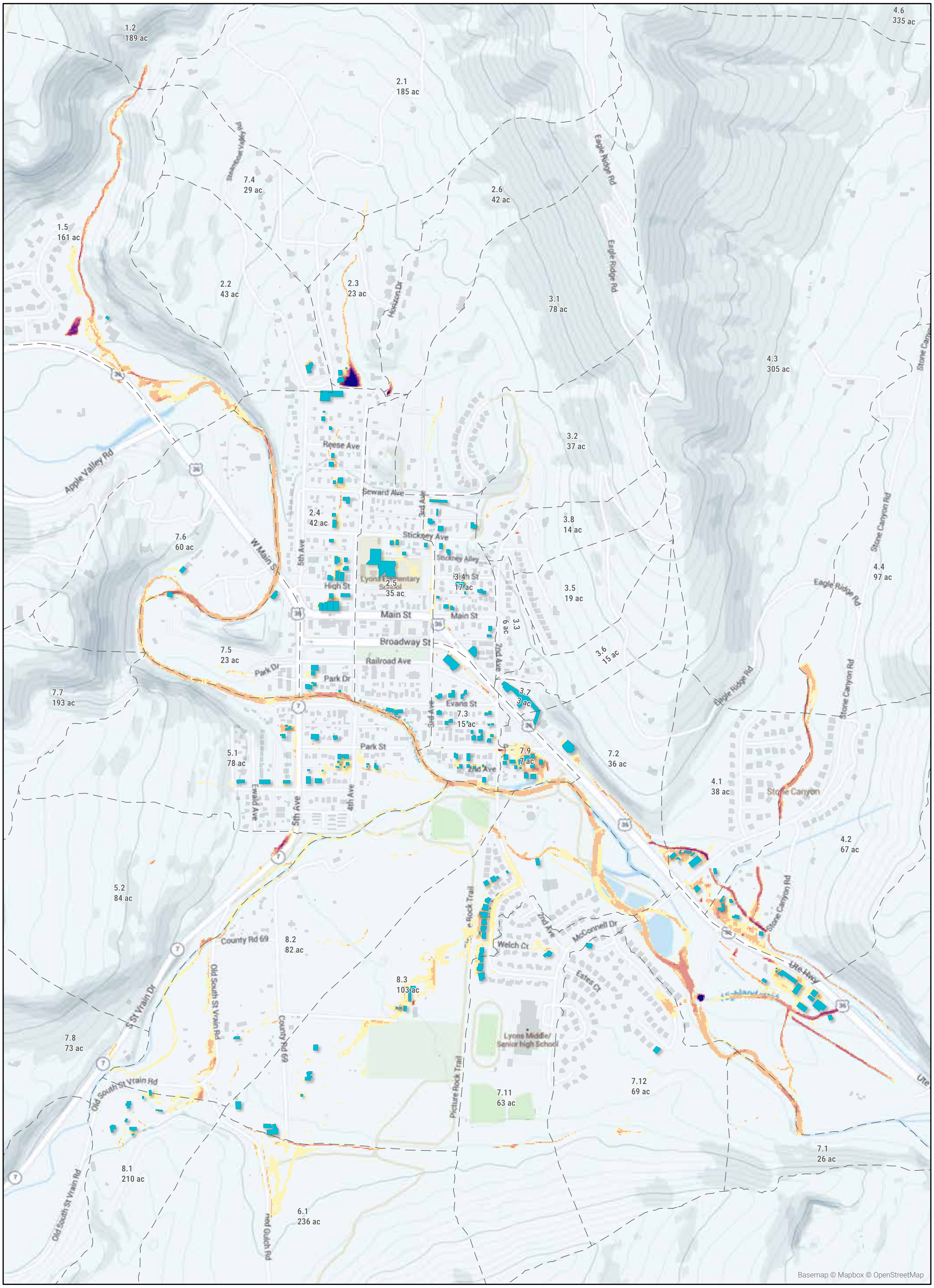
Appendix D



Lyons Stormwater Masterplan

Figure D-1: FLO2D Results: 2-Year Future Conditions

Max Flow Depth (ft)

.5 1 2 3 4 5 6+

Building Footprint

At-Risk Building

Sub-Basins

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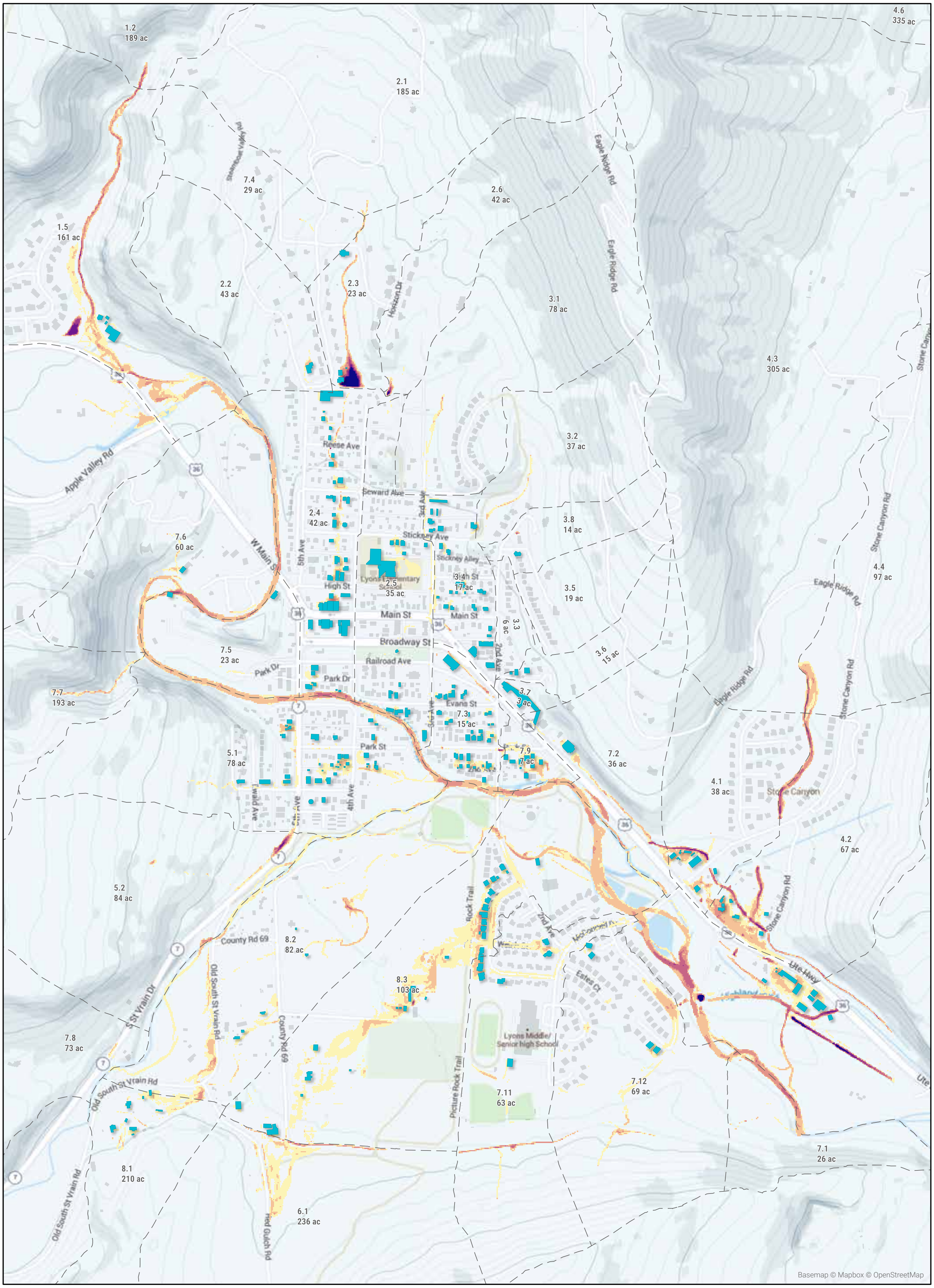

Lyons Stormwater Masterplan

Figure D-2: FLO2D Results: 5-Year Future Conditions

Max Flow Depth (ft)

.5 1 2 3 4 5 6+

Building Footprint

At-Risk Building

Sub-Basins

LYONS COLORADO

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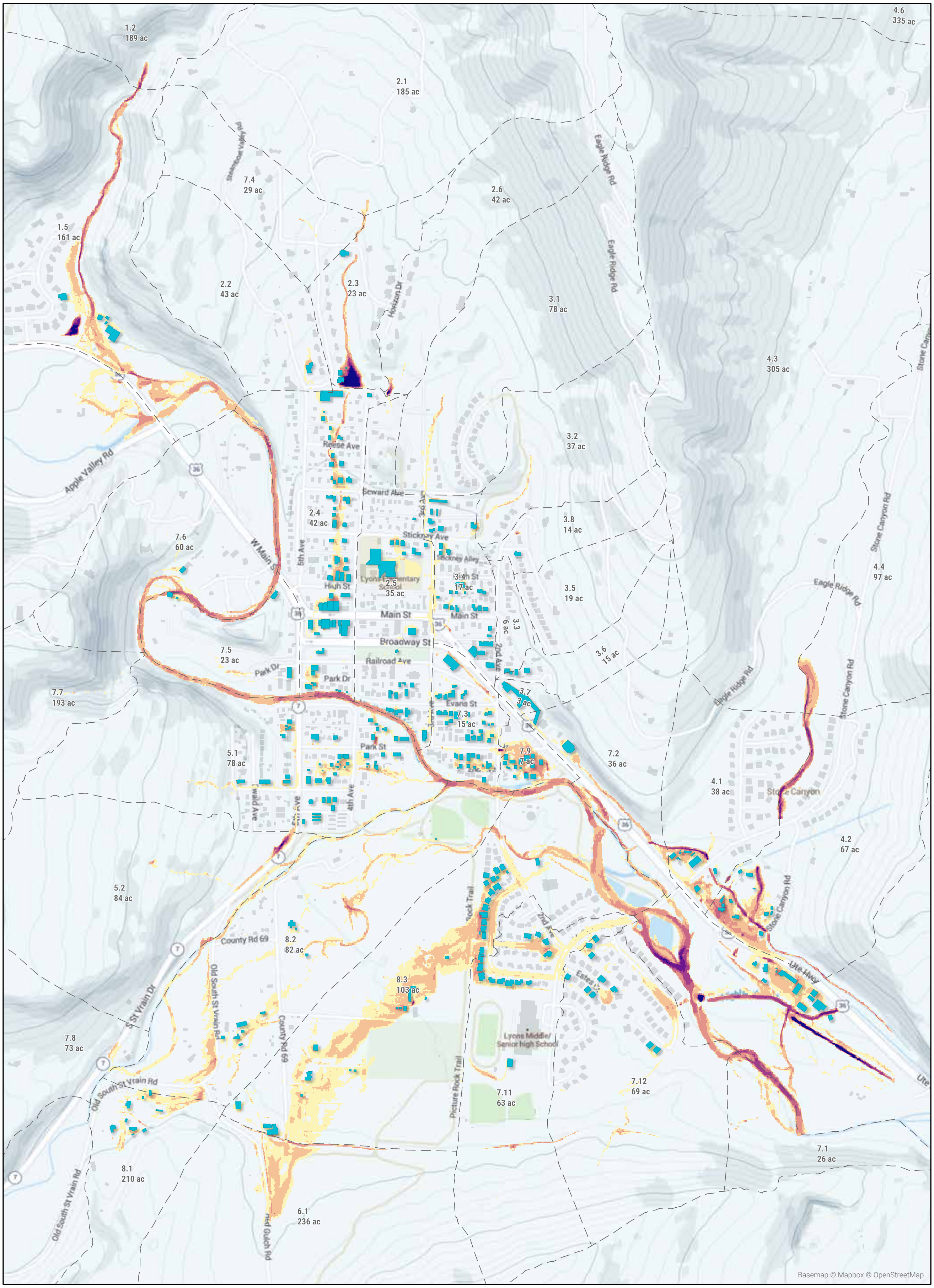


Lyons Stormwater Masterplan

Figure D-3: FLO2D Results: 10-Year Future Conditions

Max Flow Depth (ft)

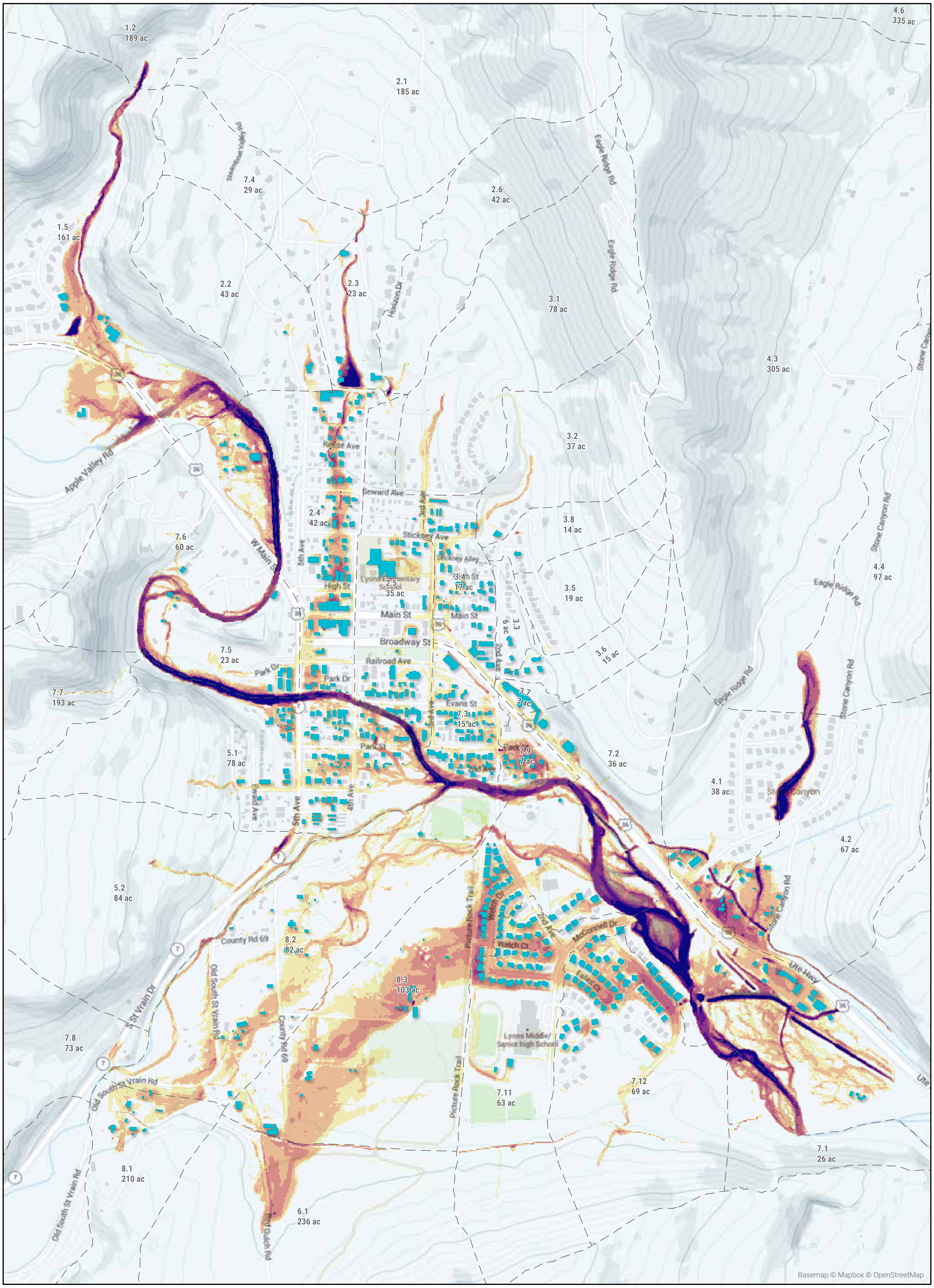
.5 1 2 3 4 5 6+

Building Footprint

At-Risk Building

Sub-Basins

ICON ENGINEERING, INC.



Lyons Stormwater Masterplan

Figure D-4: FLO2D Results: 50-Year Future Conditions

Max Flow Depth (ft)

.5 1 2 3 4 5 6+

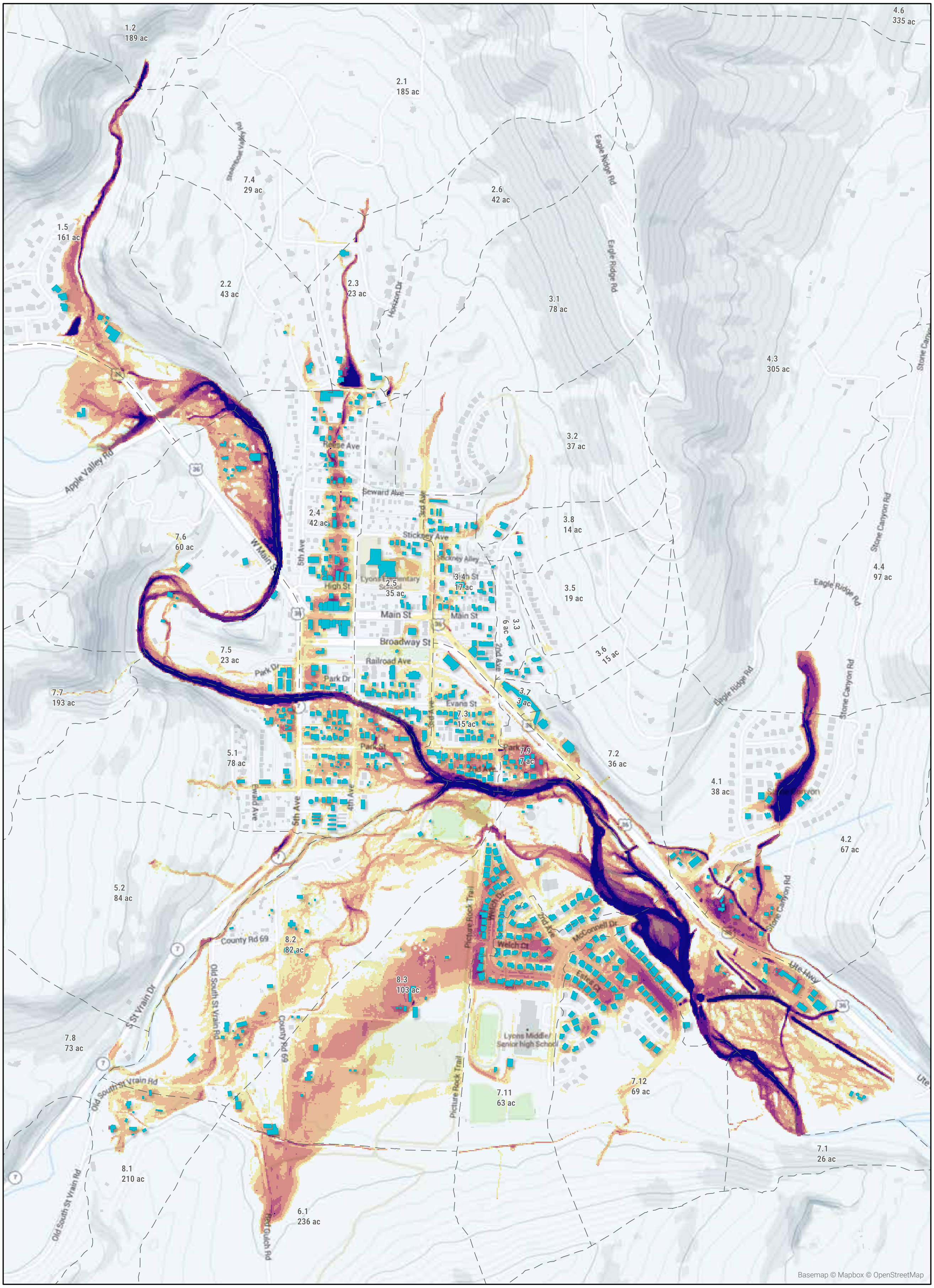
Building Footprint

At-Risk Building

Sub-Basins

LYONS COLORADO

ICON ENGINEERING, INC.



Lyons Stormwater Masterplan

Figure D-5: FLO2D Results: 100-Year Future Conditions

Max Flow Depth (ft)

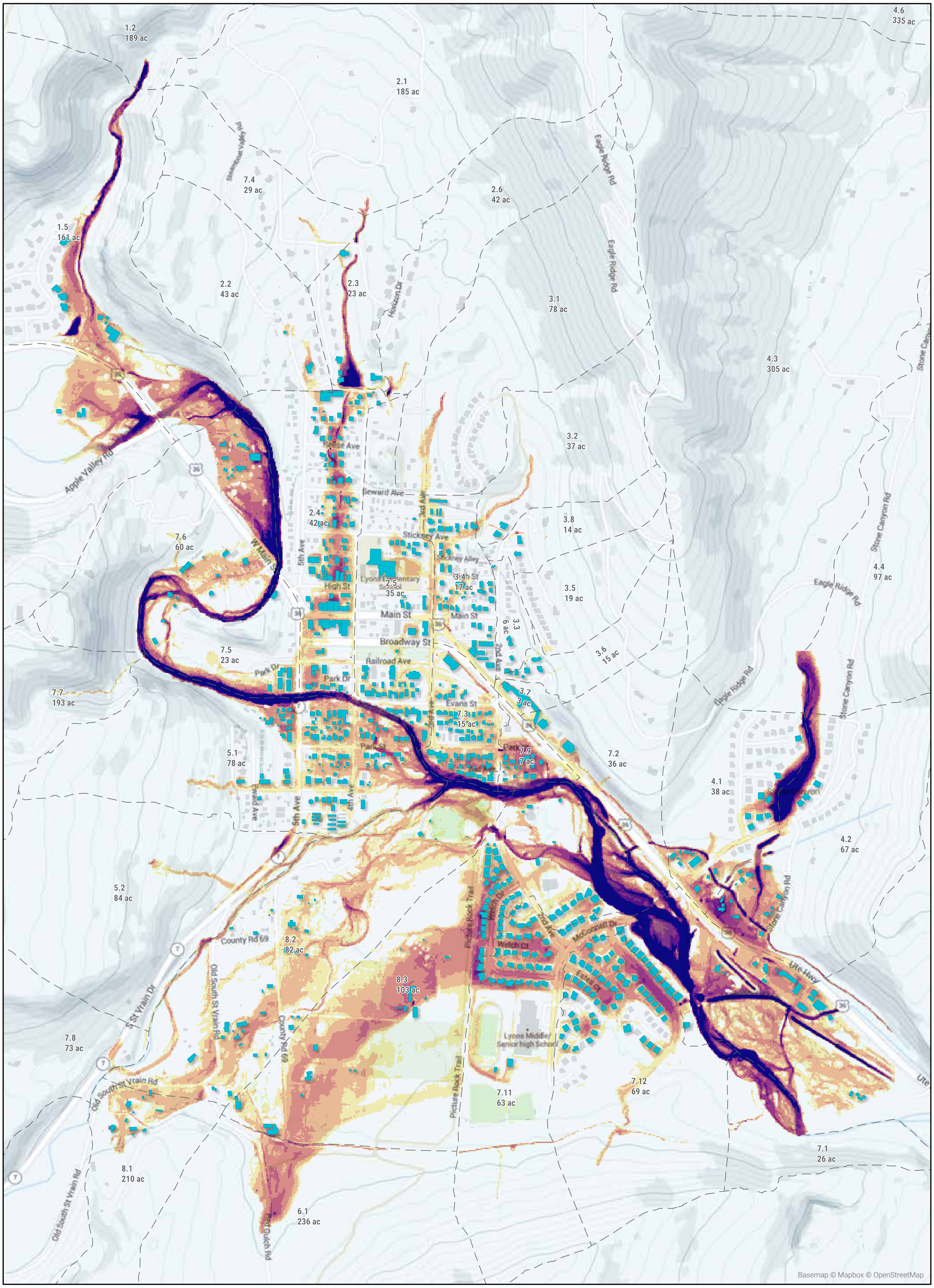
.5 1 2 3 4 5 6+

Building Footprint

At-Risk Building

Sub-Basins

ICON ENGINEERING, INC.



Lyons Stormwater Masterplan

Figure D-6: FLO2D Results: 120% Future Conditions

Max Flow Depth (ft)

.5 1 2 3 4 5 6+

Building Footprint

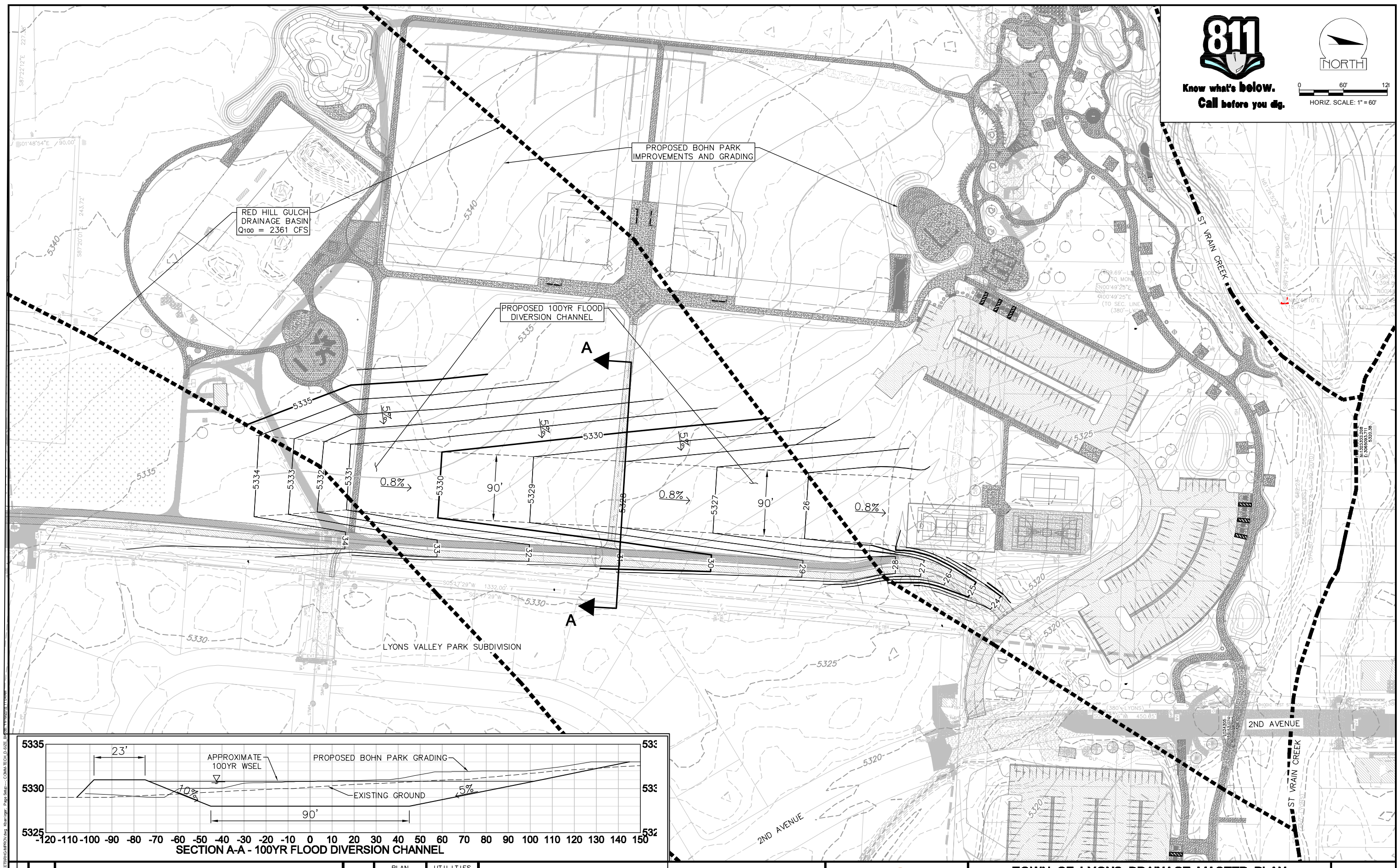
At-Risk Building

Sub-Basins

LYONS COLORADO

ICON ENGINEERING, INC.

