3.4 Detention Pond

A detention pond was designed to safely discharge the 5-year storm and protect the downstream aquatic habitat. The pond was sized by modeling the proposed stormwater network in EPA SWMM and using the Kwantlen Park rainfall data from the Surrey Design Manual. The parameters of the pond were selected ensuring compliance with the guidelines listed in The City of Surrey Design Criteria Manual and the design criteria set by the client.

3.4.1 Assumptions and Design Criteria

The source controls are assumed to be fully implemented and able to mitigate the 2-year storm; however, they are assumed to not function under the 5-year storm. Section 5.2.1c. of the Surrey Design Manual stipulates that the 5-year post-development flow rate needs to be controlled to 5-year pre-development flow rate, assumed to be 7 L/s/ha. The development area is estimated to be 10.31 ha, hence the 5-year post-development flow rate needs to be limited to 0.072 m^3/s. A summary of the design criteria is shown in Table 7.

Table 7: Detention Pond Design Criteria

Design Criteria Description	**Criteria Value**	**Imposed by**
Outlet Flow	7 L/s/ha	*Client*
Pond Depth	1.5 m	*Client*
Pond Side Slopes	2:1	*Client*
Inlet Sewer to Pond Depth	Crown of inlet manhole at or above the corresponding pond water level for the 1 in 5-year storm	*Surrey Design Criteria 5.8.4.5*
Pond Inlet and Outlet Requirements	At least 0.1m above base of the pond	*Surrey Design Criteria 5.8.4.4*

The system was analyzed using the Kwantlen Park 5-year design storms with the following durations: 2-hour, 6-hour, 12-hour, and 24-hour.

3.4.2 EPA SWMM Model

The subcatchment areas were selected by considering the contour map of the study area and land zoning, such that each area has a relatively constant slope and consistent zoning designation. The western mountainous area was neglected since a swale was designed to direct that runoff into Gallant Creek. The parks on the eastern side of the study area have also been neglected since they are assumed to either fully absorb their runoff and/or direct it to the bay.

The setup of the stormwater network EPA SWMM model is shown in Figure 16. The parameter notation used in SWMM is presented in Table 9. The values of the following subcatchment parameters are summarized in Table 10: areas, overland flow lengths, widths, average surface slope, and percent of area that is impervious. The overland flow length for each subcatchment was estimated by averaging several possible overland flow paths measured in AutoCAD. The width of each subcatchment was found as a ratio of its area to its overland flow length. The imperviousness percentages of areas were assigned according to the Surrey Design Criteria, as shown in Table 8. Where a subcatchment contained more than one land zoning, the percent imperviousness was assigned according to the proportion of the subcatchment taken by each land zoning. The parameters used in developing the SWMM model along with justifications are summarized in Table 11.

Table 8: Imperviousness of Different Land Usages

Description of Area	**% Imperviousness**
Commercial	**90**
Industrial	90
Residential	65
Parks	20
Playgrounds	20
Cemetery	20
Agricultural Land	20
Institutional	80
Passive Park	20

