ENGINEERING LIMITED

February 6, 2023

SERVICING BRIEF

2690 QUEENSWAY
PID: 014-141-582

Client: Sukhrajvir Singh
L&M Project No.: 1831-01
City File No.: RZ100784

L&M Engineering Limited
1210 Fourth Avenue, Prince George, BC V2L 3J4
Phone: (250) 562-1977

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APPENDICES: **A - Water Modelling**
B - Hazen Williams Head Loss Calculation
C - Storm Modelling

1.0 INTRODUCTION

On behalf of Sukhrajvir Singh, L&M Engineering is pleased to provide you with this Servicing Brief for the subject property located at 2690 Queensway (legally described as Block 28 District Lot 933 Cariboo District Plan 727 Except Plan PGP37011, PID 014-141-582). The subject property is currently being rezoned (City file RZ100784) to allow for future multi-family development. This Servicing Brief has been prepared to summarize the existing municipal infrastructure in the surrounding area and demonstrate how the property can be serviced with municipal water, sanitary, and storm infrastructure.

The subject property is approximately 0.611 ha in size and is located within the municipal boundaries of the City of Prince George. The subject property is currently designated as a Neighborhoods Future Land Use and Neighbourhood Corridor Future Land Use in the *City of Prince George Official Community Plan Bylaw No. 8383, 2011* (OCP) and is currently zoned C7: Transitional Commercial in the *City of Prince George Zoning Bylaw No. 7850, 2007*. A portion of the property is within the Riparian Protection Development Permit area. Rezoning application RZ100784 proposes to rezone the subject property from C7 to **RM4: Multiple Residential.**

2.0 BACKGROUND DATA AND REPORTS

L&M Engineering has reviewed the following reports in relation to the subject property development:

- City of Prince George – 2017 Sanitary Sewer Services Master Plan prepared by AECOM;
- City of Prince George – 2001 Sanitary Sewer Study prepared by McElhanney;
- City of Prince George – 2014 Water Service Network Plan prepared by Opus Dayton Knight;
- City of Prince George – Development Services Department: Design Guidelines; and
- PG Map

3.0 SITE TOPOGRAPHY & SITE ACCESS

The subject property is sparsely treed along the west with small clearings. The site topography slopes from the west side of the property to the east side at an approximate slope of 1-2%. The subject property is bordered to the west by Queensway, along the north by a lane and the terminus of Inlander Street, and the Fraser River to the east.

Based on initial comments from the city, the proposed development must be accessed from Inlander Street as direct access from Queensway would not be permitted. Access will be further reviewed in L&M's Traffic Impact Analysis Report.

4.0 DESIGN POPULATION

The site design population of the site is calculated as follows:

RM4: Multiple Residential

- The subject property is 0.611 hectares.
- RM4 zoning allows a maximum height of 3 stories and a density of 90 dwellings per hectare.
- In reference to the *CoPG Design Guidelines*, Table 2.9.1 'Design Population by Land Use Designation' for Multi-Family/ Townhouse/ Apartment is 270 people per hectare.

5.0 WATER DISTRIBUTION SYSTEM

5.1 Existing System

L&M Engineering conducted a review of the existing municipal water main infrastructure in the vicinity of the subject property. The City's water main network includes a 200 mm dia. main on Queensway, and a 150 mm dia. water main that terminates at the limit of Inlander Street. The system is part of Pressure Zone PZ1.

5.2 Domestic Water Demands

The water demand has been calculated using rates published in the City of Prince George's Design Guidelines. Table 1 outlines the calculation of the water demand.

Table 1: Estimated Water Demand

Residential			
Variable	**Result**		**Notes**
Units	55	units	
Population	2.8	ppl/ unit	People per Unit, based on Table 2.10.1 CoPG DGs
Population	154	people	
Domestic Avg Daily per Capita	475	l/d	Refer to Section 3.1.3 CoPG Design Guidelines
Average Daily Demand (ADD)	73150	l/d	= Population * Avg. Flow per Capita
MDD - Peak Factor	3.10		Refer to Section 3.1.4 CoPG Design Guidelines
PHD - Peak Factor	4.25		Refer to Section 3.1.4 CoPG Design Guidelines
Summary			
Average Daily Demand (ADD)	0.85	l/s	
Maximum Daily Demand (MDD)	2.62	l/s	
Peak Hour Demand (PHD)	3.60	l/s	

5.3 Water Modeling Results

L&M Engineering submitted design parameters to the City of Prince George for water modelling. The City's water model was analyzed under Average Day Demand (ADD), Maximum Day Demand (MDD), and Peak Hour Demand (PHD) conditions. Maximum Day conditions represent the highest recorded daily demand on the water system and Peak Hour flow conditions represent the highest demand on the system during the course of a day.

For the proposed RM4 zoned area, design parameters for two options were submitted to the city for water modelling to verify the design flows from two separate service locations. The City Guidelines require at least 125 L/s with a minimum residual pressure of 20 psi. Option 1 modelled a water connection off Inlander Street, and Option 2 modelled a connection off Queensway. The City's Water Modelling Report (WM000155) confirmed under Option 1, a service off Inlander Street would have an ADD pressure of 83.21 psi, a PHD pressure of 76.78 psi, and an available fire flow of 70.69 L/s. With Option 2, a service connection off Queensway would have an ADD pressure of 82.80 psi, a PHD pressure of 76.55 psi, and an available fire flow of 192.41 L/s. A copy of the Water Modeling Report (WM000155) is attached in Appendix A.

The water modelling concluded that the water main on Queensway could provide available fire flows of 192.41 L/s. When accounting for the pressure losses from the onsite main the resulting available fire flow is 154 L/s. The available flow of 154 L/s exceeds the minimum flow requirements of 125 L/s for apartment/townhouse developments as indicated in Table 3.2.2 of the Draft CoPG Design Guidelines. A copy of L&M's Hazen Williams Head Loss Calculation is attached under Appendix B.

The Queensway water main has an ADD pressure of 82.80 psi and a PHD pressure of 75.55 psi. The CoPG Design Guidelines indicate that the minimum system pressure during PHD conditions is 40 psi; therefore, the main can provide the required flows while maintaining the minimum system pressure.

5.4 Fire Protection Demands

In addition to the domestic water demand, an allowance for fire protection must be made. The document titled Water Supply for Public Fire Protection, produced by the Fire Underwriters Survey (FUS) is the de-facto standard in Canada for establishing fire protection requirements in municipal waterworks system design. This document presents a fire flow estimate that accounts for factors such as building construction, total floor area, material combustibility, automatic sprinkling, building separation, and occupancy.

The CoPG Design Guidelines indicate that an apartment/townhouse development requires a fire flow of 125 L/s. In the detailed design phase, the FUS will be used in conjunction with the architect to ensure the buildings require less than the available fire flow on the site. During the detailed design phase, decisions on building materials and requirements for firewalls will ensure that the required fire flow according to the FUS calculations is below the available fire flow for the site.

5.5 Proposed Water Servicing

To service the proposed development, a new 150 mm dia. service connection will be provided from the existing 200 mm dia. water main on Queensway to meet the required pressure and flow demands. The approximate service location is shown in Figure 1: Potential Water Service Tie-In Location. Since the development is privately owned, the site will require a backflow preventer and a single water meter for the future building.

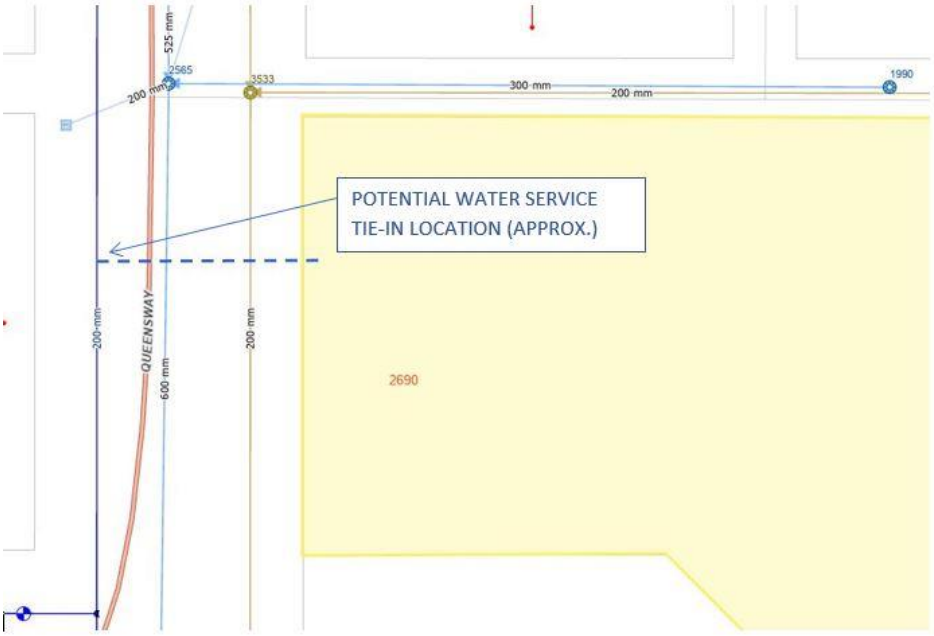

Figure 1: Potential Water Service Tie-In Location

6.0 SANITARY COLLECTION SYSTEM

6.1 Existing System

The existing sanitary network in the vicinity of the subject site consists of a 200 mm dia. main along Queensway which flows south by gravity to Village Avenue, west along Village Avenue

to Jasper Street, and then south to a pump station (PW113). PW113 pumps the sanitary sewage north to a manhole (Asset ID 3534) at Village Ave and Kaslo Street.

6.2 Existing Capacity

L&M Engineering reviewed the City of Prince George's 2017 Sanitary Sewer Services Master Plan (prepared by AECOM) and PGMap for information related to the capacity of the existing sanitary system. The studies reviewed the existing, zoning, and OCP model scenarios for the sanitary network.

L&M Engineering utilized the 2017 Master Plan to review the downstream capacity of the main from the subject property to PW113. The Existing Gravity Sewer model indicates that all of the pipes along this section are less than 50% full.

6.3 Sanitary Design Flows

The City of Prince George's Design Guidelines (Section 4.2) outlines the procedure required to determine the sanitary sewer design flows. The calculations for the design flows are summarized in Table 2.

Table 2: Estimated Sewage Design Flow Demands

Variable	Result		Notes
Population	154	ppl	Based on Population Calculation
Domestic Avg Daily per Capita	380	l/d	Refer to Section 4.2.2.6 CoPG Design Guidelines
Total Avg. Daily Flow	58520	l/d	Population * Avg. Flow per Capita
Peak Factor	4.19		Harman Equation
Total Peak Design Flow (Qs)	245199	l/d	Total Avg. Daily Design Flow * Peak Factor
Total Peak Design Flow (Qs)	2.84	l/s	Total Avg. Daily Design Flow * Peak Factor
Infiltration and Inflow			
Development Area	0.61	ha	
Infiltration Rate	11200	l/ha/d	Refer to section 4.2.2.4 (11,200 L/ha)
Infiltration (Qi)	6832	l/d	= Development Area x Infiltration Rate
Infiltration (Qi)	0.08	l/s	= Development Area x Infiltration Rate
Total Design Flow (Qs + Qi)	252031	l/d	(Qs + Qi)
Total Design Flow (Qs + Qi)	2.92	l/s	(Qs + Qi)

Based on the design flow of 2.92 L/s, the mains between the subject property and pump station PW113 have sufficient capacity to accommodate the development. A review of the downstream system confirmed the lowest available flow is with Asset ID: 10834, which has a total capacity of 16 L/s, an available capacity of 10 L/s, and a zone available capacity of 10 L/s.

6.4 Proposed Sanitary Servicing

The proposed plan to service the site with sanitary sewer is to provide a connection from the existing manhole (Asset ID 3532). The approximate service location is shown in Figure 1: Potential Water Service Tie-In Location.

Figure 2: Potential Sanitary Sewer Service Tie-In Location

7.0 STORMWATER SYSTEM

7.1 Existing System

The existing storm network in the vicinity of the subject site consists of a 300 mm dia. storm main located within the lane along the north property boundary which directs flows to a 600mm dia. storm main on Queensway. The Queensway storm flows south and into a trunk main at a manhole (Asset ID 2568) which then discharges flows into the Fraser River.

