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FUNCTIONAL SERVICING AND STORMWATER MANAGEMENT REPORT

FOR

THEBERGE HOMES DEVELOPMENT 21 WITHROW AVENUE

CITY OF OTTAWA

PROJECT NO.: 17-931

MARCH 2018 – REV 2

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FOR
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1.0 INTRODUCTION

David Schaeffer Engineering Ltd. (DSEL) has been retained to prepare a Functional Servicing and Stormwater Management Report in support of the Plan of Subdivision, Zoning By-Law Amendment (ZBLA) for the proposed development at 21 Withrow Avenue. Additionally, this report and the accompanying drawing package also support the Consent for Severance application for the residential units fronting Withrow Avenue.

The subject property is located within the City of Ottawa urban boundary, in the College ward. As illustrated in ***Figure 1***, the subject property is bounded by existing residences and Tower Road to the north, St. Helen's Place to the east, Withrow Avenue to the south and existing residences and Rita Avenue to the west. The subject property measures approximately ***0.82ha*** and is designated Residential First Density Zone (R1FF) under the current City of Ottawa zoning by-law.

Figure 1: Site Location

The proposed development involves the construction of 13 single family homes, and a detached garage for the existing residence on the property. A copy of the proposed site plan is included in ***Drawings/Figures***. The single parcel is proposed to be subdivided into 4 units fronting onto Withrow Avenue, with the remaining main property subdivided in accordance with the ***Legal Plan*** provided in ***Drawings/Figures.***

The objective of this report is to support the application for Plan of Subdivision and ZBLA by providing sufficient detail to demonstrate that the proposed development is supported by existing and proposed municipal servicing infrastructure and that the site design conforms to current City of Ottawa design standards. Please refer to the associated drawing package to support the Consent for Severance Application for the units fronting Withrow Avenue.

1.1 Existing Conditions

The subject site currently consists of one single family home and garage. which are surrounded by grassy areas and a few trees.

Sewer system and watermain distribution mapping collected from the City of Ottawa indicate that the following services exist across the property frontages within the adjacent municipal right-of-ways:

St. Helen's Place

150mm diameter watermain

200mm diameter sanitary sewer

Withrow Avenue

150mm diameter watermain

200mm diameter sanitary sewer

Cleto Avenue

150mm diameter watermain

200mm diameter sanitary sewer

300mm diameter storm sewer

Rita Avenue

150mm diameter watermain

200mm diameter sanitary sewer

1.2 Required Permits / Approvals

Development of the site is subject to the City of Ottawa Planning and Development Approvals process. The City of Ottawa must approve detailed engineering design drawings and reports, prepared to support the proposed development plan.

The subject property contains existing trees. Development, which may require removal of existing trees, maybe subject to the City of Ottawa Urban Tree Conservation By-law No. 2009-200.

It is proposed that multiple property will be serviced by a single stormwater management system. As such, it is anticipated that an Environmental Compliance Approval (ECA) through a direct submission to the Ministry of the Environment and Climate Change (MOECC) will be required.

1.3 Pre-consultation

Pre-consultation correspondence and the servicing guidelines checklist are located in ***Appendix A***.

The pre-consultation notes indicate the City requires separate stormwater requirements for the proposed 4 lots fronting Withrow Avenue and the remaining property being serviced by a private roadway. The lots fronting Withrow Avenue will be subject to a Consent of Severance Application and it is required that these units be serviced independently and directly from Withrow Avenue. It is proposed to have drainage from the 4 units fronting Withrow Avenue to be directed to the subdivision to the north, therefore, the units have been reviewed in the interim and ultimate condition with the stormwater management plan for the subdivision.

Sanitary and water servicing described in the pre-consultation notes were based on an outdated concept plan. The current plan shows only a road connection to St. Helen’s Place, therefore water and sanitary servicing proposed is different than described in the pre-consultation notes.

City of Ottawa staff have indicated the importance of retention of the landscaping edge condition of at the property line and on adjacent property. The plan and reports have been prepared in consideration of retaining the edge condition and landscaping on adjacent property.

2.0 GUIDELINES, PREVIOUS STUDIES, AND REPORTS

2.1 Existing Studies, Guidelines, and Reports

The following studies were utilized in the preparation of this report.

- **Ottawa Sewer Design Guidelines**,
  City of Ottawa, *SDG002****,*** October 2012.
  (City Standards)

- **Ottawa Design Guidelines – Water Distribution**
  City of Ottawa, October 2012.
  (Water Supply Guidelines)
  - **Technical Bulletin ISD-2010-2**
    City of Ottawa, December 15, 2010.
    (*ISD-2010-2*)

  - **Technical Bulletin ISDTB-2014-02**
    City of Ottawa, May 27, 2014.
    (*ISDTB-2014-02*)

- **Stormwater Planning and Design Manual,**
  Ministry of the Environment, March 2003.
  (SWMP Design Manual)

- **Ontario Building Code Compendium**
  Ministry of Municipal Affairs and Housing Building Development Branch, January 1, 2010 Update.
  (OBC)

- **Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems**
  National Fire Protection Association
  2014 Edition.
  (NFPA 25)

- **Merivale Road Sewer Investigation and Hydraulic Assessment Study- Final Report**
  Delcan Corporation
  January 2000.
  (Merivale Road Sewer Investigation)

3.0 WATER SUPPLY SERVICING

3.1 Existing Water Supply Services

The subject property lies within the City of Ottawa 2W pressure zone, as shown by the Pressure Zone map in ***Appendix B.*** In reality the site is serviced by the ME pressure zone and therefore is part of this pressure zone. Watermains exist within St. Helen's Place, Withrow Avenue, Cleto Avenue and Rita Avenue.

3.2 Water Supply Servicing Design

The subject property is proposed to be serviced through a connection to the existing 150mm municipal watermain within St. Helen's Place. It is proposed to service the site with a ***200mm*** watermain up to the proposed private hydrant, after which a ***50mm*** service will service the remaining development. It is proposed that ***19mm*** water service will service the individual units. The proposed hydrant is located a maximum of ***85m*** from the furthest unit, in accordance with the ***OBC***.

Water servicing for the units fronting the private site was analyzed for pressure and fire flow.

Table 1 summarizes the ***Water Supply Guidelines*** employed in the preparation of the water demand estimate.

Table 1
Water Supply Design Criteria

Design Parameter	Value
Residential Demand	350 L/p/d
Residential Maximum Daily Demand	4.9 x Average Daily *
Residential Maximum Hourly	7.4 x Average Daily *
Minimum Watermain Size	150mm diameter
Minimum Depth of Cover	2.4m from top of watermain to finished grade
During normal operating conditions desired operating pressure is within	350kPa and 480kPa
During normal operating conditions pressure must not drop below	275kPa
During normal operating conditions pressure shall not exceed	552kPa
During fire flow operating pressure must not drop below	140kPa

** Residential Max. Daily and Max. Hourly peaking factors per MOE Guidelines for Drinking-Water Systems Table 3-3 for 0 to 500 persons.*
*** Table updated to reflect ISD-2010-2*

Table 2 summarizes the anticipated water demand and boundary conditions for the proposed development, calculated using the ***Water Supply Guidelines.***

Table 2
Proposed Water Demand

Design Parameter	**Anticipated Demand[1] (L/min)**	**Boundary Conditions[2] (m H_2O / kPa)**	
Average Daily Demand	11.7	66.0	647.5
Max Day + Fire Flow	57.2 + 10,000	26.1	256.0
Peak Hour	86.3	60.9	597.4

1) Water demand calculation per ***Water Supply Guidelines***. See ***Appendix B*** for detailed calculations.
2) Boundary conditions supplied by the City of Ottawa for the demands indicated in the correspondence; assumed ground elevation 97.5m at the connection to the municipal watermain. See ***Appendix B.***

In accordance with the **ISDTB-2014-02** the units have been capped at a maximum fire flow of ***10,000 L/min***.

The City provided both the anticipated minimum and maximum water pressures, as well as, the estimated water pressure during fire flow as indicated by the correspondence in ***Appendix A***.

3.3 Watermain Modelling

EPANet was utilized to determine the availability of pressures throughout the system during average day, max day plus fire flow, and peak hour demands. This static model determines pressures based on the available head obtained from the boundary conditions provided by the City of Ottawa.

The model utilizes the Hazen-Williams equation to determine pressure drop, while the pipe properties have been selected in accordance with ***Water Supply Guidelines***. The model was prepared to assess the available pressure at the finished first floor of each building, as well as, the pressures the watermain provides to fire hydrants during fire flow conditions.

A demand of 10,000 L/min was applied to the proposed fire hydrant, and resulted in a minimum pressure of ***204.5 kPa***. This hydrant can provide the required fire flow while maintaining minimum pressures described in ***Table 1***. ***Appendix B*** contains a model sketch showing the node locations, fire demand assigned to the hydrant and resulting pressures.

Table 3
Model Simulation Output Summary

Location	**Average Day (kPa)**	**Max Day + Fire Flow (kPa)**	**Peak Hour (kPa)**
Node 2	669.3	209.8	619.3
Node 3 (Hydrant)	668.1	208.7	618.1
Node 4	667.5	205.2	611.5
Node 5	666.9	204.5	610.6
Node 6	667.4	204.9	610.9

As demonstrated in ***Table 3***, the anticipated pressures during the average day and peak hour simulations are higher than allowable pressures in ***Table 1***. Pressure reducing valves are recommended. The recommended pressures from the ***Water Supply Guidelines*** are respected during the max day + fire flow scenario. ***Appendix B*** contains output reports and model schematics for each scenario.

The model predicted that water will flow in all areas of the system and no 'dead' zones were found. ***Appendix B*** contains output reports and model schematics for each scenario.

3.4 Water Supply Conclusion

It is proposed to service the private development from one connection to the existing 150mm watermain within St. Helen's Place.

The anticipated water demand was submitted to the City of Ottawa for establishing boundary conditions.

Based on the EPANET model, pressures during max day + fire flow respect the requirements of the ***Water Supply Guidelines***. Pressures during the average day and peak hour scenario are higher than allowable pressure in ***Table 1***; thus pressure reducing valves are recommended.

The design of the water distribution system conforms to all relevant City Guidelines and Policies.

4.0 WASTEWATER SERVICING

4.1 Existing Wastewater Services

The subject property lies within the Viewmount Drive Trunk sewer catchment area and on the border of the Lynwood Trunk Sewer, as shown by the ***Trunk Sanitary Sewers and Collection Areas Map*** included in ***Appendix C***. There are existing sanitary sewers within St. Helen's Place, Withrow Avenue, Cleto Avenue and Rita Avenue. The existing site consists of a single residential unit, and anticipated wastewater flow is summarized in ***Table 4,*** below:

Table 4
Summary of Existing Wastewater Flows

Design Parameter	Anticipated Sanitary Flow[1] (L/s)
Average Dry Weather Flow Rate	0.02
Peak Dry Weather Flow Rate	0.06
Peak Wet Weather Flow Rate	0.29
1) Based on criteria shown in ***Table 5***	

Based on the ***Merivale Road Sewer Investigation*** the most restrictive leg of sewer up to the 450mm diameter trunk sewer within Merivale, is between Node 920 and 220 on St. Helen's Place with a residual capacity of ***12.8 L/s***. Refer to ***Appendix C*** for sanitary drainage figure and sanitary design sheet extracted from the ***Merivale Road Sewer Investigation***.

4.2 Wastewater Design

It is anticipated that the proposed development will be serviced via a connection to the existing 200mm sanitary sewer within St. Helen's Place. Refer to the drawing ***SSP-1*** in ***Drawings/Figures*** for sanitary servicing layout.

Table 5 summarizes the ***City Standards*** employed in the calculation of wastewater flow rates for the proposed development.

Table 5
Wastewater Design Criteria

Design Parameter	Value
Residential Demand	350 L/p/d
Peaking Factor	Harmon's Peaking Factor. Max 4.0, Min 2.0
Infiltration and Inflow Allowance	0.28L/s/ha
Sanitary sewers are to be sized employing the Manning's Equation	$Q = \frac{1}{n} A R^{2/3} S^{1/2}$
Minimum Sanitary Sewer Lateral	135mm diameter
Minimum Manning's 'n'	0.013
Minimum Depth of Cover	2.5m from crown of sewer to grade
Minimum Full Flowing Velocity	0.6m/s
Maximum Full Flowing Velocity	3.0m/s
Extracted from Sections 4 and 6 of the City of Ottawa Sewer Design Guidelines, October 2012.	

Table 6 demonstrates the anticipated peak flow from the proposed development to the sanitary connection within St. Helen's Place. See ***Appendix C*** for associated calculations.

Table 6
Summary of Proposed Wastewater Flows

Design Parameter	Anticipated Sanitary Flow[1] (L/s)
Average Dry Weather Flow Rate	0.19
Peak Dry Weather Flow Rate	0.78
Peak Wet Weather Flow Rate	1.01
1) Based on criteria shown in ***Table 5***	

The estimated sanitary flow based on the ***Site Plan*** provided in ***Drawings/Figures*** anticipates a peak wet weather flow of ***1.01L/s*** to the St. Helen's Place sanitary connection. This results in an increase of ***0.72 L/s*** compared to existing conditions.

Based on the ***Merivale Road Sewer Investigation***, the most restrictive leg of sewer up to the trunk sewer within Merivale has an available capacity of ***12.8L/s***, therefore, the increase can be accommodated in the downstream system.

4.3 Wastewater Servicing Conclusions

The site is tributary to the Viewmount Drive Trunk sewer andcurrently the site consists of a single residential unit. Sufficient capacity is available to accommodate the anticipated ***0.72L/s*** peak wet weather flow increase from the proposed development to the downstream system.

The proposed wastewater design conforms to all relevant ***City Standards***.

5.0 STORMWATER MANAGEMENT

A stormwater management strategy has been developed to ensure there is no increased risk of flooding to the surrounding residential neighbourhood due to the development. Hydraulic and hydrological models have been generated to analyze the existing, interim and proposed conditions.

5.1 Model Summary

The hydrology and hydraulics of the proposed stormwater management system were analyzed in EPASWMM using the Dynamic Wave Routing Model.

The following assumptions were made in the preparation for the EPASWMM model:

- Hydrology
  - Initial abstraction parameters per City of Ottawa standards.
  - Horton's infiltration for soil loss, per City guidelines.
  - Calculated % impervious area
  - Sub-catchment width measured as perpendicular area to catch basins for longest distance of travel.
- Hydraulics
  - Storage Nodes represent both surface and subsurface components. Each node is assigned an invert elevation that corresponds with the tributary catch basin.
  - "Regular" Node represent either connections to the sewer main or strategic maintenance hole locations. Not all structures have been included in model.
  - All conduits have been assigned a Mannings n = 0.013.
  - Orifices are all side mounted, circular and have a 0.61 discharge coefficient.

Refer to a summary of the hydrological parameters used for each sub catchment in the tables below:

Table 7
Summary of Hydrologic Parameters Existing, Interim & Proposed

Drainage Area ID	Total Area (ha)	% Impervious	Width (m)	Slope (%)	Manning's N – Pervious	Manning's N – Impervious	Initial Abstraction – Pervious	Initial Abstraction – Impervious
Existing Condition								
EX12	0.198	57	99	2	0.013	0.25	1.57	4.67
EX13	0.559	57	223.6	2	0.013	0.25	1.57	4.67
EX15	0.063	86	3	2	0.013	0.25	1.57	4.67
EX1-EX2-A1	0.804	19	60	2	0.013	0.25	1.57	4.67
A2	0.194	13	40	2	0.013	0.25	1.57	4.67
Proposed Condition								
D1-D6	0.701	54	50	2	0.013	0.25	1.57	4.67
EX2	0.041	29	27	2	0.013	0.25	1.57	4.67
EX1	0.139	39	92	2	0.013	0.25	1.57	4.67
U2	0.075	9	100	2	0.013	0.25	1.57	4.67
Interim Condition								
A1, A3, EX1, EX2	0.765	25	60	2	0.013	0.25	1.57	4.67
All Drainage Areas use Horton's Infiltration Parameters as per the ***City Standard***								

5.2 Existing Stormwater Services

Stormwater runoff from the subject property is tributary to the City of Ottawa sewer system located within the Ottawa Central sub-watershed. As such, approvals for proposed developments within this area are under the approval authority of the City of Ottawa.