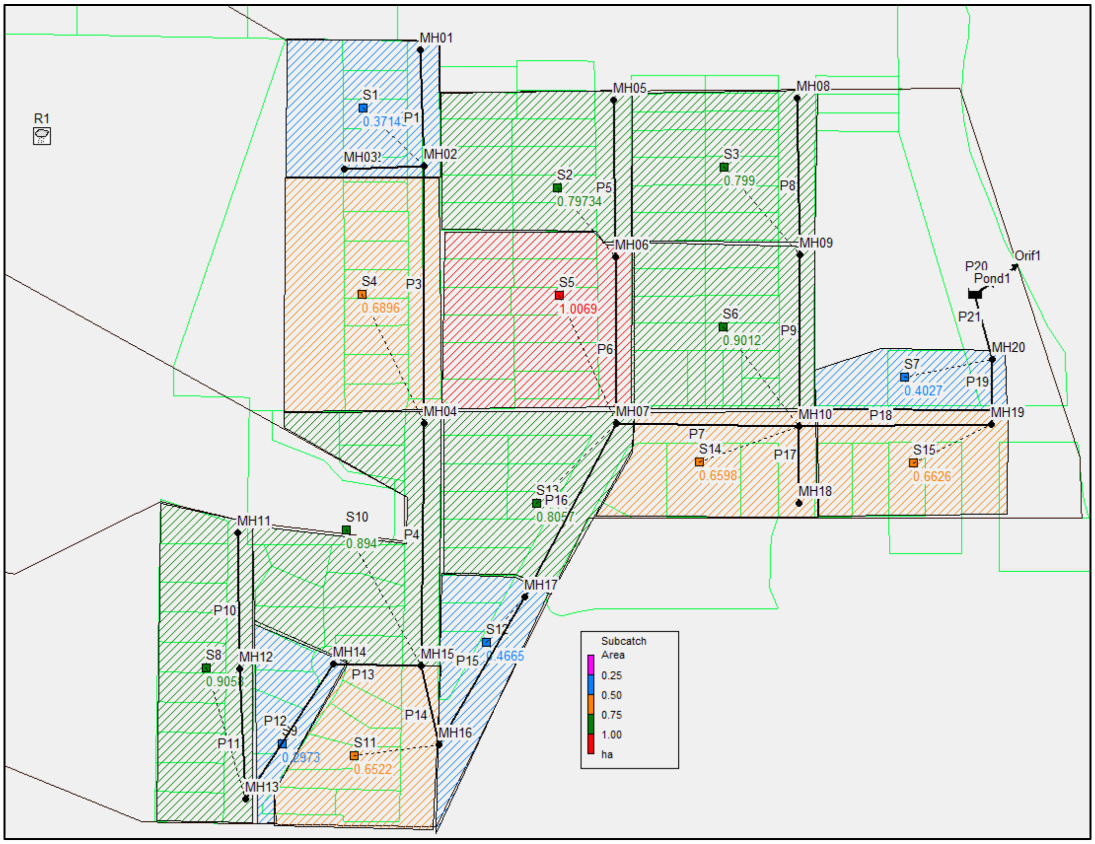


Figure 16: System Model Layout in EPA SWMM

Table 9: SWMM Parameter Notation

Parameter	SWMM Notation
Subcatchment	S
Rain Gage	R
Pipes	P
Manholes	MH
Detention Pond	Pond1
System Outlet	Orif1

Table 10: Subcatchment Parameter Values

Subcatchment ID	Area (ha)	Zoning	Overland Flow Length (m)	Width (m)	Slope (%)	% Impervious
S1	0.3714	Residential	50.0	74.3	19.2	65.0
S2	0.7973	Residential	96.2	82.9	27.6	65.0
S3	0.7990	Residential	91.3	87.5	21.9	65.0
S4	0.6896	Residential	51.5	133.9	20.7	65.0
S5	1.0069	Residential	105.0	95.9	28.7	65.0
S6	0.9012	Residential and Commercial Village	91.0	99.0	24.9	75.0
S7	0.4027	Park and Commercial Village	112.0	36.0	7.8	55.0
S8	0.9058	Residential	49.5	183.0	28.0	65.0
S9	0.2973	Residential	35.6	83.5	18.4	65.0
S10	0.8940	Residential	91.7	97.5	27.7	65.0
S11	0.6522	Residential	60.9	107.1	26.9	65.0
S12	0.4665	Residential	44.0	106.0	22.7	65.0
S13	0.8057	Residential	84.3	95.6	18.5	65.0
S14	0.6598	Park and Commercial Village	99.6	66.2	13.9	60.0
S15	0.6626	Commercial Village	90.0	73.6	6.3	90.0

Table 11: SWMM Design Parameters

Parameter Description	**Parameter Name**	**Parameter Selected with Justification**
General Properties		
Infiltration Model	Infiltration Model	Green-Ampt *as per Client*
Routing Model	Routing Model	Dynamic Wave *as per Client*
Subcatchments		
Area of Subcatchment	Area	*Justification provided in the EPA SWMM Model Section*
Width of Overland Flow	Width	*Justification provided in the EPA SWMM Model Section*
Average Surface Slope	% Slope	*Justification provided in the EPA SWMM Model Section*
Percent of Area that is Impervious	% Imperv	*Justification provided in the EPA SWMM Model Section*
Internal Routing of Runoff Between Pervious and Impervious Areas	Subarea Routing	Outlet *as per Client*
Percent of runoff routed between subareas	Percent Routed	100 *as per Client*
Groundwater parameters	Groundwater	No *as per Client*
Initial quantities of pollutant buildup	Initial Buildup	None *as per Client*
Manning’s Coefficient for Overland Flow over Impervious Area	N-Imperv	0.013 *as per Client*
Manning’s Coefficient for Overland Flow over Pervious Area	N-Perv	0.2 *as per Client*
Pipes		
Pipe Diameter	Max. Depth	Identical to Section 3.2
Pipe Length	Length	Identical to Section 3.2
Manning’s Roughness Coefficient	Roughness	0.013 *as per Client*
Junctions		
Invert Elevation of the junction	Invert El.	Identical to Section 3.2
Rain Gage		
Source of Rainfall Data	Data Source	Kwantlen Park 5-year storms *(Table 5.3.5 Surrey Design Criteria)*
Orifice		