7.2 Proposed Storm Servicing

As per Table 1 of the CoPG's Subdivision and Development Servicing Bylaw No 8618, 2014, parcels in the Urban designated areas as shown on Schedule B are required to have a storm connection to the city storm network. However, where possible, the City of Prince George's encourages developers to manage stormwater onsite and dispose of runoff through infiltration (or detention).

The preliminary geotechnical report indicates a soil substrate of sand over gravel for the property. The proposed plan to manage the onsite stormwater runoff is to utilize the native sand and gravel soils to dispose of runoff from the development with an onsite infiltration gallery. The future onsite infiltration gallery will be designed to ensure post-development run-off at pre-development flow rates for storms up to 10-year rainfall events can infiltrate into the native soils. A storm service will also be provided to accommodate overflows greater than the 1 in 10-year storm event, with a connection from the storm manhole (Asset ID 1990) within the lane or the main on Queensway. The approximate service location is shown in Figure 1: Potential Water Service Tie-In Location.

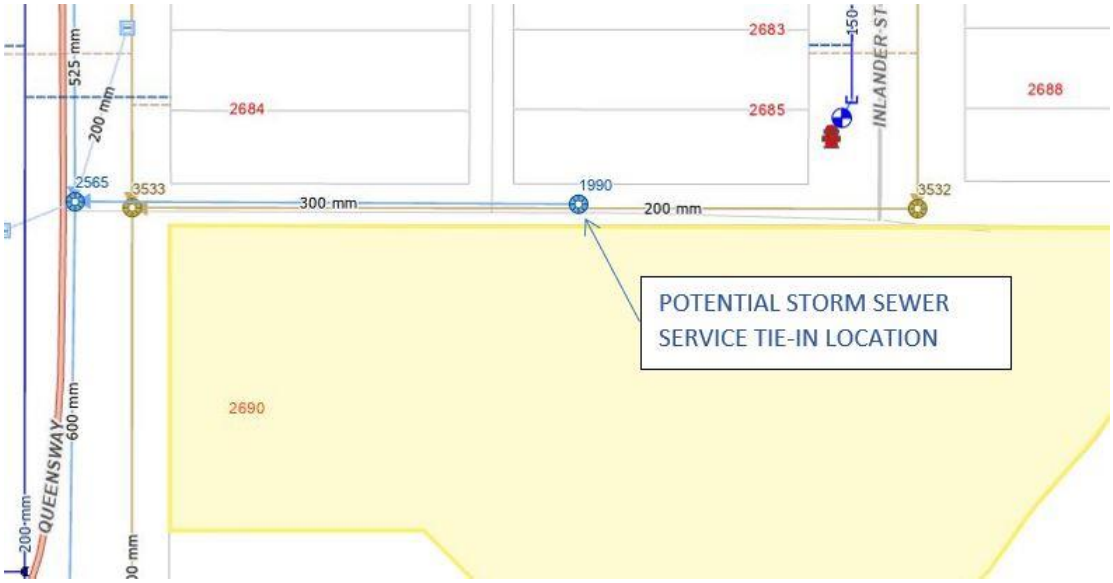

Figure 3: Potential Storm Sewer Service Tie-In Location

HydroCAD software was used to estimate the pre-and-post development peak runoffs generated during a 2, 5, 10, and 100-year, 24-hour return period storm. The following inputs were used during the analysis:

Pre-Development

- Curve Number = 58 (Woods/grass comb., Condition: Good, HSG B)
- Concentration Time = 42.5 minutes, Sheet Flow
- Storm Type: City of Prince George's 24hr Hyetograph (2017)
- Area = 0.61 ha (Subject Property)

Post-Development

- Curve Number = 95 (Urban commercial, 85% imp, HSG B)
- Concentration Time = 0 minutes
- Storm Type: City of Prince George's 24hr Hyetograph (2017)
- Area = 0.61 ha (Subject Property)

To ensure no storm flows would leave the site during 2, 5, and 10-year storm events a recharge chamber with a 2.50 m diameter base, 3.45 m tall with 1.5:1 side slopes, and utilizing a 150 mm/hr infiltration rate was modelled. The infiltration rate will need to be confirmed during the detailed design phase. Table 3 summarizes the results from the Hydro analysis for a 2, 5, 10, and 100-year storm event and the resulting flows within the site and leaving the site. A copy of L&M's Storm Water Modeling is attached under Appendix C.

Table 3: HydroCAD Results

Post Development Flow Rate (m^3/s)				
Catchment Area (Ha)	**Pre- Development Flow (m^3/s)**	**Without Recharge Chamber**	**With Recharge Chamber**	**Required Storage (m^3)**
2-Year Storm				
0.61	0.000	0.0244	0.000	20.9
5-Year Storm				
0.61	0.000	0.0434	0.000	35.8
10-Year Storm				
0.61	0.000	0.0588	0.000	47.3
100-Year Storm				
0.61	0.000	0.1147	0.048	66.0

8.0 SUMMARY

In summary, the proposed development located at 2690 Queensway, in Prince George BC, appears to be situated such that it can be adequately serviced with the nearby water, sanitary sewer, and storm sewer infrastructure. The development can tie into the sanitary sewer network within the lane along the north side of the subject property. A new water service will be required from the existing water main within Queensway. Stormwater runoff from the proposed development will be managed onsite using an onsite infiltration gallery and can tie into the storm sewer network along the lane or Queensway to accommodate overflows greater than a 1 in 10-year event.

9.0 CLOSURE

This Servicing Brief has been prepared for the City of Prince George and Atpar Developments Ltd. as the intended users. Any use that a third party makes of this report or any reliance on or decisions to be made based on it are the responsibility of such third parties. L&M Engineering Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this study. The information and data contained within this document represent L&M Engineering Limited's professional judgement in accordance with the knowledge and information available to L&M Engineering Limited at the time of the report preparation. No other warranty, expressed or implied, is made.

Sincerely,

L&M ENGINEERING LTD

Prepared by:

Aaron Haazen, EIT
Project Engineer

Reviewed by:

Terry Fjellstrom, P.Eng.
President

PERMIT TO PRACTICE
NO 1002375
2023-02-08

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APPENDIX A

WATER MODELLING

CITY OF PRINCE GEORGE
Infrastructure and Public Works

1100 Patricia Boulevard, Prince George, BC V2L 3V9
Telephone (250) 561-7511 Fax (250) 612-5603

MEMO

To: **Aaron Haazen, EIT**
L&M Engineering Limited
ahaazen@lmengineering.bc.ca

From: **Alex Childs, EIT**
1-250-614-7807
Alex.Childs@princegeorge.ca

Date: **November 22, 2022**

Subject: **WM000155 Water Modelling for 2690 Queensway PID: 014-141-582**
Total number of pages (including this sheet): 7 Original WILL NOT follow by mail.

Aaron Haazen,

Water modelling has been carried out for 2690 Queensway PID: 014-141-582 under the conditions provided by yourself via the attached email sent November 3, 2022. As requested, the scenario have been evaluated at the two locations shown on the attached maps.

The results of the modelling are outlined in Tables 1 and 2. The design fire flow from Option 1 does not meet the City guideline of at least 150l/s with a minimum residual pressure of 20psi for commercial developments, however the design flow from Option 2 does.

Table 1: Modelling Scenarios for 2690 Queensway PID: 014-141-582 Option 1

Node	Modelling Node #	Pressure During ADD	Pressure During PHD	Design Fire Flow During MDD
Node 1	1082	573.71 kPa (83.21 PSI)	529.38 kPa (76.78 PSI)	70.69 l/s*

*The design fire flow results above are limited by the velocity of the 150mm dia. Inlander Street watermain.

Table 2: Modelling Scenarios for 2690 Queensway PID: 014-141-582 Option 2

Node	Modelling Node #	Pressure During ADD	Pressure During PHD	Design Fire Flow During MDD
Node 1	1760	570.89 kPa (82.80 PSI)	527.79 kPa (76.55 PSI)	192.41 l/s

Keep in mind that the values provided are at the proposed main and any losses within the service connections must be taken into account by the designer.

If you have any questions, please contact me.

Modelling has been carried out using the most recent version of the City's water model, analyzed under Average Day Demands (ADD), Maximum Day Demands (MDD), and Peak Hour Demands (PHD). Average Day represents the expected average demand over the entire year. Maximum Day represents the average demand during the expected highest demand day of the year. Peak Hour represents the expected highest single-hour average demand with a 3-year return period. Fire Flows given are Design Fire Flows, representing the highest flow that can be drawn from a hydrant under Maximum Day Demand, without reducing pressure at any point in the network below 20 PSI.

Regards,

Alan Clark

Prepared by
Alex Childs, EIT
Engineering Technologist

Reviewed by
Al Clark, P.Eng
City Engineer

CC: Wil Wedel, Utilities Manager
Mandy Stanker, Supervisor Subdivision & Building Inspection

From: devserv
To: Paulson, Maria
Subject: FW: Water Modelling Request - 2690 Queensway
Date: Friday, November 4, 2022 10:04:56 AM
Attachments: 2690 Queensway PGMap - Water Service.pdf

From: Aaron Haazen <ahaazen@lmengineering.bc.ca>
Sent: Thursday, November 3, 2022 10:35 AM
To: devserv <devserv@princegeorge.ca>
Cc: Terry Fjellstrom <tfjellstrom@lmengineering.bc.ca>
Subject: Water Modelling Request - 2690 Queensway

Good Afternoon,

We would like to request water modelling for the proposed development at 2690 Queensway

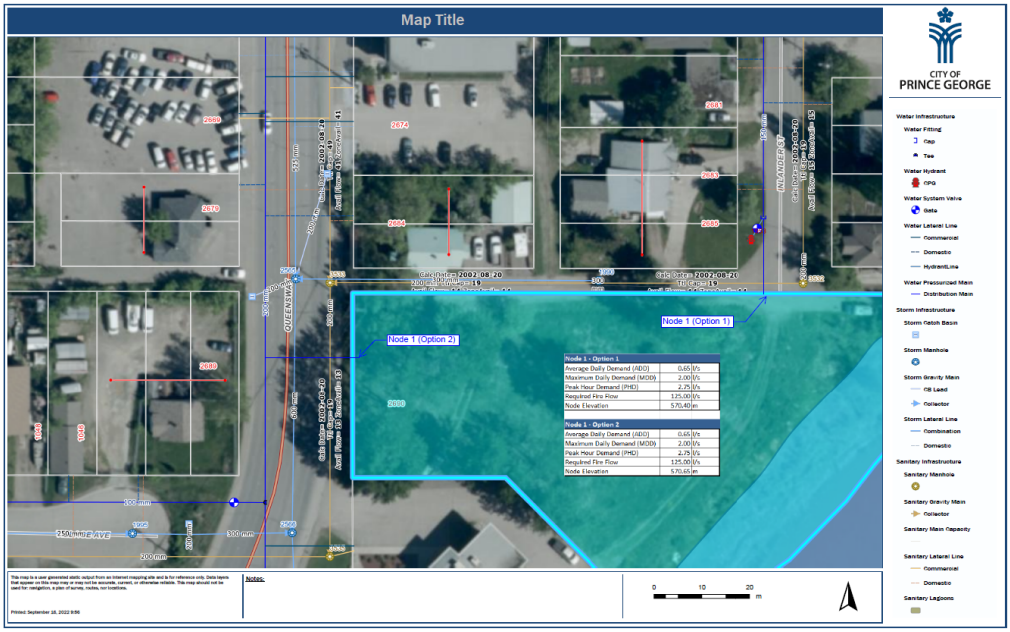
Project Information
PROPERTY INFORMATION
ADDRESS: 2690 Queensway
PID: 014-141-582
LEGAL DESCRIPTION: BLK 28 DL 933 PL 727

A pdf map of the development is attached with the node and expected flow rates.

We are looking at 2 options for servicing the site with water.
Please model the following for both options.