Flows that influence the watershed in which the subject property is located are further reviewed by the principal authority. The subject property is located within the Ottawa River watershed and is therefore subject to review by the Rideau Valley Conservation Authority (RVCA).

The existing runoff from the subject site is directed to 2 separate outlets; Tower Road and St. Helen's Place. The majority of flow is directed to St. Helen's Place where flow continues north to Tower Road. Both outlets are conveyed through a series of undefined ditch systems, which are generally draining north through the existing residential neighborhood.

In the existing condition flow from the property is conveyed to Tower Road where surface ponding would result. The existing overland flow is north through the 23 Tower Road property, refer to drawing ***SWM-1*** in ***Drawings/Figures*** for existing overland flow route.

An analysis of varying storm events was conducted to determine the critical event in the existing condition, summarized in ***Table 8*** below:

Table 8
Existing Flow from Subject Site, 100-year Storm Varying Storm Distribution

Storm Distribution	Total Flow to Tower Road (Area A2, A1, EX1, EX2) (0.998 Ha) (L/s)
3 Hr Chicago	114.3
4 Hr Chicago	119.8
6 Hr Chicago	127.2
12 Hr SCS	122.2

As shown in the above, the 6 Hr Chicago Distribution results in the highest flow from the site to Tower Road, and therefore, will be used in the existing conditions analysis.

Table 9, below, summarizes the flow from the subject property and adjacent external areas directed to Tower Road & St Helen's Place, refer to ***Appendix D*** for EPASWMM output summary.

Table 9
Existing Flow from Subject Site, 6-Hr Chicago Distribution

	Flow to St. Helen's Place from Area EX1, EX2, A1 (0.804 Ha)		Flow to Tower Road Flow from Area A2 (0.194 Ha)	
Storm Event	**Flow (L/s)**	**Runoff Volume (cu.m)**	**Flow (L/s)**	**Runoff Volume (cu.m)**
2-Year	5.9	10	6.3	10
5-Year	22.6	50	13.0	20
100-Year	89.6	240	41.7	70

An existing 300mm storm sewer exists within Cleto Ave which drains eastwards towards Merivale Road, refer to ***SWM-1*** in ***Drawings/Figures*** for existing drainage patterns from the subject site and the adjacent storm sewer. Based on the size (300mm) and slope (1.2%) of the existing sewer on Cleto Ave., there is a free flowing capacity of ***108.1 L/s***.

The existing storm sewers were analyzed during the 2, 5 and 100-year events using a 6-hour Chicago distribution. ***Table 10, below,*** summarizes the flow and surcharge at each node analyzed up to Merivale Road.

Table 10
Existing Flow in Cleto Ave Sewer, 6-Hr Chicago Distribution

Storm Event	2-Year Storm		5-Year Storm		100-Year Storm	
Node ID	**Flow (L/s)**	**Surcharge (L/s)**	**Flow (L/s)**	**Surcharge (L/s)**	**Flow (L/s)**	**Surcharge (L/s)**
AD	31.8	0	49.9	0	93.2	7.8
STM12	31.0	0	49.3	0	87.7	51.1
STM13	111.2	0	183.8	0	296.3	0
STM15	120.3	0	199.1	0	324.1	0

The inlet capacity of the area drains which convey flow from Area EX12 to the existing 300mm CSP sewer was analyzed. The inlet capacity was determined to be greater than the 100-year flow from EX12, refer to analysis in ***Appendix D*** of this report. No restrictions where therefore modeled and it is assumed EX12 can drain to the existing 300mm during the 100-year event without restriction.As illustrated above, surcharge occurs at node AD and STM12.

Please refer to existing model schematic below for more detail.

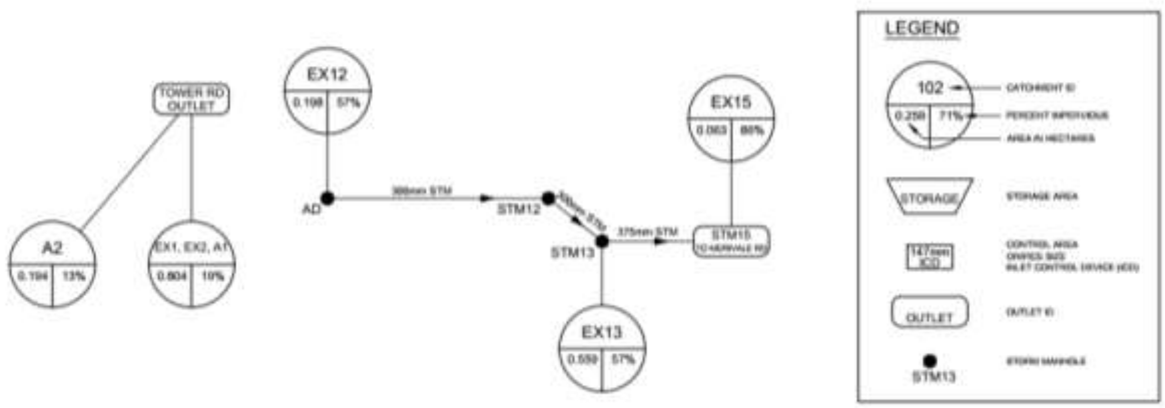

Figure 2: Existing Condition EPASWMM Node Diagram

5.3 Post-development Stormwater Management Targets

Stormwater management requirements for the proposed development were reviewed with the City of Ottawa, and are summarized below:

- Attenuate to a target release rate based on a calculated Rational Method Coefficient no more than 0.5, employing the City of Ottawa IDF parameters for a 2-year storm with a calculated time of concentration equal to or greater than 10 minutes;
- Time of concentration calculated using the Federal Aviation Administration method, slope and length based on the longest flow path to the lowest point within the subject site;
- Flow attenuation is required up to and including the 100-year storm event;
- Ensure no negative impacts to downstream stormwater network from the proposed development;
- Areas to be retained as existing to ensure the edge condition and adjacent landscaping is maintained and will continue to drain as existing thus ensuring no increase in peak flow compared to the existing condition;

- External areas directed to the site are to be accommodated in the stormwater conveyance system.

Based on the drainage area in the proposed condition of ***0.701 ha, 0.29 RC*** and a calculated time of concentration of ***21.2 minutes***, a target release rate of ***28.3 L/s*** is determined, refer to calculation in ***Appendix D*** for details. The actual release rate may vary from the target, ensuring there are no negative impacts to the downstream storm sewer system.

5.4 Proposed Stormwater Management System

As discussed in ***Section 1.3***, the City of Ottawa has stressed the importance of retaining the existing edge condition on the adjacent property. To ensure no impact to adjacent landscaping, the grading of the north-west edge of the site has been retained as existing. Alternatively, if this area is re-graded to fully capture stormwater in the on-site system, a retaining wall would be required along the north-west edge impacting the existing edge condition and off-site mature trees.

The stormwater management system is proposed to collect runoff through a series of internal swales, eventually discharging to a Ditch Inlet Catch Basin (DICB) and sewer connected to the existing 300mm diameter storm sewer within Cleto Ave. The DICB has been sized to convey the uncontrolled 100-year flow of ***182 L/s*** with a maximum head of ***0.18m***, refer to calculations in ***Appendix D***. A spill point exists at ***97.35m*** which allows for emergency flow and overflow equal to the external flow into the site to release in the 100-year event.

External drainage directed to the subject site will be conveyed through internal swales. During storm events up to the 100-year event the external drainage will be captured and controlled by the ICD. In the 100-year storm event and greater spill will occur to St. Helen's Place. Spill will occur at a rate of ***70.2 L/s*** to St. Helen's place at a maximum head of ***6cm***, the spill is less than the runoff from EX1 and EX2 of ***79.7 L/s***.

A ***147mm*** circular inlet control device (ICD) is proposed to control flow from the subject site to the release rate at a high-water level of ***97.42m*** or equal to ***0.88m*** of head above the ICD. A total flow of ***40.9 L/s*** is proposed by the orifice, however, the increase compared to the target release rate is shown to not have an impact on the downstream system.

Underground storage is required to control flow to the allowable release rate. Underground storage proposed to be provided by Brentwood Storm Tank model numbers ST-18 & ST-30 where cover allows (or equivalent approved by the City of Ottawa Planning Staff). The tanks have been broken up into 3 separate areas connected by storm sewers summarized below:

Table 11
Storage Tank Summary

Tank Detail	Tank # 1	Tank # 2	Tank # 3
Length (m) x Width (m)	59 x 3	22.3 x 2.1	7 x 10
Model #	ST-18	ST-18	ST-30
Invert (m)	96.59	96.59	96.59
Obvert (m)	97.05	97.05	97.35
Minimum Cover (mm)	530	540	650
Provided Storage (m^3)	109.8	30.6	64.5

Further details on the storage capacity and cross sections for the underground storage tanks are included in ***Appendix D.***

In addition to underground storage, surface storage is provided on-site. A total of ***12m³*** of surface ponding is available, surface ponding in rear yards is not accounted for in this calculation.

An analysis of varying storm events was conducted to determine the critical event in the existing condition, summarized in ***Table 12*** below:

Table 12
Proposed Flow from Subject Site, 100-year Storm Varying Storm Distribution

Storm Distribution	Total Flow to Internal Storage (Area D1-D6) (0.701 Ha) (L/s)	Total Storage Required (m^3)
3 Hr Chicago	237.2	208
4 Hr Chicago	244.0	209
6 Hr Chicago	252.3	209
12 Hr SCS	166.8	208

As shown in the above, the 6 Hr Chicago Distribution results in the highest peak flow and storage requirement, and therefore, will be used in the proposed condition analysis.

The storage requirements and flow are summarized in ***Table 11*** below, refer to ***Appendix D*** for EPASWMM output summary.

Table 13
Proposed Storage and Flow from Subject Site, 6-Hr Chicago Distribution

Storm Event	Flow from External Area (EX1, EX2, 0.18 Ha) (L/s)	Flow from ICD (EX1, EX2, A1, 0.881 Ha) (L/s)	Required Storage (cu.m)	Flow to Tower Road (Area U2, 0.075 Ha)	Flow to St. Helen's (L/s)
2-Year	18.5	14.5	44	3.3	0
5-Year	36.0	21.9	93	11.5	0
100-Year	79.7	40.9	209	31.2	70.2

During the 100-year storm event a storage of ***209m³*** is required to a release rate of ***40.9 L/s.***

The existing stormwater system was analyzed including the contribution from the subject property and is summarized in ***Table 12,*** below.

Table 14
Proposed Flow in Cleto Ave Sewer, 6-Hr Chicago Distribution

Storm Event	2-Year Storm		5-Year Storm		100-Year Storm	
Node ID	**Flow (L/s)**	**Surcharge (L/s)**	**Flow (L/s)**	**Surcharge (L/s)**	**Flow (L/s)**	**Surcharge (L/s)**
AD	35.5	0	56.4	0	94.4	3.05
STM12	34.8	0	55.3	0	90.8	51.0
STM13	114.6	0	189.5	0	296.3	0
STM15	123.7	0	204.7	0	324.1	0

Comparing ***Table 14*** to ***Table 10*** shows that there is approximately a ***2.7%*** increase in flow in the 2-year and 5-year event and flow is still contained within the sewer. Furthermore, there is no change flow to the Merivale Road Sewer at STM15 in the 100-year event. There is no increase in surcharge in the proposed condition at either node AD or STM12.

Please refer to proposed model schematic below for more detail.

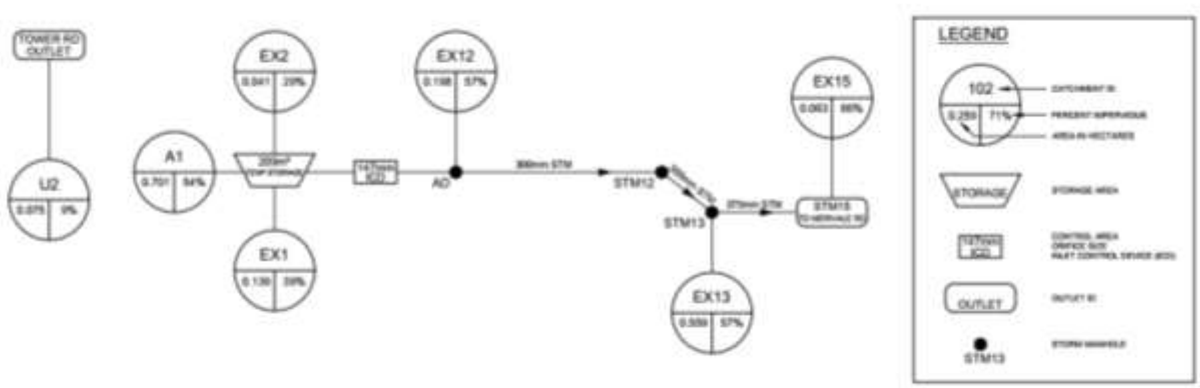

Figure 3: Proposed Condition EPASWMM Node Diagram

The stormwater management plan is proposed to re-direct flow away from Tower Road and to Cleto Avenue. This results in a reduced peak flow and runoff volume to Tower Road and provides a benefit to residents on Tower Road that currently would have issues with surface ponding and overland flow through their private property.

The flow to the existing Cleto Avenue storm sewer from the proposed development and runoff from EX12 is summarized graphically below, for the 100-year storm event.

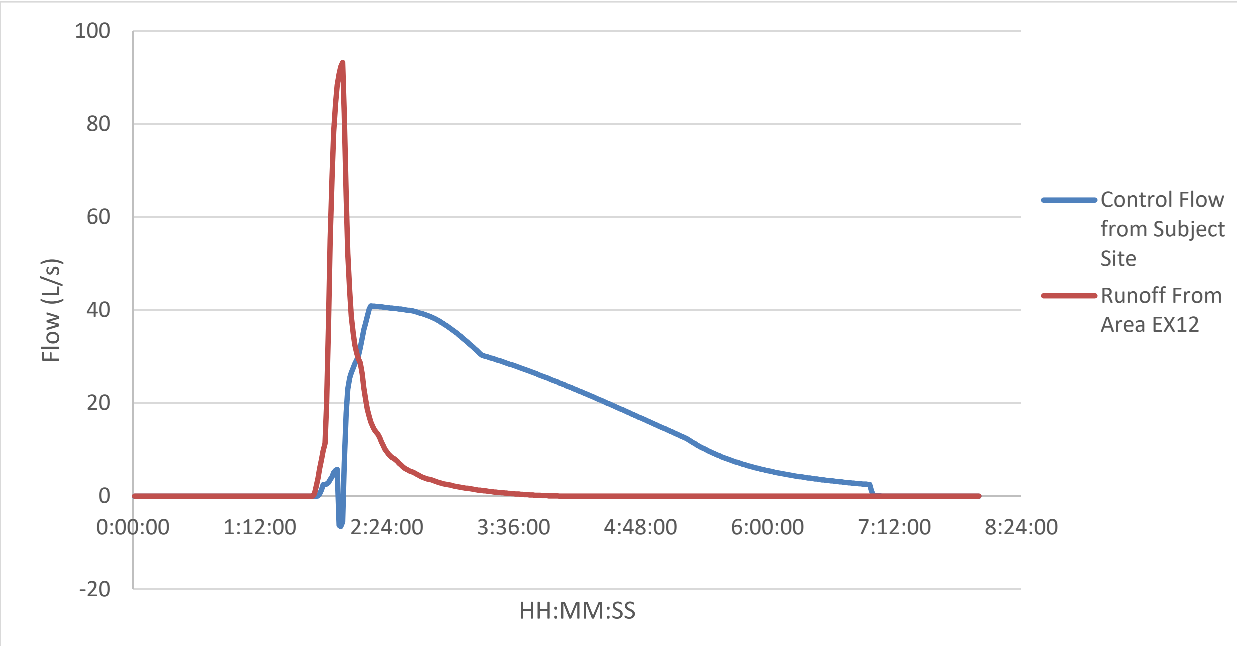

Figure 4: Flow from Subject Site, Runoff from Area EX12, 100-year Storm event 6 Hr Chicago distribution

It is proposed to service the foundation drainage from the units through the use of sump pumps discharging to surface.