Appendix E



No.	DATE	REVISIONS	APPR.	PLAN	UTILITIES
				DRAWN KDB	RESEARCHED
				DESIGNED KDB	DRAWN
				CHECKED TC	CHECKED

ICON ENGINEERING, INC.
7000 S. Yosemite Street | Suite 120 | Centennial, CO 80112
Phone (303) 221-0802 / Fax (303) 221-4019

TOWN OF LYONS DRAINAGE MASTER PLAN
CONCEPTUAL DRAINAGEWAY IMPROVEMENTS
RED HILL GULCH AT BOHN PARK

ICON PROJECT No. 15-014-LYN-415

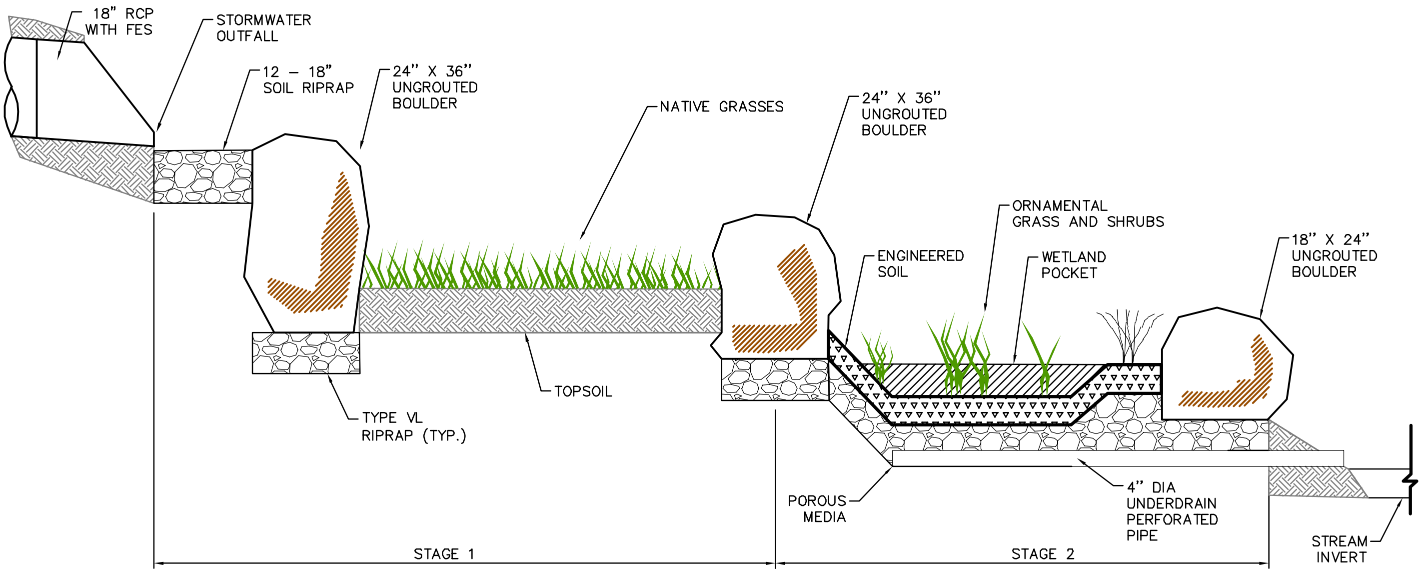
DATE NOV 2016

SHEET 1

Appendix F

Forthcoming

Appendix G



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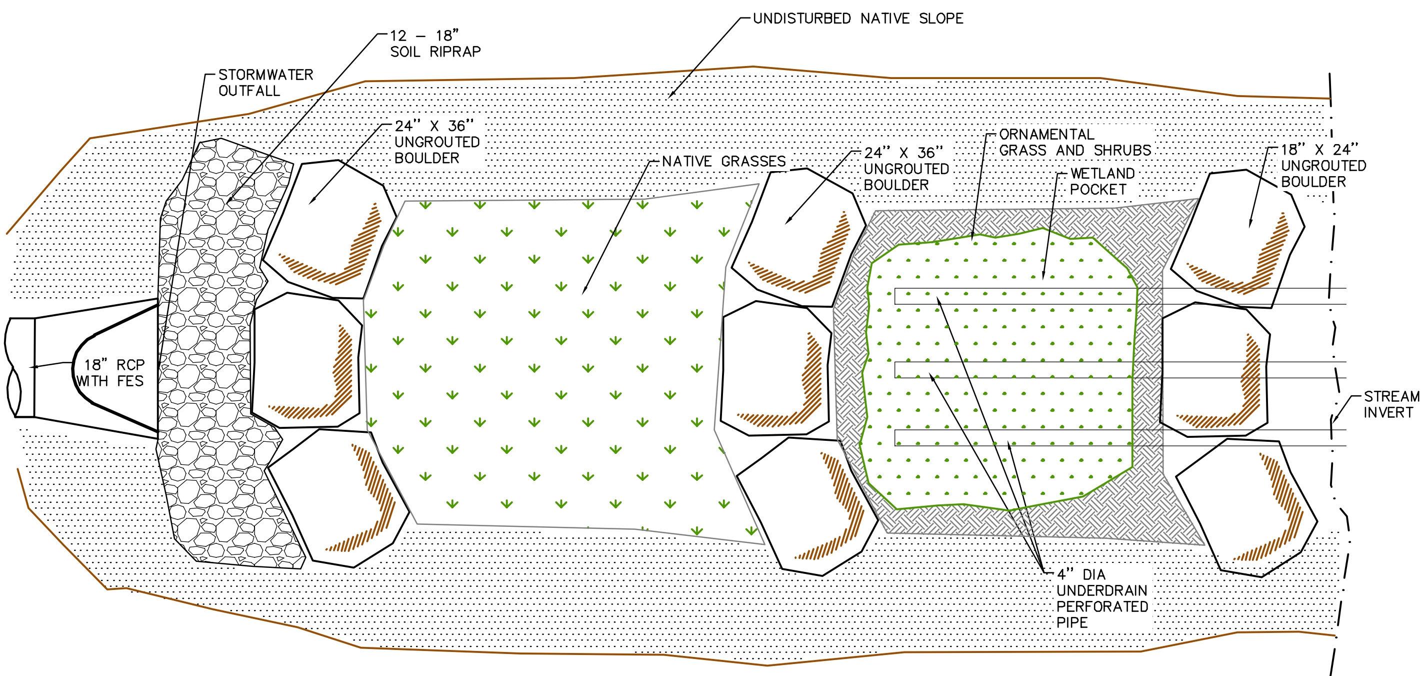


PLAN

NOTES:

A. STAGE 1 : REMOVAL OF SANDS, GRAVEL AND TRASH

B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

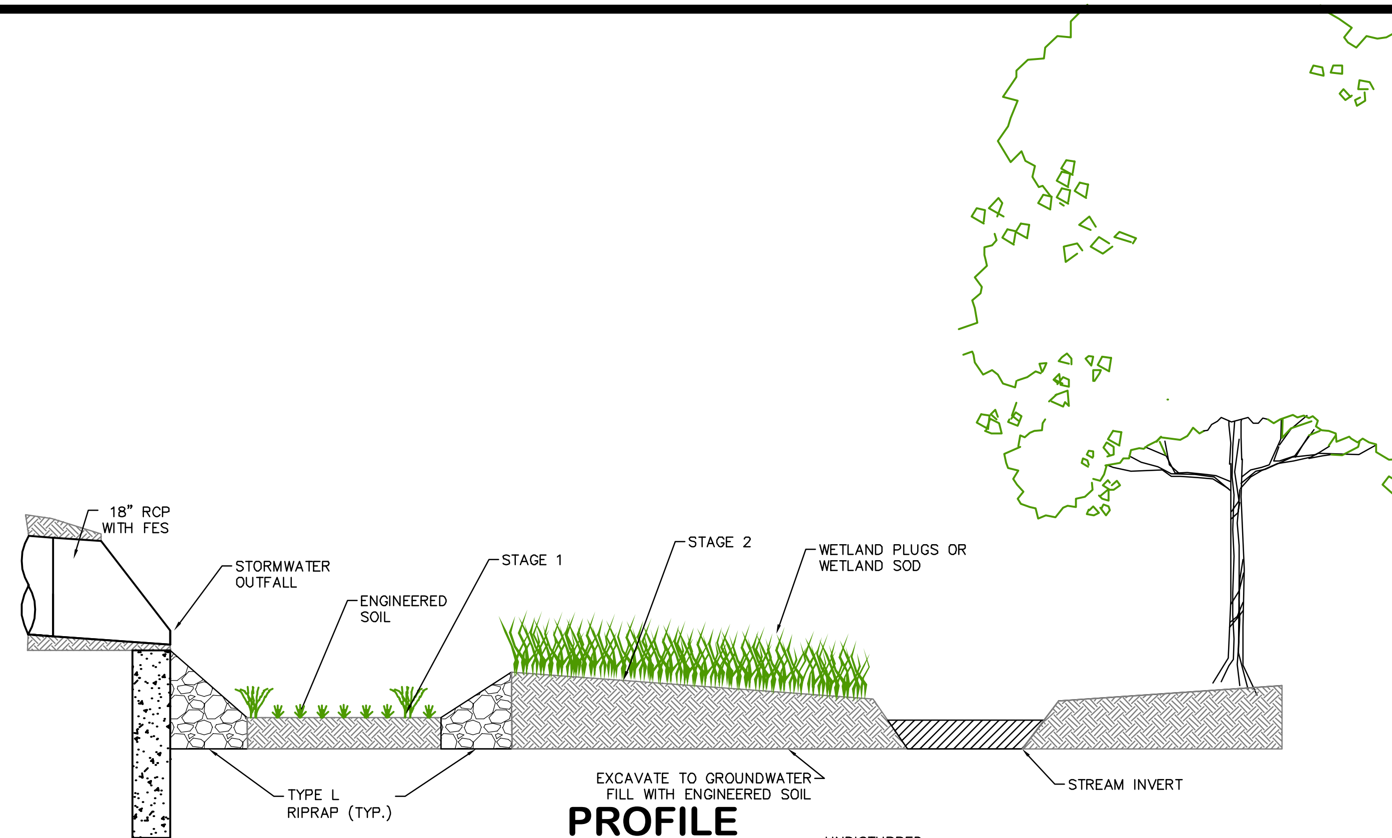
C. ENGINEERED SOIL: WELL GRADED GRANULAR SOIL WITH ORGANIC SUPPLEMENT

WATER QUALITY – CASCADE

ICON

–OUTFALL WATER QUALITY TREATMENT CONCEPT–
WELL SUITED FOR NEAR–INVERT OUTFALLS IN TIERED STREAM BANKS

DRAWN DDB	JOB NUMBER:	16–014–LYO–415
DESIGNED TWC	DATE:	SEP. 2016
CHECKED TWC	SHEET:	1



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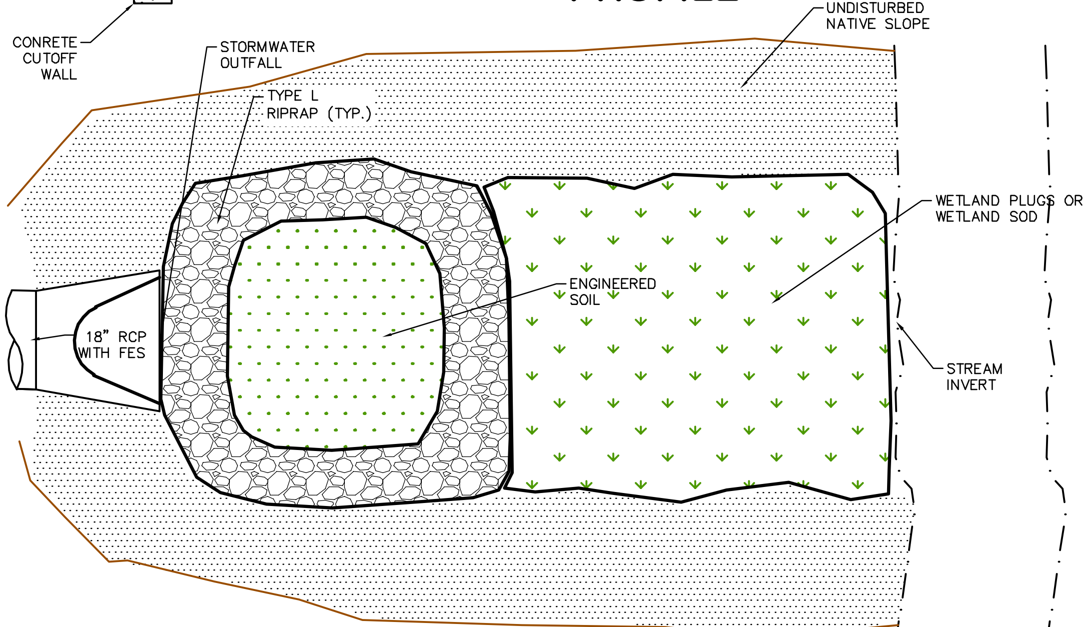


PLAN

NOTES:

A. STAGE 1 : REMOVAL OF SANDS, GRAVEL AND TRASH

B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

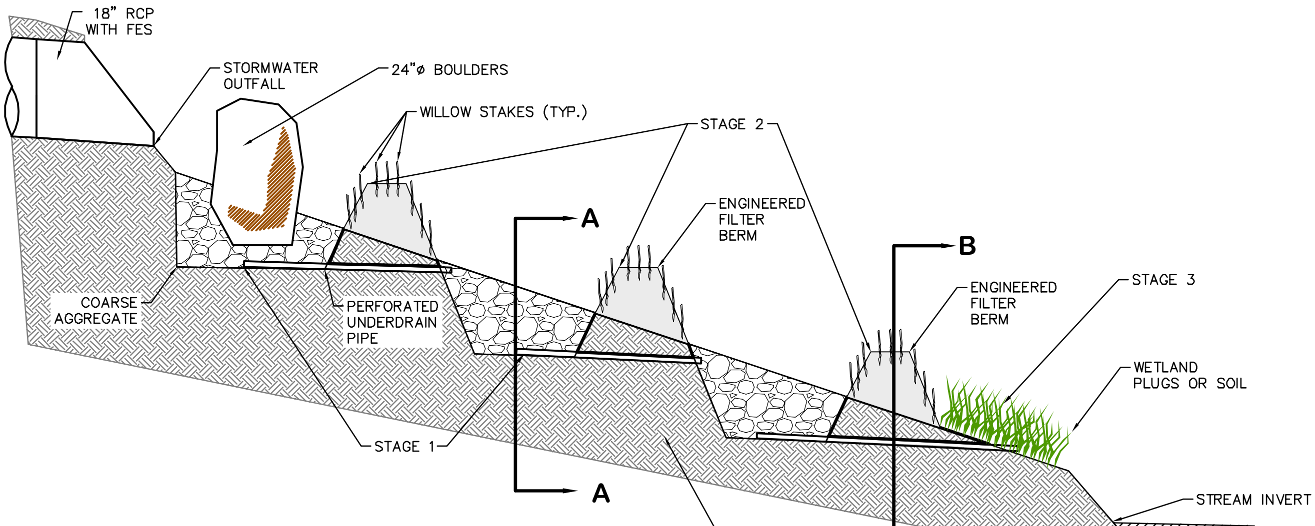
C. ENGINEERED SOIL: WELL GRADED GRANULAR SOIL WITH ORGANIC SUPPLEMENT.

WATER QUALITY – SOFT FOREBAY

ICON

–OUTFALL WATER QUALITY TREATMENT CONCEPT–
WELL SUITED FOR LOW GRADE OUTFALL WITH WIDE RIPARIAN BENCH

DRAWN DDB	JOB NUMBER: 16–014–LYO–415
DESIGNED TWC	DATE: SEP. 2016
CHECKED TWC	SHEET: 2



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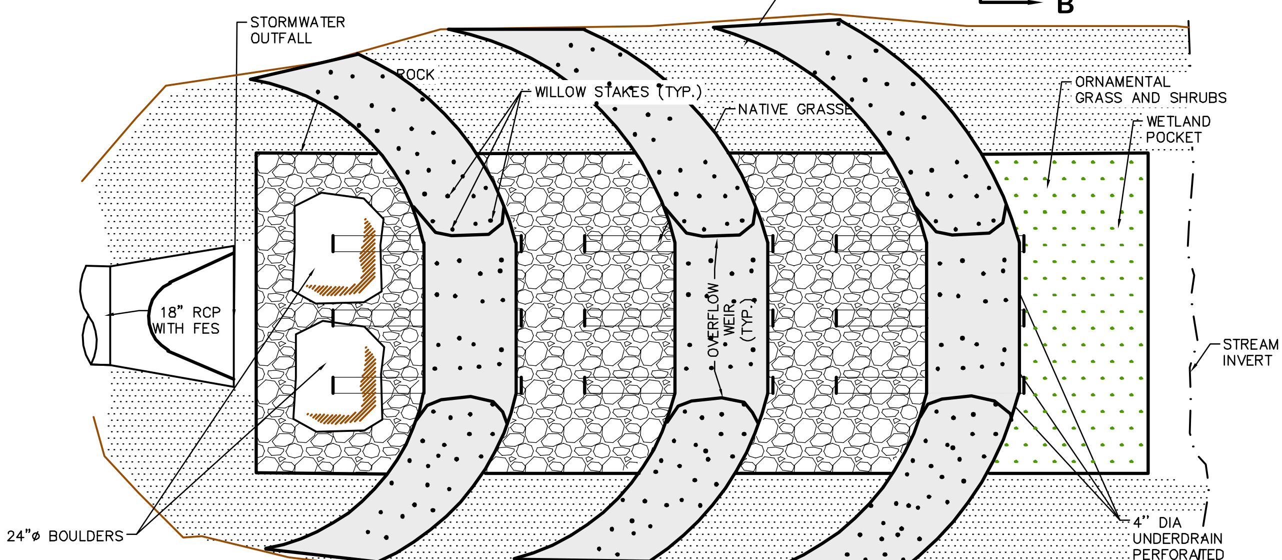
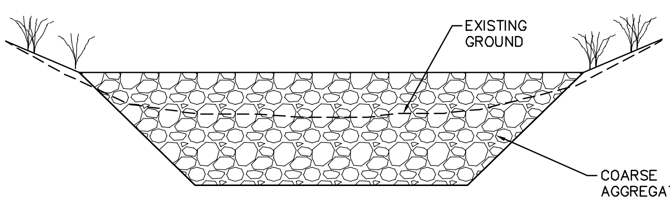
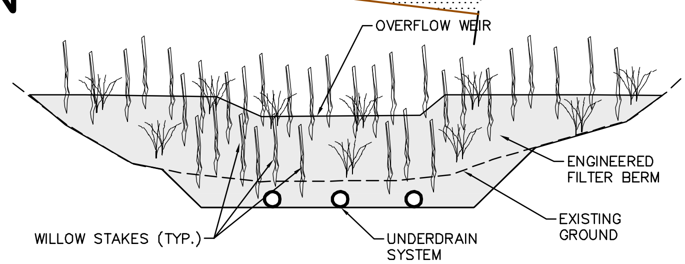


PLAN



SECTION A-A



SECTION B-B

NOTES:

A. STAGE 1 : REMOVAL OF SANDS, GRAVEL AND TRASH

B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

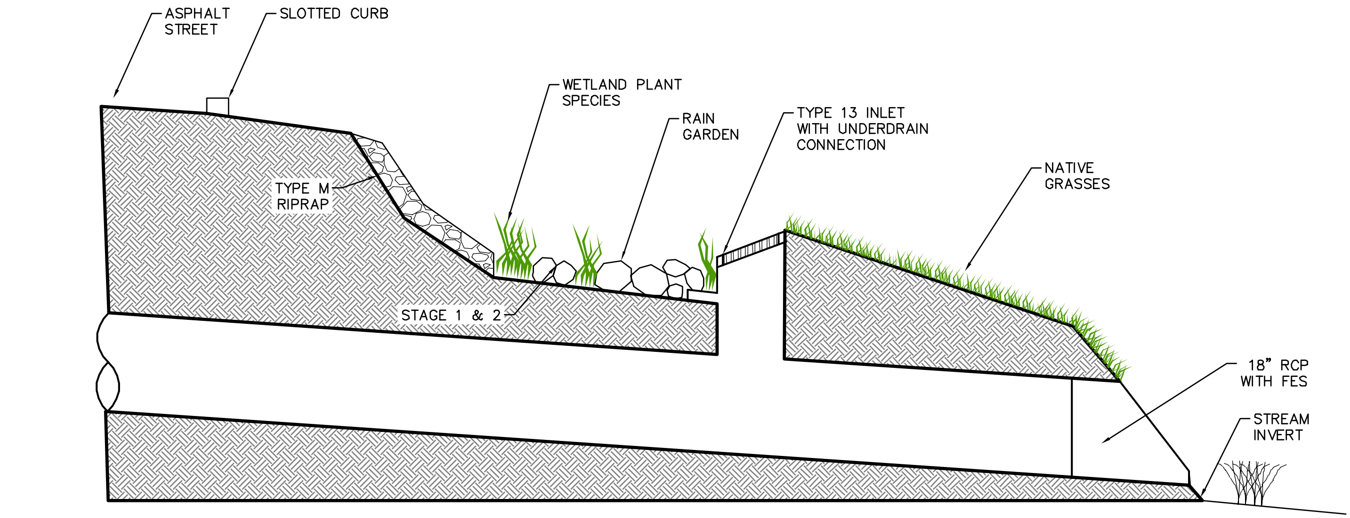
C. ENGINEERED FILTER BERM: TOPSOIL WRAPPED IN NATURAL FIBER EROSION BLANKET AND PLANTED WITH WILLOW STAKES AND GRASSES

WATER QUALITY – LIVING WALLS

ICON

–OUTFALL WATER QUALITY TREATMENT CONCEPT–
WELL SUITED FOR STEEP SLOPES

DRAWN DDB	JOB NUMBER: 16-014-LYO-415
DESIGNED TWC	DATE: SEP. 2016
CHECKED TWC	SHEET: 3



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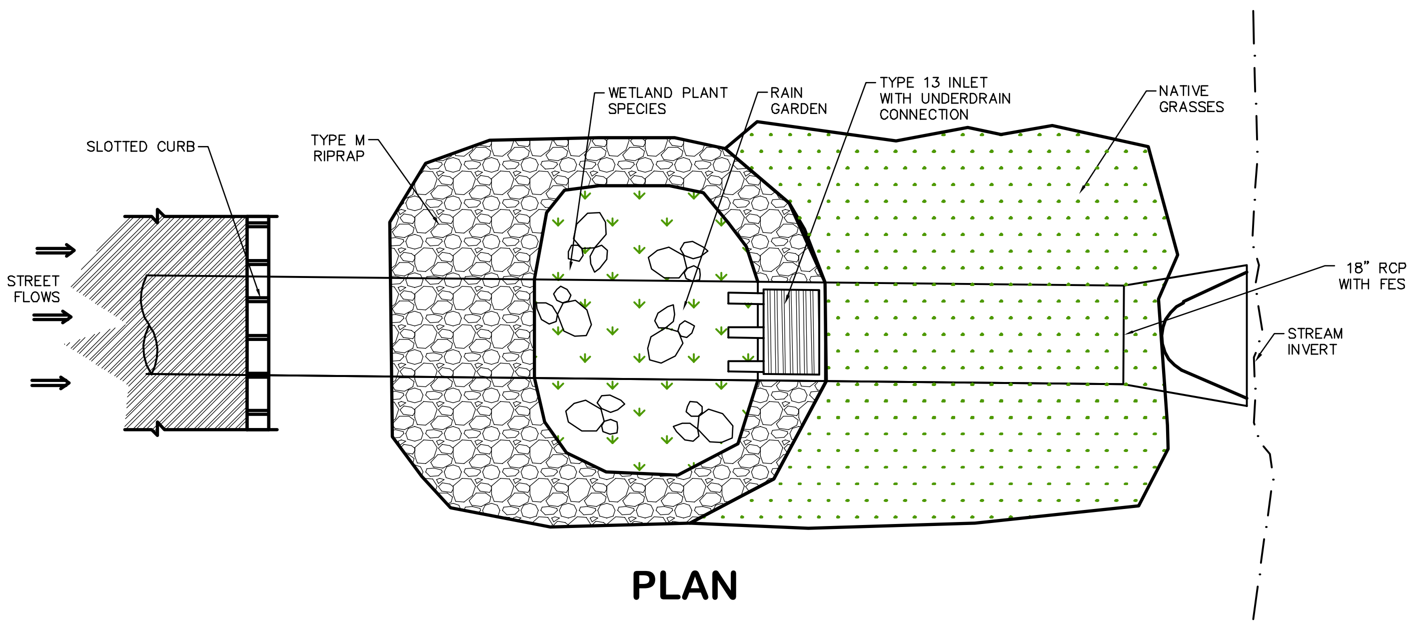