- Pressure during PHD
- Pressure during ADD
- Available Fire Flow during MDD
- Pressure during MDD with Fire flow demand (hydrant curve at node location)

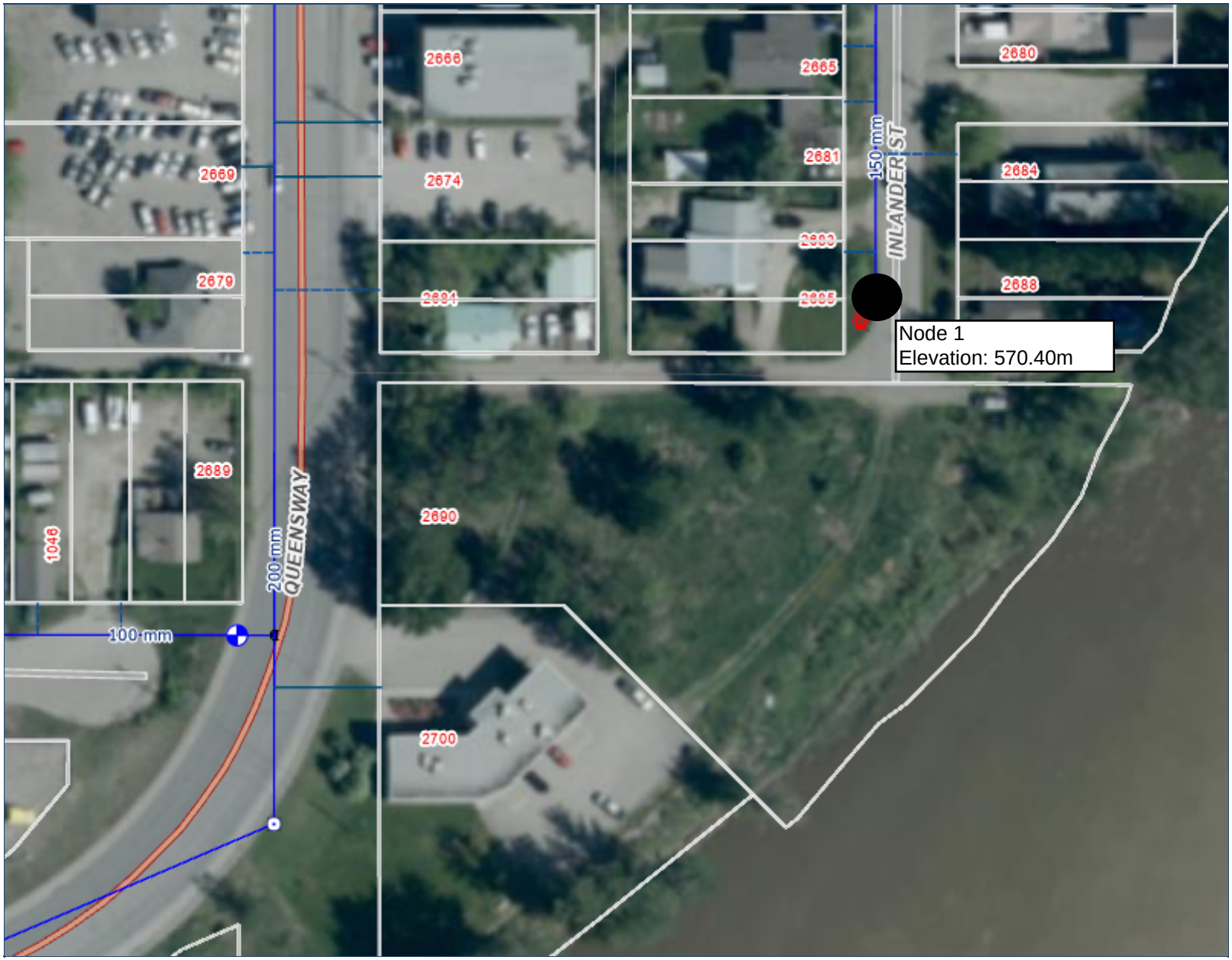
Thanks,



Aaron Haazen
Project Engineer, B.A.Sc, EIT

L&M Engineering Limited
P: (250) 562-1977 (ext 128)
C: (604) 703-9821

Node Map (Option 1)



CITY OF PRINCE GEORGE

Water Infrastructure

Water Fitting
- Bend
- Cap
- Tee

Water Hydrant
- CPG

Water System Valve
- Gate

Water Lateral Line
- Commercial
- Domestic
- HydrantLine

Water Pressurized Main
- Distribution Main

Internal Layers

Parcel Private View

Cadastre

Parcel Public View

Transportation Infrastructure

Roads
- Arterial
- Local
- Alley

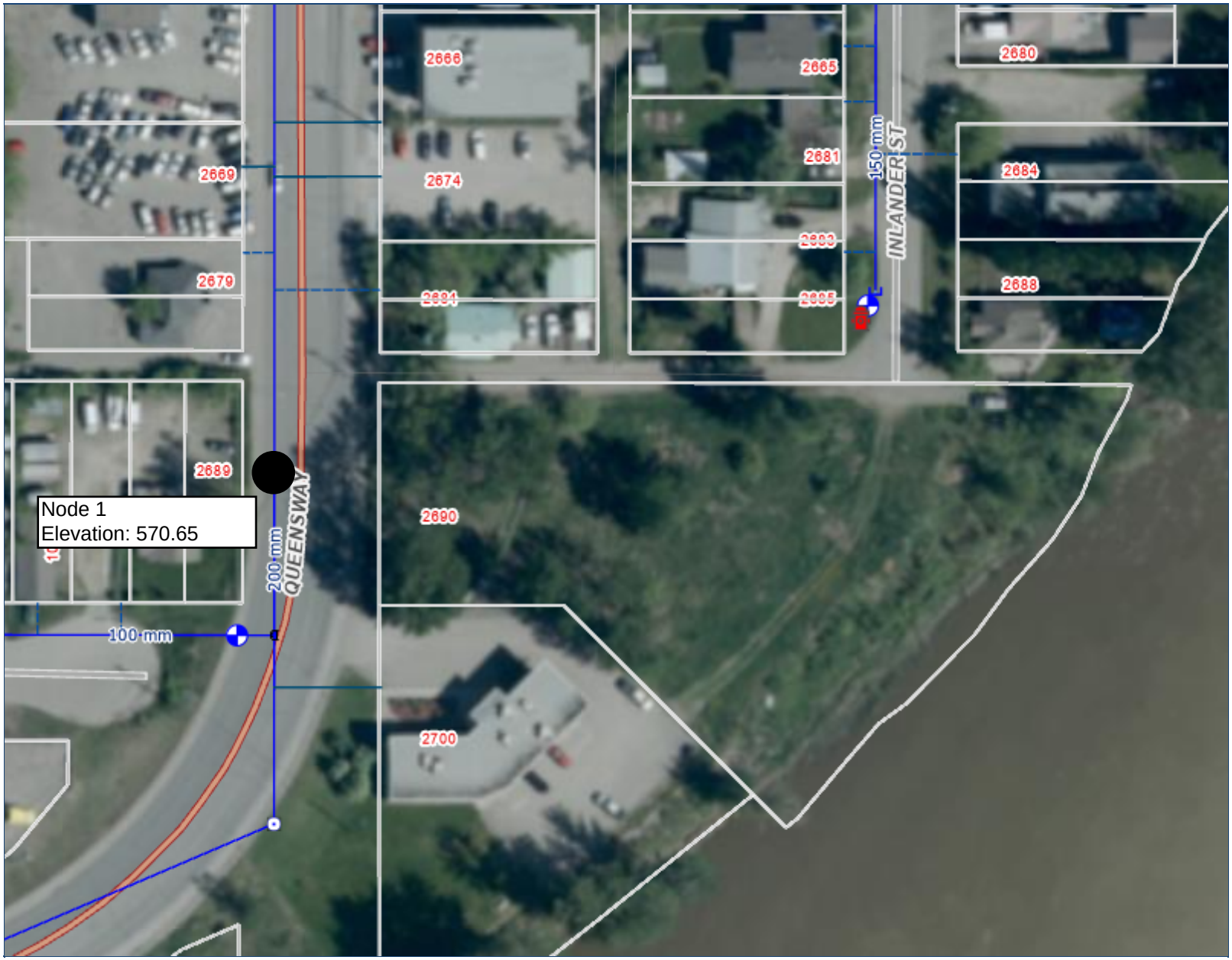
2020 Orthophotography

Printed: November 21, 2022 14:59

Notes:

0 15 30 m

Node Map (Option 2)