The development employs a rural cross section and grass swales as a best management practice. The swales have been designed with a minimal slope of 0.50% which reduces flow velocities within the swale and promotes on-site TSS removal and infiltration. The proposed stormwater management system uses ditches and culverts to convey the minor and major storm event from internal and external areas draining to the site to the DICB at the outlet. Sizing of the culverts and ditches has been included in ***Appendix D***.

Full quality controls will be provided by an external facility, per the RVCA correspondence in ***Appendix A***.

5.5 Interim Stormwater Servicing Strategy

It is proposed to develop the site in phases with the 4 units fronting Withrow Ave proceeding before the remainder of the site connected to the private road. It is proposed to provide grading such that the front portion of the units will drain to the Withrow Ave ROW and the roof and rear yard area will drain south to the future subdivision. It is proposed to provide an interim ditch with a total storage of ***46m³*** to provide quantity control for the increase in imperviousness proposed by the units fronting Withrow Avenue. A triangular outlet in the ditch will detain flow before using existing drainange patterns to discharge to St. Helen's Place. Refer to ***SWM-3*** in ***Drawings/Figures*** for interim drainage areas and interim stormwater management plan and ***Appendix D*** for interim model output files.

The flows in the interim condition are summarized below:

Table 15
Flow during Interim Condition, 6-Hr Chicago Distribution

	Flow to St. Helen's Place from Area EX1, EX2, A1 (0.765 Ha)	
Storm Event	**Flow (L/s)**	**Interim Storage Volume (m^3)**
2-Year	3.7	10
5-Year	20.2	22
100-Year	89.6	46

As shown in the above, no increase to flow to St. Helen's Place will result due to the construction of the 4 lots fronting Withrow Avenue.

Please refer to interim model schematic below for more detail.

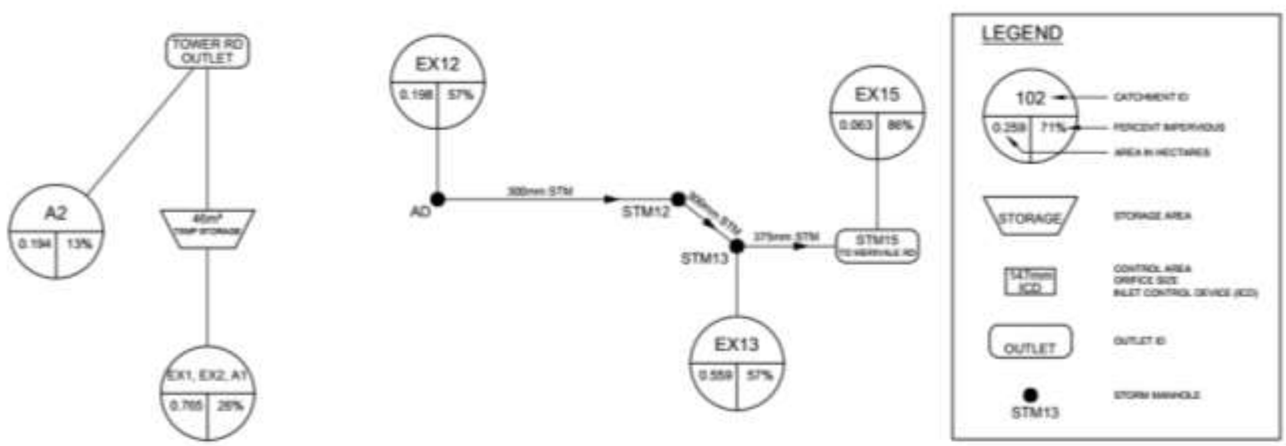

Figure 5: Proposed Condition EPASWMM Node Diagram

5.6 Stormwater Servicing Conclusions

Existing conditions result in flow from the subject property to Tower Road and St. Helen's Place. A target release rate of ***28.3 L/s*** was established based on the quantity control criteria from City of Ottawa pre-consultation. Areas to be retained as existing is to ensure the edge condition and adjacent landscaping is maintained and will continue to drain as existing. An external capacity analysis was completed for the adjacent Cleto Avenue storm sewer.

Proposed runoff to the Cleto Avenue storm sewer will be controlled through the use of a ***147mm*** inlet control device to control flow to a release rate of ***40.9 L/s***. Underground and surface storage is proposed to meet the required ***209m³*** of storage to attenuate flow.

The flow from the site can discharge to the existing sewer within Cleto Ave without any increase in risk of flooding to the downstream system.

Best management practices in the form of grassed swales are provided on-site to promote TSS removal and infiltration.

The proposed stormwater design conforms to all relevant ***City Standards*** and Policies for approval.

6.0 UTILITIES

Utility servicing will be coordinated with the individual utility companies prior to site development.

7.0 EROSION AND SEDIMENT CONTROL

Soil erosion occurs naturally and is a function of soil type, climate and topography. The extent of erosion losses is exaggerated during construction where vegetation has been removed and the top layer of soil becomes agitated.

Prior to topsoil stripping, earthworks or underground construction, erosion and sediment controls will be implemented and will be maintained throughout construction.

Silt fence will be installed around the perimeter of the site and will be cleaned and maintained throughout construction. Silt fence will remain in place until the working areas have been stabilized and re-vegetated.

Catch basins will have SILTSACKs installed under the grate during construction to protect from silt entering the storm sewer system.

A mud mat will be installed at the construction access, in order to prevent mud tracking onto adjacent roads.

Erosion and sediment controls must be in place during construction. The following recommendations to the contractor will be included in contract documents:

- Limit extent of exposed soils at any given time;
- Re-vegetate exposed areas as soon as possible;
- Minimize the area to be cleared and grubbed;
- Protect exposed slopes with plastic or synthetic mulches;
- Install silt fence to prevent sediment from entering existing ditches;
- No refueling or cleaning of equipment near existing watercourses;
- Provide sediment traps and basins during dewatering;
- Install filter cloth between catch basins and frames;
- Plan construction at proper time to avoid flooding; Establish material stockpiles away from watercourses, so that barriers and filters may be installed.

The contractor will, at every rainfall, complete inspections and guarantee proper performance. The inspection is to include:

- Verification that water is not flowing under silt barriers;
- Clean and change filter cloth at catch basins.

8.0 CONCLUSION AND RECOMMENDATIONS

David Schaeffer Engineering Ltd. (DSEL) has been retained to prepare a Functional Servicing and Stormwater Management Report in support of the Zoning By-Law Amendment and Plan of Subdivision at 21 Withrow Avenue. The preceding report outlines the following:

- Based on boundary conditions provided by the City, the existing municipal water infrastructure is capable of providing the proposed development with water within the City’s required pressure range;
- The EPANET water distribution model confirmed adequate pressure exists within fire hydrants during fire flow, and within the system for the Average Day, Max Day + Fire Flow and Peak Hour scenarios;
- The proposed development is anticipated to have a peak wet weather flow of ***1.01 L/s*** directed to the St. Helen’s Place sanitary sewer. Based on the sanitary analysis that was conducted, the existing municipal sewer infrastructure has sufficient capacity to support the development;
- Based on the ***City Standards***, the proposed development will attenuate flow to a release rate of ***40.9 L/s*** and will not have an impact on peak flows to the storm sewer within Cleto Ave;
- It is proposed to attenuate flow through underground and surface storage. It is anticipated that ***209m³*** of onsite storage will be required to attenuate flow to the established release rate above;
- Grassed swales will be provided to promote TSS removal and infiltration, full quality controls will be provided by off-site infrastructure per RVCA correspondence.

Prepared by,
David Schaeffer Engineering Ltd.

Per: Steven L. Merrick, P.Eng.

Reviewed by,
David Schaeffer Engineering Ltd.

Per: Adam D. Fobert, P.Eng.

z:\projects\17-931_theberge_21-withrow\b_design\b3_reports\b3-2_servicing (dsel)\subm2\fsr-2018-03-27_931_slm-kef.docx

APPENDIX A

Pre-Consultation

DEVELOPMENT SERVICING STUDY CHECKLIST

17-931 01/11/2017

4.1 General Content		
☐	Executive Summary (for larger reports only).	N/A
☒	Date and revision number of the report.	Report Cover Sheet
☒	Location map and plan showing municipal address, boundary, and layout of proposed development.	Drawings/Figures
☒	Plan showing the site and location of all existing services.	Figure 1
☒	Development statistics, land use, density, adherence to zoning and official plan, and reference to applicable subwatershed and watershed plans that provide context to applicable subwatershed and watershed plans that provide context to which individual developments must adhere.	Section 1.0
☒	Summary of Pre-consultation Meetings with City and other approval agencies.	Section 1.3
☒	Reference and confirm conformance to higher level studies and reports (Master Servicing Studies, Environmental Assessments, Community Design Plans), or in the case where it is not in conformance, the proponent must provide justification and develop a defendable design criteria.	Section 2.1
☒	Statement of objectives and servicing criteria.	Section 1.0
☒	Identification of existing and proposed infrastructure available in the immediate area.	Sections 3.1, 4.1, 5.1
☐	Identification of Environmentally Significant Areas, watercourses and Municipal Drains potentially impacted by the proposed development (Reference can be made to the Natural Heritage Studies, if available).	N/A
☐	Concept level master grading plan to confirm existing and proposed grades in the development. This is required to confirm the feasibility of proposed stormwater management and drainage, soil removal and fill constraints, and potential impacts to neighbouring properties. This is also required to confirm that the proposed grading will not impede existing major system flow paths.	N/A
☐	Identification of potential impacts of proposed piped services on private services (such as wells and septic fields on adjacent lands) and mitigation required to address potential impacts.	N/A
☐	Proposed phasing of the development, if applicable.	N/A
☐	Reference to geotechnical studies and recommendations concerning servicing.	N/A
☐	All preliminary and formal site plan submissions should have the following information: -Metric scale -North arrow (including construction North) -Key plan -Name and contact information of applicant and property owner -Property limits including bearings and dimensions -Existing and proposed structures and parking areas -Easements, road widening and rights-of-way -Adjacent street names	N/A

4.2 Development Servicing Report: Water		
☐	Confirm consistency with Master Servicing Study, if available	N/A
☒	Availability of public infrastructure to service proposed development	Section 3.1
☒	Identification of system constraints	Section 3.1
☒	Identify boundary conditions	Section 3.1, 3.2
☒	Confirmation of adequate domestic supply and pressure	Section 3.3

*Extracted from the City of Ottawa-Servicing Study Guidelines for Development Applications

☒	Confirmation of adequate fire flow protection and confirmation that fire flow is calculated as per the Fire Underwriter's Survey. Output should show available fire flow at locations throughout the development.	Section 3.2
☐	Provide a check of high pressures. If pressure is found to be high, an assessment is required to confirm the application of pressure reducing valves.	N/A
☐	Definition of phasing constraints. Hydraulic modeling is required to confirm servicing for all defined phases of the project including the ultimate design	N/A
☐	Address reliability requirements such as appropriate location of shut-off valves	N/A
☐	Check on the necessity of a pressure zone boundary modification	N/A
☒	Reference to water supply analysis to show that major infrastructure is capable of delivering sufficient water for the proposed land use. This includes data that shows that the expected demands under average day, peak hour and fire flow conditions provide water within the required pressure range	Section 3.2, 3.3
☐	Description of the proposed water distribution network, including locations of proposed connections to the existing system, provisions for necessary looping, and appurtenances (valves, pressure reducing valves, valve chambers, and fire hydrants) including special metering provisions.	N/A
☐	Description of off-site required feedermains, booster pumping stations, and other water infrastructure that will be ultimately required to service proposed development, including financing, interim facilities, and timing of implementation.	N/A
☒	Confirmation that water demands are calculated based on the City of Ottawa Design Guidelines.	Section 3.2
☐	Provision of a model schematic showing the boundary conditions locations, streets, parcels, and building locations for reference.	N/A

4.3 Development Servicing Report: Wastewater

☒	Summary of proposed design criteria (Note: Wet-weather flow criteria should not deviate from the City of Ottawa Sewer Design Guidelines. Monitored flow data from relatively new infrastructure cannot be used to justify capacity requirements for proposed infrastructure).	Section 4.2
☐	Confirm consistency with Master Servicing Study and/or justifications for deviations.	N/A
☐	Consideration of local conditions that may contribute to extraneous flows that are higher than the recommended flows in the guidelines. This includes groundwater and soil conditions, and age and condition of sewers.	N/A
☒	Description of existing sanitary sewer available for discharge of wastewater from proposed development.	Section 4.1
☒	Verify available capacity in downstream sanitary sewer and/or identification of upgrades necessary to service the proposed development. (Reference can be made to previously completed Master Servicing Study if applicable)	Section 4.2
☒	Calculations related to dry-weather and wet-weather flow rates from the development in standard MOE sanitary sewer design table (Appendix 'C') format.	Section 4.2, Appendix C
☒	Description of proposed sewer network including sewers, pumping stations, and forcemains.	Section 4.2
☐	Discussion of previously identified environmental constraints and impact on servicing (environmental constraints are related to limitations imposed on the development in order to preserve the physical condition of watercourses, vegetation, soil cover, as well as protecting against water quantity and quality).	N/A

*Extracted from the City of Ottawa-Servicing Study Guidelines for Development Applications

☐	Pumping stations: impacts of proposed development on existing pumping stations or requirements for new pumping station to service development.	N/A
☐	Forcemain capacity in terms of operational redundancy, surge pressure and maximum flow velocity.	N/A
☐	Identification and implementation of the emergency overflow from sanitary pumping stations in relation to the hydraulic grade line to protect against basement flooding.	N/A
☐	Special considerations such as contamination, corrosive environment etc.	N/A