PLAN

NOTES:

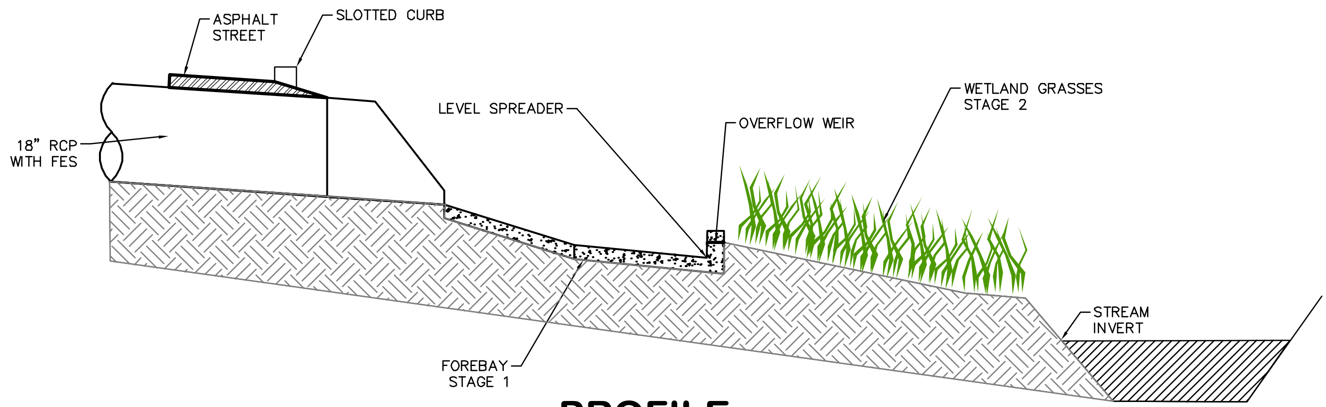
A. STAGE 1 ; REMOVAL OF SANDS, GRAVEL AND TRASH

B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

C. ENGINEERED SOIL: WELL GRADED GRANULAR SOIL WITH ORGANIC SUPPLEMENT.

WATER QUALITY – RAIN GARDEN

ICON	–OUTFALL WATER QUALITY TREATMENT CONCEPT– WELL SUITED FOR IMPERVIOUS SURFACE RUNOFF, REQUIRES PROXIMITY TO STORM SEWER	DRAWN DDB	JOB NUMBER:	16–014–LYO–415
		DESIGNED TWC	DATE:	SEP. 2016
		CHECKED TWC	SHEET:	4



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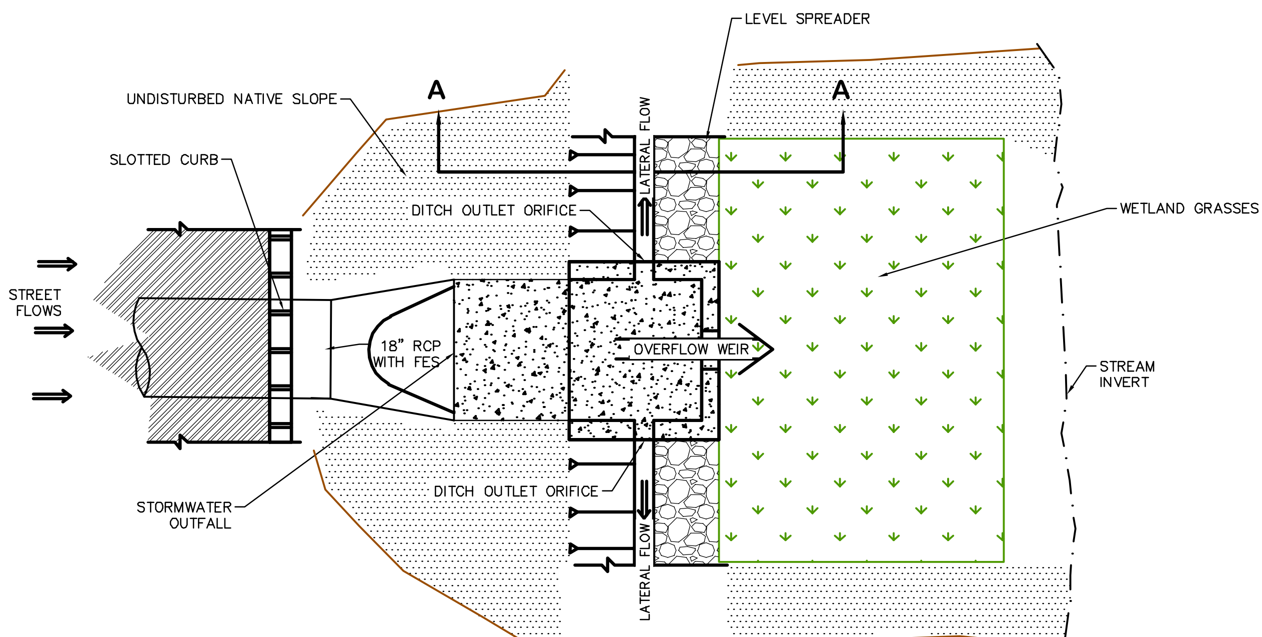
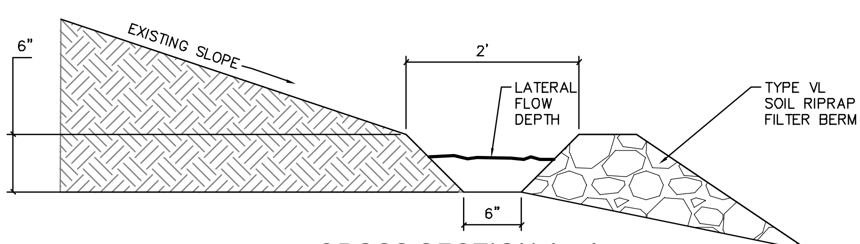


PLAN



CROSS SECTION A - A

NOTES:

A. STAGE 1 ; REMOVAL OF SANDS, GRAVEL AND TRASH

B. STAGE 2 : FILTRATION AND NUTRIENT REMOVAL

C. LATERAL DITCH SPREADS FLOWS ALONG SLOPE FOR INFILTRATION

WATER QUALITY – LEVEL SPREADER

ICON	–OUTFALL WATER QUALITY TREATMENT CONCEPT– WELL SUITED FOR WIDE SOUTH FACING STREAM BANK IN NEED OF SUPPLEMENTAL IRRIGATION	DRAWN DDB	JOB NUMBER: 16–014–LYO–415
		DESIGNED TWC	DATE: SEP. 2016
		CHECKED TWC	SHEET: 5

Appendix H

Appendix

Water Quality

Draft Ordinance Outline

Sample Ordinance Language – Cherry Hills Village

Sample Ordinance Language – Boulder County

Sample Commercial and Mixed Use Design Standards and Guidelines – Town of Lyons

Draft Stormwater Ordinance Outline

The following is a brief outline of stormwater standards that can be considered for the Town of Lyons. In general, the Town's water quality requirements are less restrictive than those required by larger municipalities governed by the Clean Water Act (MS4) but more restrictive than other smaller, unincorporated towns along the Front Range. State law, and current Town ordinances, requires land owners to control stormwater to prevent adverse impacts to downstream property owners (including water right holders). Additional ordinances can require specific BMPS for stormwater quality – this ordinance outline provides some of the key elements for future work in that regard. Sections 7, 10, and 12 are stormwater specific, the remaining sections are typically composed with a team of legal, administrative, engineering, and Town staff.

1. Purpose and Need. The Town of Lyons is situated around the confluence of two rivers, in the foothills of the Front Range, with older developments in historic drainages, and new developments in large, steep watersheds. The proximity of development to the recreation and ecological areas along and in the streams requires attention to water quality. The character of the watersheds in the development areas requires attention to run-on and run-off to ensure new properties are reasonably safe from flooding.
2. Definitions. Generally standard definitions from Boulder County or other similar ordinance.
3. Prohibitions. Generally standard information from Boulder County or other similar ordinance.
4. Exemptions. Emergency and critical facilities could be listed here. For instance, wastewater treatment plants can be exempted from certain stormwater regulations due to their proximity to streams and requirements imposed by gravity fed systems that prevent relocation or modification for stormwater quality.
5. Requirements applicable to certain discharges. Generally standard information from Boulder County or other similar ordinance. Hazardous materials, oils, grease and other key pollutants have specific requirements related to department of health or other regulations.
6. Release reporting and clean up. This section can detail how a spill or contaminant is documented and cleaned up. Generally standard information from Boulder County or other similar ordinance.
7. **Best Management Practices.**
    a. **UDFCD Volume 3 best management practices can be referenced here.**
    b. **This can also include Town specific BMPs such as Rainwater Harvesting (110 gallons / residential lot).**
    c. **In general, these are water quality improvements treating stormwater runoff from impervious surfaces. Grass swales, rain gardens, rain barrels, and UDFCD volume 3 BMPs.**
8. General Permit Requirements. Not directly applicable because the Town is not managed by a Clean Water Act permit. Reserve this section for future use.
9. Technical Standards and Specifications. UDFCD Volumes 1, 2, and 3 can be referenced here.
10. **Storm Water Management Plan.**

a. **This is the section that details when a development or redevelopment site is required to design to the Town of Lyons storm drainage design and technical criteria.**
b. **Threshold. Not all sites will be required to meet storm drainage design and technical criteria, there is a threshold for which small projects are too small to implement design and technical criteria.**
   i. **Square footage. If a project adds more than 2000 square feet of additional impervious area, the applicant needs to design stormwater systems to prevent the additional runoff generated from that new area from causing adverse impacts (flooding, water quality impairment, etc.) downstream. The 2000 SF threshold was roughly based on paving a gravel driveway, but a 1000 SF or 500-SF threshold could be equally defensible.**
   ii. **Percent increase. To account for variable lot sizes, the percent increase could be the threshold. A project that increases imperviousness by more than 10% would be required to implement stormwater management designs (detention, water quality, etc.)**
   iii. **Tiered system. A tiered system could be implemented to further specify impervious area thresholds based on lot size. Lot sizes from 0 to 20,000 SF have to implement stormwater designs for increases over 50% of existing impervious. 20,000 SF to 50,000 SF need to implement stormwater designs if they increase more than 20% over existing impervious. Lots larger than than 50,000 SF need to implement stormwater control if impervious area increases more than 10%.**
c. **Stormwater Management Plan. This part of the ordinance directs the applicant to the submittal requirements of a plan and the storm drainage and technical criteria for which that submittal will be judged.**

11. Implementation of Approved Stormwater Management Plans. This section outlines how the stormwater requirements are constructed and inspected. This is also where erosion control BMPs and inspection is noted. This can be standard language from other sample ordinances.
12. **Post-Construction requirements for permanent best management practices. This section can explain the permanent blanket easement for water quality improvements. A blanket easement has been used to allow for changes within the property such as relocating a grass swale, changing location of a detention pond, etc. The blanket easement allows flexibility for future owners to treat stormwater in new and improved ways, as long as it is treated to the same level somewhere on the property. Sample language may be:**
    a. **Comprehensive Sample language: Maintenance of all permanent best management practices shall be ensured through the creation of a formal maintenance covenant that must be approved by the TOWN and recorded against the title of the subject property. The covenant shall be binding on all subsequent owners of land served by the permanent best management practices. As part of the covenant, a schedule shall be developed, detailing when and how often maintenance will occur to ensure proper function of the permanent best management practices. The covenant shall also include plans for periodic inspections by the TOWN to ensure proper performance of**

the facility between scheduled cleanouts. The covenant shall provide for access to the facility at reasonable times for periodic inspection or any required maintenance by the TOWN, or its contractor or agent, and for regular or special assessments of property owners to ensure that the facility is maintained in proper working condition to meet design standards and any other provisions established by this Chapter. The covenant shall be memorialized on the subdivision plat, annexation plat, development agreement or other instrument, or in a separate form acceptable to the TOWN and shall be recorded in the office of the County Clerk and Recorder.

b. **Simplified sample language: A blanket easement will be recorded on the applicant's property requiring the owner to maintain the stormwater improvements in perpetuity as judged by the Town's stormwater criteria (UDFCD vol. 3). This allows the owner and future owners to change the specific BMPs within the property as long as discharge from the site is still treated in accordance with town criteria.**

13. Enforcement. This can be standard language the Town uses for enforcement provisions.
14. Penalties. This can be standard language the Town uses for penalty provisions.
15. Upset Condition. This can be standard language the Town uses for upset provisions.

Sample Ordinance Language – Cherry Hills Village

This ordinance is provided for reference. As an NPDES MS4 (Clean Water Act) regulated municipality located within the Denver Metro urbanized area, Cherry Hills Village is required to meet the NPDES permit requirements. However, the City is uniquely composed of estate properties, many lots greater than 1 acre, and a rural character. As a result, the City has developed an ordinance that requires individual lot owners that develop or redevelop the property to install a permanent water quality BMP on the property. Furthermore, they require a blanket easement that is titled to the property requiring current and future property owners to maintain the function of that water quality BMP.

As noted, this is a unique situation for a unique community. However, the blanket easement and water quality BMP is something that could be considered to meet the Town of Lyons desire for increased water quality. By spreading water quality treatment across the Town, there is increased resilience from flood hazards because the smaller water quality features through the watershed can be brought back online quicker than larger regional facilities restricted to the lower end of the watershed.

This ordinance as written has little to no direct relevance to the Town of Lyons. However, with some modification, this kind of water quality language could be used to improve a specific, targeted portion of the Town of Lyons water quality regulation.

Sec. 19-1-120. - Post-construction requirements for permanent best management practices.

(a) Owners that are subject to the requirements of this Chapter, specifically including but not limited to Section 19-1-80 of this Article, are required to address stormwater runoff quality through the use of permanent best management practices and shall maintain those best management practices in perpetuity and in accordance with the requirements of this Section. If the permittee can document that permanent BMPs exist as part of an original or previous subdivision or building process, no new BMPs will be required if the existing BMPs meet the requirements of this Chapter, specifically including but not limited to Section 19-1-90, Technical standards and specifications.

(1) All permanent best management practices of any site including, without limitation, detention basins, retention basins, ponds, inlets, outlets, outfall ditches and structures for which the owner thereof or his or her predecessor-in-interest obtained approval from the City for the construction or establishment, shall be maintained in good repair and in substantially the form, condition and nature which was represented at the time they were constructed. It is the intention of this Section that such permanent best management practices, having once been approved for construction or development, shall not be allowed to deteriorate to a condition which is in any respect inferior to the condition or state upon which the original approval for construction or development was based. For purposes of this Section, either or both the owner or tenant of the structure or real property shall be considered the responsible party.

(2) Maintenance of all permanent best management practices shall be ensured through the creation of a formal maintenance covenant that must be approved by the City and recorded against the title of the subject property. The covenant shall be binding on all subsequent owners of land served by the permanent best management practices. As part of the covenant, a schedule shall be developed, detailing when and how often maintenance will occur to ensure proper function of the permanent best management practices. The covenant shall also include plans for periodic inspections by the City to ensure proper performance of the facility between scheduled cleanouts. The covenant shall provide for access to the facility at reasonable times for periodic inspection or any required maintenance by the City, or its contractor or agent, and for regular or special assessments of property owners to ensure that the facility is maintained in proper working condition to meet design standards and any other provisions established by this Chapter. The covenant shall be memorialized on the subdivision plat, annexation plat, development agreement or other instrument, or in a separate form acceptable to the City and shall be recorded in the office of the County Clerk and Recorder.

(b) Inspections of permanent best management practices.

(1) All permanent best management practices must undergo, at the minimum, periodic inspections by the City, as deemed appropriate by the City Manager, to document maintenance and repair needs and ensure compliance with the requirements of this Chapter and accomplishment of its purposes. These needs may include, but are not limited to: the removal of silt, litter and other debris from all catch basins, inlets, ponds and detention/retention basins, outlet structures and drainage pipes;

grass cutting and vegetation removal; and necessary replacement of landscape vegetation. Any maintenance needs found by City inspection or otherwise must be addressed in a timely manner, as determined by the City Manager. The inspection and maintenance requirement may be increased as deemed necessary to ensure proper functioning of the permanent best management practices.

(2) Inspection programs may be established by the City on any reasonable basis, including but not limited to: routine inspections; random inspections; inspections based upon complaints or other notice of possible violations; inspection of drainage basins or areas identified as higher than typical sources of sediment or other contaminants or pollutants; inspections of businesses or industries of a type associated with higher than usual discharges of contaminants or pollutants or with discharges of a type which are more likely than the typical discharge to cause violations of state or federal water or sediment quality standards or the CDPS stormwater permit; and joint inspections with other agencies inspecting under environmental or safety laws. Inspections may include but are not limited to reviewing maintenance and repair records; sampling discharges, surface water, groundwater and material or water in drainage control facilities; and evaluating the condition of drainage control facilities and other stormwater treatment practices.

(3) Parties responsible for the operation and maintenance of a permanent best management practice shall make records of its installation and of all maintenance and repairs, and shall retain the records for at least two (2) years. These records shall be made available to the City during inspection of the facility and at other reasonable times upon request.

(Ord. 06 §1, 2007; Ord. 10, 2009; Ord. 10 §1, 2012)

Sample Ordinance Language – Boulder County

This ordinance is provided for reference. The Boulder County ordinance generally applies to the Town of Lyons geographically, but is limited by the fact that Lyons itself is not an NPDES MS4 (Clean Water Act) regulated community. This ordinance provides a bookend for what would be the more complicated ordinance language and stormwater regulations for the Town.

ORDINANCE NO. 2012-4

AN ORDINANCE CONCERNING ILLICIT STORMWATER DISCHARGE

WHEREAS, the County is required by state and federal law, and as a condition of its State of Colorado stormwater discharge permit, to establish by ordinance methods for controlling the introduction of pollutants into the storm drainage system, in order to protect and enhance the water quality of the state's watercourses, water bodies, and wetlands in a manner pursuant to and consistent with the State and Federal Clean Water Act; and

WHEREAS, it is necessary to repeal Ordinance No. 2005-1 regulating illicit discharges, and to enact a new ordinance in order to incorporate changes recommended by the Colorado Department of Health, to delete unnecessary language and to improve on and simplify other language based on experience gained over the last seven years; and

WHEREAS, §30-15-401(11) provides that a county which holds a municipal separate storm sewer system permit pursuant to part 5 of article 8 of title 25, C.R.S., may adopt a storm water ordinance to develop, implement and enforce the stormwater management program required by the permit; and

WHEREAS, the Board of County Commissioners of Boulder County and Boulder County Public Health ("BCPH") are given additional authority to address the discharge and threatened discharge of pollutants to the waters of the State, including

> C.R.S. §18-4-511, which makes it a crime to place any foreign substance whether solid or liquid into any body of water or watercourse; and
>
> C.R.S.§30-15-401(1)(a)(V), which provides that, in addition to the authority given counties under §18-4-511, C.R.S., above, is authorized to do all acts and make all regulations which may be necessary or expedient for the promotion of health or the suppression of disease, including the authority to restrain, fine, and punish persons for dumping rubbish, including trash, junk and garbage on public or private property, and "public or private property" is defined at C.R.S.,§18-4-511 to include "waters and watercourses"; and
>
> C.R.S. §16-13-305(1)(e), which makes any unlawful pollution or contamination of any surface or subsurface waters in this state a Class 3 Public Nuisance; and

WHEREAS, BCPH is authorized to administer and enforce the laws pertaining to public health and water quality and to investigate and abate nuisances when necessary in order to eliminate conditions affecting public health; and

WHEREAS, this ordinance is necessary to protect the health, safety, and general welfare of the citizens of Boulder County through the regulation of non-stormwater discharges to the storm drainage system.

NOW, THEREFORE, BE IT ORDAINED by the Board of County Commissioners of Boulder County:

SECTION 1. PURPOSE/INTENT.

The objectives of this ordinance are:

1. To regulate the introduction of pollutants to the storm drainage system
2. To prohibit illicit connections and discharges to the storm drainage system
3. To establish procedures to carry out the inspection, surveillance and monitoring necessary to ensure compliance with this ordinance
4. To promote public awareness of the hazards involved in the improper discharge of trash, yard waste, lawn chemicals, pet waste, wastewater, grease, oil, petroleum products, cleaning products, paint products, hazardous waste, sediment and other pollutants into the storm drainage system.

SECTION 2. DEFINITIONS.

For the purposes of this ordinance, the following shall mean:

<u>Best Management Practices (BMPs)</u> means the schedules of activities, prohibitions of practices, general good housekeeping practices, pollution prevention and educational practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants directly or indirectly to stormwater, receiving waters, or stormwater conveyance systems. BMPs also include treatment practices, operating procedures, and practices to control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw materials storage.

<u>Construction Activity</u> means activities including but not limited to clearing and grubbing, grading, excavating, and demolition.

<u>Illicit Discharge</u> means any direct or indirect non-stormwater discharge of pollutants to the storm drainage system, except as exempted in *Section 6.C.* of this ordinance.

<u>Illicit Connection</u> is defined as either of the following: Any drain or conveyance, whether on the surface or subsurface, which allows an illicit discharge to enter the storm drainage system, including but not limited to any conveyance which allows any non-stormwater discharge including sewage, process wastewater, and wash water to enter the storm drainage system, and any connection to the storm drainage system from indoor drains, sump pumps and sinks, regardless of whether said drain or connection had been previously allowed, permitted, or approved by BCPH.

<u>Hazardous Material</u> means any material, including any substance, waste, or combination thereof, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause, or significantly contribute to, a substantial present or potential hazard to human health, safety, property, or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

Mobile Washing Operation is a commercial activity involving power washing, steam cleaning, and any other method of mobile cosmetic cleaning of, by way of example, the following: vehicles, fabric, pets and/or exterior surfaces.

National Pollutant Discharge Elimination System (NPDES) Stormwater Discharge Permit means a permit issued by EPA (or by a State under authority delegated pursuant to 33 USC § 1342(b) i.e. Colorado Discharge Permit System) that authorizes the discharge of pollutants to waters of the United States, whether the permit is applicable on an individual, group, or general area-wide basis.

Non-Stormwater Discharge means any discharge to the storm drainage system that is not composed entirely of stormwater.

Person means any individual, association, organization, partnership, firm, corporation or other entity recognized by law and acting as either the owner or as the owner's agent.

Pollutant means anything, which causes or contributes to pollution. Pollutants may include, but are not limited to: paints, varnishes, and solvents; oil and other automotive fluids; non-hazardous liquid and solid wastes; yard wastes; refuse, rubbish, garbage, litter, or other discarded or abandoned objects; accumulations that may cause or contribute to pollution; floatables; pesticides, herbicides, and fertilizers; hazardous substances and wastes; sewage, fecal coliform and pathogens; dissolved and particulate metals; animal wastes; wastes and residues that result from constructing a building or structure; wastes and residues that result from mobile washing operations; noxious or offensive matter of any kind, and any soil, rock, and any type of landscaping material**.**

Premises means any building, lot, parcel of land, or portion of land whether improved or unimproved, including adjacent sidewalks and parking strips.

Storm Drainage System means the publicly owned facilities by which stormwater is collected and conveyed, including, but no limited to, any roads and drainage systems, streets, gutters, curbs, catch basins, inlets, piped storm drains, pumping facilities, retention and detention basins, and natural and manmade or altered drainage, ditches/channels/lakes/reservoirs, and other drainage structures.

Stormwater means any surface flow, runoff, and drainage consisting entirely of water from any form of natural precipitation.

Stormwater Pollution Prevention Plan or Stormwater Management Plan means a document which describes the Best Management Practices and activities to be implemented by a person or business to identify sources of pollution or contamination at a site and the actions to eliminate or reduce pollutant discharges to Stormwater, Stormwater Conveyance Systems, and/or Receiving Waters to the Maximum Extent Practicable.

Threatened Discharge means a condition creating a substantial probability of harm, when the probability and potential extent of harm make it reasonably necessary to take immediate action to prevent, reduce or mitigate damages to persons, property or natural resources.

Watercourse means a natural or artificial channel through which stormwater or floodwater can flow, either regularly or infrequently.

Waters of the State of Colorado (State waters) means any and all surface waters that are contained in or flow in or through the state of Colorado. The definition includes all watercourses, even if they are usually dry.

SECTION 3. APPLICABILITY.

This ordinance shall apply to all water entering the storm drainage system generated on any developed or undeveloped lands in unincorporated Boulder County, unless explicitly exempted by an authorized enforcement agency.

SECTION 4. RESPONSIBILITY FOR ADMINISTRATION.

Boulder County Public Health shall administer, implement, and enforce the provisions of this ordinance.

SECTION 5. ULTIMATE RESPONSIBILITY.

The standards set forth herein and promulgated pursuant to this ordinance are minimum standards; therefore this ordinance does not intend nor imply that compliance by any person will ensure that there will be no contamination, pollution, nor unauthorized discharge of pollutants.

SECTION 6. DISCHARGE PROHIBITIONS, EXEMPTIONS AND REQUIREMENTS.

A. Prohibition of Illicit Discharges

1) No person shall discharge or cause to be discharged into the storm drainage system or watercourses any pollutants or waters containing any pollutants that cause or contribute to a violation of applicable water quality standards, other than stormwater.

2) It shall be unlawful to cause pollutants to be deposited in such a manner or location as to constitute a threatened discharge into the storm drainage system or waters of the State. Pollutants that are no longer contained in a pipe, tank or other container are considered to be threatened discharges unless they are actively being cleaned up.

B. Prohibition of Illicit Connections

The construction, use, maintenance or continued existence of illicit connections to the storm drainage system is prohibited. This prohibition expressly includes, without limitation, illicit connections made in the past, regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection.

C. Exemptions

The commencement, conduct or continuance of any illicit discharge to the storm drainage system is prohibited except as described as follows:

1) The following discharges are exempt from the discharge prohibitions established by this ordinance when properly managed: water line flushing or other potable water sources, landscape irrigation or lawn watering, diverted stream flows, rising ground water, uncontaminated ground water infiltration to storm drains, uncontaminated pumped ground water, foundation or footing drains, crawl space pumps, air conditioning condensation, springs, non-commercial washing of vehicles, natural riparian habitat or wetland flows, swimming pools (if dechlorinated - typically less than one PPM chlorine).