CITY OF PRINCE GEORGE

Water Infrastructure

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Roads

- Arterial
- Local
- Alley

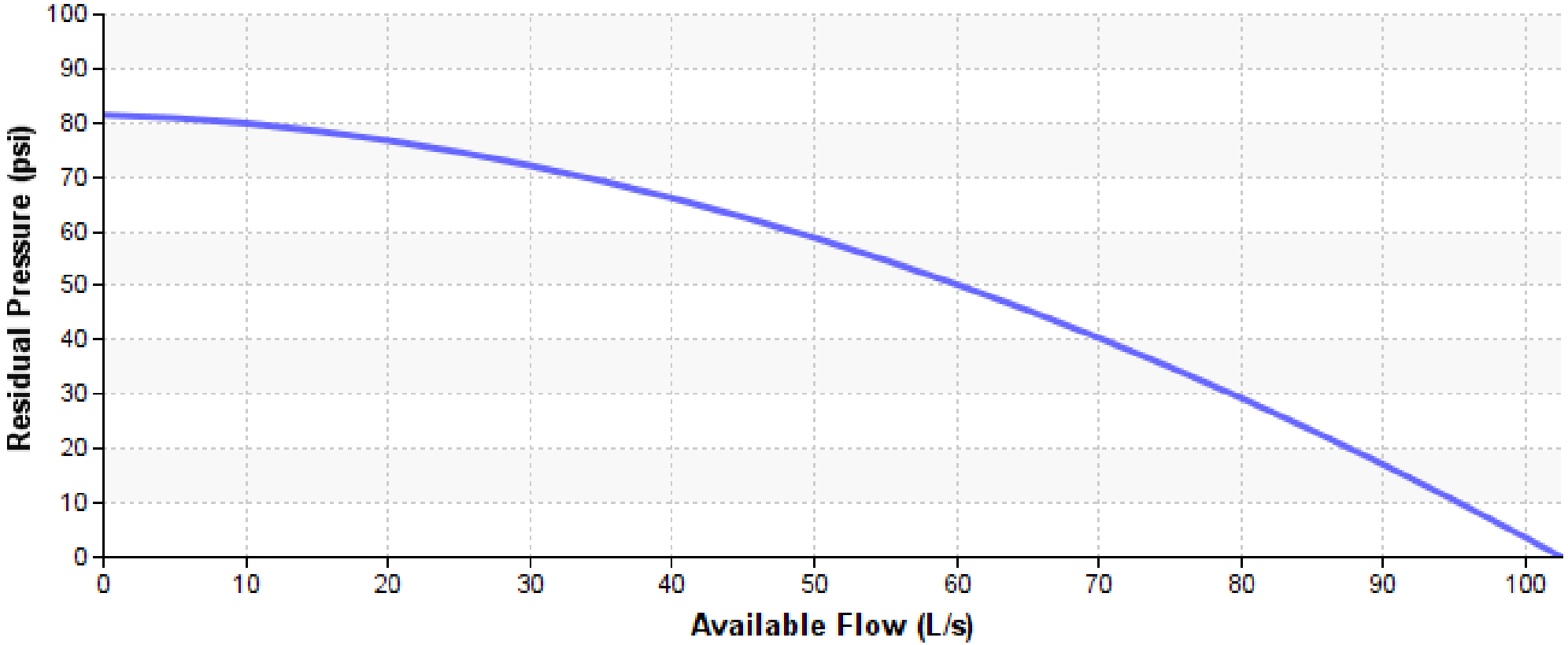
2020 Orthophotography

Printed: November 21, 2022 14:59

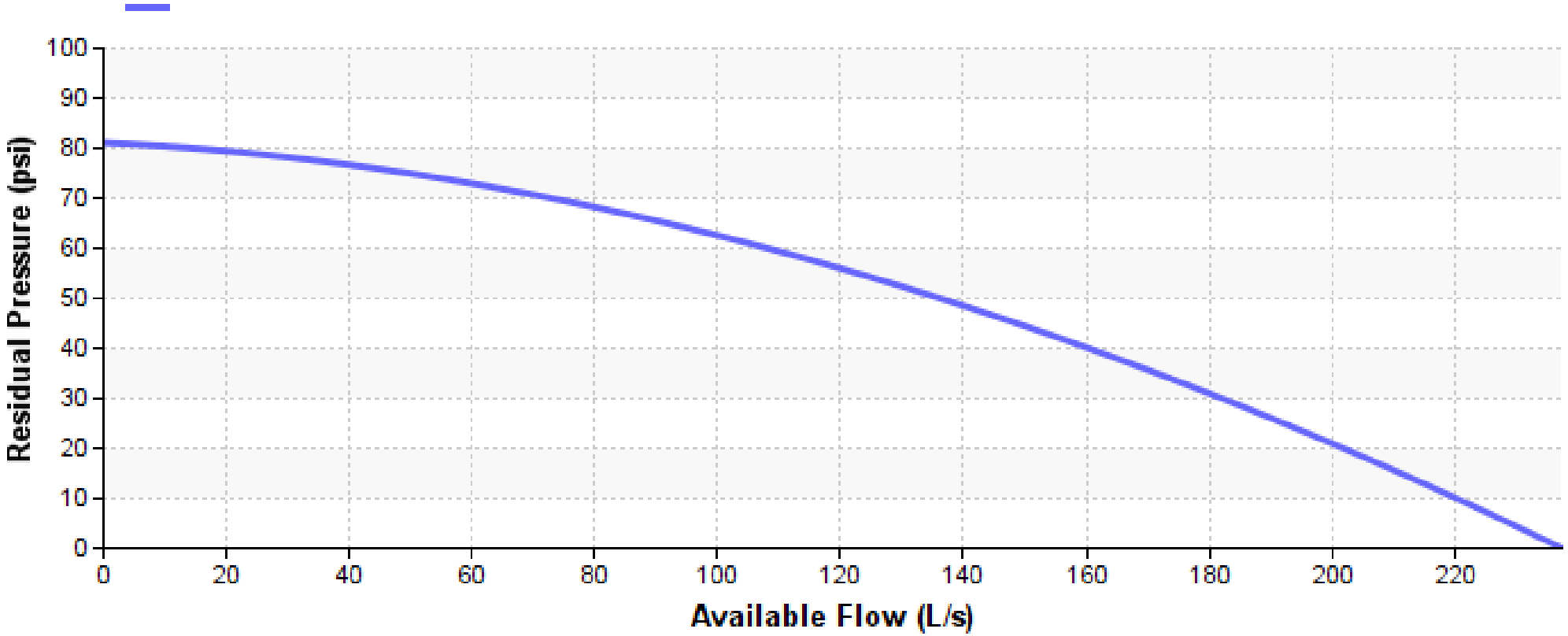
Notes:

0 15 30 m

Hydrant Curve for Node 1082 (Option 1)



Hydrant Curve for Node 1760 (Option 2)



APPENDIX B

HAZEN WILLIAMS HEADLOSS CALCULATION

L&M ENGINEERING LIMITED

Hazen Williams Equation
Headloss Calculations

Q=CD^2.63S^0.54/278780					**Project No.:**	1831-01	
S=(Q*278080/c/d^2.63)^(1/0.54)					**Calculated By:**	AH	
h_f = S*L					**Date:**	30-Nov-22	
Road to Tee							
Inputs							
Diameter	D	160	mm	0.160274	m		
Flow rate	Q	150	L/s	1982.4	Igal/min	0.15	m^3/s
rough c	C	130					
Length		55	m				
Outputs							
pipe area	A	0.020175	m^2				
pipe HL	S	0.28867	m/m				
Velocity	V=Q/A	7.43	m/s	24.39	ft/s		
	Headloss (h_f)	15.88	m	52.09	ft	**Friction Loss**	**23 psi**
	Inlet Elevation	570.65	m				
	Outlet Elevation	570.55	m				
	Static	-0.10	m			**Static Headloss**	**0 psi**
	TDH	15.78	m	51.76	ft	**Total Dynamic Headloss**	**23 psi**

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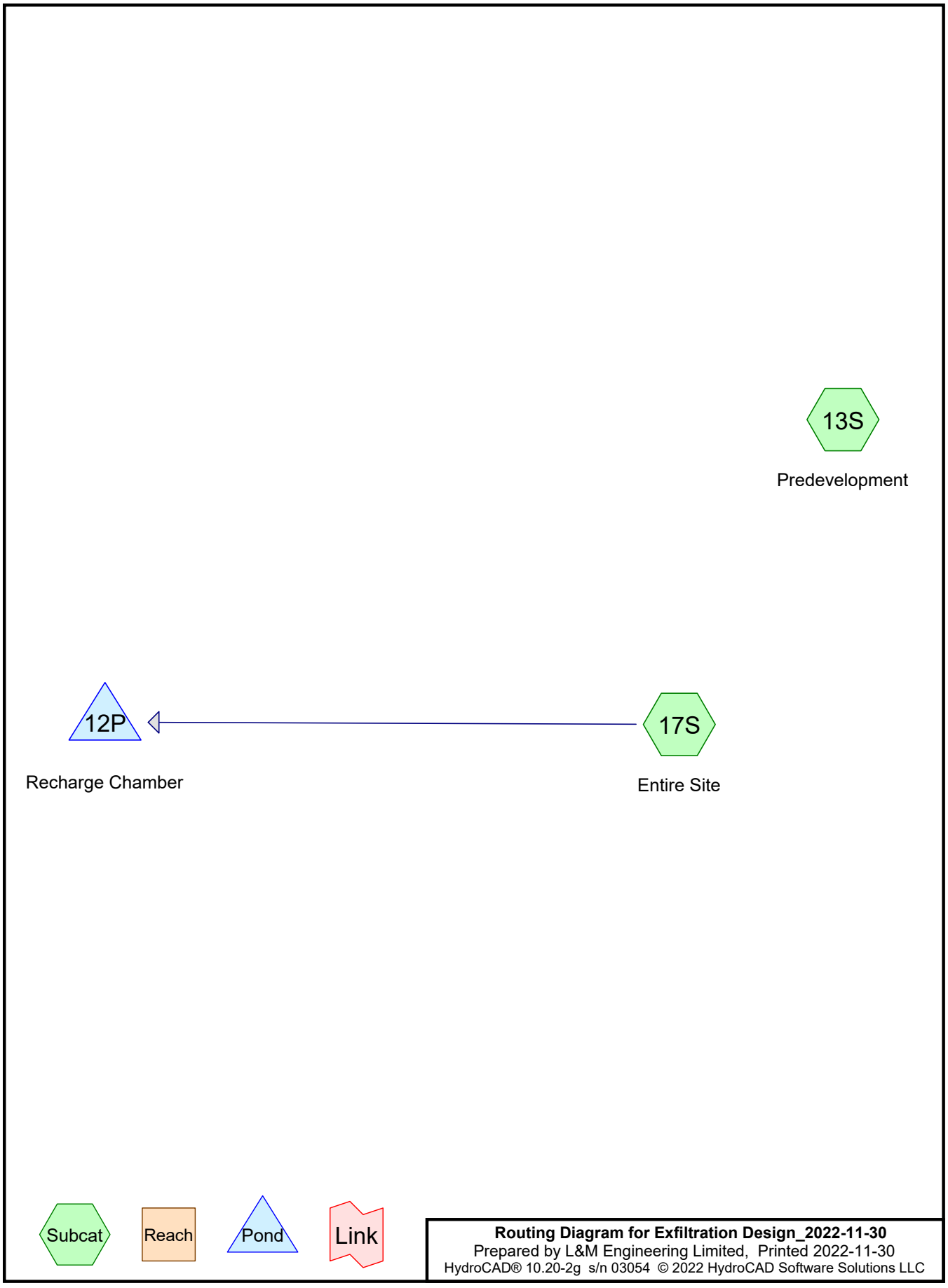


Routing Diagram for Exfiltration Design_2022-11-30
Prepared by L&M Engineering Limited, Printed 2022-11-30

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (mm)	AMC
1	CPG24hr-100y (2017)	CPG24-hr Hyetogr 100yr (2017)		Default	24.00	1	52	
2	CPG24hr-10y (2017)	CPG24-hr Hyetogr 10yr (2017)		Default	24.00	1	38	
3	CPG24hr-2y (2017)	CPG24-hr Hyetogr 2yr (2017)		Default	24.00	1	28	
4	CPG24hr-5y (2017)	CPG24-hr Hyetogr 5yr (2017)		Default	24.00	1	34	

Area Listing (all nodes)

Area (hectares)	CN	Description (subcatchment-numbers)
0.6100	92	Urban commercial, 85% imp, HSG B (17S)
0.6100	58	Woods/grass comb., Good, HSG B (13S)
1.2200	**75**	**TOTAL AREA**

Soil Listing (all nodes)

Area (hectares)	Soil Group	Subcatchment Numbers
0.0000	HSG A	
1.2200	HSG B	13S, 17S
0.0000	HSG C	
0.0000	HSG D	
0.0000	Other	
1.2200		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (hectares)	HSG-B (hectares)	HSG-C (hectares)	HSG-D (hectares)	Other (hectares)	Total (hectares)	Ground Cover	Subcatchme Numbers
0.0000	0.6100	0.0000	0.0000	0.0000	0.6100	Urban commercial, 85% imp	
0.0000	0.6100	0.0000	0.0000	0.0000	0.6100	Woods/grass comb., Good	
0.0000	**1.2200**	**0.0000**	**0.0000**	**0.0000**	**1.2200**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (meters)	Out-Invert (meters)	Length (meters)	Slope (m/m)	n	Width (mm)	Diam/Height (mm)	Inside-Fill (mm)
1	12P	3.450	3.440	1.00	0.0100	0.010	0	300	0

Time span=1.00-48.00 hrs, dt=0.01 hrs, 4701 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: Predevelopment Runoff Area=0.6100 ha 0.00% Impervious Runoff Depth=1 mm
Flow Length=80.0 m Slope=0.0100 m/m Tc=42.5 min CN=58 Runoff=0.0002 m³/s 0.007 Ml

Subcatchment 17S: Entire Site Runoff Area=0.6100 ha 85.00% Impervious Runoff Depth=32 mm
Tc=0.0 min CN=92 Runoff=0.1147 m³/s 0.198 Ml

Pond 12P: Recharge Chamber Peak Elev=3.713 m Storage=66.0 m³ Inflow=0.1147 m³/s 0.198 Ml
Discarded=0.0054 m³/s 0.158 Ml Tertiary=0.0481 m³/s 0.041 Ml Outflow=0.0536 m³/s 0.198 Ml

Total Runoff Area = 1.2200 ha Runoff Volume = 0.205 Ml Average Runoff Depth = 17 mm
57.50% Pervious = 0.7015 ha 42.50% Impervious = 0.5185 ha