4.4 Development Servicing Report: Stormwater Checklist

☒	Description of drainage outlets and downstream constraints including legality of outlets (i.e. municipal drain, right-of-way, watercourse, or private property)	Section 5.1
☒	Analysis of available capacity in existing public infrastructure.	Section 5.1, Appendix D
☐	A drawing showing the subject lands, its surroundings, the receiving watercourse, existing drainage patterns, and proposed drainage pattern.	N/A
☒	Water quantity control objective (e.g. controlling post-development peak flows to pre-development level for storm events ranging from the 2 or 5 year event (dependent on the receiving sewer design) to 100 year return period); if other objectives are being applied, a rationale must be included with reference to hydrologic analyses of the potentially affected subwatersheds, taking into account long-term cumulative effects.	Section 5.2
☒	Water Quality control objective (basic, normal or enhanced level of protection based on the sensitivities of the receiving watercourse) and storage requirements.	Section 5.2
☒	Description of the stormwater management concept with facility locations and descriptions with references and supporting information	Section 5.3
☐	Set-back from private sewage disposal systems.	N/A
☐	Watercourse and hazard lands setbacks.	N/A
☒	Record of pre-consultation with the Ontario Ministry of Environment and the Conservation Authority that has jurisdiction on the affected watershed.	Appendix A
☐	Confirm consistency with sub-watershed and Master Servicing Study, if applicable study exists.	N/A
☒	Storage requirements (complete with calculations) and conveyance capacity for minor events (1:5 year return period) and major events (1:100 year return period).	Section 5.3
☐	Identification of watercourses within the proposed development and how watercourses will be protected, or, if necessary, altered by the proposed development with applicable approvals.	N/A
☒	Calculate pre and post development peak flow rates including a description of existing site conditions and proposed impervious areas and drainage catchments in comparison to existing conditions.	Section 5.1, 5.3
☐	Any proposed diversion of drainage catchment areas from one outlet to another.	N/A
☐	Proposed minor and major systems including locations and sizes of stormwater trunk sewers, and stormwater management facilities.	N/A
☐	If quantity control is not proposed, demonstration that downstream system has adequate capacity for the post-development flows up to and including the 100-year return period storm event.	N/A
☐	Identification of potential impacts to receiving watercourses	N/A
☐	Identification of municipal drains and related approval requirements.	N/A

☒	Descriptions of how the conveyance and storage capacity will be achieved for the development.	Section 5.3
☐	100 year flood levels and major flow routing to protect proposed development from flooding for establishing minimum building elevations (MBE) and overall grading.	N/A
☐	Inclusion of hydraulic analysis including hydraulic grade line elevations.	N/A
☐	Description of approach to erosion and sediment control during construction for the protection of receiving watercourse or drainage corridors.	N/A
☐	Identification of floodplains – proponent to obtain relevant floodplain information from the appropriate Conservation Authority. The proponent may be required to delineate floodplain elevations to the satisfaction of the Conservation Authority if such information is not available or if information does not match current conditions.	N/A
☐	Identification of fill constraints related to floodplain and geotechnical investigation.	N/A

4.5 Approval and Permit Requirements: Checklist

☒	Conservation Authority as the designated approval agency for modification of floodplain, potential impact on fish habitat, proposed works in or adjacent to a watercourse, cut/fill permits and Approval under Lakes and Rivers Improvement Act. The Conservation Authority is not the approval authority for the Lakes and Rivers Improvement ct. Where there are Conservation Authority regulations in place, approval under the Lakes and Rivers Improvement Act is not required, except in cases of dams as defined in the Act.	Section 1.2
☐	Application for Certificate of Approval (CofA) under the Ontario Water Resources Act.	N/A
☐	Changes to Municipal Drains.	N/A
☐	Other permits (National Capital Commission, Parks Canada, Public Works and Government Services Canada, Ministry of Transportation etc.)	N/A

4.6 Conclusion Checklist

☒	Clearly stated conclusions and recommendations	Section 7.0
☐	Comments received from review agencies including the City of Ottawa and information on how the comments were addressed. Final sign-off from the responsible reviewing agency.	
☐	All draft and final reports shall be signed and stamped by a professional Engineer registered in Ontario	

Hannah Pepper

Subject: FW: 21 WIthrow - Boundary condition request
Attachments: wtr_opt2.pdf; wtr_opt1.pdf; 21 Withrow Sept 2017.pdf; 21 Withrow - Water Pressure Zones -20170911.pdf

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From: Balima, Nadege [mailto:Nadege.Balima@ottawa.ca]
Sent: September 11, 2017 9:17 AM
To: Brandon Chow <BChow@dsel.ca>
Subject: RE: 21 WIthrow - Boundary condition request

Good morning Brandon,
As per our phone conversation last week, the watermain on Rita and St Helen are in two different watermain pressure zones and cannot be interconnected. Below/attached are therefore the results of your request for option 1 only. I'm also providing a snapshot of the pressure zones limits in that area for your information (the blue area is the 2W zone and the purple area is the Meadowlands Zone).

The following are boundary conditions, HGL, for hydraulic analysis 21 Withrow (zone ME), assumed to be connected to the 152mm on St-Helens (see attached PDF for location).

Minimum HGL = 158.4m

Maximum HGL = 163.5m; the maximum pressure is estimated to be above 80 psi. A pressure check at completion of construction is recommended to determine if pressure control is required.

Available Flow = 155 L/s assuming a residual of 20 psi and a ground elevation of 97.5m

These are for current conditions and are based on computer model simulation.

Disclaimer: The boundary condition information is based on current operation of the city water distribution system. The computer model simulation is based on the best information available at the time. The operation of the water distribution system can change on a regular basis, resulting in a variation in boundary conditions. The physical properties of watermains deteriorate over time, as such must be assumed in the absence of actual field test data. The variation in physical watermain properties can therefore alter the results of the computer model simulation.

Please let me know if you have questions.
Regards,

Nadège Balima, P.Eng., M.P.M., LEED Green Assoc.
Project Manager, Infrastructure Approvals
Development Review Services (West)
613.580.2424 ext. 13477

From: Brandon Chow [mailto:BChow@dsel.ca]
Sent: Thursday, August 31, 2017 5:43 PM
To: Balima, Nadege <Nadege.Balima@ottawa.ca>
Subject: 21 WIthrow - Boundary condition request

Hi Nadege,

We would like to request boundary conditions for 2 options for the proposed development at 21 Withrow Ave. The proposed development will consist of 14 single family homes. 10 units will be serviced from a proposed 150mm watermain within the site and 4 units will be serviced from the existing 150mm watermain within Withrow Ave. See attached figures of the 2 options for connection point(s).

We hope that you can provide the maximum flow from the 150mm watermain in St. Helene's Place and in Rita Avenue using a fire flow of 10,000 L/m.

The anticipated water demands are summarized below:

	L/min	L/s
Avg. Daily	11.7	0.20
Max Day	57.2	0.95
Peak Hour	86.3	1.44

Thank you,

Brandon Chow
Project Coordinator / Junior Designer

DSEL
david schaeffer engineering ltd.

120 Iber Road, Unit 103
Stittsville, ON K2S 1E9

phone: (613) 836-0856 ext.532
fax: (613) 836-7183
email: bchow@DSEL.ca

Boundary Condition for 21 Withrow

Hannah Pepper

Subject: FW: 21 Withrow - FUS Estimation

From: Louise Langlois [mailto:llanglois@rlaarchitecture.ca]
Sent: Wednesday, August 30, 2017 1:51 PM
To: Steve Merrick <SMerrick@dsel.ca>
Cc: Joey Theberge <joeytheberge@thebergehomes.com>
Subject: RE: 21 Withrow - FUS Estimation

Please see my responses in red below.

L

From: Steve Merrick [SMerrick@dsel.ca]
Sent: August-30-17 9:07 AM
To: Louise Langlois
Cc: Joey Theberge
Subject: 21 Withrow - FUS Estimation

Hi Louise,

Hope all is well.

As we are working through detailed design for 21 Withrow we will need to confirm the fire flow required for the site based on the building construction. We hope you can advise on the below points:

1) Confirm square footage for each floor of the building. I just did some quick area calculations and the houses will range from approx. 2680-3660sq.ft not including basement areas.

2) Confirm construction type for the building (Wood Frame, Ordinary Construction, Non-combustible, fire resistive) Part 9 Wood frame

Extracted from FUS:

C = coefficient related to the type of construction.
= 1.5 for wood frame construction (structure essentially all combustible).
= 1.0 for ordinary construction (brick or other masonry walls, combustible floor and interior).
= 0.8 for non-combustible construction (unprotected metal structural components, masonry or metal walls).
= 0.6 for fire-resistive construction (fully protected frame, floors, roof).

Fire-Resistive Construction - Any structure that is considered fully protected, having at least 3-hour rated structural members and floors. For example, reinforced concrete or protected steel.

Non-combustible Construction - Any structures having all structural members including walls, columns, piers, beams, girders, trusses, floors, and roofs of non-combustible material and not qualifying as fire-resistive construction. For example, unprotected metal buildings.

Ordinary Construction - Any structure having exterior walls of masonry or such non-combustible material, in which the other structural members, including but not limited to columns, floors, roofs, beams, girders, and joists, are wholly or partly of wood or other combustible material.

Wood Frame Construction - Any structure in which the structural members are wholly or partly of wood or other combustible material and the construction does not qualify as ordinary construction.

3) Confirm if the building will be sprinklered. They will not be sprinklered

I will send along another email to confirm a few other items in relation to the proposed plan.

Thank in advance,

Steve Merrick, P.Eng.
Project Manager / Intermediate Designer

DSEL
david schaeffer engineering ltd.

120 Iber Road, Unit 103
Stittsville, ON K2S 1E9

phone: (613) 836-0856 ext. 561
cell: (613) 222-7816
email: smerrick@DSEL.ca

Hannah Pepper

Subject: FW: 21 Withrow - Infrastructure Follow up

From: Bill Holzman [mailto:b.holzman@holzmanconsultants.com]
Sent: Wednesday, June 28, 2017 9:21 AM
To: joeytheberge@thebergehomes.com
Cc: Reid Shepherd <r.shepherd@holzmanconsultants.com>; Adam Fobert <AFobert@dsel.ca>
Subject: Fwd: 21 Withrow - Infrastructure Follow up

fyi,
Bill

Begin forwarded message:

From: "Dickinson, Mary" <mary.dickinson@ottawa.ca>
Subject: FW: 21 Withrow - Infrastructure Follow up
Date: June 28, 2017 at 8:32:55 AM EDT
To: Bill Holzman <b.holzman@holzmanconsultants.com>

Bill
Please see below the detailed civil notes that make up part of the pre-consultation follow up for 21 Withrow.
Please let Nadege and/or me know if you have any questions.
Thanks
Mary

Mary Dickinson, MCIP, RPP
Planner
Development Review West
Urbaniste
Examen des demandes d'aménagement ouest

City of Ottawa | Ville d'Ottawa
613.580.2424 ext./poste 13923
ottawa.ca/planning / ottawa.ca/urbanisme

From: Balima, Nadege
Sent: Tuesday, June 27, 2017 4:47 PM
To: Dickinson, Mary
Subject: 21 Withrow - Infrastructure Follow up

Hi Mary,
As discussed, please find below my notes on the site at 21 Withrow.

1. The proponent may proceed with severance of lots along Withrow while ensuring that each lot:
    a) Maintains a size and imperviousness similar to what was originally planned in the subdivision for this area;
    b) Can be serviced independently for water and sanitary;
    c) Is graded to provide positive drainage and can be drained while following existing grading and drainage with no adverse effects on neighboring lots.
2. A preliminary high level stormwater analysis should be performed prior to the severance to ensure that development of the site (subdivision) can occur as planned in the future without any adverse impacts on neighboring properties. The following should be considered for storm flows:
    a) The pre-development runoff coefficient or a maximum equivalent 'C' of 0.5, whichever is less (§ 8.3.7.3 of the Ottawa Sewer Design Guidelines).
    b) A calculated time of concentration (Cannot be less than 10 minutes)
    c) Flows from the site can be accommodated by the roadside ditches without adverse impact on neighboring properties
    d) Post-development flows should be controlled to pre-developed flows for both the 2 and 100 year events. (Note that although a storm water management pond is not expected for the site, best management practices to minimize the amount of flow from the site should be incorporated in the design;)
    e) Both the interim (severance only) and the ultimate (severance and subdivision on private street) can function independently without adverse impacts on the neighboring properties and existing outlets/ditches;
3. A servicing plan, grading and drainage plan, erosion and sediment control plan as well as the high level stormwater analysis will need to be provided at the time of application for severance;
4. In addition to the information in point 3 for the subdivision, a geotechnical report, servicing and stormwater management brief will need to be submitted as part of the subdivision application;
5. If the rural type cross-section is maintained for the private street, this should also be discussed in the stormwater analysis to be submitted at the time of severance;
6. Note that water looping will likely be required due to low pressure in the area and district metering area chamber may be required on the private street;
7. The sanitary sewer connection for the future subdivision may come from Rita Avenue;
8. Keep in mind that for the private road, MOECC environmental compliance approval may be required if the lots are under different ownership (no condominium ownership).
9. With regards to the watermain analysis, you may request water boundary conditions for your watermain calculations. Requests must include the location of the service and the expected loads required by the proposed development. The following information is required:
    i. Location of service (on a plan)
    ii. Type of development and amount of fire flow required (as per FUS, 1999).
    iii. Average daily demand: ___ l/s.
    iv. Maximum daily demand: ___l/s.
    v. Maximum hourly daily demand: ___ l/s.

You may also wish to check the City's record drawings and utility plans in case there is additional plans or reports available. To purchase available documentation, please contact the City's Information Centre by email at InformationCentre@ottawa.ca or by phone at (613) 580-2424 x.44455.

Please let me know if you have any further questions.
Regards,

Nadège Balima, P.Eng., M.P.M., LEED Green Assoc.
Project Manager, Infrastructure Approvals
Development Review Services (West)
Gestionnaire de Projet, Approbation des demandes en Infrastructures
Services d'examen des demandes d'aménagement (Ouest)
Planning, Infrastructure and Economic Development Department
Service de planification, d'Infrastructure et de Développement économique
City of Ottawa | Ville d'Ottawa
613.580.2424 ext.| poste 13477
ottawa.ca/planning | ottawa.ca/urbanisme

" Nous n'héritons pas de la terre de nos ancêtres, nous l' empruntons à nos enfants". Saint-Exupéry
" We do not inherit the land from our forefathers, we borrow it from our children". Saint-Exupéry

Hannah Pepper

Subject: FW: Stormwater Quality Controls - 21 Withrow Avenue

From: Eric Lalande [mailto:eric.lalande@rvca.ca]
Sent: October 13, 2017 4:24 PM
To: Hannah Pepper <HPepper@dsel.ca>
Subject: RE: Stormwater Quality Controls - 21 Withrow Avenue

Hi Hanna,

The RVCA is looking for 80% TSS removal as part of quality control for the project. This can be accomplished either through on-site controls or off site systems prior to releasing in to a watercourse. Please outline if any quality controls are proposed to be implemented on-site. The intervening pond in Gibley Park outlets back into the municipal sewer system connecting to the Rideau River. While the travel distance should be sufficient to handle quality control for the proposal, best management practices are encouraged, where feasible.

Thanks,

Eric Lalande, MCIP, RPP
Planner, Rideau Valley Conservation Authority
613-692-3571 x1137

From: Jamie Batchelor
Sent: Wednesday, October 11, 2017 2:34 PM
To: Eric Lalande <eric.lalande@rvca.ca>
Subject: FW: Stormwater Quality Controls - 21 Withrow Avenue

From: Hannah Pepper [mailto:HPepper@dsel.ca]
Sent: Wednesday, October 11, 2017 1:55 PM
To: Jamie Batchelor <jamie.batchelor@rvca.ca>
Subject: FW: Stormwater Quality Controls - 21 Withrow Avenue

Hi Jamie,

Just wanted to follow up on the below?

Thanks!

Hannah Pepper, EIT.
Project Coordinator / Junior Designer

DSEL
david schaeffer engineering ltd.

120 Iber Road, Unit 103
Stittsville, ON K2S 1E9

phone: (613) 836-0856 ext. 569
fax: (613) 836-7183
email: hpepper@DSEL.ca

From: Hannah Pepper
Sent: October 4, 2017 11:24 AM
To: 'jamie.batchelor@rvca.ca' <jamie.batchelor@rvca.ca>
Subject: Stormwater Quality Controls - 21 Withrow Avenue

Hi Jamie,

Could you please confirm if stormwater quality controls would be necessary for a contemplated development with the following details?