Orifice Height	Height	0.15 m *to comply with Section 5.4.7.2 of Surrey Design Criteria*
Discharge Coefficient	Discharge Coeff.	0.62 *(square edged)*
Depth of bottom of orifice above invert of inlet node	Inlet Offset	0.1 m *to comply with Section 5.8.4.4 of Surrey Design Criteria*
Type of Orifice	Type	Side *as per Client*
Outfall		
Invert Elevation	Invert El.	3.5 m *to comply with Section 5.8.4.4 of Surrey Design Criteria*
Pond		
Maximum Depth of the Pond	Max. Depth	1.5 m *as per Client*
Pond Base Invert Elevation	Invert El.	5.5 m *as per Site Contours*

3.4.3 Analysis and Results

The proposed stormwater network was analyzed in EPA SWMM by running the 2-hour, 6-hour, 12-hour, and 24-hour duration 5-year design storms. The flow hydrographs at the outfall were then exported into an Excel spreadsheet. These were then used as inflows into a pond with a trial size and a stepwise mass balance at 5-minute intervals was then developed to estimate pond depths and outflows (evaluated using the orifice equation). The shape of the pond and the orifice were selected to be a truncated square pyramid and a square, respectively. The pond's base dimensions and depth along with the orifice height were iterated to minimize the pond size while meeting the imposed design criteria. The final dimensions of the pond and orifice are summarized in Table 12. The maximum depth and maximum outflow obtained for various durations of storm runs are summarized in Table 13. The storm with the 24-hour duration was found to be most critical for selecting the pond and orifice parameters. Equations that were used to find the optimal pond parameters are presented in Appendix B.

Table 12: Pond and Orifice Final Parameters

Design Object	Parameter Description	Parameter Value
Pond	Base Length and Width (m)	50
	Top Length and Width (m)	56
	Height (m)	1.5
	Volume (m^3)	4218
Orifice	Height (m)	0.15
	Area (m^2)	0.0225

Table 13: Maximum Pond Depth and Outflow for Different Duration 5-Year Storms

5-year Storm Duration	Max Pond Depth (m)	Max Outflow (m^3/s)
24hr	1.439	0.071
12hr	1.309	0.068
6hr	1.033	0.060
2hr	0.577	0.043
Limit	1.5	0.072

The orifice and pond were then added to the SWMM to verify the calculations. As seen in the time series plots for the system under the 5-year 24-hour duration storm (Figure 17), the pond does not overflow, and the pond's discharge is limited to below the pre-development flow. The time series plots for other durations of the 5-year storm are shown in Appendix C.