Summary for Subcatchment 13S: Predevelopment

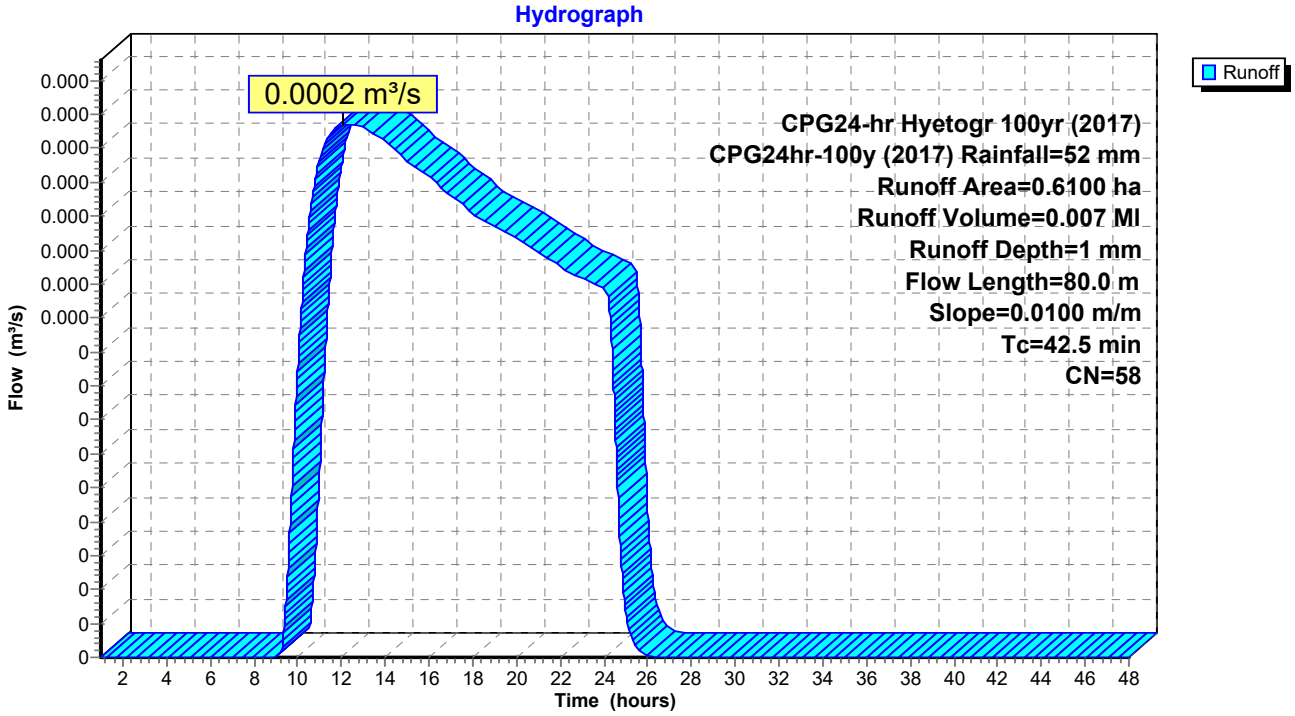
Runoff = 0.0002 m³/s @ 12.04 hrs, Volume= 0.007 Ml, Depth= 1 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 100yr (2017) CPG24hr-100y (2017) Rainfall=52 mm

Area (ha)	CN	Description
0.6100	58	Woods/grass comb., Good, HSG B
0.6100		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
42.5	80.0	0.0100	0.03		**Sheet Flow,** Range n= 0.130 P2= 28 mm

Subcatchment 13S: Predevelopment



Summary for Subcatchment 17S: Entire Site

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

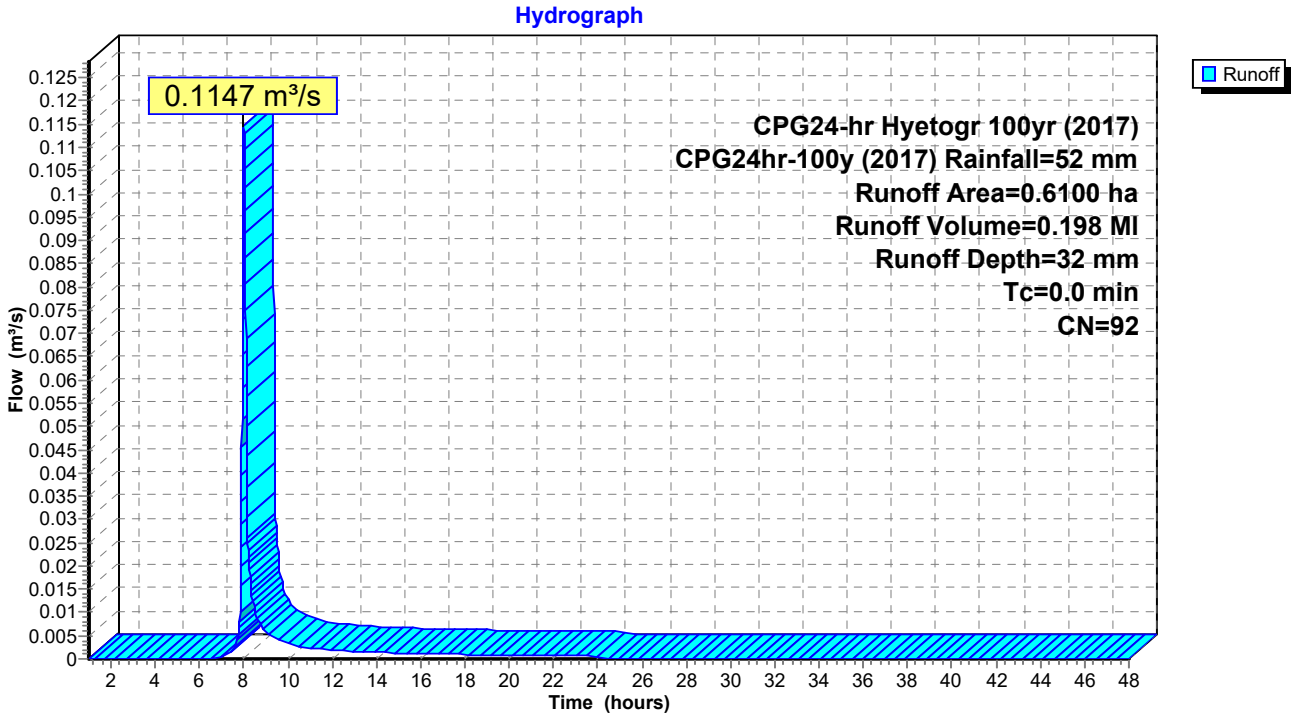
Runoff = 0.1147 m³/s @ 8.00 hrs, Volume= 0.198 Ml, Depth= 32 mm
Routed to Pond 12P : Recharge Chamber

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 100yr (2017) CPG24hr-100y (2017) Rainfall=52 mm

Area (ha)	CN	Description
0.6100	92	Urban commercial, 85% imp, HSG B
0.0915		15.00% Pervious Area
0.5185		85.00% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
0.0					**Direct Entry,**

Subcatchment 17S: Entire Site



Summary for Pond 12P: Recharge Chamber

Inflow Area = 0.6100 ha, 85.00% Impervious, Inflow Depth = 32 mm for CPG24hr-100y (2017) event
Inflow = 0.1147 m³/s @ 8.00 hrs, Volume= 0.198 Ml
Outflow = 0.0536 m³/s @ 8.12 hrs, Volume= 0.198 Ml, Atten= 53%, Lag= 7.3 min
Discarded = 0.0054 m³/s @ 8.06 hrs, Volume= 0.158 Ml
Tertiary = 0.0481 m³/s @ 8.12 hrs, Volume= 0.041 Ml

Routing by Stor-Ind method, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 3.713 m @ 8.12 hrs Surf.Area= 146.1 m² Storage= 66.0 m³

Plug-Flow detention time= 105.5 min calculated for 0.198 Ml (100% of inflow)
Center-of-Mass det. time= 105.5 min (735.7 - 630.2)

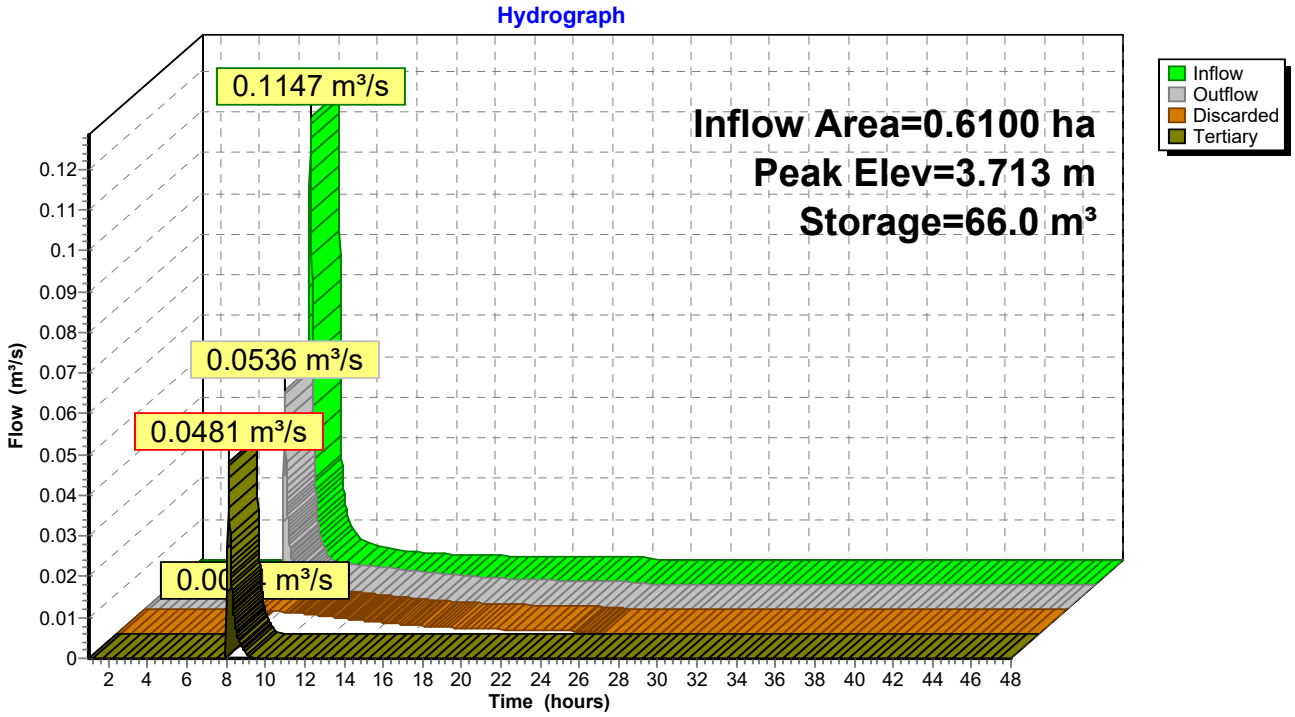
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	98.0 m³	**2.50 mD x 4.35 mH Vertical Cone/Cylinder Z=1.5** 326.8 m³ Overall x 30.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.000 m	**150.00 mm/hr Exfiltration over Surface area below 3.450 m**
#2	Tertiary	3.450 m	**300 mm Round Culvert** L= 1.00 m CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3.450 m / 3.440 m S= 0.0100 m/m Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.071 m²

Discarded OutFlow Max=0.0054 m³/s @ 8.06 hrs HW=3.523 m (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.0054 m³/s)

Tertiary OutFlow Max=0.0479 m³/s @ 8.12 hrs HW=3.712 m (Free Discharge)
└**2=Culvert** (Barrel Controls 0.0479 m³/s @ 0.98 m/s)

Pond 12P: Recharge Chamber



Time span=1.00-48.00 hrs, dt=0.01 hrs, 4701 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: Predevelopment Runoff Area=0.6100 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=80.0 m Slope=0.0100 m/m Tc=42.5 min CN=58 Runoff=0.0000 m³/s 0.000 Ml

Subcatchment 17S: Entire Site Runoff Area=0.6100 ha 85.00% Impervious Runoff Depth=20 mm
Tc=0.0 min CN=92 Runoff=0.0588 m³/s 0.124 Ml

Pond 12P: Recharge Chamber Peak Elev=3.238 m Storage=47.3 m³ Inflow=0.0588 m³/s 0.124 Ml
Discarded=0.0049 m³/s 0.124 Ml Tertiary=0.0000 m³/s 0.000 Ml Outflow=0.0049 m³/s 0.124 Ml

Total Runoff Area = 1.2200 ha Runoff Volume = 0.124 Ml Average Runoff Depth = 10 mm
57.50% Pervious = 0.7015 ha 42.50% Impervious = 0.5185 ha