The property is located at 21 Withrow Avenue and would include the construction of 13 townhome units, with the retention of one existing single family townhome. This is outlined in the attached site plan.

Stormwater from the new buildings will discharge into proposed ditches and then to existing sewers within Cleto Avenue, which drains to storm sewers within Merivale Road and then to a pond in Gibley Park. Total flow path to the pond is about 900m; please see the attached figure.

Stormwater storage onsite would be through underground storage. There is no proposed underground parking and there will be surface parking from proposed driveways for each home.

Thanks!

Hannah Pepper, EIT.
Project Coordinator / Junior Designer

DSEL
david schaeffer engineering ltd.

120 Iber Road, Unit 103
Stittsville, ON K2S 1E9

phone: (613) 836-0856 ext. 569
fax: (613) 836-7183
email: hpepper@DSEL.ca

Steve Merrick

From: Schaeffer, Gabrielle <gabrielle.schaeffer@Ottawa.ca>
Sent: Monday, February 12, 2018 2:13 PM
To: Steve Merrick
Cc: Dickinson, Mary

Subject: RE: 21 Withrow - Comments

Hi Steve,

I don't have the file in front of me today, but to answer your question now instead of wait, here is my review of my comments and the applicable changes. These changes are based on an internal discussion regarding the severance lots and their relation to the subdivision lots.

Since the Withrow lots are not part of the subdivision development:

- Comment #8 does not apply
- Change comment #58 to read "Add existing storm infrastructure within St. Helen's Place, Cleto and Tower ROWs (i.e. swale, culverts, etc) if not already done so."
- Delete the general section comment of comment #82
- Change comment #82a to read: "A discussion is required regarding how flows from the property (external tributary areas and subdivision lots) can be accommodated by the sewers and/or roadside ditches without adverse impact on neighbouring properties."
- Change comment #82b to read: "Part of neighbouring severance lots are to drain onto subdivision property, specifically roof and rear yard drainage. Discuss how interim conditions (i.e. developed severance lots while subdivision lots have not) will function without causing any adverse impacts to neighbouring properties and existing outlets/ditches. Also, discuss how the ultimate design (i.e. severance lots and subdivision lots both developed) will function without causing any adverse impacts to neighbouring properties and existing outlets/ditches.
- Change comment #82c to read: "A downstream analysis of the connecting STM sewer systems is to be provided." "The Withrow STM system is to be assessed for any impacts caused by the proposed severance lots" sentence can be deleted.

After our conversation last week and re-reading the comments, please make the additional changes to my comments:

- Change comment #53 to: Edit the text to 'or equivalent approved by City of Ottawa Planning Staff'.
- Change comment #66 to "Submit a revised request for Boundary Conditions once comments #64 and #65 have been addressed."
- Change comment #92 to read "External drainage entering the proposed storm system is to be accounted for in the design and calculations. Either a full by-pass system (i.e. dedicated swale and outlet) or a release of the external drainage from the proposed system to the existing drainage path is required. An additional option would be to outlet through the proposed connection to the Cleto storm sewer system ensuring to adverse impacts downstream."

Regards,
Gabrielle

From: Steve Merrick [mailto:SMerrick@dsel.ca]
Sent: Monday, February 12, 2018 9:00 AM
To: Schaeffer, Gabrielle <gabrielle.schaeffer@Ottawa.ca>
Subject: 21 Withrow - Comments

Hi Gabrielle,

Good to chat with you on Friday about some of the attached comments. I recall you discussing some of the comments may not be applicable after your meeting with Justin Armstrong. Can you indicate which of these comments are no longer applicable?

Let me know if you find out anything about recent flooding in this area so we can be prepared for the meeting on Thursday. See you then.

Thanks!

Steve Merrick, P.Eng.
Project Manager / Intermediate Designer

DSEL
david schaeffer engineering ltd.

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APPENDIX B

Water Supply

Water Demand Design Flows per Unit Count
City of Ottawa - Water Distribution Guidelines, July 2010

Domestic Demand

Type of Housing	Per / Unit	Units	Pop
Single Family	3.4	1	4
Semi-detached	2.7		0
Townhouse	2.7		0
Apartment			0
Bachelor	1.4		0
1 Bedroom	1.4		0
2 Bedroom	2.1		0
3 Bedroom	3.1		0
Average	1.8		0

	Pop	Avg. Daily		Max Day		Peak Hour	
		m^3/d	L/min	m^3/d	L/min	m^3/d	L/min
Total Domestic Demand	4	1.4	1.0	13.3	9.2	20.0	13.9

Institutional / Commercial / Industrial Demand

Property Type	Unit Rate		Units	Avg. Daily m^3/d	Avg. Daily L/min	Max Day m^3/d	Max Day L/min	Peak Hour m^3/d	Peak Hour L/min
Commercial floor space	2.5	$L/m^2/d$		0.00	0.0	0.0	0.0	0.0	0.0
Office	75	$L/9.3m^2/d$		0.00	0.0	0.0	0.0	0.0	0.0
Industrial - Light	35,000	L/gross ha/d		0.00	0.0	0.0	0.0	0.0	0.0
Industrial - Heavy	55,000	L/gross ha/d		0.00	0.0	0.0	0.0	0.0	0.0
			Total I/CI Demand	0.0	0.0	0.0	0.0	0.0	0.0
			Total Demand	**1.4**	**1.0**	**13.3**	**9.2**	**20.0**	**13.9**

Water Demand Design Flows per Unit Count
City of Ottawa - Water Distribution Guidelines, July 2010

DSEL

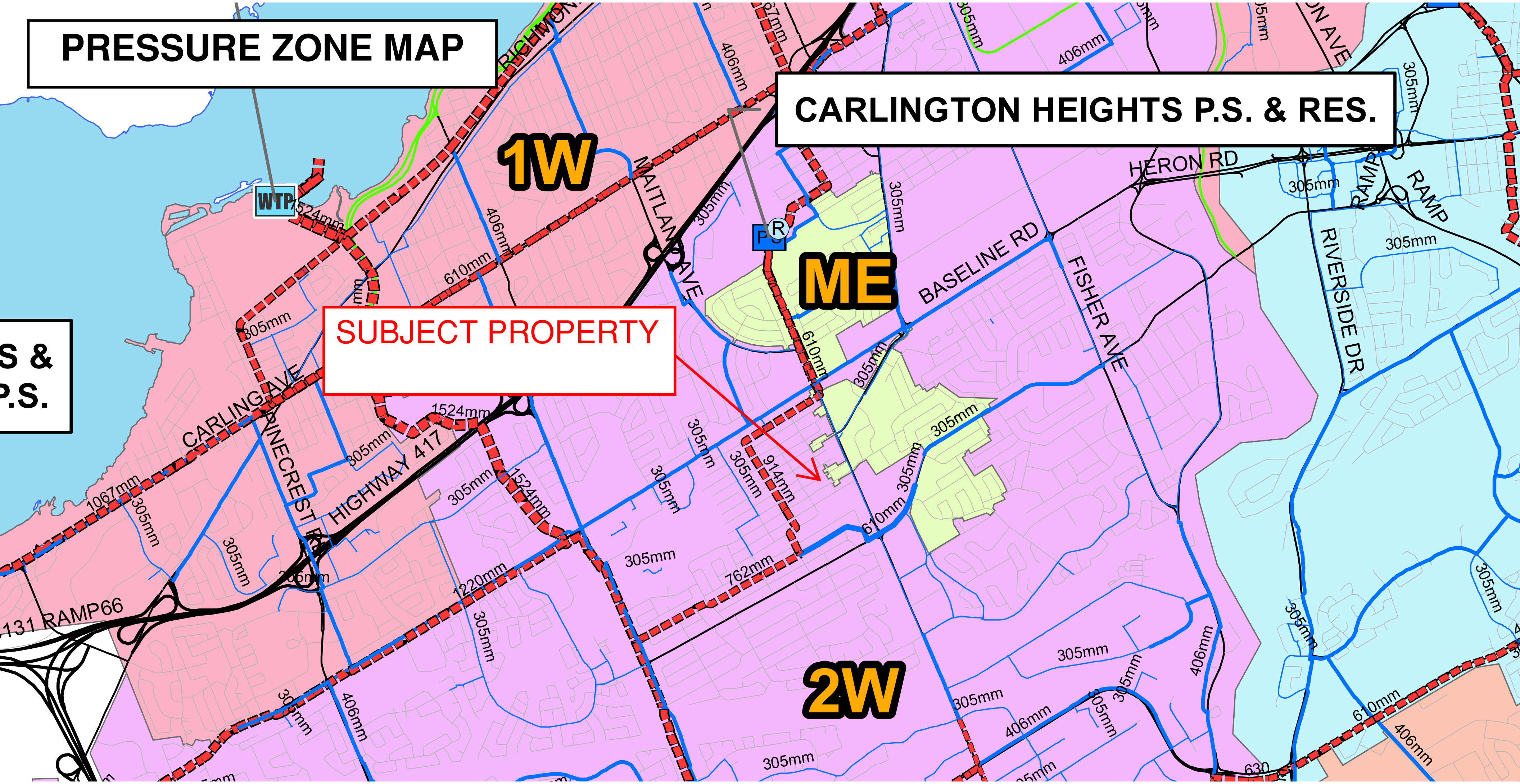
Domestic Demand

Type of Housing	Per / Unit	Units	Pop
Single Family	3.4	14	48
Semi-detached	2.7		0
Townhouse	2.7		0
Apartment			0
Bachelor	1.4		0
1 Bedroom	1.4		0
2 Bedroom	2.1		0
3 Bedroom	3.1		0
Average	1.8		0

	Pop	Avg. Daily		Max Day		Peak Hour	
		m^3/d	L/min	m^3/d	L/min	m^3/d	L/min
Total Domestic Demand	48	16.8	11.7	82.3	57.2	124.3	86.3

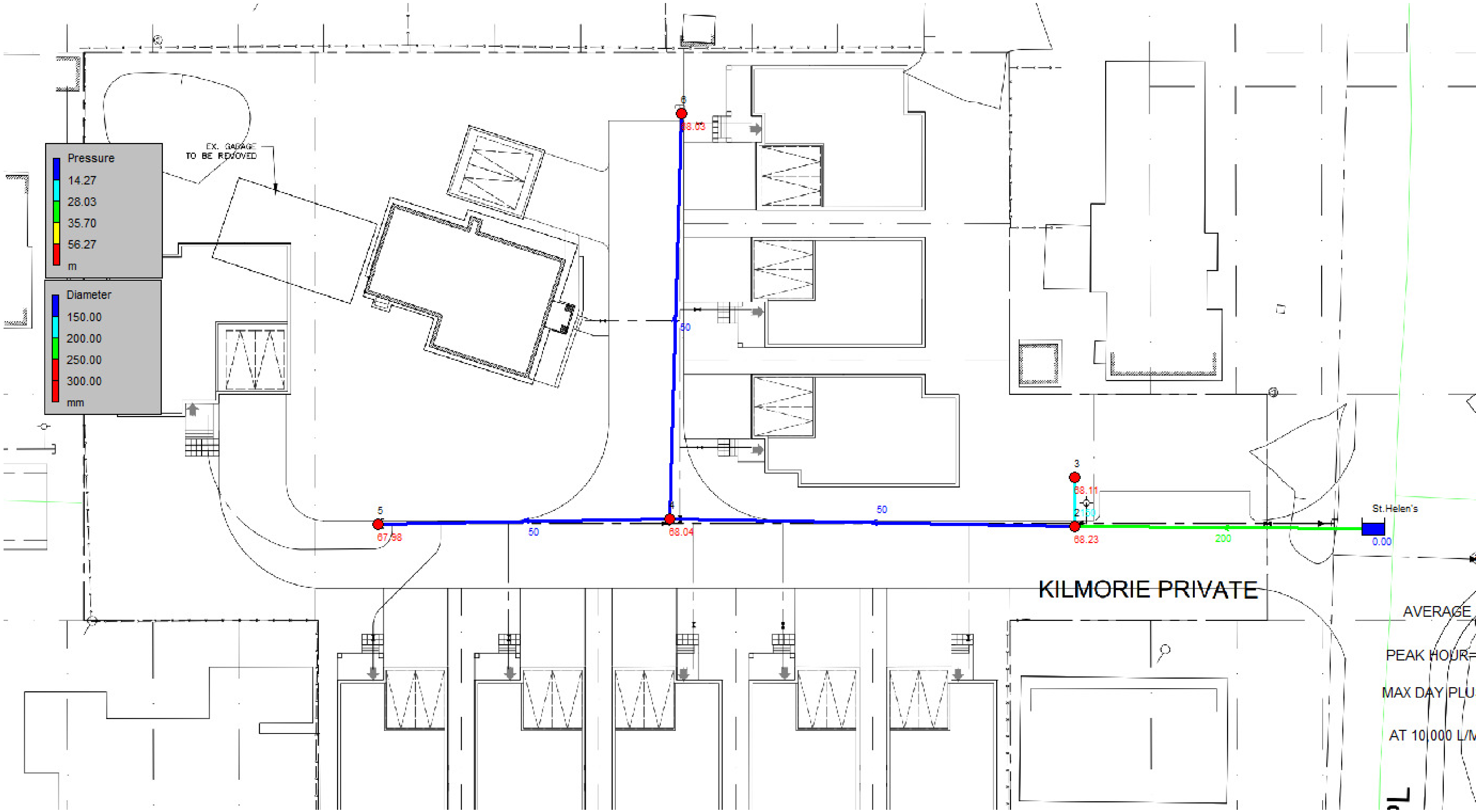
Institutional / Commercial / Industrial Demand

Property Type	Unit Rate		Units	Avg. Daily		Max Day		Peak Hour	
				m^3/d	L/min	m^3/d	L/min	m^3/d	L/min
Commercial floor space	2.5	$L/m^2/d$		0.00	0.0	0.0	0.0	0.0	0.0
Office	75	$L/9.3m^2/d$		0.00	0.0	0.0	0.0	0.0	0.0
Industrial - Light	35,000	L/gross ha/d		0.00	0.0	0.0	0.0	0.0	0.0
Industrial - Heavy	55,000	L/gross ha/d		0.00	0.0	0.0	0.0	0.0	0.0
			Total I/CI Demand	0.0	0.0	0.0	0.0	0.0	0.0
			Total Demand	**16.8**	**11.7**	**82.3**	**57.2**	**124.3**	**86.3**


PRESSURE ZONE MAP
CARLINGTON HEIGHTS P.S. & RES.
SUBJECT PROPERTY
1W
ME
2W
WTP
CARLING AVE
PINECREST RD
HIGHWAY 417
MAITLAND AVE
BASELINE RD
FISHER AVE
HERON RD
RIVERSIDE DR
RAMP
131 RAMP66
1067mm
1524mm
1220mm
762mm
914mm
610mm
406mm
305mm

MODEL SCEHMATIC (NODE ID, ELEVATIONS, ROUGHNESS)