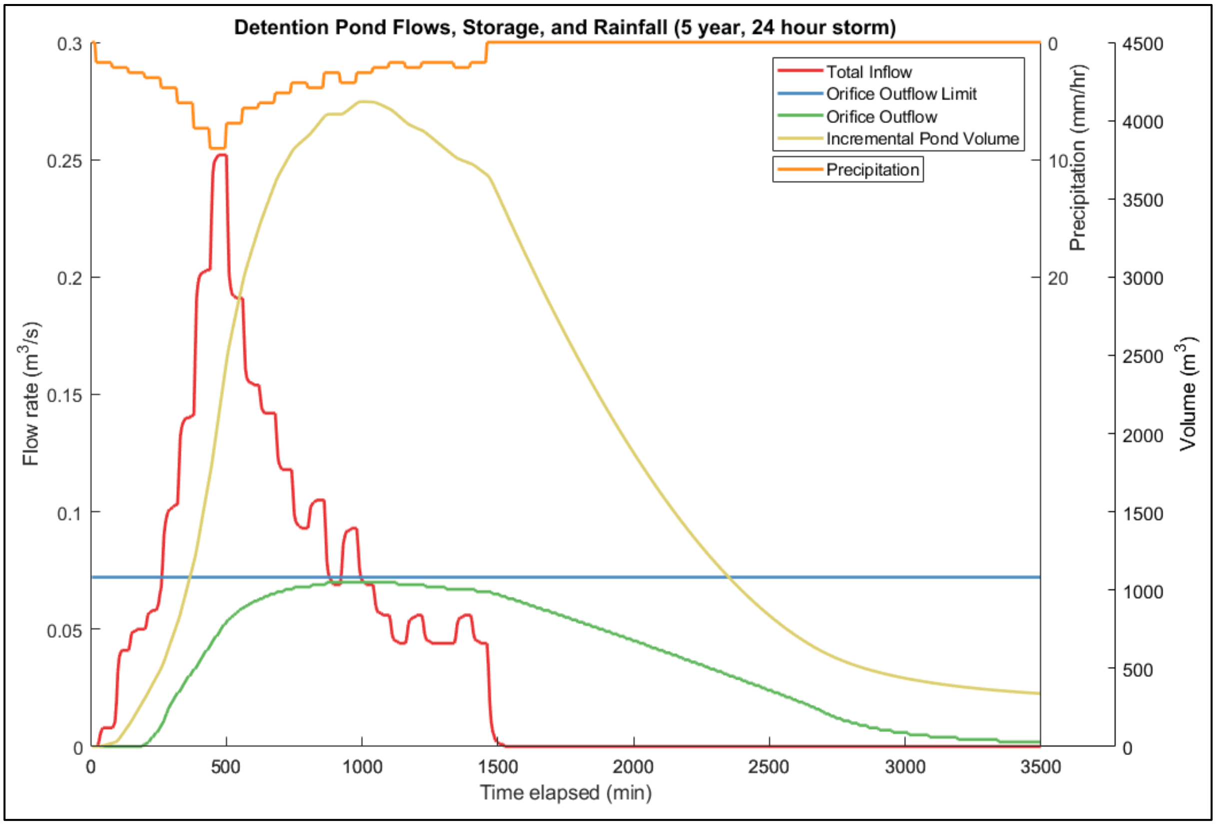


Figure 17: Time Series Plot for Pond's Hydraulic Parameters Under 5-Year 24-Hour Duration Storm

The detention pond will be located in Panorama Park, slightly north of the last manhole. The location, shape, and dimensions of the pond are shown in Figure 18.