Summary for Subcatchment 13S: Predevelopment

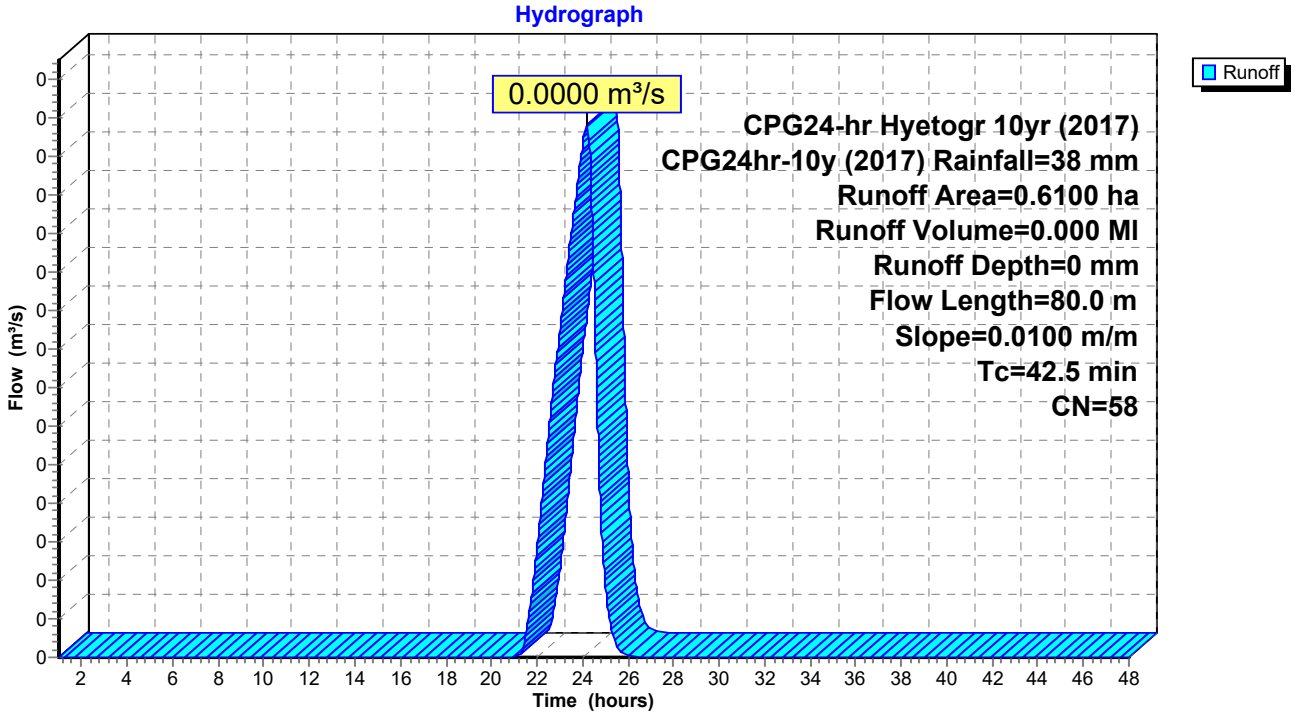
Runoff = 0.0000 m³/s @ 24.18 hrs, Volume= 0.000 Ml, Depth= 0 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 10yr (2017) CPG24hr-10y (2017) Rainfall=38 mm

Area (ha)	CN	Description
0.6100	58	Woods/grass comb., Good, HSG B
0.6100		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
42.5	80.0	0.0100	0.03		**Sheet Flow,** Range n= 0.130 P2= 28 mm

Subcatchment 13S: Predevelopment



Summary for Subcatchment 17S: Entire Site

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

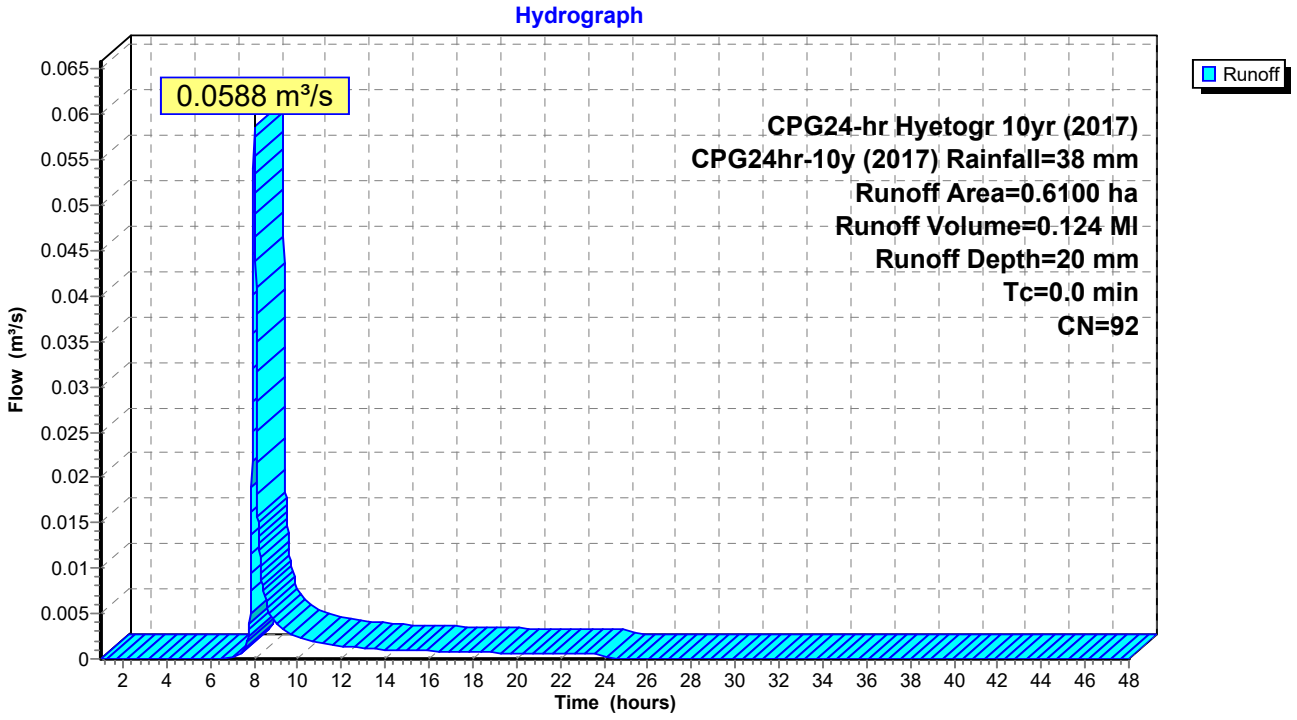
Runoff = 0.0588 m³/s @ 8.00 hrs, Volume= 0.124 Ml, Depth= 20 mm
Routed to Pond 12P : Recharge Chamber

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 10yr (2017) CPG24hr-10y (2017) Rainfall=38 mm

Area (ha)	CN	Description
0.6100	92	Urban commercial, 85% imp, HSG B
0.0915		15.00% Pervious Area
0.5185		85.00% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
0.0					**Direct Entry,**

Subcatchment 17S: Entire Site



Summary for Pond 12P: Recharge Chamber

Inflow Area = 0.6100 ha, 85.00% Impervious, Inflow Depth = 20 mm for CPG24hr-10y (2017) event
Inflow = 0.0588 m³/s @ 8.00 hrs, Volume= 0.124 Ml
Outflow = 0.0049 m³/s @ 8.77 hrs, Volume= 0.124 Ml, Atten= 92%, Lag= 45.7 min
Discarded = 0.0049 m³/s @ 8.77 hrs, Volume= 0.124 Ml
Tertiary = 0.0000 m³/s @ 1.00 hrs, Volume= 0.000 Ml

Routing by Stor-Ind method, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 3.238 m @ 8.77 hrs Surf.Area= 117.2 m² Storage= 47.3 m³

Plug-Flow detention time= 119.7 min calculated for 0.124 Ml (100% of inflow)
Center-of-Mass det. time= 119.7 min (781.4 - 661.7)

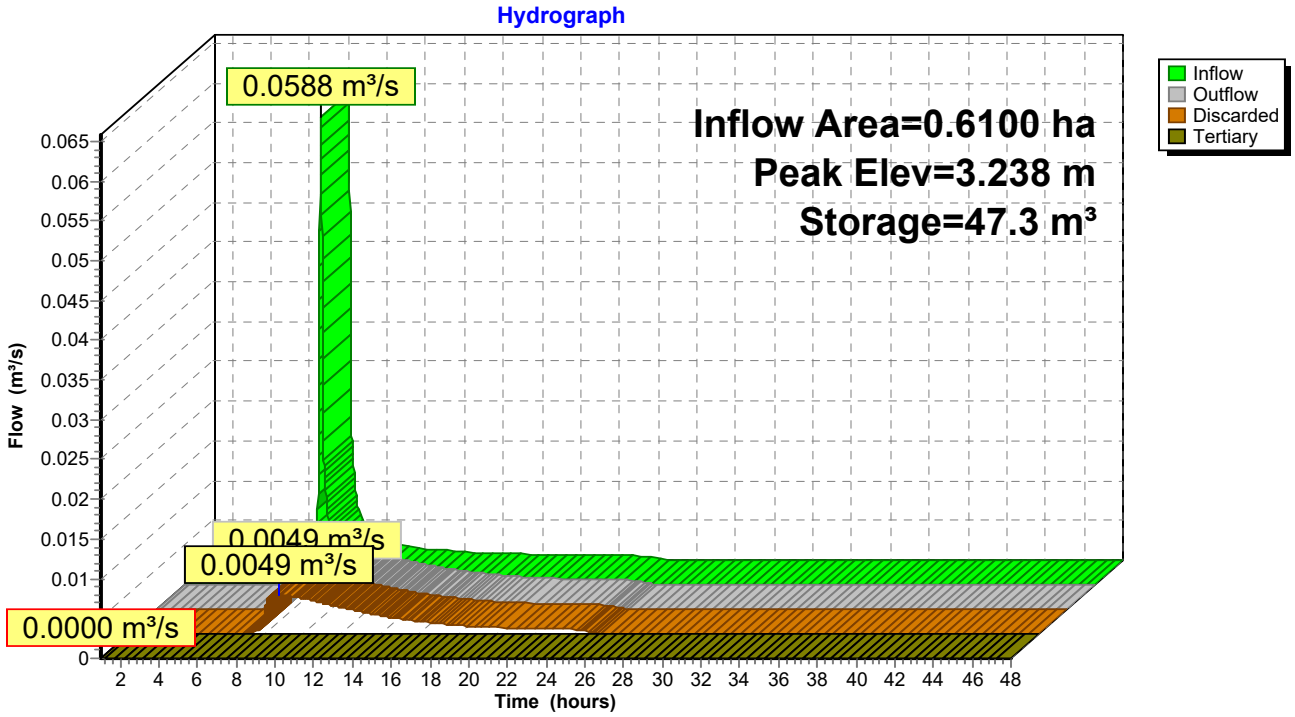
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	98.0 m³	**2.50 mD x 4.35 mH Vertical Cone/Cylinder Z=1.5** 326.8 m³ Overall x 30.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.000 m	**150.00 mm/hr Exfiltration over Surface area below 3.450 m**
#2	Tertiary	3.450 m	**300 mm Round Culvert** L= 1.00 m CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3.450 m / 3.440 m S= 0.0100 m/m Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.071 m²

Discarded OutFlow Max=0.0049 m³/s @ 8.77 hrs HW=3.238 m (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.0049 m³/s)

Tertiary OutFlow Max=0.0000 m³/s @ 1.00 hrs HW=0.000 m (Free Discharge)
└**2=Culvert** (Controls 0.0000 m³/s)

Pond 12P: Recharge Chamber



Time span=1.00-48.00 hrs, dt=0.01 hrs, 4701 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: Predevelopment Runoff Area=0.6100 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=80.0 m Slope=0.0100 m/m Tc=42.5 min CN=58 Runoff=0.0000 m³/s 0.000 Ml

Subcatchment 17S: Entire Site Runoff Area=0.6100 ha 85.00% Impervious Runoff Depth=12 mm
Tc=0.0 min CN=92 Runoff=0.0244 m³/s 0.074 Ml

Pond 12P: Recharge Chamber Peak Elev=2.280 m Storage=20.9 m³ Inflow=0.0244 m³/s 0.074 Ml
Discarded=0.0029 m³/s 0.074 Ml Tertiary=0.0000 m³/s 0.000 Ml Outflow=0.0029 m³/s 0.074 Ml

Total Runoff Area = 1.2200 ha Runoff Volume = 0.074 Ml Average Runoff Depth = 6 mm
57.50% Pervious = 0.7015 ha 42.50% Impervious = 0.5185 ha