AVERAGE DAY SCHEMATIC



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**********************************************************************
*                          E P A N E T                               *
*                  Hydraulic and Water Quality                       *
*                  Analysis for Pipe Networks                        *
*                         Version 2.0                                *
**********************************************************************
```

Input File: 2018-03-27_931_wtr_hjp.net

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
1	6	4	38.3	50
2	4	5	23.3	50
3	4	2	40	50
4	2	St.Helen's	23	200
5	2	3	1.9	150

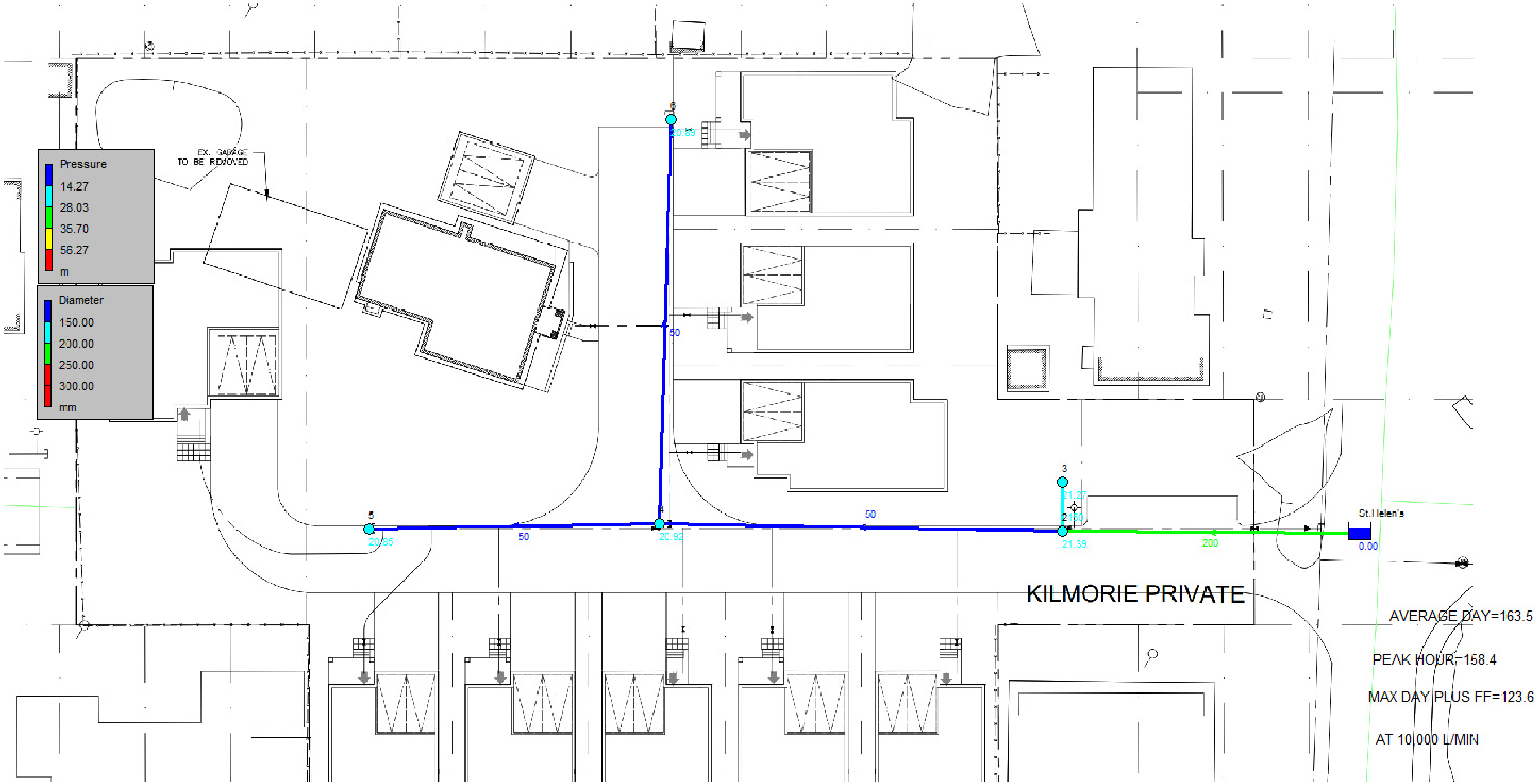
Node Results:

Node ID	Demand LPM	Head m	Pressure m	Quality	
2	0.00	163.50	68.23	0.00	
3	0.00	163.50	68.11	0.00	
4	3.40	163.49	68.04	0.00	
5	2.67	163.48	67.98	0.00	
6	2.67	163.48	68.03	0.00	
St.Helen's	-8.74	163.50	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPM	Velocity m/s	Unit Headloss m/km	Status
1	-2.67	0.02	0.04	Open
2	2.67	0.02	0.04	Open
3	-8.74	0.07	0.37	Open
4	-8.74	0.00	0.00	Open
5	0.00	0.00	0.00	Open

MAX DAY + FIRE FLOW SCENARIO



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**********************************************************************
*                             E P A N E T                            *
*                     Hydraulic and Water Quality                    *
*                     Analysis for Pipe Networks                     *
*                            Version 2.0                             *
**********************************************************************
```

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Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
1	6	4	38.3	50
2	4	5	23.3	50
3	4	2	40	50
4	2	St.Helen's	23	200
5	2	3	1.9	150

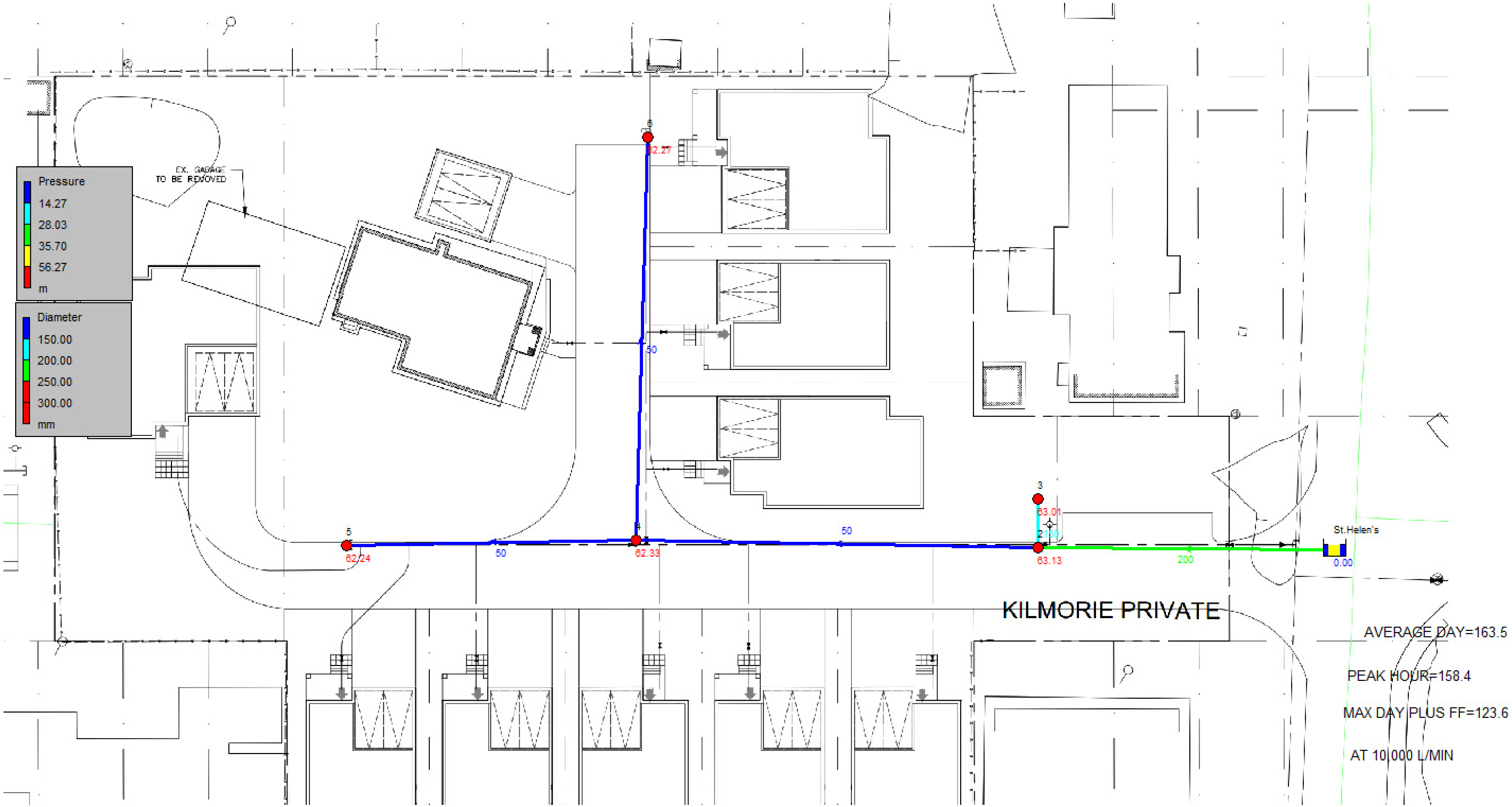
Node Results:

Node ID	Demand LPM	Head m	Pressure m	Quality	
2	9996.00	116.66	21.39	0.00	
3	0.00	116.66	21.27	0.00	
4	16.66	116.37	20.92	0.00	
5	13.08	116.35	20.85	0.00	
6	13.08	116.34	20.89	0.00	
St.Helen's	-10038.83	123.60	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPM	Velocity m/s	Unit Headloss m/km	Status
1	-13.08	0.11	0.79	Open
2	13.08	0.11	0.78	Open
3	-42.83	0.36	7.16	Open
4	-10038.83	5.33	301.90	Open
5	0.00	0.00	0.00	Open