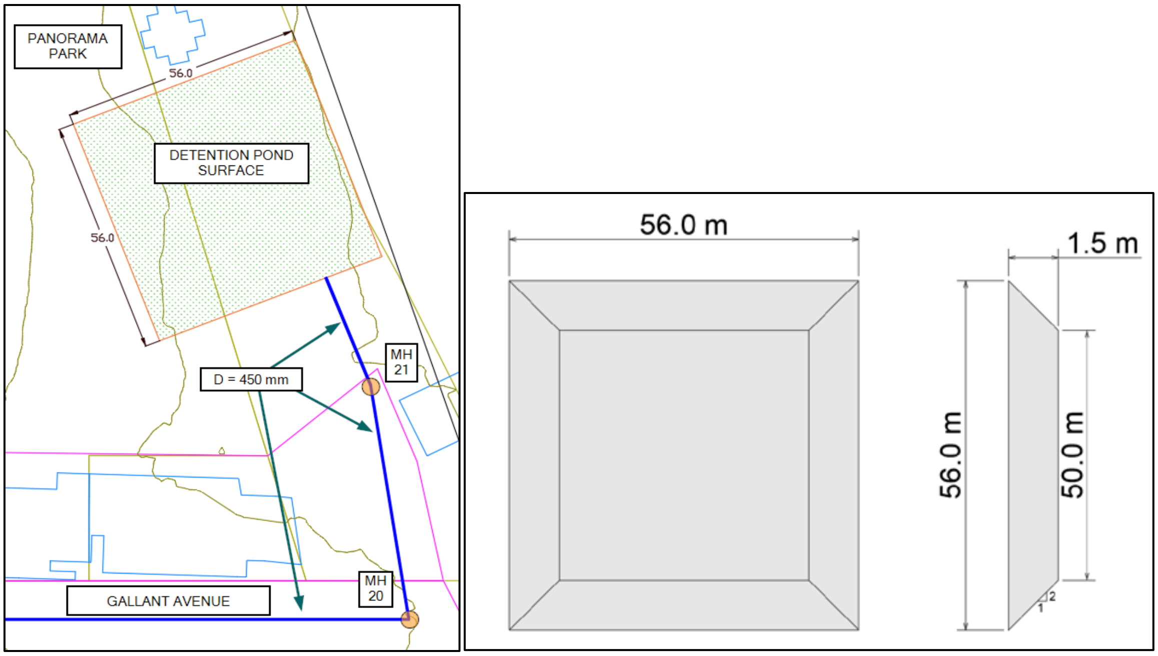


Figure 18: Location, Shape and Dimensions of the Detention Pond

APPENDIX B

SAMPLE CALCULATIONS

Detention Pond Sizing:

The following formulas were developed for the spreadsheet iterations to size the pond:

$$Q_{in} - Q_{out} = \frac{\Delta V}{\Delta t}$$

$$\Delta V = \frac{1}{3}(a^2 + ab + b^2)\Delta h$$

$$\Delta h = \frac{3(Q_{in} - Q_{out})\Delta t}{(a^2 + ab + b^2)}$$

$$Q_{out} = CA\sqrt{2gh}$$

$$Q_{in} \equiv total\ inflow\ into\ the\ pond$$

$$\Delta V \equiv change\ in\ volume\ of\ the\ pond$$

$$a \equiv base\ side\ length\ of\ the\ pond$$

$$b \equiv top\ side\ length\ of\ the\ pond$$

$$h \equiv height\ of\ water\ in\ the\ pond\ above\ the\ invert\ of\ outlet$$

$$\Delta t \equiv time\ step\ (5\ min)$$

$$Q_{out} \equiv orifice\ discharge\ from\ the\ pond$$

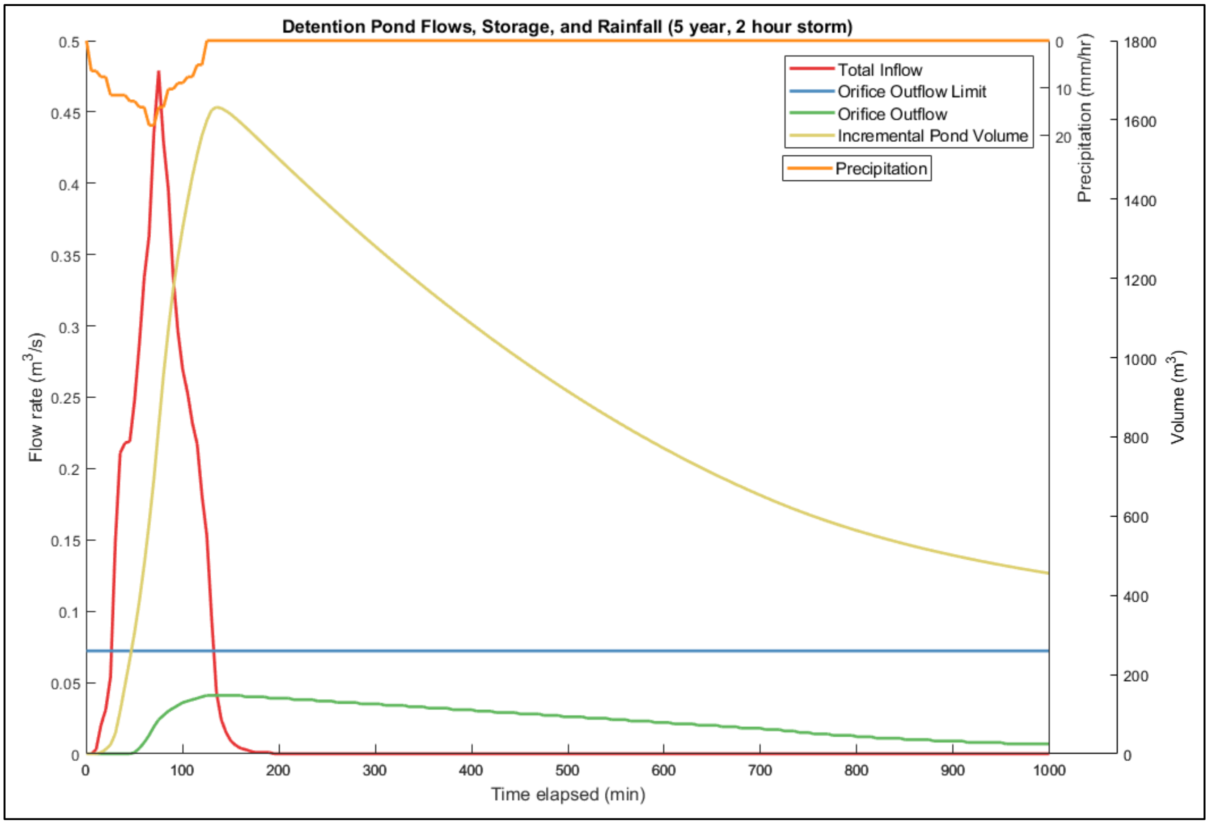
$$A \equiv area\ of\ the\ orifice$$

$$C \equiv orifice\ discharge\ coefficient$$

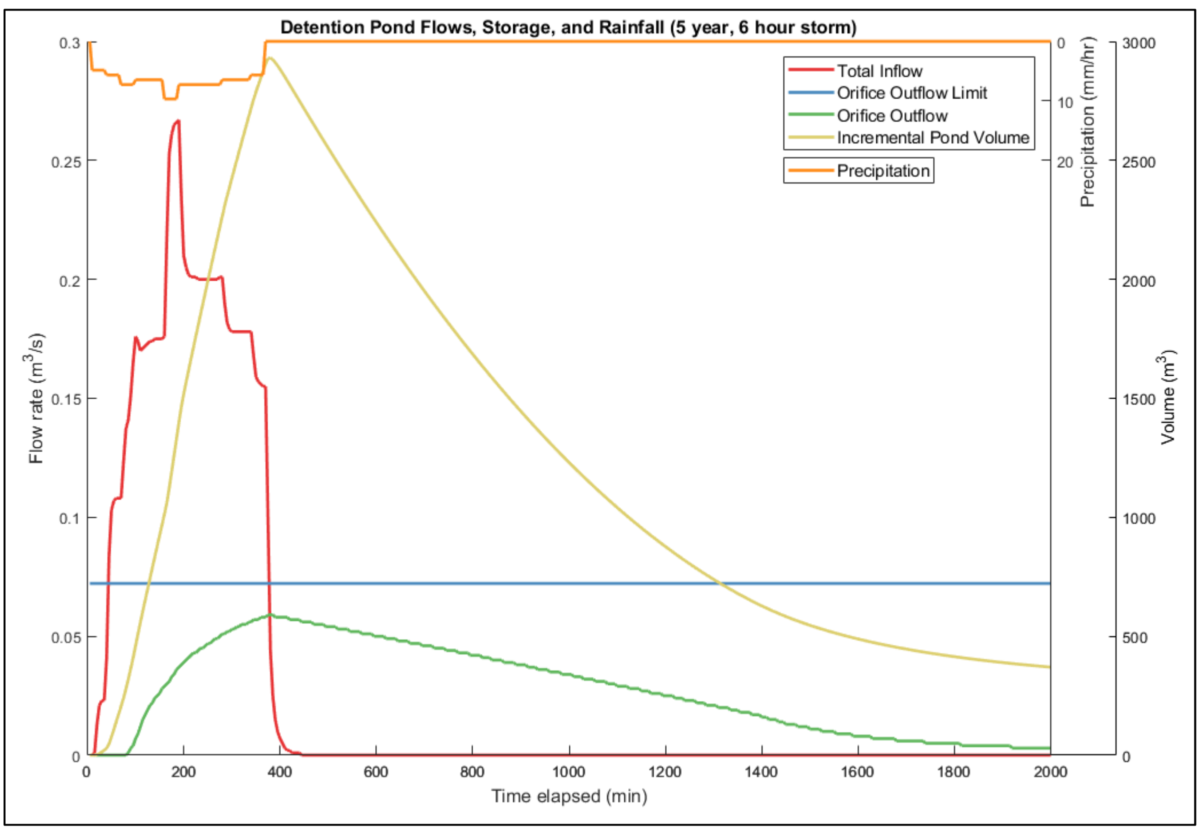
$$g \equiv acceleration\ due\ to\ gravity$$