Summary for Subcatchment 13S: Predevelopment

[45] Hint: Runoff=Zero

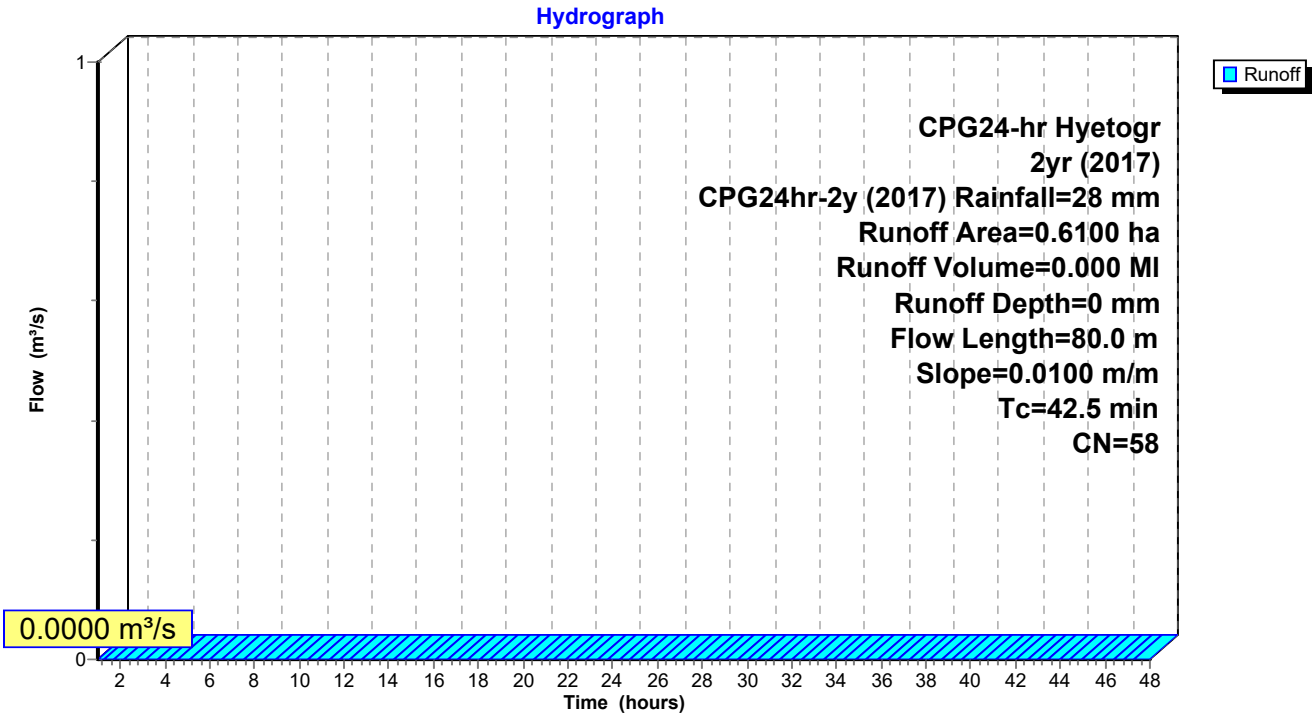
Runoff = 0.0000 m³/s @ 1.00 hrs, Volume= 0.000 Ml, Depth= 0 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 2yr (2017) CPG24hr-2y (2017) Rainfall=28 mm

Area (ha)	CN	Description
0.6100	58	Woods/grass comb., Good, HSG B
0.6100		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
42.5	80.0	0.0100	0.03		**Sheet Flow,** Range n= 0.130 P2= 28 mm

Subcatchment 13S: Predevelopment



Summary for Subcatchment 17S: Entire Site

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

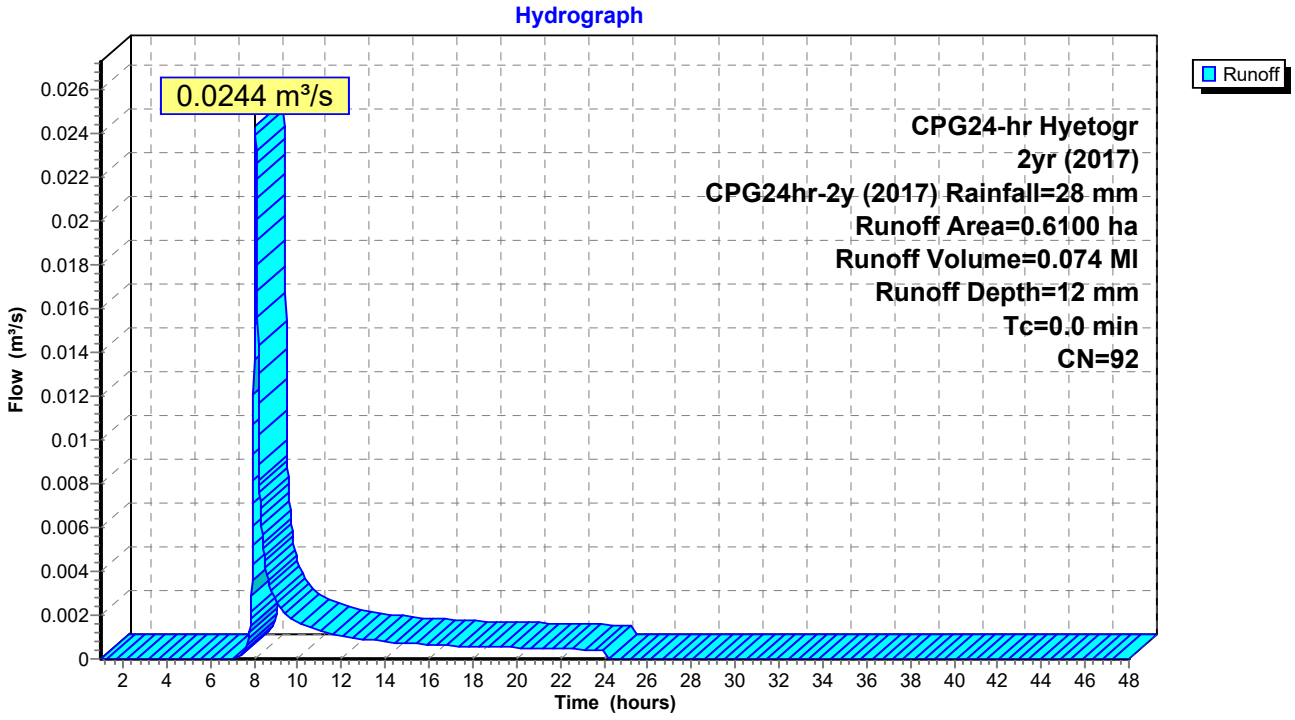
Runoff = 0.0244 m³/s @ 8.06 hrs, Volume= 0.074 Ml, Depth= 12 mm
Routed to Pond 12P : Recharge Chamber

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 2yr (2017) CPG24hr-2y (2017) Rainfall=28 mm

Area (ha)	CN	Description
0.6100	92	Urban commercial, 85% imp, HSG B
0.0915		15.00% Pervious Area
0.5185		85.00% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
0.0					**Direct Entry,**

Subcatchment 17S: Entire Site



Summary for Pond 12P: Recharge Chamber

Inflow Area = 0.6100 ha, 85.00% Impervious, Inflow Depth = 12 mm for CPG24hr-2y (2017) event
Inflow = 0.0244 m³/s @ 8.06 hrs, Volume= 0.074 Ml
Outflow = 0.0029 m³/s @ 8.90 hrs, Volume= 0.074 Ml, Atten= 88%, Lag= 49.9 min
Discarded = 0.0029 m³/s @ 8.90 hrs, Volume= 0.074 Ml
Tertiary = 0.0000 m³/s @ 1.00 hrs, Volume= 0.000 Ml

Routing by Stor-Ind method, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 2.280 m @ 8.90 hrs Surf.Area= 68.5 m² Storage= 20.9 m³

Plug-Flow detention time= 87.8 min calculated for 0.074 Ml (100% of inflow)
Center-of-Mass det. time= 87.8 min (802.5 - 714.7)

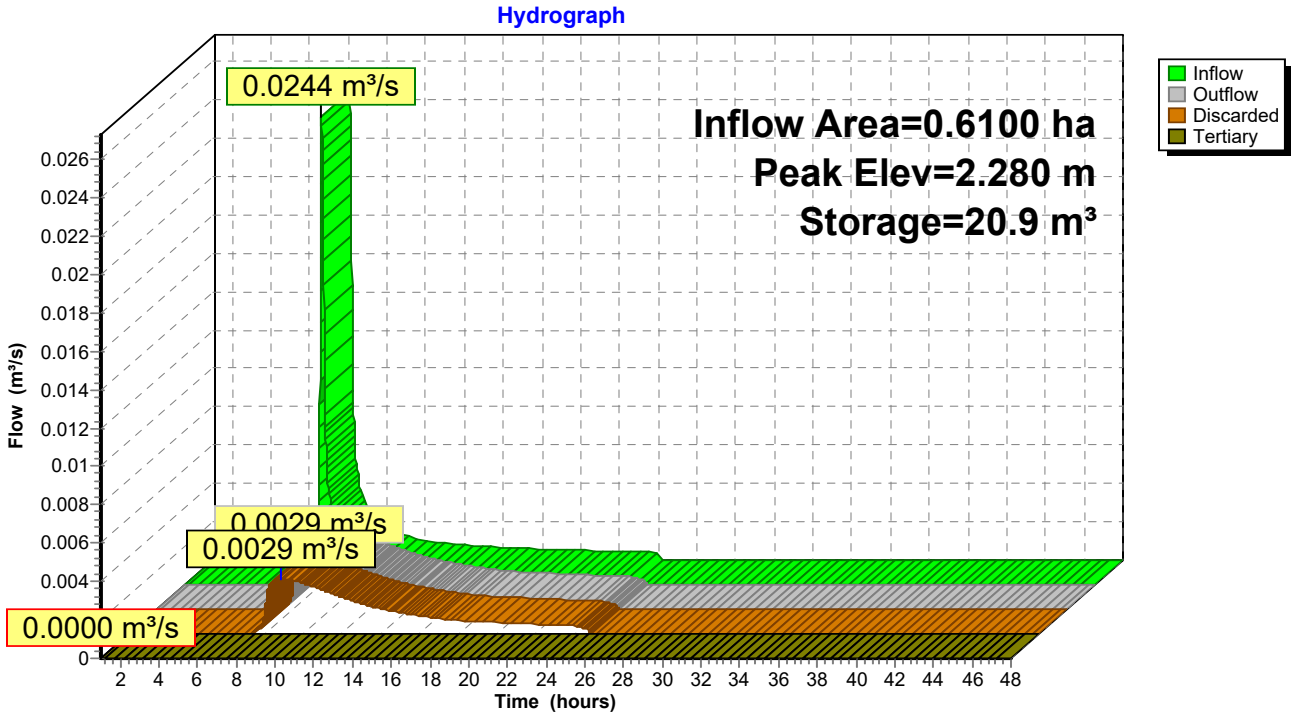
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	98.0 m³	**2.50 mD x 4.35 mH Vertical Cone/Cylinder Z=1.5** 326.8 m³ Overall x 30.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.000 m	**150.00 mm/hr Exfiltration over Surface area below 3.450 m**
#2	Tertiary	3.450 m	**300 mm Round Culvert** L= 1.00 m CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3.450 m / 3.440 m S= 0.0100 m/m Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.071 m²

Discarded OutFlow Max=0.0029 m³/s @ 8.90 hrs HW=2.280 m (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.0029 m³/s)

Tertiary OutFlow Max=0.0000 m³/s @ 1.00 hrs HW=0.000 m (Free Discharge)
└**2=Culvert** (Controls 0.0000 m³/s)

Pond 12P: Recharge Chamber



Time span=1.00-48.00 hrs, dt=0.01 hrs, 4701 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: Predevelopment Runoff Area=0.6100 ha 0.00% Impervious Runoff Depth=0 mm
Flow Length=80.0 m Slope=0.0100 m/m Tc=42.5 min CN=58 Runoff=0.0000 m³/s 0.000 Ml

Subcatchment 17S: Entire Site Runoff Area=0.6100 ha 85.00% Impervious Runoff Depth=17 mm
Tc=0.0 min CN=92 Runoff=0.0434 m³/s 0.103 Ml

Pond 12P: Recharge Chamber Peak Elev=2.881 m Storage=35.8 m³ Inflow=0.0434 m³/s 0.103 Ml
Discarded=0.0041 m³/s 0.103 Ml Tertiary=0.0000 m³/s 0.000 Ml Outflow=0.0041 m³/s 0.103 Ml