PEAK HOUR SCHEMATIC



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**********************************************************************
*                           E P A N E T                              *
*                   Hydraulic and Water Quality                      *
*                   Analysis for Pipe Networks                       *
*                         Version 2.0                                *
**********************************************************************
```

Input File: 2018-03-27_931_wtr_hjp.net

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
1	6	4	38.3	50
2	4	5	23.3	50
3	4	2	40	50
4	2	St.Helen's	23	200
5	2	3	1.9	150

Node Results:

Node ID	Demand LPM	Head m	Pressure m	Quality	
2	0.00	158.40	63.13	0.00	
3	0.00	158.40	63.01	0.00	
4	25.16	157.78	62.33	0.00	
5	19.76	157.74	62.24	0.00	
6	19.76	157.72	62.27	0.00	
St.Helen's	-64.68	158.40	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPM	Velocity m/s	Unit Headloss m/km	Status
1	-19.76	0.17	1.70	Open
2	19.76	0.17	1.68	Open
3	-64.68	0.55	15.41	Open
4	-64.68	0.03	0.02	Open
5	0.00	0.00	0.00	Open

APPENDIX C

Wastewater Collection

Wastewater Design Flows per Unit Count
City of Ottawa Sewer Design Guidelines, 2004

Site Area			0.82	**ha**
Extraneous Flow Allowances				
		Infiltration / Inflow	**0.23**	**L/s**

Domestic Contributions

Unit Type	Unit Rate	Units	Pop
Single Family	3.4	1	4
Semi-detached and duplex	2.7		0
Townhouse	2.7		0
Stacked Townhouse (Duplex)	2.3		0
Apartment			
Bachelor	1.4		0
1 Bedroom	1.4		0
2 Bedroom	2.1		0
3 Bedroom	3.1		0
Average	1.8		0
Type of Housing	**Per/Bed**	**Beds**	**Pop**
Boarding*	1		0

Total Pop	**4**	
Average Domestic Flow	**0.02**	**L/s**
Peaking Factor	**4.00**	
Peak Domestic Flow	**0.06**	**L/s**

Institutional / Commercial / Industrial Contributions

Property Type	Unit Rate		No. of Units	Avg Wastewater (L/s)
Water Closets **	150	L/hr		0.00
Restaurant***	125	L/seat/d		0.00
Commercial floor space*	5	$L/m^2/d$		0.00
Hospitals	900	L/bed/d		0.00
School	70	L/student/d		0.00
Industrial - Light**	35,000	L/gross ha/d		0.00
Industrial - Heavy**	55,000	L/gross ha/d		0.00

Average I/C/I Flow	**0.00**
Peak Institutional / Commercial Flow	0.00
Peak Industrial Flow**	0.00
Peak I/C/I Flow	**0.00**

** assuming a 12 hour commercial operation*
*** peak industrial flow per City of Ottawa Sewer Design Guidelines Appendix 4B*

Total Estimated Average Dry Weather Flow Rate	**0.02**	**L/s**
Total Estimated Peak Dry Weather Flow Rate	**0.06**	**L/s**
Total Estimated Peak Wet Weather Flow Rate	**0.29**	**L/s**

* Based on a daily demand of 200L/day per person as identified by Appendix 4-A of the Sewer design guidelines
** Water closets demand of 150 L/hour from Appendix 4-A of the Sewer design guidelines, assuming a 12 hour operation
***Assuming 1 seat is approximately equal to 9.3 m^2

Theberge Homes
21 Withrow Avenue
Proposed Sanitary Flow

Wastewater Design Flows per Unit Count
City of Ottawa Sewer Design Guidelines, 2004

Site Area 0.82 **ha**

Extraneous Flow Allowances

Infiltration / Inflow **0.23 L/s**

Domestic Contributions

Unit Type	Unit Rate	Units	Pop
Single Family	3.4	14	48
Semi-detached and duplex	2.7		0
Townhouse	2.7		0
Stacked Townhouse (Duplex)	2.3		0
Apartment			
Bachelor	1.4		0
1 Bedroom	1.4		0
2 Bedroom	2.1		0
3 Bedroom	3.1		0
Average	1.8		0
Type of Housing	**Per/Bed**	**Beds**	**Pop**
Boarding*	1		0

Total Pop **48**

Average Domestic Flow **0.19 L/s**

Peaking Factor **4.00**

Peak Domestic Flow **0.78 L/s**

Institutional / Commercial / Industrial Contributions

Property Type	Unit Rate		No. of Units	Avg Wastewater (L/s)
Water Closets	150	L/hr		0.00
Restaurant	125	L/seat/d		0.00
Commercial floor space*	5	L/m^2/d		0.00
Laundry*	1,200	L/machine/d		0.00
Hospitals	900	L/bed/d		0.00
School	70	L/student/d		0.00

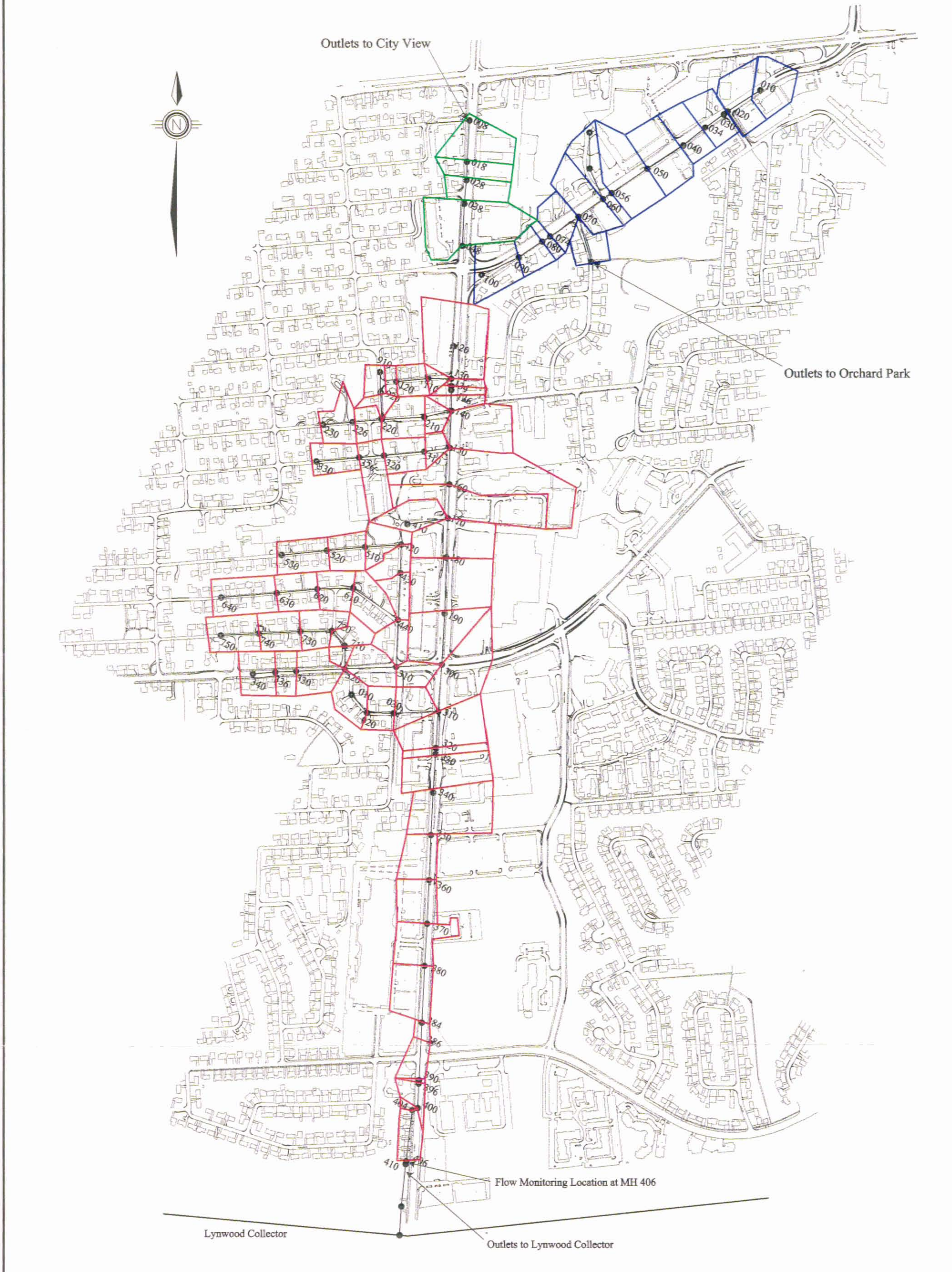
Average I/C/I Flow **0.00**

Peak Institutional / Commercial Flow 0.00
Peak Industrial Flow** 0.00
Peak I/C/I Flow **0.00**

** assuming a 12 hour commercial operation*

Total Estimated Average Dry Weather Flow Rate	**0.19**	**L/s**
Total Estimated Peak Dry Weather Flow Rate	**0.78**	**L/s**
Total Estimated Peak Wet Weather Flow Rate	**1.01**	**L/s**

* Based on a daily demand of 200L/day per person as identified by Appendix 4-A of the Sewer design guidelines



LEGEND

- South Merivale Sanitary Basin
- Clyde Avenue Sanitary Basin
- North Merivale Sanitary Basin

DELCAN

NEPEAN

Sanitary Drainage Basins

Date: January 2000	Figure 1.2

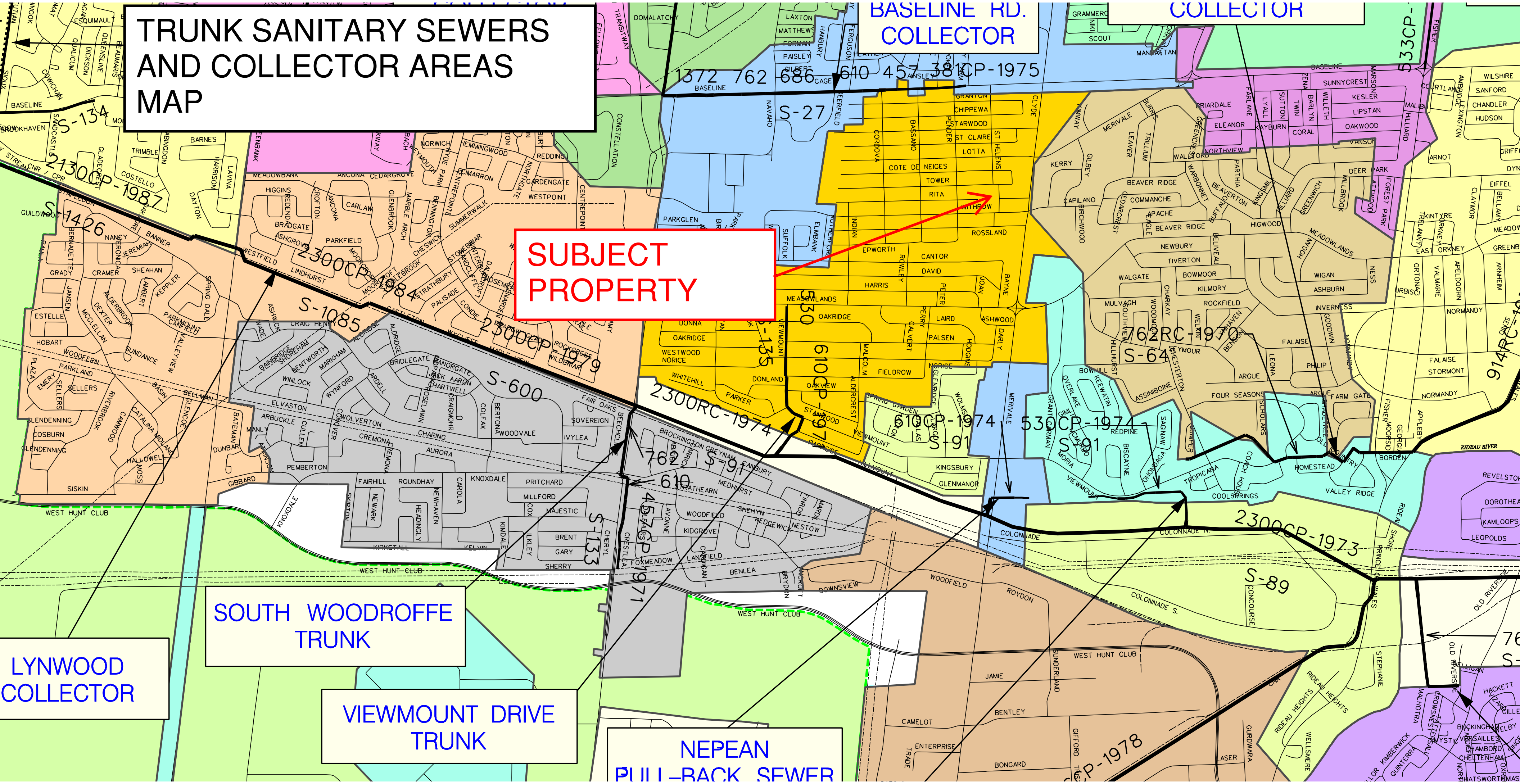
SOUTH MERIVALE SANITARY SEWER DESIGN SHEET: Theoretical Design Flows

commercial flow (_ L/1000 sqm/d) 5000
q = average daily per capita flow (_ L/cap,d) 350
persons per dwelling 3.31
I = unit of peak extraneous flow (_ L/ha,s) 0.28
M = peaking factor
Q (p) = peak population flow (L/s)
Q (I) = peak extraneous flow (L/s)
Q (d) = peak design flow

M = 1 + 14/(4+sqrtP) where P is population in 1000's
Q(p) = PqM/86.4 (L/s)
Q (I) = IA (L/s) where A = area in hectares
Q (d) = Q (p) + Q (I) (L/s)

Location			Residential Flow Calculations				Commercial Flow Calculations				Catchment Area I/I Flow Calculations			Peak	Existing Sewer (n = 0.013)						Residual
Street	From MH	To MH	Individual Population	Cumulative Population	Peaking factor M	Residential Flow Q(p) (L/s)	Individual Building Area (1000 m^2)	Cumulative Building Area	Peaking factor	Commercial Flow (L/s)	Individual Area (ha)	Cumultaive Area (ha)	Peak extraneous flow Q(I) (L/s)	design flow Q (d) (L/s)	Length (m)	Pipe Size (mm)	Type of pipe	Grade %	Capacity (L/s)	Full flow velocity (m/s)	Capacity (L/s)
Merivale	120	130	0.0	0	4.0	0.0	8.8	8.8	1.5	0.8	2.170	2.17	0.61	1.4	70.9	203	CP	0.33	19.41	0.6	18.0
Rita	120	110	19.9	20	4.0	0.3	0.0	0.0	1.5	0.0	0.452	0.45	0.13	0.4	62.3	203	AC	0.60	26.17	0.8	25.7
	110	130	0.0	20	4.0	0.3	0.0	0.0	1.5	0.0	0.180	0.63	0.18	0.5	66.5	203	AC	0.20	15.11	0.5	14.6
Merivale	130	134	0.0	20	4.0	0.3	0.0	8.8	1.5	0.8	0.137	2.94	0.82	1.9	15.5	254	AC	0.10	19.44	0.4	17.5
	134	136	0.0	20	4.0	0.3	0.6	9.4	1.5	0.8	0.198	3.14	0.88	2.0	9.3	254	AC	0.69	51.06	1.0	49.0
	136	140	0.0	20	4.0	0.3	0.4	9.8	1.5	0.9	0.293	3.43	0.96	2.1	43.9	254	AC	0.45	41.24	0.8	39.1
St Helen's	910	920	6.6	7	4.0	0.1	0.0	0.0	1.5	0.0	0.296	0.30	0.08	0.2	55.0	203	AC	0.24	16.55	0.5	16.4
	920	220	3.3	10	4.0	0.2	0.0	0.0	1.5	0.0	0.205	0.50	0.14	0.3	54.3	203	AC	0.15	13.09	0.4	12.8
Withrow	230	226	16.6	17	4.0	0.3	0.0	0.0	1.5	0.0	0.664	0.66	0.19	0.5	42.0	203	AC	1.50	41.38	1.3	40.9
	226	220	13.2	30	4.0	0.5	0.0	0.0	1.5	0.0	0.408	1.07	0.30	0.8	61.5	203	AC	2.13	49.31	1.5	48.5
	220	210	9.9	50	4.0	0.8	0.0	0.0	1.5	0.0	0.760	2.33	0.65	1.5	80.1	203	AC	0.36	20.27	0.6	18.8
	210	140	3.3	53	4.0	0.9	3.5	3.5	1.5	0.3	0.314	2.65	0.74	1.9	78.0	203	AC	0.40	21.37	0.7	19.5
Merivale	140	150	0.0	73	4.0	1.2	3.5	16.8	1.5	1.5	1.346	7.42	2.08	4.7	78.7	254	AC	0.64	49.18	1.0	44.5
Rossland	330	326	23.2	23	4.0	0.4	0.0	0.0	1.5	0.0	0.650	0.65	0.18	0.6	116.5	203	AC	1.12	35.76	1.1	35.2
	326	320	6.6	30	4.0	0.5	0.0	0.0	1.5	0.0	0.882	1.53	0.43	0.9	88.0	203	AC	1.67	43.67	1.3	42.8
	320	310	3.3	33	4.0	0.5	0.0	0.0	1.5	0.0	0.652	2.18	0.61	1.1	62.5	203	AC	1.07	34.95	1.1	33.8
	310	150	0.0	33	4.0	0.5	0.0	0.0	1.5	0.0	0.277	2.46	0.69	1.2	60.5	203	AC	0.94	32.76	1.0	31.5
Merivale	150	160	0.0	106	4.0	1.7	19.8	36.6	1.5	3.2	2.867	12.75	3.57	8.5	78.4	254	AC	0.54	45.17	0.9	36.7
	160	170	0.0	106	4.0	1.7	0.4	36.9	1.5	3.2	1.917	14.67	4.11	9.0	73.7	254	AC	0.47	42.14	0.8	33.1
Easement	410	170	0.0	0	4.0	0.0	1.0	1.0	1.5	0.1	0.716	0.72	0.20	0.3	95.5	203	AC	0.39	21.10	0.7	20.8
Merivale	170	180	0.0	106	4.0	1.7	0.2	38.2	1.5	3.3	1.351	16.74	4.69	9.7	74.5	457	AC	0.36	176.97	1.1	167.3
	180	190	0.0	106	4.0	1.7	16.6	54.8	1.5	4.8	1.994	18.73	5.24	11.7	120.3	533	AC	0.18	188.70	0.8	177.0
	190	300	0.0	106	4.0	1.7	10.8	65.6	1.5	5.7	1.416	20.15	5.64	13.0	120.3	457	AC	0.29	158.83	1.0	145.8
Meadwlands	340	336	29.8	30	4.0	0.5	0.0	0.0	1.5	0.0	0.731	0.73	0.20	0.7	54.5	203	AC	2.00	47.79	1.5	47.1
	336	330	13.2	43	4.0	0.7	0.0	0.0	1.5	0.0	0.435	1.17	0.33	1.0	84.0	203	AC	1.13	35.92	1.1	34.9
	330	320	26.5	70	4.0	1.1	0.0	0.0	1.5	0.0	0.806	1.97	0.55	1.7	112.5	203	AC	0.39	21.10	0.7	19.4
	320	310	23.2	172	4.0	2.8	0.0	0.0	1.5	0.0	0.745	5.64	1.58	4.4	109.0	203	AC	0.61	26.39	0.8	22.0
	310	300	0.0	367	4.0	6.0	0.0	0.0	1.5	0.0	0.428	12.86	3.60	9.6	92.0	203	AC	0.40	21.37	0.7	11.8
Harris	750	740	16.6	17	4.0	0.3	0.0	0.0	1.5	0.0	0.867	0.87	0.24	0.5	69.5	203	AC	4.10	68.42	2.1	67.9
	740	730	33.1	50	4.0	0.8	0.0	0.0	1.5	0.0	0.757	1.62	0.45	1.3	69.0	203	AC	0.41	21.64	0.7	20.4
	730	720	16.6	66	4.0	1.1	0.0	0.0	1.5	0.0	0.688	2.31	0.65	1.7	69.0	203	AC	0.41	21.64	0.7	19.9
	720	710	6.6	73	4.0	1.2	0.0	0.0	1.5	0.0	0.423	2.74	0.77	1.9	45.5	203	AC	0.33	19.41	0.6	17.5
	710	320	6.6	79	4.0	1.3	0.0	0.0	1.5	0.0	0.186	2.92	0.82	2.1	47.5	203	AC	0.63	26.82	0.8	24.7

residual capacity is based on gravity flow


TRUNK SANITARY SEWERS
AND COLLECTOR AREAS
MAP
SUBJECT
PROPERTY
BASELINE RD.