2) Discharges from emergency firefighting activities and water incidental to street sweeping (including associated sidewalks and medians) not associated with construction.

3) Dye testing is an allowable discharge, but requires a verbal notification to BCPH 24 hours prior to the time of the test.

4) The discharge prohibition shall also not apply to any non-stormwater discharge permitted under an NPDES or CDPHE permit.

5) The prohibitions set forth in this section shall not apply to any non-stormwater discharge for which an authorization, or formal commitment to not pursue enforcement actions under a policy or waste discharge order is issued and administered under the authority of the CDPHE, provided that the discharger is in full compliance with all requirements of the policy or order.

D. Requirements Applicable to Potential Dischargers

1) Cleaning of Paved Surfaces Required. The owner of any paved parking lot, street or drive shall clean the pavement as required to prevent the buildup and discharge of pollutants. The visible buildup of mechanical fluid, waste materials, sediment or debris is a violation of this ordinance. Paved surfaces shall be cleaned by dry sweeping, wet vacuum sweeping, collection and treatment of wash water or other methods in compliance with this Ordinance.

2) Mobile Washing Operations. Mobile washing operations shall not discharge to the storm drainage system in violation of this Ordinance.

3) Maintenance of Equipment. Any leak or spill related to equipment maintenance in an outdoor, uncovered area should be contained to prevent the potential release of pollutants.

4) Materials Storage: Materials including, but not limited to, stockpiles used in construction and landscaping activities shall be stored to minimize the release of pollutants.

5) Pesticides, Herbicides and Fertilizers. Pesticides, herbicides and fertilizers shall be applied in accordance with manufacturer recommendations and applicable laws. Excessive application shall be avoided.

SECTION 7. INDUSTRIAL OR CONSTRUCTION ACTIVITY DISCHARGES.

Any person subject to an industrial or construction activity NPDES stormwater discharge permit shall comply with all provisions of such permit. Proof of compliance with said permit may be required in a form acceptable to BCPH prior to the allowing of discharges to the storm drainage system.

SECTION 8. ACCESS AND INSPECTION OF PROPERTIES AND FACILITIES.

1) Whenever BCPH has reasonable cause to believe that there exists, or potentially exists, in or upon any premises any condition which constitutes a violation of this ordinance, BCPH shall have the right to enter the premises at any reasonable time to determine if the owner or operator is complying with all requirements of this ordinance. In the event that the owner or occupant refuses entry after a request to enter has been made, BCPH is hereby empowered to seek assistance from a court of competent jurisdiction in obtaining such entry.

2) Any violation that is part of the County's stormwater quality management program required by the County's MS4 permit from the Colorado Water Quality Division, and that remains unabated following notice of violation, may be administratively abated by the County in accordance with C.R.S. section 30-15-401(11). BCPH shall seek an administrative entry and abatement (seizure) warrant, and shall execute the warrant in accordance with the directions of the court. BCPH may assess the reasonable cost of the abatement, including five percent for inspection and other incidental costs, upon the property by recording a notice of such assessment with the County Clerk and Recorder specifying a reasonable time within which the assessment must be paid to the County, which generally shall be within thirty (30) days. Once recorded, the assessment shall be a lien against the property until paid and shall have priority based upon its date of recording. If the assessment is not paid within the time specified in the notice, BCPH may request the County Clerk and Recorder certify that fact to the County Treasurer, who shall collect the assessment, together with a ten percent penalty for the cost of collection, in the same manner as taxes are collected.

3) BCPH shall have the right to set up on the property of any discharger to the storm drainage system such devices that are necessary to conduct an investigation of such discharges. The investigation may include, but is not limited to, the following: sampling of any discharge or process waters, the taking of photographs, interviewing staff on alleged violations, and access to any and all facilities or areas within the premises that may have any effect on the discharge.

4) BCPH may, without prior notice, act to prevent an actual or threatened discharge which presents or may present an imminent danger to the environment, public health or safety, or to the storm drainage system or waters of the State. If a Person fails to comply with a verbal or written order issued in such an emergency, BCPH may take such steps as are necessary to prevent or minimize the danger.

SECTION 9. REQUIREMENT TO PREVENT, CONTROL, AND REDUCE STORMWATER POLLUTANTS BY THE USE OF BEST MANAGEMENT PRACTICES.

The owner or operator of a commercial or industrial establishment shall provide, at their own expense, reasonable protection from accidental discharge of prohibited materials or other wastes into the storm drainage system or watercourses through the use of these structural and non-structural BMPs. Further, any person responsible for a property or premises, which is, or may be, the source of an illicit discharge may be required to implement, at said person's expense, additional structural and non-structural BMPs to prevent the further discharge of pollutants to the storm drainage system.

SECTION 10. NOTIFICATION OF SPILLS.

Notwithstanding other requirements of law, as soon as any person responsible for a premises, or responsible for emergency response for such premises has information of any known or suspected release of materials which are resulting or may result in illicit discharges into stormwater, the storm drainage system, or waters of the State, said person shall take all necessary steps to ensure the discovery, containment, and cleanup of such release. In the event of such a release of hazardous materials said person shall immediately notify emergency response agencies of the occurrence via emergency dispatch services.

SECTION 11. VIOLATIONS, ENFORCEMENT AND PENALTIES.

Notice of Violation.

Whenever BCPH finds that a person has violated a prohibition or failed to meet a requirement of this Ordinance, BCPH may order compliance by verbal or written notice of violation to the responsible person. Such notice may require without limitation:

(1) The immediate elimination of illicit connections or discharges;
(2) That violating discharges, practices, or operations shall cease and desist;
(3) The abatement or remediation of stormwater pollution or contamination hazards and the restoration of any affected property;
(4) Payment to cover administrative and remediation costs; and
(5) The implementation of source control or treatment BMPs.

Once the illicit discharge or connection is eliminated, and if abatement of a violation and/or restoration of affected property is required, the notice shall set forth a deadline within which such remediation or restoration must be completed. Said notice shall further advise that, should the violator fail to remediate or restore within the established deadline, BCPH may seek the enforcement of the work through injunction or other legal means, or the work will be done by a designated governmental agency or a contractor and the expense thereof shall be charged to the violator.

Criminal Prosecution.
Any person that has violated or continues to violate this ordinance shall be liable to criminal prosecution to the fullest extent of the law, and shall be subject to a criminal penalty authorized pursuant to Colorado Revised Statutes, Title 30, Article 15. BCPH may recover all attorneys' fees, court costs and other expenses associated with enforcement of this ordinance, including sampling and monitoring expenses.

Violations Deemed a Public Nuisance.
In addition to the enforcement processes and penalties provided, any condition caused or permitted to exist in violation of any of the provisions of this Ordinance is a threat to public health, safety, and welfare, and is declared and deemed a nuisance, and may be summarily abated or restored at the violator's expense, and/or a civil action to abate, enjoin, or otherwise compel the cessation of such nuisance may be taken.

Remedies Not Exclusive.
The remedies listed in this ordinance are not exclusive of any other remedies available under any applicable federal, state or local law, and it is within the discretion of BCPH to seek cumulative remedies.

SECTION 12. SEVERABILITY.

If any provision, clause, sentence or paragraph of this Ordinance or the application thereof to any person or circumstances shall be held invalid, such invalidity shall not affect the other provisions of this Ordinance which can be given effect without the invalid provision or application, and to this end the provisions of this Ordinance are declared to be severable.

SECTION 13. EFFECTIVE DATE, REPEAL OF PRIOR ORDINANCE.

This article shall be effective sixty (60) days from and after the date of its adoption and final publication. Ordinance No. 2005-1 shall be repealed as of such effective date.

INTRODUCED, READ AND ADOPTED ON FIRST READING on October 30, 2012, and ordered published in the BOULDER DAILY CAMERA.

THE BOARD OF COMMISSIONERS
OF THE COUNTY OF BOULDER, COLORADO

____
Cindy Domenico, Chair

ATTEST:

____
Clerk to the Board

ADOPTED ON SECOND AND FINAL READING on November 29, 2012.

THE BOARD OF COMMISSIONERS
OF THE COUNTY OF BOULDER, COLORADO

____
Cindy Domenico, Chair

ATTEST:

____
Clerk to the Board

TOWN OF LYONS

COMMERCIAL DEVELOPMENT AND MIXED USE DEVELOPMENT

DESIGN STANDARDS AND GUIDELINES

Adopted _______________

Sample Commercial and Mixed Use Design Standards and Guidelines – Town of Lyons

This is provided for reference only. This is sample language used in previously published standards and guidelines. This general language and intent could be merged with a truncated and reduce version of the Boulder Ordinance. This general language and intent could be merged with an expanded and customized Cherry Hills Village water quality ordinance.

In any case, these references are meant to provide general parameters, parts, and recommendations for customizing an ordinance or other legislation to support the sustainable management of stormwater quality in the Town of Lyons.

6. Dumpsters and their enclosures shall be located and designed to facilitate collection and to minimize negative impact on-site or to neighboring properties, or public rights-of-way**. (S)**
7. All dumpsters and all other waste disposal activities shall be adequately screened or otherwise concealed from the view of persons traveling on any public street, sidewalk or other public ways. **(S)**

H. Water Quality Control and Drainage

Intent: Preserve natural drainage and design stormwater improvements as landscape amenities to enhance the project, slow stormwater runoff, capture water pollutants, prevent erosion and minimize impervious surfaces. Storm water and snow-melt from rooftops, paved areas, and lawns carry plant debris, soil particles, and dissolved chemicals into rivers and streams. Site development plans should employ management and best engineering practices to protect storm water discharge from these undesirable elements, before releasing water off site or into the Town's storm drainage system or natural waterways.

Site drainage should be designed to minimize water collection near building foundations, entrances, service ramps and primary pedestrian routes.

In addition to the Town of Lyons's Storm Drainage and Technical Criteria, the following standards and guidelines apply.

Standards and Guidelines:

1. Storm water should not drain directly into the public storm drainage system or released overland into rivers or streams without first going through peak runoff mitigation and water quality treatment systems. **(G)**
2. Design all storm sewers, grassed swales and other drainage channels in accordance with the Town of Lyons storm drainage design and technical criteria. **(S)**
3. Avoid hard concrete-lined channel designs, where practical. If a hard channel design is necessary, use a more natural approach that incorporates river rock or natural rock channel lining when possible. **(G)**
4. Utilize accepted design criteria and recommendations of the Urban Drainage and Flood Control District (or other commonly recognized and appropriate engineering standards) and the Town of Lyons for detention pond design and to enhance water quality. **(S)**
5. Design on-site drainage and detention facilities with attractive, landscape features and amenities. **(S)**
6. Integrate local durable materials in pond design, such as flagstone terracing. **(G)**
7. Every development plan shall be accompanied by a drainage plan and report prepared by a licensed professional engineer in the State of Colorado in accordance with the Manual of Design Criteria and Standard Specifications for the Construction of Public Improvements. **(S)**
8. The plan and report is subject to review and acceptance by the Town. **(S)**

9. The drainage design shall:
    a. Restrict runoff from a parcel to historic conditions, unless otherwise indicated in the Town's Master Drainage Plan, or demonstrate that doing so would be detrimental to the overall system; **(S)**
    b. Accept and convey runoff in its historic manner, unless otherwise indicated in the Town's Master Drainage Plan, or unless other offsite permanent arrangements are made. **(S)**
    c. Include easements in favor of the Town to facilitate emergency maintenance of controls, structures, features or other improvements that, when not operating correctly, could result in damage to adjacent property or to the Town. **(S)**
    d. Respect existing conditions and adjacent properties and follow general topographic constraints of the site and adjacent lands. **(S)**
10. Drainage improvements serving a regional area may be turned over to the Town for ownership and maintenance if accepted by the Board of Trustees and approved easements and agreements are in place. Drainage improvements serving a common ownership, cluster development, shopping plaza, industrial park, or other similar development will remain under the ownership and maintenance of the owner or managing association. Easements will be required in favor of the Town as noted above. **(S)**
11. Drainage plans and reports shall be accompanied by an Erosion and Sediment Control Plan. **(S)** Erosion and Sediment Control Plans are required for construction and for permanent improvements. Erosion and Sediment Control Plans shall:
    a. Encompass the phasing of a development or site design. **(S)**
    b. Be in consideration of other upstream and downstream property owners, drainage conveyances, and the north and south St. Vrain Creeks. **(S)**
    c. Protect existing vegetation. **(S)**
    d. Minimize disturbance to natural lands and geologic features. **(S)**
    e. Address construction related dust mitigation. **(S)**
    f. Include details and specifications for the proper installation and maintenance of temporary and permanent improvements. **(S)**
    g. Comply with all applicable state and federal standards including but not limited to the Colorado State Department of Health and Environment. **(S)**
12. Parking Lot Stormwater Management:
    a. Stormwater runoff should be routed or directed over perimeter and interior plantings to the greatest extent possible. **(G)**
    b. Stormwater runoff management should facilitate infiltration as close to where it falls as possible provided it does not harm structures or hard surface pavements. **(G)**
    c. The consolidation of planting islands to be used for storm water quality enhancement is encouraged and allowed for the promotion of plant growth and cleansing of runoff. **(G)**
    d. The use of biofiltration techniques such as constructed rain gardens to filter pollutants carried by runoff and infiltrate stormwater for irrigation is recommended. **(G)**
    e. Use of permeable concrete or asphalt pavement systems for parking lots is strongly encouraged. **(G)**

13. The Town of Lyons considers sustainability to be an important consideration for today's actions. As such, drainage design should consider sustainability through local treatment of surface runoff, infiltration and capture and use of runoff on site (provided such use is not in violation of applicable State regulations).

Appendix I

TOWN OF LYONS

STORM DRAINAGE CRITERIA ADDENDUM

TO URBAN DRAINAGE STORM DRAINAGE CRITERIA MANUALS (VOLUMES 1, 2, AND 3)

Date: October 2016

Prepared By: ICON Engineering

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Purpose of this Manual

The purpose of this manual is to set forth the criteria to be used in the design of drainage systems within the Town of Lyons, Colorado. All subdivision plats, planned unit development, or any other proposed construction must include adequate storm drainage analysis using this manual supplemented by the UDSCM and Boulder County criteria as a guide.

Whenever possible master drainage plan studies should be referenced for proposed developments located within the study area. Although the Town of Lyons lies outside of the Urban Drainage and Flood Control District, the regional drainage concepts written in the Urban Storm Drainage Criteria Manual (USDCM) can be applied to Lyons. Many of the communities outside of Denver have also adopted the UDSCM for their communities with an addendum to fit their specific community needs.

All section numbers referenced are based off of USDCM Volumes 1, and 2 dated June 2001 Revised April 2008, and USDCM Volume 3 dated November 2010 available for download from their website at www.udfcd.org.

Prior to any construction of development activity, there must be an adequate plan for storm drainage in compliance with all regulations and specifications set forth in this Manual and approved by the Town.

Master Drainage Study

Any annexation or planned unit development (PUD) in excess of 40 acres or phased commercial/industrial development in excess of 10 acres is required to prepare a master drainage study. The purpose of the study is to identify major drainageways, ponding areas, siting and sizing of culverts, bridges, open channels and drainage basins which are tributary to the proposed development. The master drainage study should discuss alternatives to the drainage problems identified by the study. Downstream drainage facilities should be thoroughly analyzed to confirm they can convey the developed runoff. The report shall include but not be limited to:

- Calculations for peak flow from all off-site tributary drainage basins.
- Calculations for peak flow within the proposed development.
- Discussion and analysis of downstream facilities.
- Discussion of drainage problems and solutions which may be anticipated to occur within the development.
- Reports shall be bound and typed on 8-1/2” x 11” paper.

The drawings shall include, but not limited to the following information:

- Any and all flood plains
- Existing topography (Two-foot intervals)
- Location and size of open channels, bridges, culverts, storm sewers, and ponding areas.
- Identification of drainage basins within and tributary to the development.
- Location of all streets.

- Scales as small as 1”=500’ may be used to show the entire development and all off-site drainage areas. (Drawings shall be 22” x 34”).

Preliminary Drainage Report

A preliminary drainage report must be approved prior to approval of any final plat, planned building group or planned unit development. The report must be approved by engineering and planning staff prior to Planning Commission action. A Planning Commission action without engineering approval risks violation of State statues for water rights, floodplain regulations, and other water resource criterion.

The purpose of the preliminary drainage study is to identify and propose specific solutions to any on-site drainage problems that will occur as a result of the proposed development. Off-site information required on the preliminary drainage study is similar to that of the master drainage study and may be omitted from the preliminary drainage study when adequately analyzed by a master drainage study. The preliminary drainage report must include adequate topography to verify all conclusions regarding off-site drainage. Unless known, the capacity of downstream drainage structures must be thoroughly analyzed to determine their ability to convey the developed discharge.

Whenever the possibility of downstream flooding or property damage exists, it will be necessary to utilize either detention or retention ponds to reduce the developed discharge to an acceptable rate.

The preliminary drainage report shall include, but not limited to:

- A description of the property (Township, Range, Section, surrounding developments, major drainage channels, general topography, ground cover).
- Detailed analysis of receiving structures
- Adequate on-site analysis to determine the location and required capacity of culverts, bridges, open channels, detention ponds and storm sewers
- Report shall be bound and typed on 8-1/2” x 11” paper. Drawings, figures, plates, and tables shall be bound with the report or included in a folder/pocket attached to the report.

Drawings accompanying the report shall include, but not limited to, the following:

- Scales as small as 1”=500’ may be used to show the entire development and all off-site drainage areas. (Drawings shall be 22” x 34”).
- All floodplains affecting the property must be shown.
- Topography map of the development showing street layout and/or building location on a contour interval not to exceed two feet
- Location and size of all drainage structures
- Drainage patterns within the proposed developments

Whenever open channels are planned, the following additional information shall be required:

- Preliminary profile showing existing and proposed grades

- Cross sections on 100-foot stations showing existing and proposed cross sections and required right-of-way
- Location and size of all structures
- As-built profiles of any existing utilities which may be affected by the channel construction.

Inlet and storm sewer size calculations are not required with the preliminary drainage study because the number of subbasins analyzed in the report should be held to the smallest practical amount.

Final Drainage Report

The final drainage report shall be a detailed study and analysis of the proposed development. It shall include detailed calculations for all runoff within the proposed development, and detailed calculations for the design of all drainage structures within the development. The final drainage report shall be typed on 8-1/2" x 11" paper. Drawings, figures, plates, and/or tables shall be bound with the report or included in a folder/pocket attached to the report.

Construction plans for all drainage structures, grading plans and street grades, where applicable, shall also be included with and considered as a part of the final drainage study.

Drawings and calculations comprising the final drainage report shall include but not limited to:

- Existing and proposed contours (Two-foot intervals)
- Location and elevations of city benchmarks. All elevations shall be on a NAVD 88 datum.
- Property lines
- Street, names and grades
- Existing drainage facilities and structures, including existing irrigation ditches, roadside ditches, drainageways, swales, gutter flow directions, culverts, etc. All pertinent information such as size, shape, slope, location, etc., shall also be included to facilitate review and approval of drainage plans.
- Overall drainage area boundary and drainage subarea boundaries
- Proposed type of curb and gutter, gutter flow direction, including cross pans.
- Proposed storm sewers and open drainageways and right-of-way requirements, including proposed inlets, manholes, culverts, erosion control and energy dissipation devices, and other appurtenances.
- Proposed outfall point for runoff from the developed area and facilities to convey flows to the final outfall point without damage to downstream properties.
- Routing and accumulative flows at various critical points for the minor storm runoff
- Routing and accumulative flows at various critical points for the major storm runoff
- Details of detention storage facilities and outlet works.
- Critical minimum finished floor elevations for protection from major storm runoff.
- An overall drawing of the proposed development which shall show the following information:
  - Location and size of all drainage structures
  - General flow patterns within the development

- Finished floor elevations of all buildings
- Flood level in all streets in which the curb is overtopped during the 100-year storm.
- All drainage basins within the development.
- All floodplains within the proposed development
- Location and elevation of all existing and proposed utilities affected by or affecting the drainage design
- All drawings shall be on 22” x 34” sheets.

USDCM VOLUME 1

DRAINAGE POLICY

1.1 Policy – Accepted

1.2 Principles – Accepted

1.3 Basic Knowledge – Accepted

1.4 Planning – Accepted

Change:

"A master plan for storm drainage should be developed and maintained in an up-to-date fashion at all times for each urbanizing drainage watershed in the Denver region."

To:

"The town Masterplan should be updated based on annexations, hydrologic study changes by FEMA, CWCB, or other agencies, and following capital improvement projects, or not less than every five (5) years."

1.5 Technical Issues– Accepted

Change:

"Proper design and construction of stormwater detention and retention basins are necessary to minimize future maintenance and operating costs to avoid public nuisances and health hazards. This is particularly important, given the many detention and retention facilities in the Denver region."

To:

Proper design and construction of stormwater detention basins are necessary to minimize future maintenance and operating costs to avoid public nuisances and health hazards.

Change:

"The various governmental agencies within the Denver region have adopted and need to maintain their floodplain management programs."

To:

The Town of Lyons has adopted the FEMA NFIP floodplain ordinance as required by the CWCB and needs to maintain their floodplain management programs.

1.6 Flood Insurance – Accepted

1.7 Implementation – Accepted

2.0 PRINCIPLES

2.1 Drainage Is a Regional Phenomenon That Does Not Respect the Boundaries Between Government Jurisdictions or Between Properties – Accepted

2.2 A Storm Drainage System Is a Subsystem of the Total Urban Water Resource System – Accepted

2.3 Every Urban Area Has an Initial (i.e., Minor) and a Major Drainage System, Whether or Not They Are Actually Planned and Designed – Accepted

2.4 Runoff Routing Is Primarily a Space Allocation Problem – Accepted

2.5 Planning and Design of Stormwater Drainage Systems Generally Should Not Be Based on the Premise That Problems Can Be Transferred From One Location to Another – Accepted

2.6 An Urban Storm Drainage Strategy Should Be a Multi-Objective and Multi-Means Effort – Accepted

2.7 Design of the Stormwater Drainage System Should Consider the Features and Functions of the Existing Drainage System – Accepted

2.8 In New Developments, Attempts Should Be Made to Reduce Stormwater Runoff Rates and Pollutant Load Increases After Development to the Maximum Extent Practicable – Accepted

2.9 The Stormwater Management System Should Be Designed Beginning With the Outlet or Point of Outflow From the Project, Giving Full Consideration to Downstream Effects and the Effects of Off-Site Flows Entering the System – Accepted

2.10 The Stormwater Management System Should Receive Regular Maintenance – Accepted

2.11 Floodplains Need to Be Preserved Whenever Feasible and Practicable – Accepted

2.12 Reserve Sufficient Right-of-Way for Lateral Movement of Incised Floodplains – Accepted

3.0 BASIC KNOWLEDGE – Deleted *(Although the concepts by title are valuable to the Town of Lyons, the content is UDFCD specific and is therefore deleted to avoid confusion. i.e. 3.1.4 Library references plans and reports within the UDFCD.)*

3.1 Data Collection - Deleted

3.1.1 Storm Runoff and Flood Damage - Deleted

3.1.2 Rainfall-Runoff Relationships - Deleted

3.1.3 Inventory of Successful Projects - Deleted

3.1.4 Library - Deleted

3.1.5 Runoff Magnitudes - Deleted

3.2 Floodplain Data - Deleted

3.2.1 Small Waterways - Deleted

3.2.2 Data Inventory - Deleted

3.2.3 Floodplains - Deleted

3.2.4 Priority for Data Acquisition - Deleted

3.3 Data Use - Deleted

3.3.1 Master Plan - Deleted

3.3.2 Public Cost - Deleted

3.3.3 Easements - Deleted

4.0 PLANNING

4.1 Total Urban System - Amended

Change:

“Master plans for storm drainage have been developed and maintained in an up-to-date fashion for most of the watersheds in the Denver region. An effort to complete the coverage of master plans for yet unplanned areas of the District should be continued until full coverage is achieved.”

To:

“The Town Master Plan should be updated based on annexations, hydrologic study changes by FEMA, CWCB, or other agencies, and following capital improvement projects, or not less than every five (5) years.”

4.1.1 Development Plan - Accepted

4.1.2 Master Plan- Amended- Amended

Delete entire first paragraph

Change:

"The District has established a suitable format for master plan reports and drawings so that a uniform planning approach and coordination of efforts can more easily be made. Master planning should be done in enough detail and with adequate thoroughness to provide a ready drainage development guide for the future in a particular watershed. "

To:

"Any master plan for the town should be done in enough detail and with adequate thoroughness to provide a ready drainage development guide for the future. Guidelines for drainage reports are provided in sections for the Master Drainage Study, Preliminary Drainage Report, and Final Drainage Report."

4.1.3 Planning Process Ingredients- Amended

Change:

"2. Initial Drainage System Planning. All local and regional planning must take into consideration the initial drainage system to transport the runoff from storms expected to occur once every 2 to 10 years."

To:

2. Initial Drainage System Planning. All local and regional planning must take into consideration the initial drainage system to transport the runoff from storms expected to occur once every 2 years.

4.1.4 Local and Regional Planning- Accepted

4.1.5 Site Planning- Accepted

4.1.6 Water Quality- Amended

Change:

"Sanitary sewage systems that overflow or bypass untreated sewage into surface streams should not be permitted in the Denver region."

To:

Sanitary sewage systems that overflow or bypass untreated sewage into surface streams should not be permitted in the town.

4.2 Multiple-Objective Considerations- Accepted

4.2.1 Lower Drainage Costs- Accepted

4.2.2 Open Space - Accepted

4.2.3 Transportation - Accepted

4.3 Natural Channels- Accepted

4.3.1 Channelization- Amended

Add:

It shall be the policy of the town to review proposed channel designs on a case-by-case basis. Proposed modifications to natural channels shall be approved only if the work causes no injury to water rights and is not in violation of State of Federal Law.

4.3.2 Channel Storage- Accepted

4.3.3 Major Runoff Capacity- Accepted

4.3.4 Maintenance and Maintenance Access- Accepted

4.4 Transfer of Problems- Accepted

4.4.1 Intra-Watershed Transfer- Accepted

4.4.2 Inter-Watershed Transfer- Accepted

4.4.3 Watershed Planning- Accepted

4.5 Detention and Retention Storage- Amended

Add:

"The policy of the Town of Lyons shall be to require regional and/or on-site detention for all future developments. Temporary or interim detention/retention may be required if the downstream regional facilities have not yet been constructed per the applicable Master Plan. It is the town's policy to require detention of runoff from the 100-year storm falling on the developed site and release of the detained water at the rate of the runoff of the 5-year storm falling on the undeveloped site. Detention releases based on soil types are not approved for the town.