APPENDIX C

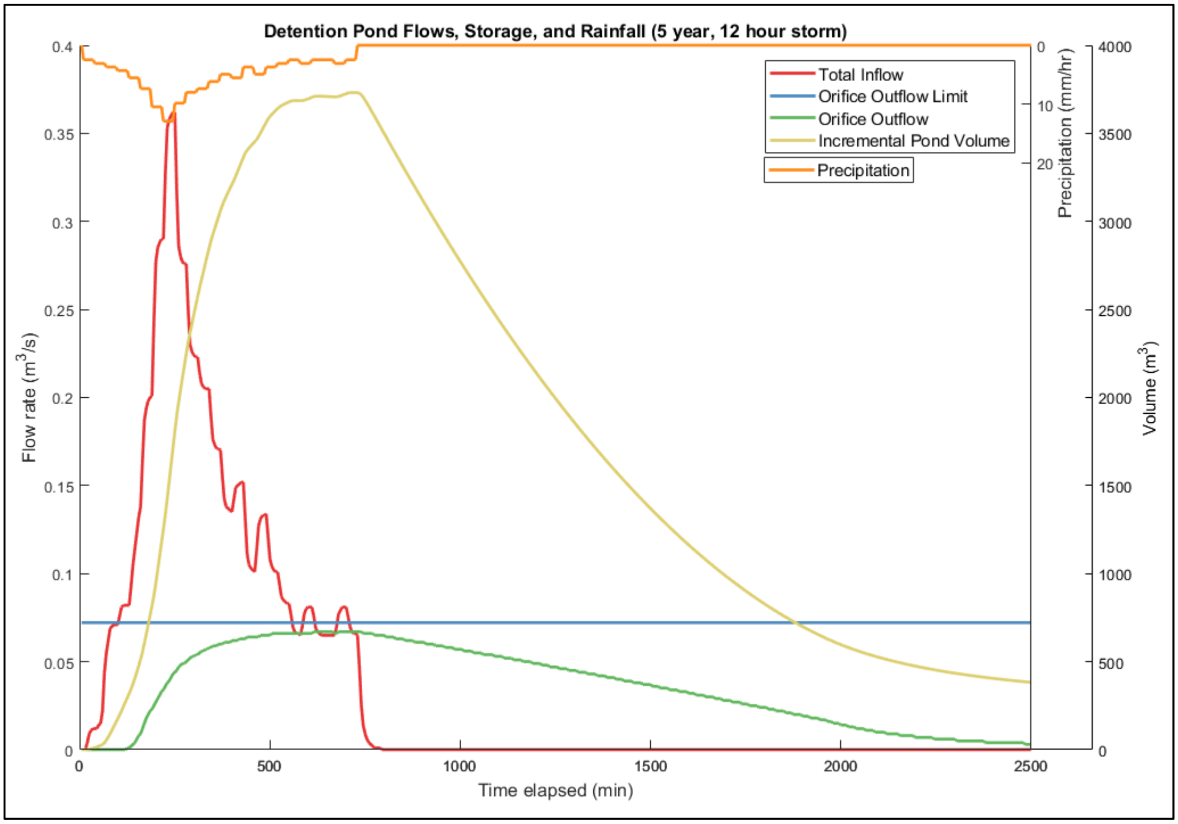
TIME SERIES PLOTS OF POND’S HYDRAULIC PARAMETERS



Detention Pond Flows, Storage, and Rainfall (5 year, 2 hour storm)
Total Inflow
Orifice Outflow Limit
Orifice Outflow
Incremental Pond Volume
Precipitation
Flow rate (m3/s)
Precipitation (mm/hr)
Volume (m3)
Time elapsed (min)



Detention Pond Flows, Storage, and Rainfall (5 year, 6 hour storm)
Total Inflow
Orifice Outflow Limit
Orifice Outflow
Incremental Pond Volume
Precipitation
Flow rate (m3/s)
Precipitation (mm/hr)
Volume (m3)
Time elapsed (min)


Detention Pond Flows, Storage, and Rainfall (5 year, 12 hour storm)
Total Inflow
Orifice Outflow Limit
Orifice Outflow
Incremental Pond Volume
Precipitation
Flow rate (m3/s)
Time elapsed (min)
Precipitation (mm/hr)
Volume (m3)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
500
1000
1500
2000
2500
10
20
3000
3500
4000