Total Runoff Area = 1.2200 ha Runoff Volume = 0.103 Ml Average Runoff Depth = 8 mm
57.50% Pervious = 0.7015 ha 42.50% Impervious = 0.5185 ha

Summary for Subcatchment 13S: Predevelopment

[45] Hint: Runoff=Zero

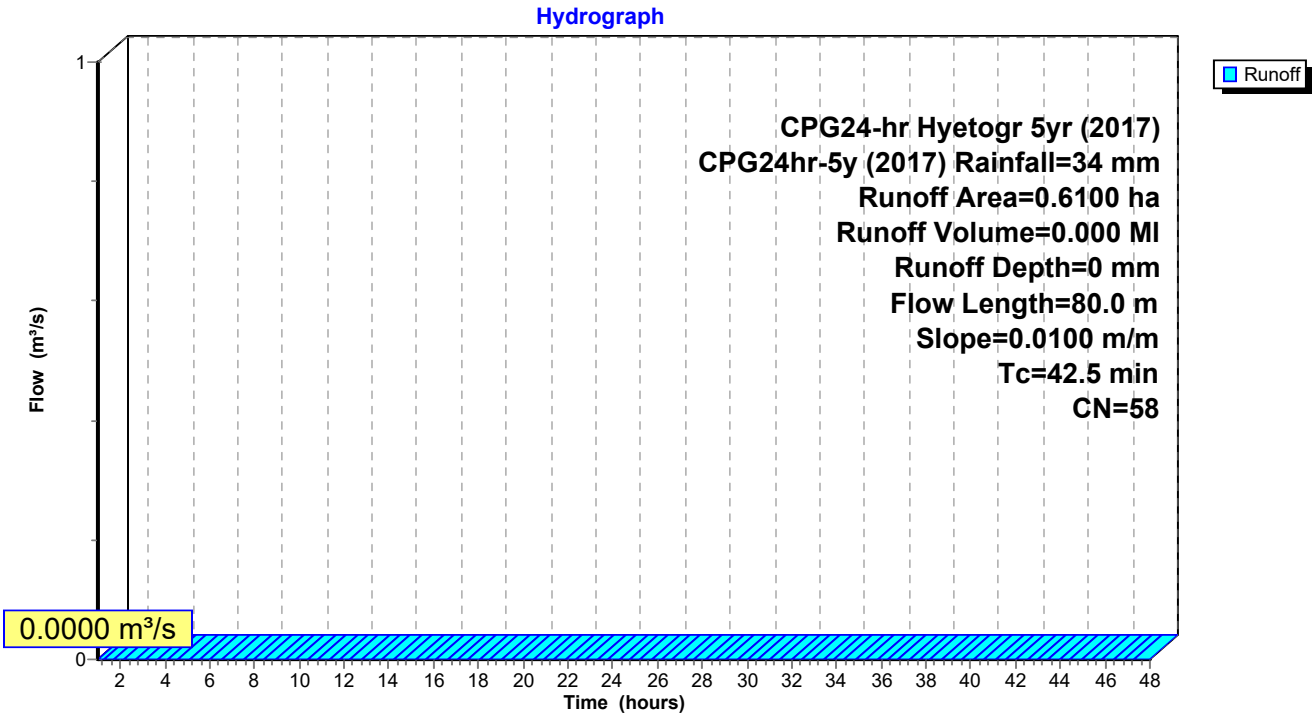
Runoff = 0.0000 m³/s @ 1.00 hrs, Volume= 0.000 Ml, Depth= 0 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 5yr (2017) CPG24hr-5y (2017) Rainfall=34 mm

Area (ha)	CN	Description
0.6100	58	Woods/grass comb., Good, HSG B
0.6100		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
42.5	80.0	0.0100	0.03		**Sheet Flow,** Range n= 0.130 P2= 28 mm

Subcatchment 13S: Predevelopment



Summary for Subcatchment 17S: Entire Site

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

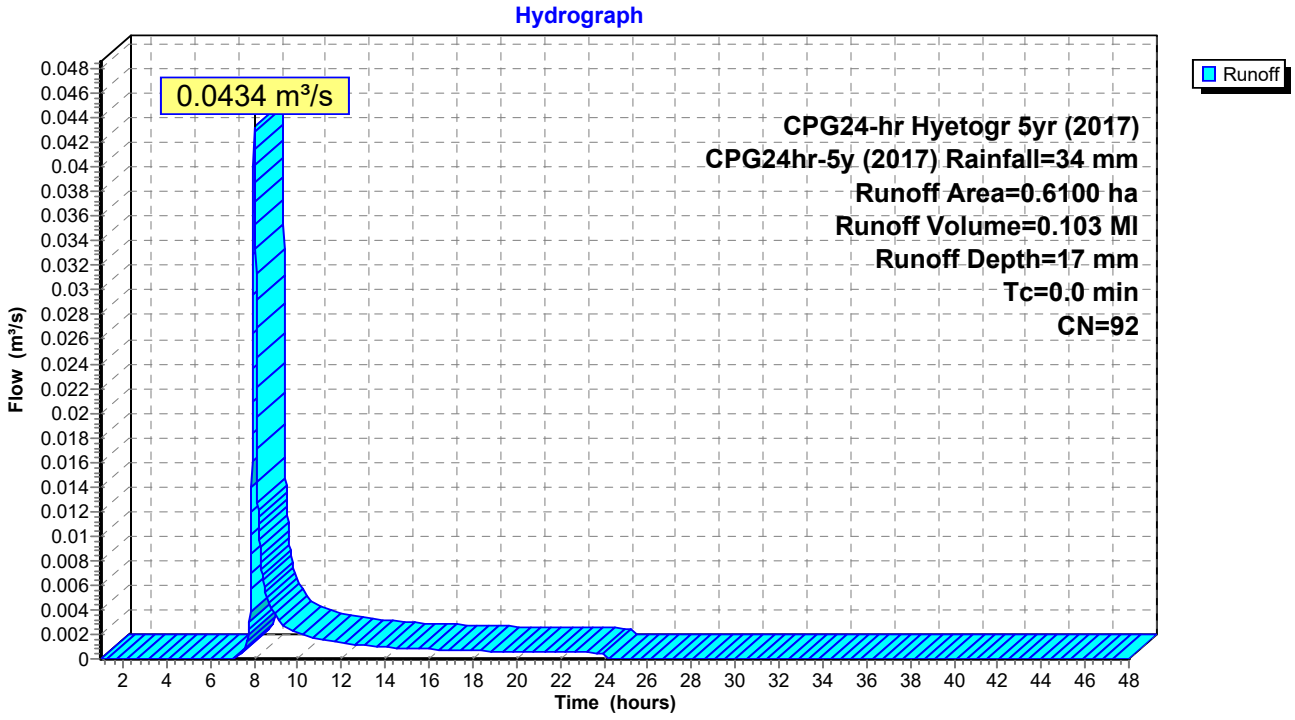
Runoff = 0.0434 m³/s @ 8.01 hrs, Volume= 0.103 Ml, Depth= 17 mm
Routed to Pond 12P : Recharge Chamber

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
CPG24-hr Hyetogr 5yr (2017) CPG24hr-5y (2017) Rainfall=34 mm

Area (ha)	CN	Description
0.6100	92	Urban commercial, 85% imp, HSG B
0.0915		15.00% Pervious Area
0.5185		85.00% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
0.0					**Direct Entry,**

Subcatchment 17S: Entire Site



Summary for Pond 12P: Recharge Chamber

Inflow Area = 0.6100 ha, 85.00% Impervious, Inflow Depth = 17 mm for CPG24hr-5y (2017) event
Inflow = 0.0434 m³/s @ 8.01 hrs, Volume= 0.103 Ml
Outflow = 0.0041 m³/s @ 8.79 hrs, Volume= 0.103 Ml, Atten= 91%, Lag= 47.0 min
Discarded = 0.0041 m³/s @ 8.79 hrs, Volume= 0.103 Ml
Tertiary = 0.0000 m³/s @ 1.00 hrs, Volume= 0.000 Ml

Routing by Stor-Ind method, Time Span= 1.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 2.881 m @ 8.79 hrs Surf.Area= 97.5 m² Storage= 35.8 m³

Plug-Flow detention time= 107.8 min calculated for 0.103 Ml (100% of inflow)
Center-of-Mass det. time= 107.8 min (786.7 - 678.9)

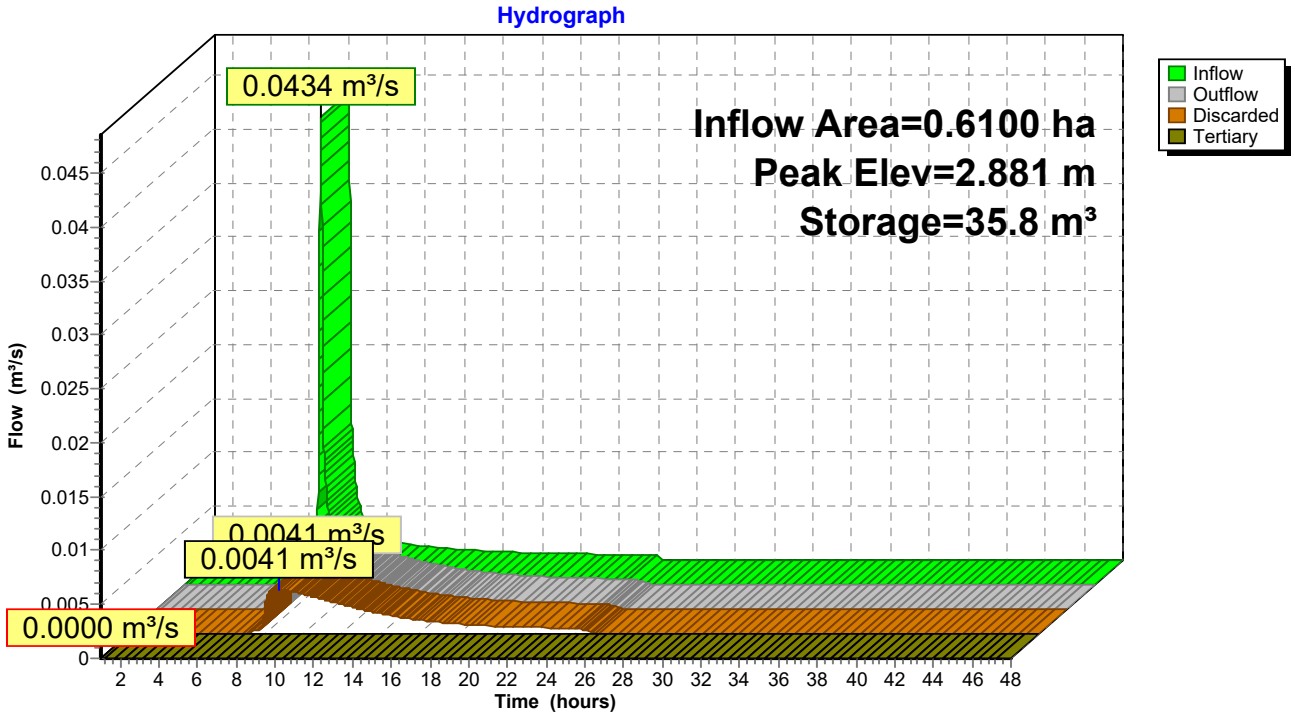
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	98.0 m³	**2.50 mD x 4.35 mH Vertical Cone/Cylinder Z=1.5** 326.8 m³ Overall x 30.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.000 m	**150.00 mm/hr Exfiltration over Surface area below 3.450 m**
#2	Tertiary	3.450 m	**300 mm Round Culvert** L= 1.00 m CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3.450 m / 3.440 m S= 0.0100 m/m Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.071 m²

Discarded OutFlow Max=0.0041 m³/s @ 8.79 hrs HW=2.881 m (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.0041 m³/s)

Tertiary OutFlow Max=0.0000 m³/s @ 1.00 hrs HW=0.000 m (Free Discharge)
└**2=Culvert** (Controls 0.0000 m³/s)

Pond 12P: Recharge Chamber



APPENDIX C

STORM MODELLING