Proposed development must provide for the safe conveyance of offsite flows through the proposed development site. Offsite flow may be routed through or around the proposed detention facilities. Positive drainage must be provided. The town will not approve any detention pond that does not drain in less than 72 hours, or causes injury to water rights, or is in violation of State or Federal law.

All detention facilities must be recorded with the State database: Stormwater Detention and Infiltration Facility Notification in compliance with Colorado Revised Statute §37-92-602(8)(b)(I)(A). Additional information is presented on the state website: https://maperture.digitaldataservices.com/gvh/?viewer=cswdif

Owing to the updated guidance from the State Engineer on 72 hour drain time, retention facilities must meet that same threshold. Retention facilities holding water longer than 72 hours are subject to review by the State Engineer for water rights, augmentation, or other basin requirements. At a minimum, any drainage plan proposing retention facilities must prove infiltration rates of soils in the retention facility can empty the pond within 72 hours. Drainage plans proposing retention must also consider clogging pore spaces in the pond bottom, seasonal variation in groundwater and its impact on infiltration rates, and other criteria required by the Town Engineer.

4.5.1 Upstream Storage - Accepted

4.5.2 Minimized Directly Connected Impervious Area Development - Accepted

4.5.3 Downstream Storage - Accepted

4.5.4 Reliance on Non-Flood-Control Reservoirs - Amended

Delete entire paragraph

Add:

"Jurisdictional dams are classified by the State Engineer as low, moderate, or high hazard structures depending on conditions downstream. Dams are classified as high hazard structures when, in the event of failure, there is a potential loss of life. Dams presently rated as low or moderate hazard structures may be changed to high hazard rating if development occurs within the potential path of flooding due to a dam breach. In this case, the reservoir owners would be liable for the cost of upgrading the structure to meet the higher hazard classification.

The Policy of the Town of Lyons shall be to:

1. Restrict upstream development to areas outside of the jurisdictional dam water surface elevation created by a 100-year storm plus freeboard.

2. Restrict downstream development to areas outside of the jurisdictional dam 100-year floodplain. The jurisdictional dam 100-year floodplain is defined as either:

   a. The 100-year floodplain downstream of the emergency spillway assuming the dam is full to the elevation of the emergency spillway at the beginning of the 100-year storm and the 100-year storm is routed through the dam and out the emergency spillway,

   b. Or the path that the basin's 100-year floodplain would form through the downstream development if the dam were removed by the owner.

4.5.5 Reliance on Embankments - Amended

Change:

"The detention of floodwaters behind embankments created by railroads, highways or roadways resulting from hydraulically undersized culverts or bridges should not be utilized by the drainage engineer for flood peak mitigation when determining the downstream flood peaks for channel capacity purposes unless such detention has been covered by a binding agreement approved by the District."

To:

"The detention of floodwaters behind embankments created by railroads, highways or roadways resulting from hydraulically undersized culverts or bridges should not be utilized by the drainage engineer for flood peak mitigation when determining the downstream flood peaks for channel capacity purposes unless such detention has been covered by a binding agreement approved by the Town.

Historical development within the Town limits includes mining, rail, and associated infrastructure subsequently repurposed in part or in full for private and public uses. Applicants should carefully review existing topographic features to ensure stability of embankments, fill, slopes, and other surface and sub-surface features."

5.0 TECHNICAL CRITERIA

5.1 Design Criteria - Amended

Change:

"Storm drainage planning and design should adhere to the criteria developed and presented in this Manual maintained by the District."

To:

"Storm drainage planning and design should adhere to the criteria developed and presented in this Manual maintained by the Town."

5.1.1 Design Criteria- Amended

Change:

"The design criteria presented herein represent current good engineering practice, and their use in the Denver region is recommended. The criteria are not intended to be an ironclad set of rules that the planner and designer must follow; they are intended to establish guidelines, standards and methods for sound planning and design."

To:

"The design criteria presented herein represent current good engineering practice, and their use in the Town of Lyons is recommended. The criteria are not intended to be an ironclad set of rules that the planner, engineer, and designer must follow; they are intended to establish guidelines, standards and methods for sound planning and design. The planner, engineer, designer, and owner should carefully coordinate with Town staff to collect the best available data for the watersheds affecting the subject property."

5.1.2 Criteria Updating - Accepted

5.1.3 Use of Criteria - Accepted

5.2 Initial and Major Drainage - Accepted

5.2.1 Design Storm Return Periods - Amended

Delete second paragraph

5.2.2 Initial Storm Provisions - Amended

Change:

"The initial storm drainage system, capable of safely handling 2- to 10-year floods depending on local criteria, is necessary to reduce the frequency of street flooding and maintenance costs, to provide protection against regularly recurring damage from storm runoff, to help create an orderly urban system, and to provide convenience to urban residents."

To:

"The initial storm drainage system, capable of safely handling 2-year floods, is necessary to reduce the frequency of street flooding and maintenance costs, to provide protection against regularly recurring damage from storm runoff, to help create an orderly urban system, and to provide convenience to urban residents. Considerations shall be made to ensure downstream facilities are sized to accept flows associated with any new development."

5.2.3 Major Storm Provisions - Accepted

5.2.4 Critical Facilities - Accepted

5.2.5 Major Drainage Channels - Accepted

5.2.6 Tailwater -Accepted

5.3 Runoff Computation - Accepted

5.3.1 Accuracy - Accepted

5.4 Streets - Accepted

5.4.1 Use of Streets - Amended

Change:

"Bubblers (inverted siphons which convey flows beneath roadways) are not encouraged in the Denver region because of possible plugging with sediment and difficulty in maintaining them."

To:

Bubblers (inverted siphons which convey flows beneath roadways) are not encouraged in Lyons because of possible plugging with sediment and difficulty in maintaining them."

Add:

"Street conveyance in portions of the Town is an important means of stormwater conveyance due to limitations of excavation for pipe systems in the rock subgrade present in the majority of the northern side of the St. Vrain."

5.5 Irrigation Ditches- Amended

Add:

Lyons does not allow the discharge of stormwater runoff from developed areas into irrigation ditches and facilities except as required by water rights or where such discharges are in conformance with approved Master Drainage plans. Further, wherever new development will alter patterns of drainage into irrigation ditches by increasing flow rates or volumes, or will change the historic concentration points of runoff, the Town shall require each new development to obtain written consent of the appropriate ditch company before approving the drainage design and development.

Where irrigation and stormwater conveyance intersect, the Town will recommend gravity flow for the stormwater system to prevail and siphon, pump, or other forced flow regimes be reserved for irrigation flows. Irrigation systems typically have a routine maintenance cycle built around seasonal flow patterns unlike perpetual flows within Town storm sewer systems."

5.5.1 Use of Ditches- Amended

Change:

"Land planners downhill from a ditch should plan for pre-ditch drainage conditions as well as continued ditch seepage."

To:

"Land planners and engineers with a proposed development downhill from a ditch shall plan for pre-ditch drainage conditions as well as continued ditch seepage.

Add:

For new development, it shall be the policy of Lyons to prohibit undetained discharges to roadside ditches located in the Town right-of-way. In the event a proposed development wishes to design stormwater discharge to a Town right-of-way, the developer, at the request of the Town, shall have the requirement to design and construct drainage improvements to the right-of-way at the developers' own expense. Such improvements shall include, but not be limited to: detention ponds, armored channels, culverts, level spreaders, and other drainage facilities. Cost-sharing of such needed improvements may be borne by adjacent, upstream, or downstream developments, such cost sharing to be negotiated by the developer. The Town of Lyons will require written agreements and construction bonding of such offsite drainage improvements.

5.5.2 Ditch Perpetuation - Accepted

5.5.3 Conformance With Master Plan - Accepted

Change:

“Use of irrigation ditches for collection and transport of either initial or major storm runoff should be prohibited unless specifically provided in a District's master plan or approved by the District and the ditch owner.”

To:

“Use of irrigation ditches for collection and transport of either initial or major storm runoff should be prohibited unless specifically provided in the Town’s master plan or approved in writing by the Town and the ditch owner.”

5.6 Detention and Retention Facilities Maintenance - Amended

Change:

“The significant cost of handling stormwater runoff, coupled with the social benefits to be derived from proper storm drainage facilities, points towards the use of detention and retention basins for storage of stormwater runoff in the Denver region. Maintenance provisions must be arranged. Maintenance of detention or retention facilities includes the removal of debris, excessive vegetation from the embankment, and sediment. Without maintenance, a detention/retention facility will become an unsightly social liability and eventually become ineffective.”

To:

“The significant cost of handling stormwater runoff, coupled with the social benefits to be derived from proper storm drainage facilities, points towards the use of detention basins for storage of stormwater runoff in the Town. Maintenance provisions must be arranged, documented, and reviewed annually. Maintenance of detention facilities includes the removal of debris, trimming excessive vegetation from the embankment, sediment removal, and other procedures set forth by Town Maintenance personnel and engineering staff. Without maintenance, a detention facility will become an unsightly social liability, eventually become ineffective, and ultimately could become a threat to public health and safety.”

5.6.1 Water Quality – Accepted

Add:

“Colorado House Bill 1005, provides that rain barrels can only be installed at single-family households and multi-family households with four or fewer units. A maximum of two rain barrels can be used at each household and the combined storage of the two rain barrels cannot exceed 110 gallons. Rain barrels can only be used to capture rainwater from rooftop downspouts and the captured rainwater must be used to water outdoor lawns, plants and/or gardens on the same property from which the rainwater was captured. Rain barrel water cannot be used for drinking or other indoor water uses. The capture and use of rainwater using rain barrels does not constitute a water right.

The Town will consider drainage plans that utilize rain barrels to offset water quality and detention requirements. In no circumstance will rain barrels completely eliminate other water quality or detention requirements."

6.0 FLOODPLAIN MANAGEMENT

6.1 Purpose - Amended

Delete:

"Various governmental agencies within the Denver region should initiate floodplain management programs."

6.2 Goals - Amended

Change:

"To reduce the vulnerability of Denver region residents to the danger and damage of floods."

To:

To reduce the vulnerability of the Town's residents to the danger and damage of floods.

6.3 National Flood Insurance Program- Accepted

6.3.1 Participation - Accepted

6.3.2 New Development - Amended

If a CLOMR/LOMR submittal is needed with a development application, Lyons shall follow the requirements of the floodplain ordinance.

The Town of Lyons reserves the right to outsource engineering review of all CLOMR and LOMR submittals received with a development application. The Developers shall reimburse the Lyons for all outsourced engineering review costs. Upon FEMA approval of a CLOMR or LOMR, payment of all outsourced engineering review costs is due and payable to Lyons. It is possible for developers to contract directly with one of the Town's outsourced Consultant(s) for the preparation of CLOMR's and LOMR's, if they so desire. However, the Town maintains the right to in in-house or outsourced independent review of the application before providing Town concurrence."

6.4 Floodplain Management - Accepted

6.5 Floodplain Filling- Accepted

6.6 New Development - Accepted

6.7 Strategies and Tools - Accepted

6.7.1 Exposure to Floods - Accepted

6.7.2 Development Policies - Accepted

6.7.3 Preparedness - Accepted

6.7.4 Flood Proofing - Accepted

6.7.5 Flood Forecasting - Accepted

6.7.6 Flood Modification - Accepted

6.7.7 Impact of Modification - Accepted

7.0 IMPLEMENTATION

7.1 Adoption of Drainage Master Plans – Amended

Change:

“This *Manual* and master plans should be adopted and used by all governmental agencies operating within the District.”

To:

This Manual and masterplans should be adopted and used by all parties operating within the Town.

7.1.1 Manual Potential - Accepted

7.2 Governmental Operations - Accepted

7.3 Amendments - Amended

Change:

“Problems in urban drainage administration encountered by any governmental agency should be reviewed by the District to determine if equity or public interests indicate a need for drainage policy, practice, or procedural amendments. The District should continually review the needs of the Denver region in regard to urban runoff criteria and should recommend changes as necessary to this *Manual*.”

To:

Problems in urban drainage administration encountered by anyone should be reviewed by the Town to determine if equity or public interests indicate a need for drainage policy, practice, or procedural amendments. The Town should continually review the needs of the town in regard to urban runoff criteria and should recommend changes as necessary to this *Manual*.

7.4 Financing - Accepted

7.4.1 Drainage Costs - Accepted

7.5 Drainage Improvements - Amended

Add:

The policy of Lyons regarding the design and construction of improvements within the Master Drainage Plan shall be set forth below:

a. Lyons shall identify needed design and construction of improvements as set forth in adopted Master Drainage Plans for existing and future growth areas.
b. The drainage systems for future development and redevelopment shall be designed and constructed by the Developer(s).
c. The Developers shall be responsible for design and construction of temporary or interim storm drainage systems required due to the lack of adequate storm drainage facilities downstream of new development.
d. The Developers may be responsible for design and construction of permanent storm drainage systems required due to the lack of adequate storm drainage facilities downstream of new development.

8.0 REFERENCES - *Accepted*

DRAINAGE LAW - Deleted

1.0 SUMMARY OF CURRENT GENERAL PRINCIPLES OF DRAINAGE AND FLOOD CONTROL LAW - Deleted

1.1 Introduction - Deleted

1.2 Legal Principles - Deleted

2.0 GENERAL PRINCIPLES OF DRAINAGE LAW - Deleted

2.1 Private Liability - Deleted

2.1.1 Common Enemy Rule - Deleted

2.1.2 Civil Law Rule - Deleted

2.1.3 Reasonable Use Rule - Deleted

2.2 Municipal Liability - Deleted

2.2.1 Planning Drainage Improvements - Deleted

2.2.2 Construction, Maintenance, and Repair of Drainage Improvements - Deleted

2.2.3 Summary - Deleted

2.3 Municipal Liability for Acts of Others - Deleted

2.3.1 Acts or Omissions of Municipal Officers, Agents, or Employees - Deleted

2.3.2 Municipal Liability for Acts of Developers - Deleted

2.4 Personal Liability of Municipal Officers, Agents, and Employees - Deleted

3.0 DRAINAGE IMPROVEMENTS BY A LOCAL GOVERNMENT - Deleted

3.1 Constitutional Power - Deleted

3.2 Statutory Power - Deleted

3.2.1 Statutes—Municipalities - Deleted

3.2.1.1 Municipal Powers—Public Property and Improvements - Deleted

3.2.1.2 Public Improvements—Special Improvement Districts in Municipalities - Deleted

3.2.1.3 Public Improvements—Improvement Districts in Municipalities - Deleted

3.2.1.4 Sewer and Water Systems—Municipalities - Deleted

3.2.2 Statutes—County - Deleted

3.2.2.1 Public Improvements—Sewer and Water Systems - Deleted

3.2.2.2 County Public Improvement Districts - Deleted

3.2.2.3 Public Improvements—Local Improvement Districts—Counties- Deleted

3.2.2.4 Flood Control—Control of Stream Flow - Deleted

3.2.2.5 Conservancy Law—Flood Control - Deleted

3.2.2.6 Drainage Districts - Deleted

3.2.3 Statutes—State - Deleted

3.2.3.1 Colorado Land Use Act - Deleted

3.2.3.2 Drainage of State Lands - Deleted

3.2.3.3 Water Conservation Board of Colorado - Deleted

3.2.3.4 State Canals and Reservoirs - Deleted

3.2.3.5 Regulatory Impairment of Property Rights - Deleted

3.2.3.6 Intergovernmental Relationships - Deleted

3.2.4 Urban Drainage and Flood Control Act - Deleted

4.0 FINANCING DRAINAGE IMPROVEMENTS - Deleted

4.1 Capital Improvement - Deleted

4.2 Local Improvement - Deleted

4.3 Special Improvement - Deleted

4.4 Service Charge - Deleted

4.5 Developer’s Cost - Deleted

4.6 The Taxpayers Bill of Rights, Article X, Section 20, Colorado Constitution - Deleted

4.7 Water Activities—Enterprise Statute 37-45.1-101 C.R.S - Deleted

5.0 FLOODPLAIN MANAGEMENT - Deleted

5.1 Floodplain Regulations - Deleted

5.1.1 Constitutional Considerations- Deleted

5.1.2 Statutory Grants of Power - Deleted

5.1.3 Court Review of Floodplain Regulations - Deleted

5.1.3.1 Restriction of Uses - Deleted

5.1.3.2 Health Regulations - Deleted

5.1.3.3 Determination of Boundaries - Deleted

5.2 Flood Insurance - Deleted

5.3 Flood Warning Systems and Notification - Deleted

6.0 SPECIAL MATTERS - Deleted

6.1 Irrigation Ditches - Deleted

6.2 Dams and Detention Facilities - Deleted

6.3 Water Quality - Deleted

6.4 Professional Responsibility - Deleted

7.0 CONCLUSION - Deleted

PLANNING

1.0 THE DRAINAGE SUBSYSTEM - Accepted

1.1 Planning - Accepted

1.2 Planning Philosophy - Accepted

1.3 Drainage Management Measures - Accepted

1.4 Water Quality - Accepted

2.0 EARLY PLANNING ADVANTAGES - Accepted

2.1 Advantages - Accepted

2.2 New Development - Accepted

2.3 Get the Facts - Accepted

2.4 Regulatory Considerations - Accepted

3.0 CONSIDER DRAINAGE BENEFITS - Accepted

3.1 Benefits- Accepted

4.0 MASTER PLANNING

4.1 Master Plan - Accepted

4.2 Uniformity - Accepted

5.0 PLANNING FOR THE FLOODPLAIN

5.1 Floodplains - Accepted

5.2 Concept of Floodplain Regulation - Accepted

5.3 Tools - Accepted

6.0 PLANNING FOR MAJOR DRAINAGE

6.1 Major Drainage - Accepted

6.2 Initial Route Considerations - Accepted

6.3 The Master Plan - Accepted

6.4 Open Channels- Accepted

7.0 PLANNING FOR INITIAL DRAINAGE

7.1 Initial Drainage - Amended

Change:

"The initial storm has been defined for the area served by the District to have a return frequency ranging from once in 2 years to once in 10 years."

To:

The initial storm has been defined for Lyons to have a return frequency once in 2 years.

7.2 Streets - Accepted

8.0 PLANNING FOR STORAGE

8.1 Upstream Storage - Accepted

8.2 Downstream Storage - Accepted

8.3 Channel Storage -Accepted

8.4 Other Benefits-Accepted

9.0 PLANNING FOR STORM SEWERS

9.1 Storm Sewers -Amended

Change:

"It is what directly contributes to the orderly growth of a community by handling the storm runoff expected to occur once every two to ten years."

To:

It is what directly contributes to the orderly growth of a community by handling the storm runoff expected to occur once every two years.

9.2 Function of Storm Sewers -Accepted

9.3 Layout Planning-Accepted

9.4 System Sizing –Amended

Change:

"The suggested design return periods to be used by local jurisdictions in the Denver region for storm sewer design for all land uses is 2- to 10-years."

To:

The design return period to be used for storm sewer design in Lyons is the 2-year storm for all land uses. Storm sewers passing flow under Town roads shall have a minimum design capacity for the 10-year storm and a minimum diameter of 18 inches or equivalent open area. System sizing design shall adhere to Boulder County street inundation criteria.

9.5 Inlets -Accepted

9.6 Alternate Selection-Accepted

10.0 PLANNING FOR OPEN SPACE

10.1 Greenbelts -Accepted

11.0 PLANNING FOR TRANSPORTATION

11.1 Coordination Needed-Accepted

12.0 CLEAN WATER ACT SECTION 404 PERMITTING PROCESS

12.1 Purpose of the 404 Permit-Accepted

12.2 Activities Requiring Permit-Accepted

12.3 Who Should Obtain a Permit-Accepted

12.4 Definition of Waters of the United States-Accepted

12.5 Pre-Application Meetings-Accepted

13.0 REFERENCES

RAINFALL

1.0 OVERVIEW - Amended

Rainfall values were determined using NOAA ATLAS 2 Volume III. These values were used into UDFCD's UD-Rain v.1.01 spreadsheet to convert these values from the 6-hr and 24-hr storms present in the NOAA ATLAS to more frequently used storm durations. Intensity-Duration-Frequency and Depth-Duration-Frequency graphs and tables were created using point values from the UD-Rain worksheet. Intensity-Duration-Frequency values can be seen in Table 1 and Figure 1. Depth-Duration-Frequency values can be found in Table 2 and Figure 2.

2.0 RAINFALL DEPTH-DURATION-FREQUENCY

2.1 Rainfall Depth-Duration-Frequency Maps - Deleted

2.2 Rainfall Depths For Durations Between 1- and 6-Hours - Amended

Table 1: Rainfall Depth (in) at Time Duration

Return Period	Rainfall Depth in Inches at Time Duration								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*3-hr*	*6-hr*	*24-hr*
2-yr	0.27	0.43	0.54	0.62	0.95	1.10	1.22	1.40	1.90
5-yr	0.38	0.61	0.77	0.89	1.35	1.56	1.71	1.95	2.65
10-yr	0.46	0.73	0.92	1.06	1.61	1.85	2.02	2.30	3.05
25-yr	0.55	0.88	1.10	1.28	1.95	2.22	2.43	2.75	3.80
50-yr	0.64	1.02	1.28	1.48	2.26	2.55	2.76	3.10	4.25
100-yr	0.72	1.15	1.45	1.68	2.55	2.84	3.06	3.40	4.85
500-yr	0.90	1.44	1.81	2.09	3.19	3.56	3.83	4.26	6.01

3.0 DESIGN STORM DISTRIBUTION FOR CUHP

3.1 Temporal Distribution

3.2 Adjustment to Rainfall Distribution for Watershed Size - Amended

Due to the size of the Lyons watershed, there is no need for any area adjustment.

4.0 INTENSITY-DURATION CURVES FOR RATIONAL METHOD - Amended

Table 2: Rainfall Intensity (in/hr) at Time Duration

Return Period	Rainfall Intensity in Inches Per Hour at Time Duration								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*3-hr*	*6-hr*	*24-hr*
2-yr	3.22	2.57	2.16	1.49	0.95	0.59	0.44	0.26	0.09
5-yr	4.58	3.65	3.07	2.12	1.35	0.84	0.62	0.37	0.13
10-yr	5.47	4.37	3.66	2.53	1.61	1.00	0.74	0.44	0.15
25-yr	6.60	5.27	4.42	3.05	1.95	1.21	0.90	0.53	0.18
50-yr	7.66	6.11	5.13	3.55	2.26	1.40	1.04	0.62	0.21
100-yr	8.66	6.91	5.80	4.01	2.55	1.59	1.18	0.70	0.24
500-yr	10.83	8.63	7.25	5.01	3.19	1.98	1.47	0.87	0.30

5.0 BASIS FOR DESIGN STORM DISTRIBUTION - Accepted

6.0 SPREADSHEET DESIGN AIDS - Accepted

7.0 EXAMPLES - Deleted

7.1 Example Computation of Point Rainfall - Deleted

7.2 Example Distribution of Point Rainfall - Deleted

7.3 Example Preparation of Intensity-Duration-Frequency Curve - Deleted

8.0 REFERENCES - Accepted

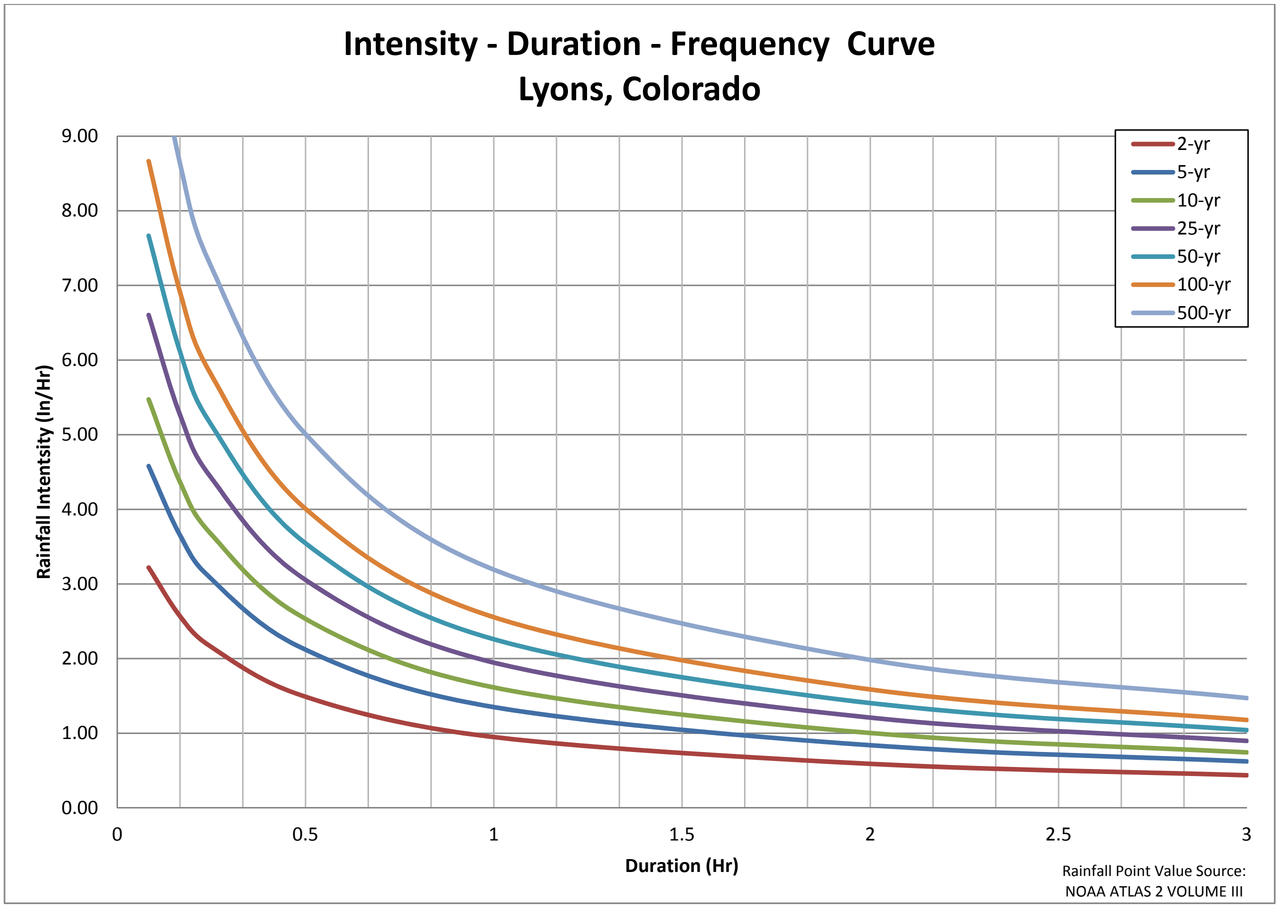

Figure 1: Intensity-Duration-Frequency Curve

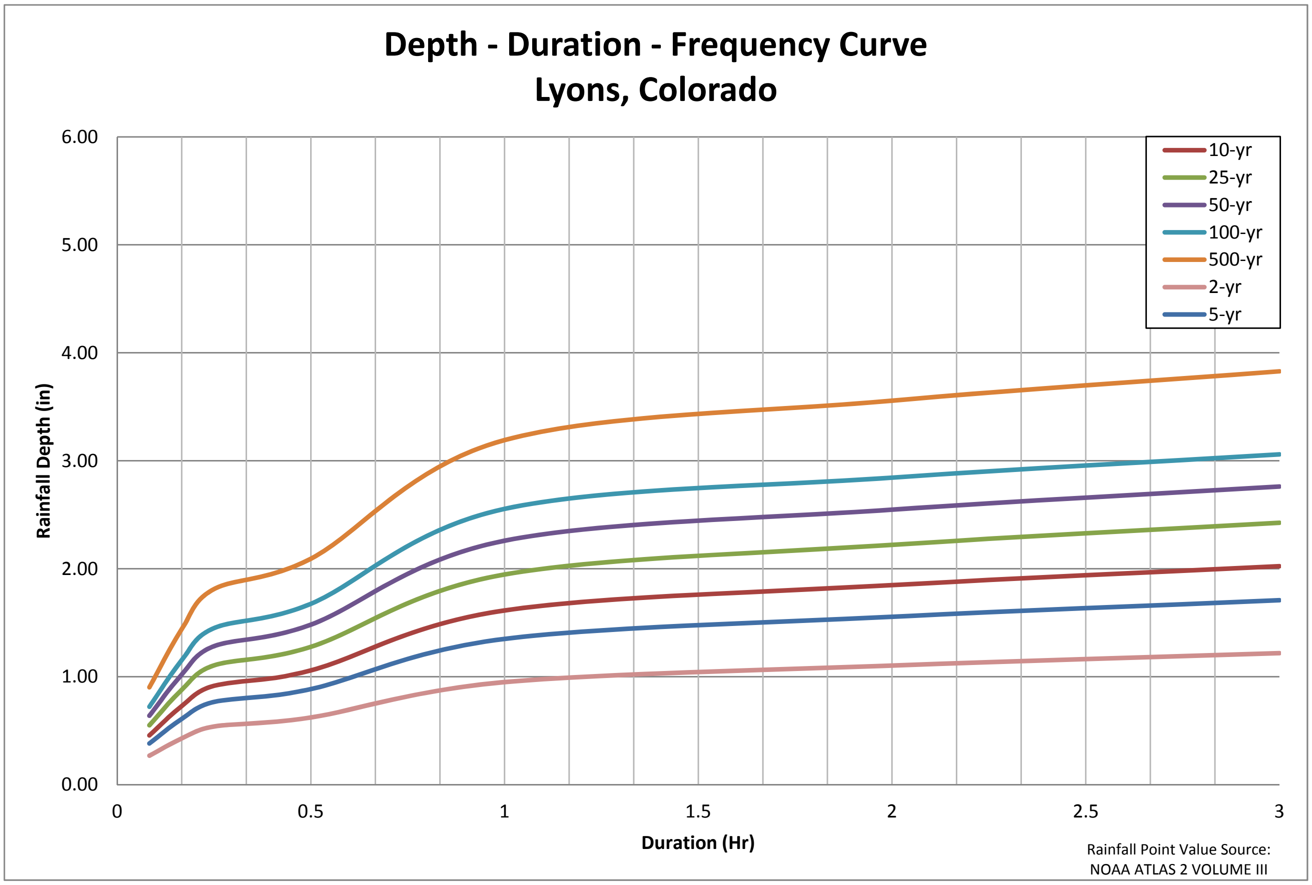

Figure 2: Depth-Duration-Frequency Curve

RUNOFF

1.0 OVERVIEW - Accepted

2.0 RATIONAL METHOD - Accepted

2.1 Rational Formula- Accepted

2.2 Assumptions- Accepted

2.3 Limitations- Accepted

2.4 Time of Concentration - Accepted

2.4.1 Initial Flow Time- Accepted

2.4.2 Overland Travel Time - Accepted

2.4.3 First Design Point Time of Concentration in Urban Catchments- Accepted

2.4.4 Minimum Time of Concentration- Accepted

2.4.5 Common Errors in Calculating Time of Concentration - Accepted

2.5 Intensity- Accepted

2.6 Watershed Imperviousness- Amended

The intensity for a design point should be selected from **Error! Reference source not found.**

2.7 Runoff Coefficient – Accepted

3.0 COLORADO URBAN HYDROGRAPH PROCEDURE- Accepted

3.1 Background- Accepted

3.2 Effective Rainfall for CUHP- Accepted

3.2.1 Pervious-Impervious Area- Accepted

3.2.2 Depression Losses- Accepted

3.2.3 Infiltration- Accepted

3.3 CUHP Parameter Selection- Accepted

3.3.1 Rainfall- Accepted

3.3.2 Catchment Description- Accepted

3.3.3 Catchment Delineation Criteria- Accepted

3.3.3 Combining and Routing Sub-Catchment CUHP Hydrographs- Accepted

4.0 EPA SWMM AND HYDROGRAPH ROUTING- Accepted

4.1 Software Description- Accepted

4.1.1 Surface Flows and Flow Routing Features- Accepted

4.1.2 Flow Routing Method of Choice - Accepted

4.2 Data Preparation for the SWMM Software- Accepted

4.2.1 Step 1—Method of Discretization - Accepted

4.2.2 Step 2—Estimate Coefficients and Functional/Tabular Characteristic of Storage and Outlets- Accepted

4.2.3 Step 3—Preparation of Data for Computer Input - Accepted

5.0 OTHER HYDROLOGIC METHODS - Accepted

5.1 Published Hydrologic Information -Amended

Change:

"The District has prepared hydrologic studies for the majority of the major drainageways within District boundaries. These studies contain information regarding peak flow and runoff volume from the 2-year through 100-year storm events for numerous design points within the watershed. They also contain information regarding watershed and sub-watershed boundaries, soil types, percentage imperviousness, and rainfall. The studies are available at the District library. When published flow values are available from the District for any waterway of interest, these values should be used for design unless there are compelling reasons to modify the published values."

To:

The Town of Lyons has a master plan containing information regarding peak flow and runoff volume from the 2-year through 100-year storm events for numerous design points within the watershed. The report also contains information regarding watershed and sub-watershed boundaries, soil types, percentage imperviousness, and rainfall. The study is available through the Town. These flow values should be used for design unless there are compelling reasons to modify the published values.

5.2 Statistical Methods – Amended

Statistical methods should not be applied to watersheds within Lyons.

6.0 SPREADSHEETS AND OTHER SOFTWARE - Accepted

7.0 EXAMPLES - Accepted

7.1 Rational Method Example 1 - Accepted

7.2 Rational Method Example 2 - Accepted

7.3 Effective Rainfall Example - Accepted

8.0 REFERENCES

APPENDIX A - DETAILS OF THE COLORADO URBAN HYDROGRAPH PROCEDURE (CUHP) - Accepted

STREETS/INLETS/STORM SEWERS

1.0 INTRODUCTION

1.1 Purpose - Accepted

1.2 Urban Stormwater Collection and Conveyance Systems - Accepted

1.3 Components of Urban Stormwater Collection and Conveyance Systems - Accepted

Change:

"Urban stormwater collection and conveyance systems within the District are comprised of three primary components: (1) street gutters and roadside swales, (2) stormwater inlets, and (3) storm sewers (and appurtenances like manholes, junctions, etc.)."

To:

Urban stormwater collection and conveyance systems within the town are comprised of three primary components: (1) street gutters and roadside swales, (2) stormwater inlets, and (3) storm sewers (and appurtenances like manholes, junctions, etc.).

1.4 Minor and Major Storms - Accepted

2.0 STREET DRAINAGE

2.1 Street Function and Classification - Accepted

2.2 Design Considerations - Amended

Change:

"Based on these considerations, the District has established encroachment (spread) standards for the minor storm event. These standards were given in the POLICY chapter and are repeated in Table ST-2 for convenience."

To:

Based on these considerations, the town has established encroachment (spread) standards for the minor storm event. These standards were given in the POLICY chapter of the USDCM and are repeated in Table ST-2 for convenience.

2.3 Hydraulic Evaluation – Accepted

2.3.1 Curb and Gutter - Accepted

2.3.1.1 Gutters With Uniform Cross Slopes (i.e., Where Gutter Cross Slope = Street Cross Slope) – Accepted

2.3.1.2 Gutters With Composite Cross Slopes (i.e., Where Gutter Cross Slope ≠ Street Cross Slope) – Accepted

2.3.1.3 Allowable Gutter Hydraulic Capacity - Amended

Change:

“There are two sets of reduction factors developed for Denver metropolitan areas (Guo 2000b).”

To:

There are two sets of reduction factors developed for Denver metropolitan areas (Guo 2000b) and shall be utilized for the town.

2.4 Major Storm Hydraulics

2.4.1 Purpose and Objectives - Accepted

2.4.2 Street Hydraulic Capacity - Accepted

3.0 INLETS

3.1 Inlet Functions, Types and Appropriate Applications - Accepted

Add:

The standard inlets permitted for use in the town streets are:

Table 3: Permitted Inlet Type Use

INLET TYPE PERMITTED USE	
Curb Opening Inlet Type R	All street types with 6” vertical curb
Grated Inlet Type C	All streets with a roadside ditch or swale
Grated Inlet Type 13	Alleys or private drives with a valley gutter
Combination Inlet Type 13	All street types with 6” vertical curb

3.2 Design Considerations – Accepted

3.3 Hydraulic Evaluation – Accepted

3.3.1 Grate Inlets (On a Continuous Grade) – Accepted

3.3.2 Curb-Opening Inlets (On a Continuous Grade) – Accepted

3.3.3 Combination Inlets (On a Continuous Grade) – Accepted

3.3.4 Slotted Inlets (On a Continuous Grade) – Accepted

3.3.5 Inlets Located in Sumps - Accepted

3.3.6 Inlet Clogging - Accepted

3.3.6 Inlet Clogging - Amended

Add:

To account for effects which decrease the capacity of the various types of inlets, such as debris plugging, pavement overlaying and variations in design assumptions, the theoretical capacity calculated for the inlets is to be reduced by the factors presented below for the standard inlets permitted for use in the town.

Table 4: Allowable Inlet Capacity

ALLOWABLE INLET CAPACITY		
CONDITION	INLET TYPE	PERCENT OF THEORETICAL CAPACITY ALLOWED
Sump or Continuous Grade	CDOT Type R	
	5’ length	88
	10’ length	92
	15’ length	95
Continuous Grade	Combination Type 13	66
Sump	Grate Type C	50
Sump	Grate Type 13	50
Sump	Combination Type 13	65

3.4 Inlet Location and Spacing on Continuous Grades

3.4.1 Introduction - Accepted

3.4.2 Design Considerations - Amended

Delete:

“Table ST-2 lists pavement encroachment standards for minor storms in the Denver metropolitan area.”

3.4.3 Design Procedure - Accepted

4.0 STORM SEWERS

4.1 Introduction - Accepted

4.2 Design Process, Considerations, and Constraints - Amended

Change:

"Pipes sizes smaller than 15 inches are not recommended for storm sewers."

To:

The minimum size storm sewer pipe within a Public Right-of-Way or Public Drainage Easement shall be 15 inches in diameter or equivalent open area.

4.3 Storm Sewer Hydrology

4.3.1 Peak Runoff Prediction - Accepted

4.4 Storm Sewer Hydraulics (Gravity Flow in Circular Conduits)

4.4.1 Flow Equations and Storm Sewer Sizing - Amended

Add:

"The Manning's roughness coefficient "n" for all storm sewer pipe capacity Boulder County calculations shall be 0.013 regardless of pipe material (i.e. Concrete, PVC, or HDPE) with the exception of corrugated metal pipes which shall have a coefficient of 0.025."

4.4.2 Energy Grade Line and Head Losses - Accepted

4.4.2.1 Losses at the Downstream Manhole—Section 1 to Section 2 - Accepted

4.4.2.2 Losses in the Pipe, Section 2 to Section 3. - Accepted

4.4.2.3 Losses at the Upstream Manhole, Section 3 to Section 4 - Accepted

4.4.2.4 Juncture and Bend Losses at the Upstream Manhole, Section 4 to Section 1 - Accepted

4.4.2.5 Transitions - Accepted

4.4.2.6 Curved Sewers - Accepted

4.4.2.7 Losses at Storm Sewer Exit - Accepted

4.5 Hydraulic and Energy Grade Line Calculations - Amended

Add:

"The hydraulic grade line and energy grade line shall be calculated for each storm sewer system and included in the Final Drainage Report. Each storm sewer system shall be profiled on the Final Construction Drawings and shall include the design flow hydraulic grade line (HGL). The energy grade line (EGL) for the design flow shall be at least 6 inches below the final finished elevation of the manhole rims and inlet flow lines."

5.0 SPREADSHEETS - Accepted

6.0 EXAMPLES - Accepted

6.1 Example—Triangular Gutter Capacity- Accepted

6.2 Example—Composite Gutter Capacity - Accepted

6.3 Example—Composite Gutter Spread - Accepted

6.4 Example—V-Shaped Swale Capacity - Accepted

6.5 Example—V-Shaped Swale Design - Accepted

6.6 Example—Major Storm Street Capacity- Accepted

6.7 Example—Grate Inlet Capacity - Accepted

6.8 Example—Curb-Opening Inlet Capacity - Accepted

6.9 Example—Curb-Opening Inlet Capacity - Accepted

6.10 Example—Combination Inlet Capacity - Accepted

6.11 Example—Curb-Opening Inlet in a Sump Condition - Accepted

6.12 Example—Storm Sewer Hydraulics (Akan and Houghtalen 2002) - Accepted

6.13 Example—Storm Sewer Hydrology - Accepted

7.0 REFERENCES

MAJOR DRAINAGE

1.0 INTRODUCTION

1.1 General – Accepted

1.2 Types of Major Drainage Channels – Accepted

1.3 Overview of Chapter – Accepted

1.4 Issues in Major Drainage Planning and Engineering – Accepted

1.5 Fluvial Geomorphology – Accepted

1.5.1 Stream Channel Characterization – Accepted

1.5.2 Effects of Urbanization on Stream Channels – Accepted

1.5.3 Stable Channel Balance – Accepted

1.5.4 References for Additional Information – Accepted

2.0 PLANNING

2.1 General – Accepted

2.2 Impacts of Urbanization and Associated Effects – Accepted

2.3 Special Considerations for Semi-Arid Climates – Accepted

2.4 Route Considerations – Accepted

2.4.1 Present Flow Path – Accepted

2.4.2 Historic Flow Path – Accepted

2.4.3 Permitting and Regulations – Accepted

2.4.4 Public Safety – Accepted

2.4.5 Public Acceptance – Accepted

2.4.6 Alternate Routes – Accepted

2.4.7 Maintenance – Accepted

2.4.8 Route Cost – Accepted s

2.4.9 Recreational Use Potential – Accepted

2.4.10 Environmental Considerations – Accepted

2.4.11 Presentation of Choice – Accepted

2.4.12 Underground Conduits – Accepted

2.4.13 Two-Stage Channels – Accepted

2.5 Layout – Accepted

2.5.1 Working Map – Accepted

2.5.2 Preliminary Plan and Profile – Accepted

2.6 Master Planning or Preliminary Design – Accepted

2.6.1 Criteria for Final Hydrology – Accepted

2.7 The Master Plan – Accepted

2.7.1 Report – Amended

The previous section, 4.1 Master Plan - Accepted

, along with Preliminary Drainage Report and Final Drainage Report outlined the requirements for drainage studies within the town.

2.7.2 Drawings – Amended

See Section 2.7.1 for links to drawing requirements for drainage studies within the town.

3.0 OPEN CHANNEL DESIGN PRINCIPLES

3.1 General Open Channel Flow Hydraulics – Accepted

3.1.1 Types of Flow in Open Channels – Accepted

3.1.2 Roughness Coefficients – Accepted

3.1.3 Flow Regime – Accepted

3.1.3.1 Critical Flow – Accepted

3.1.3.2 Subcritical Flow – Accepted

3.1.3.3 Supercritical Flow – Amended

Change:

“In the Denver region, all channels carrying supercritical flow shall be lined with continuously reinforced concrete linings, both longitudinally and laterally.”

To:

"In Lyons, all channels carrying supercritical flow shall be lined with continuously reinforced concrete linings, both longitudinally and laterally."

3.2 Preliminary Design Criteria

3.2.1 Design Velocity–Accepted

3.2.2 Design Depths–Accepted

3.2.3 Design Slopes

3.2.3.1 Channel Slope–Accepted

3.2.3.2 Side Slopes -Amended

Add following Paragraph 1:

"For constructed or natural channels with side slopes steeper than 2:1, appropriate construction setbacks not less than 5 feet laterally from the channel edge may be required to allow potential future channel meandering. Rock excavated channels may be submitted for approval of smaller setbacks based on consistency, erosion potential, and stability of the rock subgrade. Access for maintenance may require easement."

3.2.4 Curvature and Transitions–Accepted

3.2.5 Design Discharge Freeboard –Accepted

3.2.6 Erosion Control –Accepted

3.2.7 Summary of Preliminary Design Guidance–Amended

Add to Table MD-2:

"Grass lined open channels conveying < 50 cfs may reduce the minimum 1.0 foot freeboard requirement to the freeboard required to conveying 1.33 times the 100-year design flow. The reduced freeboard may only occur if a 1.0-foot minimum freeboard is not physically or reasonably possible and a variance request is submitted."

3.2.8 Maintenance Eligibility–Amended

Delete first paragraph

Add:

Lyons will only maintain eligible major drainage ways by special agreement. The requirements below must be satisfied as of (adoption date) for a major drainage channel to be eligible for maintenance. Note that the town's "Maintenance Eligibility Guidelines" may change with time.

3.2.8.1 Natural Channels (Open Floodplain Design) – Accepted

3.2.8.2 Open Floodway Design (Natural Channel With Floodplain Encroachment) – Accepted

3.2.8.3 Grass-Lined Channel Design – Amended

Change:

“The design for a grass-lined channel must meet the following criteria to be eligible for District maintenance:”

To:

The design for a grass-lined channel must meet the following criteria to be eligible for maintenance:

3.3 Choice of Channel Type and Alignment

3.3.1 Types of Channels for Major Drainageways – Accepted

3.3.2 Factors to Consider in Selection of Channel Type and Alignment – Accepted

3.3.3 Environmental Permitting Issue – Accepted

3.3.4 Maintenance – Amended

Change:

“A maintenance access road with a minimum passage width of 12 feet shall be provided along the entire length of all major drainageways. The local government may require the road to be surfaced with 6 inches of Class 2 roadbase or a 5-inch-thick concrete slab.”

To:

The town and the design engineer shall work together to provide access to all major drainageways as determined appropriate at the time of preliminary and final design.

3.4 Design Flows– Accepted

3.5 Choice of Channel Lining– Accepted

4.0 OPEN-CHANNEL DESIGN CRITERIA

4.1 Grass-Lined Channels– Accepted

4.1.1 Design Criteria – Accepted

4.1.1.1 Design Velocity and Froude number– Accepted

4.1.1.2 Design Depths– Accepted

4.1.1.3 Design Slopes – Accepted

4.1.1.4 Curvature– Accepted

4.1.1.5 Design Discharge Freeboard – Accepted

4.1.2 Grass and Vegetation Selection and Use – Accepted

4.1.3 Channel Cross Sections– Accepted

4.1.3.1 Side Slopes – Accepted

4.1.3.2 Depth– Accepted

4.1.3.3 Bottom Width– Accepted

4.1.3.4 Trickle and Low-Flow Channels – Accepted

4.1.3.5 Outfalls Into Channel– Accepted

4.1.4 Roughness Coefficients – Accepted

4.1.5 Trickle and Low-Flow Channels – Amended

Add:

“Under drain pipes shall not be used in lieu of trickle channel within the town but will be considered by the town on a case-by-case basis. Any under drain pipe that is installed will require clean outs not less than every 50 feet, pipe bedding, and headwalls or manholes at the outlet.

4.1.6 Erosion Control – Accepted

4.1.6.1 Erosion at Bends – Accepted

4.1.6.2 Riprap Lining of Grass-lined Channels – Accepted

4.1.7 Water Surface Profile – Accepted

4.1.8 Maintenance – Amended

Change:

"A stable maintenance access road with a minimum passage width of 12 feet shall be provided along the entire length of all major drainageways. The local government may require the road to have an all-weather surface such as a 5-inch-thick concrete pavement."

To:

The town and the design engineer shall work together to provide access to all major drainageways as determined appropriate at the time of preliminary and final design.

4.1.9 Calculation Tool – Accepted

4.1.10 Design Submittal Checklist – Accepted

4.2 Composite Channels – Accepted

4.2.1 Design Criteria – Accepted

4.2.2 Design Procedure – Accepted

4.2.3 Life Expectancy and Maintenance – Amended

Change:

"A maintenance access road with a minimum passage width of 12 feet shall be provided along the entire length of all major drainageways. The local government may require the road to be surfaced with 6 inches of Class 2 roadbase or a 5-inch-thick concrete slab."

To:

The town and design engineer shall work together to provide access to all major drainageways as determined appropriate at the time of preliminary and final design.

4.2.4 Calculation Example for Wetland Bottom Channel – Accepted

4.2.5 Design Submittal Checklist – Accepted

4.3 Concrete-Lined Channels – *Accepted*

4.3.1 Design Criteria

4.3.1.1 Design Velocity and Froude Number – Accepted

4.3.1.2 Design Depths – Accepted

4.3.1.3 Curvature – Accepted

4.3.1.4 Design Discharge Freeboard – Accepted

4.3.2 Concrete Lining Specifications

4.3.2.1 Concrete Lining Section – Accepted

4.3.2.2 Concrete Joints – Accepted

4.3.2.3 Concrete Finish – Accepted

4.3.2.4 Underdrain – Accepted

4.3.3 Channel Cross Section – Accepted

4.3.3.1 Side Slopes – Accepted

4.3.3.2 Depth – Accepted

4.3.3.3 Bottom Width – Accepted

4.3.3.4 Trickle and Low-Flow Channels – Accepted

4.3.3.5 Outfalls Into Channel – Accepted

4.3.4 Safety Requirements – Accepted

4.3.5 Calculation Tools – Accepted

4.3.6 Maintenance – Accepted

4.3.7 Design Submittal Checklist – Accepted

4.4 Riprap-Lined Channels – *Accepted*

4.4.1 Types of Riprap – Accepted

4.4.1.1 Ordinary and Soil Riprap – Accepted

4.4.1.2 Grouted Boulders – Accepted

4.4.1.3 Wire-Enclosed Rock (Gabions) – Amended

Change:

“For these reasons, the District discourages the use of wire-enclosed rock.”

To:

For these reasons, the town discourages the use of wire-enclosed rock.

4.4.2 Design Criteria -Accepted

4.4.2.1 Design Velocity – Accepted

4.4.2.2 Design Depths – Accepted

4.4.2.3 Riprap Sizing – Accepted

4.4.2.4 Riprap Toes – Accepted

4.4.2.5 Curves and Bends – Accepted

4.4.2.6 Transitions – Accepted

4.4.2.7 Design Discharge Freeboard – Accepted

4.4.3 Roughness Coefficient –Accepted

4.4.4 Bedding Requirements – Accepted

4.4.4.1 Granular Bedding –Accepted

4.4.4.2 Filter Fabric– Accepted

4.4.5 Channel Cross Section

4.4.5.1 Side Slopes –Accepted

4.4.5.2 Depth – Accepted

4.4.5.3 Bottom Width – Accepted

4.4.5.4 Outfalls Into Channel –Accepted

4.4.6 Erosion Control– Accepted

4.4.7 Maintenance – Amended

Change:

"A maintenance access road with a minimum passage width of 12 feet shall be provided along the entire length of all major drainageways. The local government may require the road to have an all-weather surface such as 5-inch-thick concrete pavement."

To:

The town and design engineer shall work together to provide access to all major drainageways as determined appropriate at the time of preliminary and final design.

4.4.8 Calculation Example– Accepted

4.4.9 Design Submittal Checklist– Accepted

4.5 Bioengineered Channels – Amended

Change:

"The District advocates the integration of bioengineering techniques into drainage planning, design, and construction when the use of such channels is consistent with the District's policies concerning flow carrying capacity, stability, maintenance, and enhancement of the urban environment and wildlife habitat."

To:

The town advocates the integration of bioengineering techniques into drainage planning, design, and construction when the use of such channels is consistent with the town's policies concerning flow carrying capacity, stability, maintenance, and enhancement of the urban environment and wildlife habitat.

4.5.1 Components – Accepted

4.5.2 Applications – Accepted

4.5.3 Bioengineering Resources – Amended

Change:

"The purpose of this section is to provide the designer with an overview of bioengineering and basic guidelines for the use of bioengineered channels on major drainage projects within the District."

To:

The purpose of this section is to provide the designer with an overview of bioengineering and basic guidelines for the use of bioengineered channels on major drainage projects within the town.

4.5.4 Characteristics of Bioengineered Channels – Amended

Change (1):

"In the absence of grade control structures, especially in the semi-arid climate of the Denver area, purely bioengineered channels will normally be subject to bed and bank erosion, channel instability, and degradation."

To:

In the absence of grade control structures, especially in the semi-arid, high altitude climate of the Lyons area, purely bioengineered channels will normally be subject to bed and bank erosion, channel instability, seasonal variations, and degradation.

Change (2):

"In addition to grade controls, most bioengineered channels require some structural methods to assist the vegetation with maintaining channel stability."

To:

In addition to grade controls, bioengineered channels will require some structural methods to assist the vegetation with maintaining channel stability.

4.5.5 Advantages of Bioengineered Channels – Amended

Change:

"Public reaction to bioengineered channels is generally favorable, not only in metropolitan Denver, but also regionally and nationally."

To:

Public reaction to bioengineered channels is generally favorable, not only in northern Colorado, but also regionally and nationally.

Change (6):

“Create a living system that may strengthen over time.”

To:

Create a living system that will strengthen over time.

Add (8):

“8. Are less costly to maintain”

4.5.6 Technical Constraints – Amended

Change:

“The following constraints are associated with bioengineered channels:”

To:

The following constraints may be associated with bioengineered channels:

Change (2):

“The semi-arid conditions that characterize Denver can be at odds with the need for an adequate water supply for maintaining the vegetation”

To:

The semi-arid conditions that characterize Lyons can be at odds with the need for an adequate water supply for maintaining the vegetation

Change (3):

“A basic design criterion within the District is to demonstrate channel stability during the major (100-year) storm, due to public safety and property protection concerns within urban areas.”

To:

A basic design criterion within Lyons is to demonstrate channel stability during the major (100-year) storm, due to public safety and property protection concerns within urban areas.

Delete:

“Large trees can threaten the integrity of structural protection by root invasion, by toppling and damaging the protection works, by toppling and directing flow into an adjacent unprotected bank, or by leaving voids in embankments due to decomposition.”

Change:

“Many of these problems may be avoided through selection of the appropriate type and species of vegetation. Such selections and expert advice must be obtained from qualified individuals in revegetation and bioengineering. Invasion by other species is quite likely over the years the bioengineered channel is in operation.”

To:

Many of these problems may be avoided through selection of the appropriate type and species of vegetation. Such selections and expert advice must be obtained from qualified individuals in revegetation and bioengineering. Consideration of native plant species can provide additional confidence in the long term sustainability of the natural vegetation. Resources available through the Colorado State University Extension and Colorado Native Plant Society can be useful references during planning, design, and management of a project.

4.5.7 Design Guidelines – Accepted

4.6 Natural Channels

Change:

"Natural waterways in the Denver region are sometimes in the form of steep-banked gulches, which have eroding banks and bottoms."

To:

Natural waterways are sometimes in the form of steep-banked gulches, which have eroding banks and bottoms.

Change:

"In the Denver area, most natural waterways will need drops and/or erosion cutoff check structures to maintain a mild channel slope and to control channel erosion."

To

In Lyons, most natural waterways will need drops and/or erosion cutoff check structures to maintain a mild channel slope and to control channel erosion.

Change (2):

"A water surface profile should be defined in order to identify the 100-year floodplain, to control earthwork, and to build structures in a manner consistent with the District's and local floodplain regulations and ordinances."

To:

A water surface profile should be defined in order to identify the 100-year floodplain, to control earthwork, and to build structures in a manner consistent with the Lyons floodplain regulations and ordinances.

4.7 Retrofitting Open-Channel Drainageways – Accepted

4.7.1 Opportunities for Retrofitting – Accepted

4.7.2 Objectives of Retrofitting – Accepted

4.7.3 Natural and Natural-Like Channel Creation and Restoration – Accepted

5.0 RECTANGULAR CONDUITS

5.1 Hydraulic Design – Accepted

5.1.1 Entrance – Accepted

5.1.2 Internal Pressure – Accepted

5.1.3 Curves and Bends – Accepted

5.1.4 Transitions – Accepted

5.1.5 Air Entrainment – Accepted

5.1.6 Major Inlets – Accepted

5.1.7 Sedimentation – Accepted

5.2 Appurtenances – Accepted

5.2.1 Energy Dissipators – Accepted

5.2.2 Access Manholes – Accepted

5.2.3 Vehicle Access Points – Accepted

5.2.4 Safety – Accepted

5.2.5 Air Venting – Accepted

6.0 LARGE PIPES – Accepted

6.1 Hydraulic Design – Accepted

6.1.1 Entrance – Accepted

6.1.2 Internal Pressure – Accepted

6.1.3 Curves and Bends – Accepted

6.1.4 Transitions – Accepted

6.1.5 Air Entrainment and Venting – Accepted

6.1.6 Major Inlets – Accepted

6.2 Appurtenances – Accepted

6.3 Safety – Accepted

7.0 PROTECTION DOWNSTREAM OF PIPE OUTLETS

7.1 Configuration of Riprap Protection – Accepted

7.2 Required Rock Size – Accepted

7.3 Extent of Protection – Accepted

7.4 Multiple Conduit Installations – Accepted

8.0 Sediment – Accepted

9.0 Examples – Accepted

9.1 Example MD-1: Normal Depth Calculation with Normal Worksheet

9.2 Example MD-2: Composite Section Calculations Using Composite Design Worksheet

9.3 Example MD-3: Riprap Lined Channel Calculations Using Riprap Channel Worksheet

10.0 REFERENCES

USDCM VOLUME 2

HYDRAULIC STRUCTURES

1.0 USE OF STRUCTURES IN DRAINAGE

1.1 Introduction – Accepted

1.2 Channels Used for Boating – Accepted

1.3 Channel Grade Control Structures – Accepted

1.4 Wetland Channel Grade Control – Accepted

1.5 Conduit Outlet Structures – Accepted

1.6 Bridges – Accepted

1.7 Transitions and Constrictions – Accepted

1.8 Bends and Confluences – Accepted

1.9 Rundowns – Accepted

1.10 Energy Dissipation – Accepted

1.11 Maintenance – Accepted

1.12 Structure Safety and Aesthetics – Accepted

2.0 CHANNEL GRADE CONTROL STRUCTURES (CHECK AND DROP STRUCTURES)

2.1 Planning for the Future – Accepted

2.1.1 Outline of Section – Accepted

2.1.2 Boatable Channels – Deleted

2.1.3 Grass and Wetland Bottom Channels – Accepted

2.1.4 Basic Approach to Drop Structure Design –Accepted

2.2 Drop Selection – Accepted

2.3 Detailed Hydraulic Analysis – Accepted

2.3.1 Introduction – Accepted

2.3.2 Crest and Upstream Hydraulics –Accepted

2.3.3 Water Surface Profile Downstream of the Crest – Accepted

2.3.7.1 Critical Depth Along a Drop Structure. –Accepted

2.3.7.2 Hydraulic Analysis. –Accepted

2.3.7.3 Manning's n for Concrete, Boulders and Grouted Boulders –Accepted

2.3.7.4 Avoid Low Froude Number Jumps in Grass-Lined Channels. –Accepted

2.3.4 Hydraulic Jump Location – Accepted

2.3.5 Jump and Basin Length – Accepted

2.3.6 Seepage Analysis – Accepted

2.3.7 Force Analysis – Accepted

2.3.7.1 Shear Stress – Accepted

2.3.7.2 Buoyant Weight of Structure –Accepted

2.3.7.3 Impact, Drag and Hydrodynamic Lift Forces – Accepted

2.3.7.4 Turning Force – Accepted

2.3.7.5 Friction – Accepted

2.3.7.6 Frost Heave – Accepted

2.3.7.7 Seepage Uplift Pressure –Accepted

2.3.7.8 Dynamic Pressure Fluctuations– Accepted

2.3.7.9 Overall Analysis– Accepted

2.4 Simplified Drop Structure Designs for District's Grass-Lined Channels

2.4.1 Introduction and Cautions –Accepted

2.4.2 Applicability of Simplified Channel Drop Designs –Accepted

2.4.3 Simplified Grouted Sloping Boulder Drop Design – Accepted

2.4.4 Vertical Hard Basin Drops –Accepted

2.5 Baffle Chute Drops– Accepted

2.6 Seepage Control – Accepted

2.6.1 Seepage Analysis Methods –Accepted

2.6.2 Foundation/Seepage Control Systems – Accepted

2.7 Simplified Minimum Design Approach for Boatable Channels –Deleted

2.8 Construction Concerns: Grass-Lined Channels –Accepted

2.8.1 Foundation/Seepage Control – Accepted

2.8.2 Baffle Chute Construction – Accepted

2.8.3 Vertical Hard Basin Construction – Accepted

2.8.4 Sloping Grouted Boulder Construction –Accepted

2.9 Low-Flow Check and Wetland Structures– Accepted

3.1 General –Accepted

3.2 Impact Stilling Basin– Accepted

3.2.1 Modified Impact Basins for Smaller Outlets– Accepted

3.2.2 Low-flow Modifications – Accepted

3.2.3 Multiple Conduit Installations – Accepted

3.2.4 General Design Procedure for Type IV Impact Basin– Accepted

3.3 Pipe Outlet Rundowns –Accepted

3.3.1 Baffle Chute Rundown – Accepted

3.3.2 Grouted Boulder Chute Rundown – Accepted

3.4 Low Tailwater Riprap Basins at Pipe Outlets

3.4.1 General – Accepted

3.4.2 Objective – Accepted

3.4.3 Low Tailwater Basin Design – Accepted

3.4.3.1 Finding Flow Depth and Velocity of Storm Sewer Outlet Pipe – Accepted

3.4.3.2 Riprap Size – Accepted

3.4.3.3 Basin Length – Accepted

3.4.3.4 Basin Width – Accepted

3.4.3.5 Other Design Requirements – Accepted

3.5 Culvert Outlets – Accepted

4.0 BRIDGES

4.1 Basic Criteria – Accepted

4.1.1 Design Approach – Accepted

4.1.2 Bridge Opening Freeboard – Amended

Add:

"The bridge low chord elevation shall be a minimum 1-foot above the 100-year water energy grade line."

4.2 Hydraulic Analysis – Accepted

4.2.1 Expression for Backwater – Accepted

4.2.2 Backwater Coefficient – Accepted

4.2.3 Effect of M and Abutment Shape (Base Curves) – Accepted

4.2.4 Effect of Piers (Normal Crossings) – Accepted

4.3 Design Procedure – Accepted

5.0 TRANSITIONS AND CONSTRICTIONS

5.1 Introduction – Accepted

5.2 Transition Analysis – Accepted

5.2.1 Subcritical Transitions – Accepted

5.2.2 Supercritical Transition Analysis – Accepted

5.3 Constriction Analysis – Accepted

5.3.1 Constrictions With Upstream Subcritical Flow – Accepted

6.0 BENDS AND CONFLUENCES

6.1 Introduction – Accepted

6.2 Bends – Accepted

6.2.1 Subcritical Bends – Accepted

6.2.2 Supercritical Bends – Accepted

6.3 Confluences – Accepted

6.3.1 Subcritical Flow Confluence Design – Accepted

7.0 RUNDOWNS

7.1 Cross Sections – Accepted

7.2 Design Flow – Accepted

7.3 Flow Depth – Accepted

7.4 Outlet Configuration for Trickle Channel – Accepted

7.5 Outlet Configuration for Wetland Channel – Accepted

7.6 Grouted Boulder Rundowns – Accepted

8.0 MAINTENANCE

8.1 General – Accepted

8.2 Access – Accepted

8.3 Maintenance Optimization – Accepted

9.0 BOATABLE DROPS – Accepted

9.1 Introduction – Accepted

9.2 Retrofitting Existing Structures – Accepted

9.2.1 Downstream Face – Accepted

9.2.2 Boat Chute– Accepted

9.2.3 Sharp Edges– Accepted

9.2.4 Barriers and Signing– Accepted

9.2.5 Portages – Accepted

9.3 Safety – Accepted

10.0 STRUCTURE AESTHETICS, SAFETY AND ENVIRONMENTAL IMPACT

10.1 Introduction – Accepted

10.2 Aesthetics and Environmental Impact – Accepted

10.3 Safety– Accepted

11.0 CHECKLIST – Accepted

12.0 REFERENCES

CULVERTS

1.0 INTRODUCTION AND OVERVIEW – Accepted

1.1 Required Design Information – Accepted

1.1.1 Discharge – Accepted

1.1.2 Headwater – Amended

Add:

The maximum culvert headwater to diameter ratios is:

STORM FREQUENCY	HEADWATER TO DIAMETER
10-Year	HW/D < 1.0
100-Year	HW/D < 1.5

The minimum culvert capacities are:

STREET CLASSIFICATION	MINIMUM CAPACITY (RECURRENCE INTERVAL)
Local	10-Year
Collector	10-Year
Arterial	10-Year

When the flow exceeds the capacity of the culvert and overtops the cross street, the flow over the street crown shall not exceed the minor storm and major storm depth limits presented in Chapter 3, Planning, Section 9.4 of the manual. Lyons may require additional culvert capacity in order to prevent flooding of adjacent properties.

1.1.3 Tailwater – Accepted

1.1.4 Outlet Velocity – Accepted

2.0 CULVERT HYDRAULICS

2.1 Key Hydraulic Principles– Accepted

2.1.1 Energy and Hydraulic Grade Lines – Amended

Add:

"The hydraulic grade line and energy grade line shall be determined for each culvert system and included in the Final Drainage Report. Each culvert system shall be profiled on the Final Construction Drawings and shall include the design flow hydraulic grade line."

2.1.2 Inlet Control – Accepted

2.1.3 Outlet Control – Accepted

2.2 Energy Losses – Accepted

2.2.1 Inlet Losses – Accepted

2.2.2 Outlet Losses – Accepted

2.2.3 Friction Losses – Accepted

3.0 CULVERT SIZING AND DESIGN

3.2 Use of Capacity Charts – Accepted

3.3 Use of Nomographs– Accepted

3.4 Computer Applications, Including Design Spreadsheet – Accepted

3.5 Design Considerations – Accepted

3.5.1 Design Computation Forms– Accepted

3.5.2 Invert Elevations – Accepted

3.5.3 Culvert Diameter– Amended

Add:

"Lyons requires a minimum culvert diameter of 15 inches. Lyons may require additional culvert capacity in order to prevent flooding of adjacent properties."

Add:

"The Manning's roughness coefficient "n" for all culvert pipe sizing calculations shall be 0.013 regardless of pipe material (Concrete, PVC, or HDPE) with the exception of corrugated metal pipes which shall have a coefficient of 0.025."

3.5.4 Limited Headwater – Accepted

3.6 Culvert Outlet– Accepted

3.7 Minimum Slope – Accepted

4.0 CULVERT INLETS

4.1 Projecting Inlets – Amended

Add:

At a minimum, a culvert entrance and outlet shall include a flared end section. Erosion protection (riprap, etc.) may be required.

4.1.1 Corrugated Metal Pipe – Accepted

4.1.2 Concrete Pipe – Accepted

4.2 Inlets with Headwalls – Accepted

4.2.1 Corrugated Metal Pipe – Accepted

4.2.2 Concrete Pipe – Accepted

4.2.3 Wingwalls – Accepted

4.2.4 Aprons 24 – Accepted

4.3 Special Inlets – Accepted

4.3.1 Corrugated Metal Pipe – Accepted

4.3.2 Concrete Pipe – Accepted

4.3.3 Mitered Inlets – Accepted

4.3.4 Long Conduit Inlets – Accepted

4.4 Improved Inlets – Accepted

5.0 Inlet Protection

5.1 Debris Control – Accepted

5.2 Buoyancy – Accepted

6.0 OUTLET PROTECTION

6.1 Local Scour – Accepted

6.2 General Stream Degradation – Accepted

7.0 GENERAL CONSIDERATIONS

7.1 Culvert Location– Accepted

7.2 Sedimentation– Accepted

7.3 Fish Passage – Accepted

7.4 Open Channel Inlets – Accepted

7.5 Transitions – Accepted

7.6 Large Stormwater Inlets – Accepted

7.6.1 Gratings – Accepted

7.6.2 Openings – Accepted

7.6.3 Headwater – Accepted

7.7 Culvert Replacements – Accepted

7.8 Fencing for Public Safety – Accepted

8.0 TRASH/SAFETY RACKS – Amended

Change:

“The District strongly recommends against the installation of trash racks at culvert outlets, because debris or a person carried into the culvert will impinge against the rack, thus leading to pressurized conditions within the culvert, virtually destroying its flow capacity and creating a greater hazard to the public or a person trapped in the culvert than not having one.”

To:

The town strongly recommends against the installation of trash racks at culvert outlets, because debris or a person carried into the culvert will impinge against the rack, thus leading to pressurized conditions within the culvert, virtually destroying its flow capacity and creating a greater hazard to the public or a person trapped in the culvert than not having one.

8.1 Collapsible Gratings – Amended

Change:

“The District does not recommend the use of collapsible gratings.”

To:

Lyons does not recommend the use of collapsible gratings.

8.2 Upstream Trash Collectors– Accepted

9.0 DESIGN EXAMPLE

9.1 Culvert Under an Embankment – Accepted

10.0 CHECKLIST – Accepted

11.0 CAPACITY CHARTS AND NOMOGRAPHS– Accepted

12.0 REFERENCES

STORAGE

1.0 OVERVIEW – Accepted

2.0 APPLICATION OF DIFFERENT TYPES OF STORAGE – Amended

Add (6):

"Above ground parking lot detention ponds may be utilized when land area for a grassed lined detention pond is not available. To prevent damage to and floatation of automobiles, parking lot detention ponds shall not exceed 12 inches in depth at any point. Parking lot detention ponds shall have signage to inform the general public about the potential for flooding. The 100-year water surface elevation of a parking lot detention pond shall not encroach into a public street."

3.0 HYDROLOGIC AND HYDRAULIC DESIGN BASIS

3.1 Procedures for the Sizing of Storage Volumes – Accepted

3.1.1 Use of Simplified On-Site Detention Sizing Procedures – Accepted

3.1.2 Use of Hydrograph Routing Detention Sizing Procedure – Amended

Change:

"Whenever the area limits described above in Section 3.1.1. are exceeded (for tributary catchments larger than 90 acres for empirical equations and FAA Method and 160 acres for the *Full Spectrum Detention* method), the District recommends the use of hydrograph flood routing procedures (e.g., using CUHP- generated hydrographs and reservoir routing calculations)."

To:

Whenever the area limits described above in Section 3.1.1. are exceeded (for tributary catchments larger than 90 acres for empirical equations and FAA Method and 160 acres for the *Full Spectrum Detention* method), the town recommends the use of hydrograph flood routing procedures (e.g., using CUHP- generated hydrographs and reservoir routing calculations).

Add:

"Sizing of detention storage volumes shall utilize outflow hydrographs that have been properly calculated to account for variable head discharge rates.

3.1.3 Water Quality Capture Volume in Sizing Detention Storage – Amended

Add:

"The water quality capture volume shall be considered a portion of the total 100-yr detention pond volume."

3.2 Sizing of On-Site Detention Facilities

3.2.1 Maximum Allowable Unit Release Rates for On-Site Facilities – Amended

Change:

"These maximum releases rates will apply for all on-site detention facilities unless other rates are recommended in a District- approved master plan."

To:

These maximum releases rates will apply for all on-site detention facilities unless other rates are recommended in the town master plan.

3.2.2 Empirical Equations for the Sizing of On-Site Detention Storage Volumes– Amended

Change:

"The following set of empirical equations provided preliminary estimates of on-site detention facility sizing for areas within the District."

To:

The following set of empirical equations provided preliminary estimates of on-site detention facility sizing for areas within Lyons.

Change:

"If the District has a master plan that contains specific guidance for detention storage or sizing of on-site detention facilities, those guidelines should be followed instead."

To:

Where the town's master plan contains specific guidance for detention storage or sizing of on-site detention facilities, those guidelines should be followed instead.

3.2.3 Rational Formula-Based Modified FAA Procedure –Accepted

3.2.4 Simplified Full-Spectrum Detention Sizing (Excess Urban Runoff Flow Control) –Accepted

3.2.5 Excess Urban Runoff Flow Control at Regional Facilities –Accepted

3.2.6 Multi-Level Control –Amended

Change:

"The District recommends that no more than two levels of controls, in addition to the WQCV controls, be used for on-site detention facilities."

To:

The town recommends that no more than two levels of controls, in addition to the WQCV controls, be used for on-site detention facilities.

3.2.7 On-Site Detention and UDFCD 100-year Floodplain Management Policy – Accepted

3.3 Design Storms for Sizing Storage Volumes– Amended

Add:

The 10-year and 100-year storms shall be the design storms for all water quality and detention pond designs, respectively, within Lyons. Each storm should be detained to be released at the historic rate for each respective storm.

3.3.1 Water Quality Capture Volume –Accepted

3.3.2 Drainage and Flood Control – Amended

Change:

"Whenever a District-approved master plan recommends detention sites and release rates, or on-site detention/retention storage and release rates, this sizing and rates should be used in final design of detention/retention facilities."

To:

Whenever a town-approved master plan recommends detention sites and release rates, or on-site detention/retention storage and release rates, this sizing and rates should be used in final design of detention/retention facilities.

3.3.3 Spillway Sizing –Amended

Add:

"Each detention pond shall contain an emergency spillway capable of conveying the peak 100-year storm discharge draining into the detention pond. The invert of the emergency spillway shall be set equal to or above the 100-year water surface elevation. The depth of flow out the emergency spillway shall be < 6 inches and the spillway shall have effective erosion protection."

3.3.4 Retention Facilities – Amended

Change:

"When a retention basin is proposed as a temporary solution, the District recommends that it be sized to capture, as a minimum, the runoff equal to 1.5 times the 24-hour, 100-year storm plus 1-foot of freeboard."

To:

When a retention basin is proposed as a temporary solution, the town recommends that it be sized to capture, as a minimum, the runoff equal to 1.5 times the 24-hour, 100-year storm plus 1-foot of freeboard.

Add:

"The town will not approve any detention or retention pond that does not drain in less than 72 hours, or causes injury to water rights, or is in violation of State or Federal law.

3.4 Reservoir Routing of Storm Hydrographs for Sizing of Storage Volumes – Amended

Change (2):

"Determine the inflow hydrograph to the storage basin and the allowable peak discharge from the basin for the design storm events. The hydrograph may be available in published district outfall system planning or a major drainageway master plan report. The allowable peak discharge is limited by the local criteria or by the requirements spelled out in a District-approved master plan.

To:

The allowable peak discharge is limited by the local criteria or by the requirements spelled out in a town-approved master plan.

3.4.1 Initial Sizing – Accepted

3.4.2 Initial Shaping – Amended

Change:

"This does not mean that the District encourages the use of storage facilities with uniform geometric properties. To the contrary, the District encourages designers to collaborate with landscape architects to develop storage facilities that are visually attractive, fit into the fabric of the landscape, and enhance the overall character of an area."

To:

This does not mean that the town encourages the use of storage facilities with uniform geometric properties. To the contrary, the town encourages designers to collaborate with landscape architects to develop storage facilities that are visually attractive, fit into the fabric of the landscape, and enhance the overall character of an area.

3.4.3 Outlet Works Design – Accepted

3.4.4 Preliminary Design – Accepted

3.4.5 Final Design – Accepted

4.0 FINAL DESIGN CONSIDERATIONS – Amended

Change:

"The District urges all designers to review and adhere to the guidance in such references because the failure of even small embankments can have serious consequences for the public and the municipalities downstream of the embankment."

To:

The town urges all designers to review and adhere to the guidance in such references because the failure of even small embankments can have serious consequences for the public and the municipalities downstream of the embankment.

4.1 Storage Volume – Accepted

4.2 Potential for Multiple Uses – Accepted

4.3 Geometry of Storage Facilities– Accepted

4.3 Geometry of Storage Facilities – Amended

Change:

"Several key features should be incorporated in all storage facilities located within the District."

To:

Several key features should be incorporated in all storage facilities located within Lyons.

4.4 Embankments and Cut Slopes – Amended

Change (2):

"Freeboard – The elevation of the top of the embankment shall be a minimum of 1 foot above the water surface elevation when the emergency spillway is conveying the maximum design or emergency flow."

To:

Freeboard – The elevation of the top of the embankment shall be a minimum of 1 foot above the 100-year water surface elevation in the detention pond.

Add (5):

Emergency Spillway Downstream Protection – In order to protect the emergency spillway from catastrophic erosion failure, buried riprap shall be placed from the emergency spillway downhill to the embankment toe of slope and covered with 6 inches of topsoil. The riprap shall be sized at the time of final engineering design. Grouting of the riprap may be required

Add (6):

Concrete Cutoff Wall – A concrete cutoff wall, 8 inches thick, 3 foot deep, extending 5 feet into the embankment beyond the emergency spillway opening, is encouraged on all private detention ponds and required on all publicly-owned regional detention ponds. A concrete cutoff wall will permanently define the emergency spillway opening. The emergency spillway elevation shall be tied back into the top of embankment using a maximum slope of 4:1.

4.5 Linings – Accepted

4.6 Inlets– Accepted

4.7 Outlet Works – Amended

Add:

The outlet pipe of regional detention ponds shall contain a minimum of two (2) concrete cutoff walls embedded a minimum of 18" into undisturbed earthen soil. The cutoff walls shall be a minimum of 8 inches thick. The outlet pipe bedding material shall consist of native earthen soil and not granular bedding material to at least the first downstream manhole or daylight point.

4.8 Trash Racks – Amended

Add:

For safety reasons, trash rack angles are to be 3 horizontal to 1 vertical (3:1) or flatter per Urban Drainage research (Nelson & Kroeger, 2005).

4.9 Vegetation – Accepted

4.10 Operation and Maintenance– Amended

Add (15):

An operations maintenance manual for each water quality pond, detention pond, and outlet structure facility shall be developed and provided to the town at the time of final submittal.

4.11 Access – Amended

Add:

Drivable access applies only to Regional Detention facilities within Lyons. Each regional detention pond will be considered on a case-by-case basis at the time of final design.

4.12 Geotechnical Considerations – Accepted

4.13 Environmental Permitting and Other Considerations – Accepted

5.0 DISTRICT MAINTENANCE ELIGIBILITY FOR DETENTION FACILITIES– Amended

Add:

Regional Master Planned detention ponds, designed and constructed by or on behalf of Lyons, shall be owned and maintained by the town as specified in the applicable Development Agreement(s). All other detention ponds shall be considered privately owned and privately maintained.

6.0 DESIGN EXAMPLES– Accepted

6.1 Example—Empirical Equations Sizing of a Detention Basin
6.2 Example—Rational Method Analysis
6.3 Example—Hydrograph Procedure Preliminary Sizing

7.0 CHECKLIST – Accepted

8.0 REFERENCES

FLOOD PROOFING

1.0 FLOOD PROOFING

1.1 Definition of Flood Proofing – Accepted

1.2 Overview of Flood-Proofing Methods – Accepted

1.2.1 Classification of Flood Proofing – Amended

Change:

"In the Denver metropolitan area, flood-proofing efforts should focus on permanent measures due to the rapid response of most of the Front Range stream systems."

To:

"In Lyons, flood-proofing efforts should focus on permanent measures due to the rapid response of most of the Front Range stream systems."

1.2.2 FEMA Recommended Methods – Accepted

1.3 Approach of Manual Relative to Flood-Proofing Guidance – Accepted

1.4 Regulatory Considerations – Accepted

1.5 Flood Proofing In the Context of Overall Floodplain Management – Accepted

2.0 WHEN TO FLOOD PROOF

2.1 How Flooding Can Damage Structures – Accepted

2.1.1 Depth/Elevation of Flooding – Accepted

2.1.2 Flow Velocity – Accepted

2.1.3 Flood Frequency – Accepted

2.1.4 Rate of Rise and Rate of Fall – Accepted

2.1.5 Duration – Accepted

2.1.6 Debris Impact – Accepted

2.2 When Flood Proofing is Not Appropriate – Accepted

2.3 Typical Causes of Flooding Problems – Accepted

2.3.1 Inadequate Street Conveyance – Accepted

2.3.2 Inadequate Storm Sewer Conveyance – Accepted

2.3.3 Inadequate Drainage Channel Conveyance – Accepted

2.3.4 Sewage Backup– Accepted

3.0 FLOOD PROOFING METHODS

3.1 Overview of Six Methods Identified by FEMA – Accepted

3.1.1 Elevation – Accepted

3.1.2 Wet Flood Proofing – Accepted

3.1.3 Dry Flood Proofing– Accepted

3.1.4 Relocation– Accepted

3.1.5 Levees and Floodwalls – Accepted

3.1.6 Demolition– Accepted

3.2 Engineering Aspects– Accepted

3.2.1 Analysis of Flood Hazards– Accepted

3.2.2 Site Characteristics– Accepted

3.2.3 Building Characteristics – Accepted

3.3 Selection of Flood-Proofing Techniques –Accepted

3.3.1 Regulatory Considerations – Accepted

3.3.2 Appearance – Accepted

3.3.3 Accessibility –Accepted

3.3.4 Human Intervention Required –Accepted

3.3.5 Benefit/Cost Analysis –Accepted

3.3.6 Other –Accepted

4.0 PROVIDING ASSISTANCE TO PROPERTY OWNERS

4.1 Decision Making Process for Property Owners– Accepted

4.1.1 Determine Flood Hazards –Amended

Change:

“Information about flooding in the area is available from the District and local officials.”

To:

"Information about flooding in the area is available from the Town of Lyons."

4.1.2 Inspect Structure – Accepted

4.1.3 Contact Local Officials – Accepted

4.1.3 Contact Local Officials – Amended

Change:

"The District and local officials have copies of the FIS and FIRM published for the community by FEMA."

To:

"The town and local officials have copies of the FIS and FIRM published for the community by FEMA."

4.1.4 Consult With Professionals – Accepted

4.2 Potential Sources of Financial Assistance at Federal, State, and Local Levels – Accepted

5.0 REFERENCES

REVEGETATION

1.0 INTRODUCTION – Amended

Change:

“This chapter provides information on methods and plant materials needed for revegetation of drainage facilities within the Urban Drainage and Flood Control District (District).”

To:

This chapter provides information on methods and plant materials needed for revegetation of drainage facilities within the town of Lyons.

Change:

“The semi-arid nature of the climate, prevalence of introduced weeds, and variety of soil types encountered in the District virtually mandate prompt implementation of a revegetation plan to achieve revegetation success.”

To:

The semi-arid nature of the climate, prevalence of introduced weeds, and variety of soil types encountered in Lyons virtually mandate prompt implementation of a revegetation plan to achieve revegetation success. Specific consideration of native plant species and their inherent limitations and advantages should be part of every revegetation plan.”

2.0 SCOPE OF THIS CHAPTER AND RELATION TO OTHER RELEVANT DOCUMENTS – Amended

Add:

See revisions to RV tables included in this chapter for seed mix recommendations.

3.0 GENERAL GUIDELINES FOR REVEGETATION

3.1 Plant Materials – Accepted

3.2 Site Preparation – Amended

Add:

Before revegetation work is started, an inventory of vegetation should be taken. If noxious weeds, as listed on the State of Colorado index, exist on-site, appropriate steps need to be taken before, during, and after work is completed, to control their spread. Contact the Town of Lyons for additional information if needed.

3.3 Seeding and Planting – Amended

Add:

Seed mixtures should be coated with Mycorrhiza at the rate of 2 pounds per acre at the time of seeding. If mulching with straw, be sure the straw is seed free and weed free.

3.4 Maintenance – Amended

Change:

“Access to and grazing on recently revegetated areas should be limited with temporary fencing and signage while plants are becoming established (normally the first year).”

To:

Access to and grazing on recently revegetated areas should be limited with temporary fencing and signage while plants are becoming established (for 1 to 2 years at least).

Change:

“Weed infestations should be managed using appropriate physical, chemical, or biological methods as soon as possible. (See the other documents referenced for details on weed management options.)”

To:

Weed infestations should be managed using appropriate physical or chemical methods as soon as possible.

Add:

The project owners/developer, not Lyons, will be responsible for site maintenance until vegetative establishment.

4.0 PREPARATION OF A PLANTING PLAN

4.1 General – Accepted

4.2 Soil Amendments – Amended

Change:

“Since soil pH is typically suitable within the District, amendments are usually needed for increasing organic matter content or providing nutrients in the form of fertilizers.”

To:

“Since soil pH is typically suitable within Lyons, amendments are usually needed for increasing organic matter content or providing nutrients in the form of fertilizers.”

Change:

“Consideration should be given to importing topsoil, instead of amending poor quality subsoil, as this may be less expensive.”

To:

“Consideration should be given to importing topsoil, from the vicinity, instead of amending poor quality subsoil, as this may be less expensive.”

Change:

"Both of these materials are relatively new and show promise as soil conditioners and sources of slow-release fertilizers for revegetation work in the District."

To:

Both of these materials are relatively new and show promise as soil conditioners and sources of slow-release fertilizers for revegetation work in the town.

4.2.1 Humate Conditioner – Accepted

4.2.2 Biosol – Accepted

4.3 Recommended Seed Mixes – Amended

Change:

"Recommended seed mixes for the bottom (wet soils) and side slopes of drainage facilities within the District are included in Tables RV-1 and RV-2."

To:

Recommended seed mixes for the bottom (wet soils) and side slopes of drainage facilities within Lyons are included in Tables RV-1 and RV-2.

Add:

The inclusion of wild flowers in the seed mix is optional in Lyons. Areas seeded along Boulder County roads may be spot sprayed in the county to control the spread of noxious weeds. This spraying may affect some wild flower species. Do not plant trees or shrubs in the town right-of-way.

Delete:

Redtop (Agrostis alba) from Table RV-1

Nuttall's sunflower (Holianthus nuttallii) from Table RV-1

Canadian bluegrass (Ruebens) (Poa compressa) from Table RV-2

Flax* (Linum lewisii) from Table RV-2

Blue Flax (Linum lewisii) from Table RV-3

Canby bluegrass (Poa canbyi) from Table RV-4

Flax (Linum lewisii) from Table RV-4

Change:

Common Name (Variety)	Scientific Name	Growth Season	Growth Form	Seeds/Lb	Lbs PLS/Acre
Blue grama (Hachita)	*Chondrosum gracile*	Warm	Sod/bunch	825,000	2.1

To:

Blue grama (Hachita)	*Chondrosum gracile*	Warm	Sod/bunch	825,000	0.3

Change:

Common Name (Variety)	Scientific Name	Growth Season	Growth Form	Seeds/Lb	Lbs PLS/Acre
Sand dropseed	*Sporobolus cryptandrus*	Warm	Bunch	5,298,000	0.3

To:

Sand dropseed	*Sporobolus cryptandrus*	Warm	Bunch	5,298,000	2.1

Delete:

Flax (Linum lewisii) from Table RV-5

Blue Flax (Linum lewisii) from Table RV-7

California poppy (Eschscholtzia californica) from Table RV-7

Blackeyed Susan (Rudbeckia hirta) from Table RV-7

Rubber rabbitbrush (Chrysothamnus nauseosus) from Table RV-8

Spanish bayonet (Yucca glauca) from Table RV-8

Smart weed (Polygonum persicaria) from Table RV-9

Foxtail barley (Hordeum jubatum) from Table RV-9

Refer to Grass Seeding Recommendations for Boulder County:

4.4 Trees, Shrubs and Wetland Plantings – Accepted

4.5 Mulching – Amended

Add:

- At least 70 percent of the mulch by weight shall be 10 inches or more in length.
- The appropriate use of fabric blankets under trees and shrubs is suggested

4.6 Bioengineering – Accepted

4.7 Collection of Live Stakes, Willow Cuttings, and Poles – Accepted

4.7.1 Harvest Procedure – Accepted

4.7.2 Installation – Accepted

5.0 POST-CONSTRUCTION MONITORING – Amended

Change:

“This is especially important for establishing native species since it may take several years for vegetation to become adequately established. Sites should be observed several times during their first two growing seasons and at least once a year thereafter.”

To:

“This is especially important for establishing native species since it may take three to five years for vegetation to become adequately established. Sites should be observed several times during their first two or three growing seasons and at least twice a year thereafter.”

6.0 REFERENCES

DESIGN EXAMPLES – Accepted

Add:

Use the UDFCD C1, C2, C3 coefficients within the “Detention Volume by Modified FAA Method” spreadsheet.

USCDM VOLUME 3

PREFACE

1.0 Acknowledgements – Accepted

2.0 Purpose – Accepted

3.0 Overview – Accepted

4.0 Revisions to USDCM Volume 3 – Accepted

5.0 Acronyms and Abbreviations – Accepted

CHAPTER 1 - STORMWATER MANAGEMENT AND PLANNING

1.0 Introduction – Accepted

2.0 Urban Stormwater Characteristics – Accepted

3.0 Stormwater Management Requirements under the Clean Water Act – Accepted

3.1 Clean Water Act Basics – Accepted

3.2 Colorado's Stormwater Permitting Program – Accepted

3.2.1 Construction Site Stormwater Runoff Control – Accepted

3.2.2 Post-construction Stormwater Management – Accepted

3.2.3 Pollution Prevention/Good Housekeeping – Accepted

3.3 Total Maximum Daily Loads and Stormwater Management – Accepted

4.0 Four Step Process to Minimize Adverse Impacts of Urbanization – Amended

Change:

"UDFCD has long recommended a Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainageways, and implementing long-term source controls."

To:

Lyons recommends a Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainageways, and implementing long-term source controls.

4.1 Step 1. Employ Runoff Reduction Practices – Accepted

4.2 Step 2. Implement BMPs That Provide a Water Quality Capture Volume with Slow Release – Accepted

4.3 Step 3. Stabilize Drainageways – Accepted

Change:

"Many drainageways within UDFCD boundaries are included in major drainageway or outfall systems plans, identifying needed channel stabilization measures."

To:

The Lyons master plan identifies needed channel stabilization measures along drainageway in the town.

4.4 Step 4. Implement Site Specific and Other Source Control BMPs – Accepted

5.0 Onsite, Subregional and Regional Stormwater Management – Accepted

6.0 Conclusion – Amended

Change:

“UDFCD criteria are based on a Four Step Process focused on reducing runoff volumes, treating the remaining WQCV, stabilizing receiving drainageways and providing targeted source controls for post-construction operations at a site.”

To:

Lyons criteria is based on Four Step Process focused on reducing runoff volumes, treating the remaining WQCV, stabilizing receiving drainageways and providing targeted source controls for post-construction operations at a site.

7.0 References

Chapter 2 - BMP Selection

1.0 BMP Selection – Accepted

1.1 Physical Site Characteristics – Accepted

1.2 Space Constraints – Accepted

1.3 Targeted Pollutants and BMP Processes – Accepted

1.4 Storage-Based Versus Conveyance-Based – Accepted

1.5 Volume Reduction – Accepted

1.6 Pretreatment – Accepted

1.7 Treatment Train – Accepted

1.8 Online Versus Offline Facility Locations – Accepted

1.9 Integration with Flood Control – Accepted

1.9.1 Sedimentation BMPs – Accepted

1.9.2 Infiltration/Filtration BMPs – Accepted

1.10 Land Use, Compatibility with Surroundings, and Safety – Accepted

1.11 Maintenance and Sustainability – Accepted

1.12 Costs – Accepted

2.0 BMP Selection Tool – Accepted

3.0 Life Cycle Cost and BMP Performance Tool – Accepted

3.1 BMP Whole Life Costs – Amended

Change:

"In addition, UDFCD recommends the cost of administering a stormwater management program also be included as a long-term cost for BMPs. Reporting whole life costs in terms of net present value (NPV) is an effective method for comparing mutually exclusive alternatives (Newnan 1996)."

To:

In addition, the cost of administering a stormwater management program also be included as a long-term cost for BMPs. Reporting whole life costs in terms of net present value (NPV) is an effective method for comparing mutually exclusive alternatives (Newnan 1996).

Change:

"All cost estimates are considered "order-of-magnitude" approximations, hence UDFCD's recommendation of using this concept primarily at the planning level."

To:

All cost estimates are considered "order-of-magnitude" approximations, hence the Town's recommendation of using this concept primarily at the planning level.

Change:

- **"Contingency/Engineering/Administration Costs:** The additional costs of designing and permitting a new BMP are estimated as a percentage of the total construction costs. For Denver-area projects, a value of 40% is recommended if no other information is available."

To:

- **Contingency/Engineering/Administration Costs:** The additional costs of designing and permitting a new BMP are estimated as a percentage of the total construction costs. For Lyons projects, a value of 40% is recommended if no other information is available.

Change:

- **"Administration Costs:** The costs of administering a stormwater management program are estimated as percentage of the average annual maintenance costs of a BMP. For Denver-area projects, a value of 12% is recommended if no other information is available."

To:

- **"Administration Costs:** The costs of administering a stormwater management program are estimated as percentage of the average annual maintenance costs of a BMP. For Lyons projects, a value of 12% is recommended if no other information is available."

3.2 BMP Performance

Change:

"Instead, UDFCD recommends an approach that is expected to predict long-term (i.e. average annual) BMP pollutant removal and runoff volume reduction with reasonable accuracy, using BMP performance data reported in the International Stormwater BMP Database (as discussed in Section 1.3)."

To:

"Instead, Lyons recommends an approach that is expected to predict long-term (i.e. average annual) BMP pollutant removal and runoff volume reduction with reasonable accuracy, using BMP performance data reported in the International Stormwater BMP Database (as discussed in Section 1.3)."

3.3 Cost Effectiveness – Accepted

4.0 Conclusion – Accepted

5.0 References

Chapter 3 – Calculating the WQCV and Volume Reduction

1.0 Introduction – Accepted

2.0 Hydrologic Basis of the WQCV

2.1 Development of the WQCV – Accepted

2.2 Optimizing the Capture Volume – Accepted

2.3 Attenuation of the WQCV (BMP Drain Time) – Accepted

2.4 Excess Urban Runoff Volume (EURV) and Full Spectrum Detention – Accepted

3.0 Calculation of the WQCV – Accepted

4.0 Quantifying Volume Reduction – Accepted

4.1 Conceptual Model for Volume Reduction BMPs—Cascading Planes – Accepted

4.2 Watershed/Master Planning-level Volume Reduction Method – Accepted

4.3 Site-level Volume Reduction Methods – Accepted

4.3.1 SWMM Modeling Using Cascading Planes – Accepted

4.3.2 IRF Charts and Spreadsheet – Accepted

4.4 Other Types of Credits for Volume Reduction BMPs/LID – Accepted

5.0 Examples

5.1 Calculation of WQCV – Accepted

5.2 Volume Reduction Calculations for Storage-based Approach – Accepted

5.3 Effective Imperviousness Spreadsheet – Accepted

6.0 Conclusion – Accepted

7.0 References

Chapter 4 – Treatment BMPs

1.0 Overview – Accepted

2.0 Treatment BMP Fact Sheets – Amended

Change:

“UDFCD does not provide endorsement or approval of specific practices; instead, guidance is provided identifying when use of underground BMPs may be considered and the minimum criteria that should be met when site constraints do not enable aboveground treatment of runoff or when underground devices are used to provide pretreatment for site-specific or watershed-specific purposes.”

To:

Lyons does not provide endorsement or approval of specific practices; instead, guidance is provided identifying when use of underground BMPs may be considered and the minimum criteria that should be met when site constraints do not enable aboveground treatment of runoff or when underground devices are used to provide pretreatment for site-specific or watershed-specific purposes.

3.0 References

Treatment BMP Fact Sheets

T-1 Grass Buffer – Accepted

T-2 Grass Swale – Accepted

T-3 Bioretention (Rain Garden or Porous Landscape Detention) – Accepted

T-4 Green Roof – Accepted

T-5 Extended Detention Basin (EDB) – Accepted

T-6 Sand Filter – Accepted

T-7 Retention Pond – Amended

Add:

Retention facilities are normally not allowed in Lyons, but will be considered for special circumstances.

Retention facilities shall be sized to contain a volume equal to twice the 100-year storm runoff volume plus one foot of freeboard. Water within a retention facility shall be mechanically removed and disposed of off-site by the property owner within 48 hours after a storm event. Lyons will not approve any detention or retention pond that does not drain in less than 72 hours, or causes injury to water rights, or is in violation of State or Federal law.

T-8 Constructed Wetland Pond – Accepted

T-9 Constructed Wetland Channel – Accepted

T-10 Permeable Pavements: – Accepted

T-10.1 Permeable Interlocking Concrete Pavements (PICP) – Accepted

T-10.2 Concrete Grid Pavement – Accepted

T-10.3 Pervious Concrete – Accepted

T-10.4 Porous Gravel Pavement – Accepted

T-10.5 Reinforced Grass Pavement – Accepted

T-11 Underground BMPs – Accepted

T-12 Outlet Structures – Accepted

Chapter 5 – Source Control BMPs

1.0 Introduction – Accepted

2.0 Structural Source Controls – Accepted

3.0 Procedural Source Control BMPs – Accepted

3.1 Municipal Operations– Accepted

3.2 Commercial and Industrial Operations– Accepted

3.3 Residential Activities – Accepted

4.0 Combining Source Control BMPs to Target Pollutants of Concern – Accepted

5.0 References

Source Control BMP Fact Sheets

S-1 Covering Outdoor Storage and Handling Areas – Accepted

S-2 Spill Prevention, Containment and Control – Accepted

S-3 Disposal of Household Waste – Accepted

S-4 Illicit Discharge Controls – Accepted

S-5 Good Housekeeping – Accepted

S-6 Preventative Maintenance – Accepted

S-7 Vehicle Maintenance, Fueling and Storage – Accepted

S-8 Use of Pesticides, Herbicides and Fertilizers – Accepted

S-9 Landscape Maintenance – Accepted

S-10 Snow and Ice Management – Accepted

S-11 Street Sweeping and Cleaning – Accepted

S-12 Storm Sewer System Cleaning – Accepted

Chapter 6 – BMP Maintenance

1.0 Introduction – Accepted

2.0 Defining Maintenance Responsibility for Public and Private Facilities – Accepted

3.0 Developing a Maintenance Plan – Accepted

4.0 Grass Buffers and Swales – Accepted

4.1 Inspection – Accepted

4.2 Debris and Litter Removal – Accepted

4.3 Aeration – Accepted

4.4 Mowing – Accepted

4.5 Irrigation Scheduling and Maintenance – Accepted

4.6 Fertilizer, Herbicide, and Pesticide Application – Accepted

4.7 Sediment Removal – Accepted

5.0 Bioretention (Rain Garden or Porous Landscape Detention) – Accepted

5.1 Inspection – Accepted

5.2 Debris and Litter Removal – Accepted

5.3 Mowing and Plant Care – Accepted

5.4 Irrigation Scheduling and Maintenance – Accepted

5.5 Replacement of Wood Mulch – Accepted

5.6 Sediment Removal and Growing Media Replacement – Accepted

6.0 Green Roofs – Accepted

6.1 Inspection – Accepted

6.2 Plant Care and Media Replacement – Accepted

6.3 Irrigation Scheduling and Maintenance – Accepted

7.0 Extended Detention Basins (EDBs) – Accepted

7.1 Inspection – Accepted

7.2 Debris and Litter Removal – Accepted

7.3 Mowing and Plant Care – Accepted

7.4 Aeration – Accepted

7.5 Mosquito Control – Accepted

7.6 Irrigation Scheduling and Maintenance – Accepted

7.7 Sediment Removal from the Forebay, Trickle Channel, and Micropool – Accepted

7.8 Sediment Removal from Basin Bottom – Accepted

7.9 Erosion and Structural Repairs – Accepted

8.0 Sand Filters – Accepted

8.1 Inspection – Accepted

8.2 Debris and Litter Removal – Accepted

8.3 Filter Surface Maintenance – Accepted

8.4 Erosion and Structural Repairs – Accepted

9.0 Retention Ponds and Constructed Wetland Ponds – Accepted

9.1 Inspection – Accepted

9.2 Debris and Litter Removal – Accepted

9.3 Aquatic Plant Harvesting – Accepted

9.4 Mosquito Control – Accepted

9.5 Sediment Removal from the Forebay – Accepted

9.6 Sediment Removal from the Pond Bottom – Accepted

10.0 Constructed Wetland Channels – Accepted

10.1 Inspection – Accepted

10.2 Debris and Litter Removal – Accepted

10.3 Aquatic Plant Harvesting – Accepted

10.4 Sediment Removal – Accepted

11.0 Permeable Pavement Systems – Accepted

11.1 Inspection – Accepted

11.2 Debris Removal, Sweeping, and Vacuuming – Accepted

11.3 Snow Removal – Accepted

11.4 Full and Partial Replacement of the Pavement or Infill Material – Accepted

12.0 Underground BMPs – Accepted

12.1 Inspection– Accepted

12.2 Debris Removal, Cartridge Replacement, and Vacuuming – Accepted

13.0 References

Chapter 7 – Construction BMPs

1.0 Introduction – Accepted

2.0 Fundamental Erosion and Sediment Control Principles

2.1 Erosion – Accepted

2.2 Sedimentation – Accepted

2.3 Effective Erosion and Sediment Control– Accepted

3.0 Colorado Construction Stormwater Discharge Permits – Accepted

3.1 Preparing and Implementing a Stormwater Management Plan (SWMP) – Accepted

3.1.1 General SWMP Recommendations – Accepted

3.1.2 SWMP Elements – Accepted

3.2 Inspections – Accepted

3.2.1 Inspection Frequency – Accepted

3.2.2 Inspection Records – Accepted

3.3 Maintenance – Accepted

3.4 Disposition of Temporary Measures – Accepted

3.5 2009 Federal Effluent Limitation Guidelines – Accepted

4.0 Overview of Construction BMPs – Accepted

4.1 Erosion Control Measures – Accepted

4.2 Sediment Control Measures – Accepted

4.3 Site Management – Accepted

4.4 Materials Management – Accepted

4.5 Proprietary BMPs – Accepted

5.0 BMP Selection and Planning– Accepted

5.1 Site Assessment – Accepted

5.2 Slope-Length and Runoff Considerations – Accepted

5.3 Using the Revised Universal Soil Loss Equation – Accepted

5.4 BMP Functions – Accepted

5.5 Consistency with Other Plans – Accepted

5.5.1 Drainage Plans – Accepted

5.5.2 Post Construction Stormwater Management – Accepted

5.5.3 Air Quality Plans – Accepted

5.6 Guidelines for Integrating Site Conditions and BMPs into a SWMP – Accepted

6.0 Construction Dewatering – Accepted

7.0 Construction in Waterways – Accepted

8.0 Considerations for Linear Construction Projects – Accepted

8.1 General Considerations – Accepted

8.2 Underground Utility Trenching Criteria – Accepted

9.0 References

Construction BMP Fact Sheets – Accepted

Erosion Controls

EC-1 Surface Roughening (SR) – Accepted

EC-2 Temporary and Permanent Seeding (TS/PS) EC-3 Soil Binders (SB) – Accepted

EC-4 Mulching (MU) – Accepted

EC-5 Compost Blanket and Filter Berm (CB) – Accepted

EC-6 Rolled Erosion Control Products (RECP) (multiple types) – Accepted

EC-7 Temporary Slope Drains (TSD) – Accepted

EC-8 Temporary Outlet Protection (TOP) – Accepted

EC-9 Rough Cut Street Control (RCS) – Accepted

EC-10 Earth Dikes and Drainage Swales (ED/DS) – Accepted

EC-11 Terracing (TER) – Accepted

EC-12 Check Dams (CD) (multiple types) – Accepted

EC-13 Streambank Stabilization (SS) – Accepted

EC-14 Wind Erosion / Dust Control (DC) – Accepted

Materials Management

MM-1 Concrete Washout Area (CWA) – Accepted

MM-2 Stockpile Management (SP) (multiple types) – Accepted

MM-3 Good Housekeeping Practices (GH) – Accepted

Sediment Controls

SC-1 Silt Fence (SF) – Accepted

SC-2 Sediment Control Log (SCL) – Accepted

SC-3 Straw Bale Barrier (SBB) – Accepted

SC-4 Brush Barrier (BB) – Accepted

SC-5 Rock Sock (RS) – Accepted

SC-6 Inlet Protection (IP) (multiple types) – Accepted

SC-7 Sediment Basin (SB) – Accepted

SC-8 Sediment Trap (ST) – Accepted

SC-9 Vegetative Buffers (VB) – Accepted

SC-10 Chemical Treatment (CT) – Accepted

Site Management and Other Specific Practices

SM-1 Construction Phasing/Sequencing (CP) – Accepted

SM-2 Protection of Existing Vegetation (PV) – Accepted

SM-3 Construction Fence (CF) – Accepted

SM-4 Vehicle Tracking Control (VTC) (multiple types) – Accepted

SM-5 Stabilized Construction Roadway (SCR) – Accepted

SM-6 Stabilized Staging Area (SSA) – Accepted

SM-7 Street Sweeping and Vacuuming (SS) – Accepted

SM-8 Temporary Diversion Methods (TDM) – Accepted

SM-9 Dewatering Operations (DW) – Accepted

SM-10 Temporary Stream Crossing (TSC) (multiple types) – Accepted

SM-11 Temporary Batch Plant (TBP) – Accepted

SM-12 Paving and Grinding Operations (PGO) – Accepted

Appendix J

Link to download

Appendix K

Link to download

References