COLLECTOR
COLLECTOR
SOUTH WOODROFFE
TRUNK
LYNWOOD
COLLECTOR
VIEWMOUNT DRIVE
TRUNK
NEPEAN
PULL-BACK SEWER
S-134
2130CP-1987
S-1426
2300CP-1984
S-1085
2300CP-1979
S-600
2300RC-1974
S-133
457CP-1971
762 S-91
610
1372 762 686 610 457 381CP-1975
S-27
530
S-135
610CP-1971
610CP-1974
S-91
530CP-1974
S-91
762RC-1970
S-64
2300CP-1973
S-89
CP-1978
533CP-
914RC-

SANITARY SEWER CALCULATION SHEET - PROPOSED CONDITIONS

PROJECT: **Theberge Homes**
LOCATION: **21 Withrow Avenue**
FILE REF: **17-931**
DATE: **29-Mar-18**

DESIGN PARAMETERS
Avg. Daily Flow Res. 350 L/p/d
Peak Fact Res. Per Harmons: Min = 2.0, Max =4.0
Peak Fact. Comm. 1.5
Peak Fact. Instit. 1.5
Peak Fact. Indust. per MOE graph
Infiltration / Inflow 0.28 L/s/ha
Min. Pipe Velocity 0.60 m/s full flowing
Max. Pipe Velocity 3.00 m/s full flowing
Mannings N 0.013

Location				Residential Area and Population										Commercial		Institutional		Industrial		Infiltration					Pipe Data								
Street Name	Area ID	Up	Down	Area (ha)	Number of Units by type: Singles	Semi's	Town's	Apt's**	Pop.	Cumulative Area (ha)	Cumulative Pop.	Peak. Fact. (-)	Q_{res} (L/s)	Area (ha)	Accu. Area (ha)	Area (ha)	Accu. Area (ha)	Area (ha)	Accu. Area (ha)	Q_{C+I+I^*} (L/s)	Total Area (ha)	Accu. Area (ha)	Infiltration Flow (L/s)	Total Flow (L/s)	DIA (mm)	Slope (%)	Length (m)	$A_{hydraulic}$ (m^2)	R (m)	Velocity (m/s)	Q_{cap} (L/s)	Q / Q full (-)	Qresidual (L/s)
Kilmorie Private	A2	SAN4	SAN2	0.170	4				14.0	0.170	14.0	4.00	0.23		0.00		0.00		0.00	0.0	0.170	0.170	0.048	0.27	200	0.35	36.6	0.031	0.050	0.62	19.4	0.01	19.1
Kilmorie Private	A3	SAN3	SAN3	0.322	4				14.0	0.322	14.0	4.00	0.23		0.00		0.00		0.00	0.0	0.322	0.322	0.090	0.32	200	0.35	20.0	0.031	0.050	0.62	19.4	0.02	19.1
Kilmorie Private	A1	SAN2	SAN1	0.218	2				7.0	0.540	35.0	4.00	0.57		0.00		0.00		0.00	0.0	0.218	0.710	0.199	0.77	200	0.35	61.4	0.031	0.050	0.62	19.4	0.04	18.6

APPENDIX D

Stormwater Management

Estimated Peak Stormwater Flow Rate
City of Ottawa Sewer Design Guidelines, 2012

Drainage Area A1 to St Helen's Place
Existing Drainage Charateristics From Internal Site - East

Area	0.62	ha
C	0.29	Rational Method runoff coefficient
L	90	m
Up Elev	98.85	m
Dn Elev	97.37	m
Slope	1.6	%
Tc	21.23	min

1) Time of Concentration per Federal Aviation Administration

tc, in minutes
C, rational method coefficient, (-)
L, length in ft
S, average watershed slope in %

$$t_c = \frac{1.8(1.1 - C)L^{0.5}}{S^{0.333}}$$

Stormwater - Proposed Development
City of Ottawa Sewer Design Guidelines, 2012

Target Flow Rate

Area	0.70	ha
C	0.29	Rational Method runoff coefficient
t_c	21.2	min
	2-year	
i	50.2	mm/hr
Q	28.3	L/s

Estimated Post Development Peak Flow from Attenuated Areas

Area ID A1
Available Sub-surface Storage
Maintenance Structures

Sewers

ID	**U/G STORG.**	**U/G STORG.**
Storage Pipe Dia (mm)	ST-18	ST-36
Height (mm)	457	914
V_{sewer} (m^3)	132.4	64.5

*Top of lid or max ponding elevation = ____ 97.41

Total Subsurface Storage (m^3) 196.9

Stage Attenuated Areas Storage Summary

		Surface Storage			**Surface and Subsurface Storage**			
	Stage	**Ponding**	**h_o**	**delta d**	**V***	**V_{acc}****		
	(m)	**(m^2)**	**(m)**	**(m)**	**(m^3)**	**(m^3)**		
Orifice INV	96.54	-	0.00			0.0		
U/G STORAGE INV	96.59	-	0.05	0.05	0.0	0.0		
DICB T/L	96.95	0.36	0.41	0.36	134.2	134.2		
Storage Tank #1, #2 OBV	97.05	10.00	0.51	0.10	37.7	171.8		
AX PONDING / Top of Storage Tank 3	97.35	52.00	0.81	0.30	33.9	205.8		
Top of Spillway	97.41	52.0	0.87	0.06	3.1	208.9		

* V=Incremental storage volume
**V_{acc}=Total surface and sub-surface

Theberge Homes
21 Withrow Avenue
Ditch Calculation Sheet - 100 Year Storm

									Ditch Data												
	Area	Area	C	Indiv AxC	Acc AxC	T_C	I	Q	depth	Side Slope*	Bot. Width	Mannings	Slope	Length	A_{flow}	Wet. Per.	R	Velocity	Qcap	Time Flow	Q / Q full
		(ha)	(-)			(min)	(mm/hr)	(L/s)	(mm)	(X:1)	(m)	n	(%)	(m)	(m^2)	(m)	(m)	(m/s)	(L/s)	(min)	(-)
	EX1	0.139	0.47	0.07	0.07																
	D1	0.386	0.57	0.22	0.29	10.0	178.6	141.5	400	2	0	0.03	0.50	79.8	0.320	1.789	0.18	0.75	239.5	1.8	0.59
						11.8															
	D2	0.141	0.59	0.08	0.08	10.0	178.6	41.3	360	2	0	0.03	0.50	72.9	0.259	1.610	0.16	0.70	180.8	1.7	0.23
						11.7															
	D3	0.055	0.75	0.04	0.04	10.0	178.6	20.5	400	2	0	0.03	0.50	47.5	0.320	1.789	0.18	0.75	239.5	1.1	0.09
						11.1															
	D4	0.034	0.80	0.03	0.44	11.7	164.1	199.2	370	2	0	0.03	0.80	25.7	0.274	1.655	0.17	0.90	246.0	0.5	0.81
						12.2															
	EX2	0.041	0.4	0.02	0.02																
	D5	0.052	0.41	0.02	0.04	10.0	178.6	18.7	330	2	0	0.03	0.50	39.3	0.218	1.476	0.15	0.66	143.4	1.0	0.13
						11.0															
	D6	0.033	0.44	0.01	0.49	12.2	160.5	218.2	500	2	0	0.03	0.50	18.8	0.500	2.236	0.22	0.87	434.2	0.4	0.50
						12.6	158.0														

* Side slopes of 2:1 used as this represents the worst case scenario for ditch flow capacity

Theberge Homes
21 Withrow Avenue
Culvert/Sewer Calculation Sheet - 100 Year Storm

								Sewer Data								
Area ID	**Area**	**C**	**Indiv AxC**	**Acc AxC**	**T_{C**}**	**I**	**Q**	**DIA**	**Slope**	**Length**	**$A_{hydraulic}$**	**R**	**Velocity**	**Qcap**	**Time Flow**	**Q / Q full**
	(ha)	**(-)**			**(min)**	**(mm/hr)**	**(L/s)**	**(mm)**	**(%)**	**(m)**	**(m^2)**	**(m)**	**(m/s)**	**(L/s)**	**(min)**	**(-)**
EX1	0.139	0.47	0.07	0.07												
D1	0.386	0.57	0.22	0.29	10.0	178.6	141.5	375	1.25	5.0	0.110	0.094	1.77	196.0	0.0	0.72
D2	0.141	0.59	0.08	0.08	10.0	178.6	41.3	300	0.50	5.0	0.071	0.075	0.97	68.4	0.1	0.60
D3	0.055	0.75	0.04	0.04	10.0	178.6	20.5	300	0.50	5.0	0.071	0.075	0.97	68.4	0.1	0.30
D4	0.034	0.80	0.03	0.15	10.0	178.6	75.2									
EX2	0.041	0.40	0.02	0.02												
D5	0.052	0.41	0.02	0.04	10.0	178.6	18.7									
D6	0.033	0.44	0.01	0.49	10.0	178.6	242.7									
DICB101*	0.000	0.00	0.00	0.49	10.0	178.6	40.8	300	0.35	30.9	0.071	0.075	0.81	57.2	0.6	0.71
AD102	0.000	0.00	0.00	0.00	10.0	178.6	40.8	300	0.35	9.7	0.071	0.075	0.81	57.2	0.2	0.71

*Pipe sized for the proposed controlled elease rate

STORMTANK® Module Volume Calculator

Inputs

Project Name: 21 Withrow Avenue - Storage Tank #1

Engineer: Date: 10/31/2017

Units: SI Shape: Square/Rectangle

Liner: No Location: N/A

Stacking: Single Height: 457.2

Stone Storage: All Porosity: 40%

Dimensions

Module
Length: 59 m
Width: 3 m

Excavation
Length: 59.6 m
Width: 3.6 m

Stone
Leveling Bed: 0 m
Top Backfill: 0.3 m
Compacted Fill: 0.3 m

Results

Capacity:

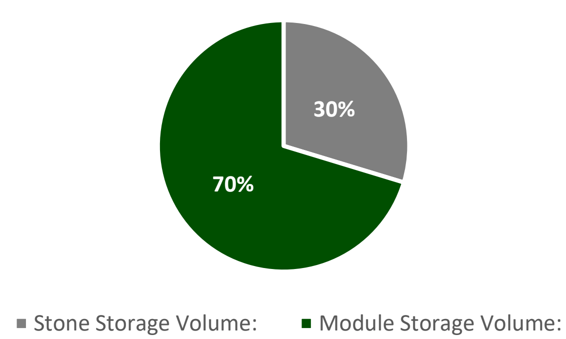
Stone Storage Volume: 32.62 m^3
Module Storage Volume: 77.22 m^3
Total Storage Volume: 109.83 m^3

Quantities:

Required Excavation: 226.83 m^3
Required Stone Volume: 81.54 m^3

Estimated Geotextile: 1,039.47 m^2
Estimated Liner: 0.00 m^2
(Estimations include 10% for scrap and overlap)

Storage Capacity Ratio

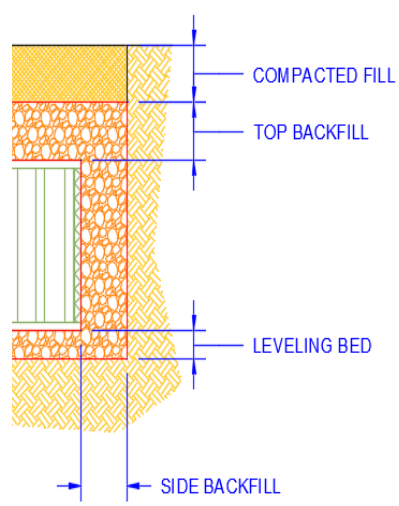


Basin Detail

Component Quantities:

	Bottom Layer	Top Layer	Total
Height	457.2	N/A	457.2
# of Modules	423	N/A	423
# of Platens	847	N/A	847
# of Side Panels	271	N/A	271
# of Columns	3,387	N/A	3,387
# of Stacking Pins	0	N/A	0

Cross-Section:



StormTank Module Volume Calculator

Inputs

Project Name:	21 Withrow Avenue - Storage Tank #2		
Engineer:		Date:	10/31/2017
Units:	SI	Shape:	Square/Rectangle
Liner:	No	Location:	N/A
Stacking:	Single	Height:	457.2
Stone Storage:	All	Porosity:	40%

Dimensions

Module

Length:	22.3	m
Width:	2.1	m

Excavation

Length:	22.9	m
Width:	2.7	m

Stone

Leveling Bed:	0	m
Top Backfill:	0.3	m
Compacted Fill:	0.3	m

Results

Capacity:

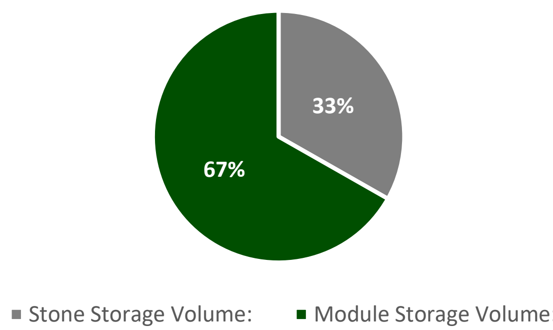
Stone Storage Volume:	10.16	m^3
Module Storage Volume:	20.43	m^3
Total Storage Volume:	30.59	m^3

Quantities:

Required Excavation:	65.37	m^3
Required Stone Volume:	25.41	m^3
Estimated Geotextile:	309.33	m^2
Estimated Liner:	0.00	m^2

(Estimations include 10% for scrap and overlap)

Storage Capacity Ratio

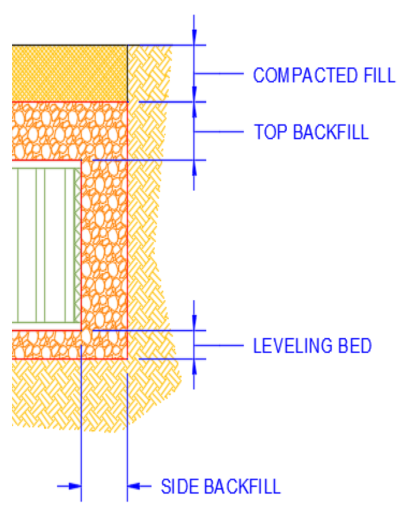


Basin Detail

Component Quantities:

	Bottom Layer	Top Layer	Total
Height	457.2	N/A	457.2
# of Modules	112	N/A	112
# of Platens	224	N/A	224
# of Side Panels	107	N/A	107
# of Columns	896	N/A	896
# of Stacking Pins	0	N/A	0

Cross-Section:



STORMTANK® Module Volume Calculator

Inputs

Project Name:	21 Withrow Avenue - Storage Tank #2		
Engineer:		Date:	10/31/2017
Units:	SI	Shape:	Square/Rectangle
Liner:	No	Location:	N/A
Stacking:	Single	Height:	762
Stone Storage:	All	Porosity:	40%

Dimensions

Module

Length:	7	m
Width:	10	m

Excavation

Length:	7.6	m
Width:	10.6	m

Stone

Leveling Bed:	0	m
Top Backfill:	0.3	m
Compacted Fill:	0.3	m

Results

Capacity:

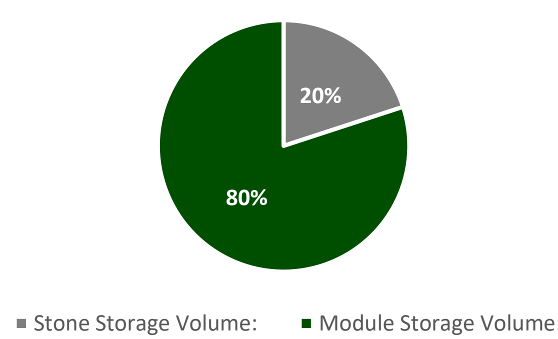
Stone Storage Volume:	12.89	m^3
Module Storage Volume:	51.63	m^3
Total Storage Volume:	64.52	m^3

Quantities:

Required Excavation:	109.72	m^3
Required Stone Volume:	32.21	m^3
Estimated Geotextile:	406.32	m^2
Estimated Liner:	0.00	m^2

(Estimations include 10% for scrap and overlap)

Storage Capacity Ratio

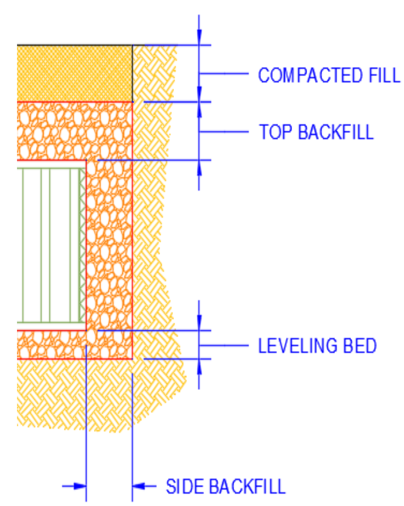


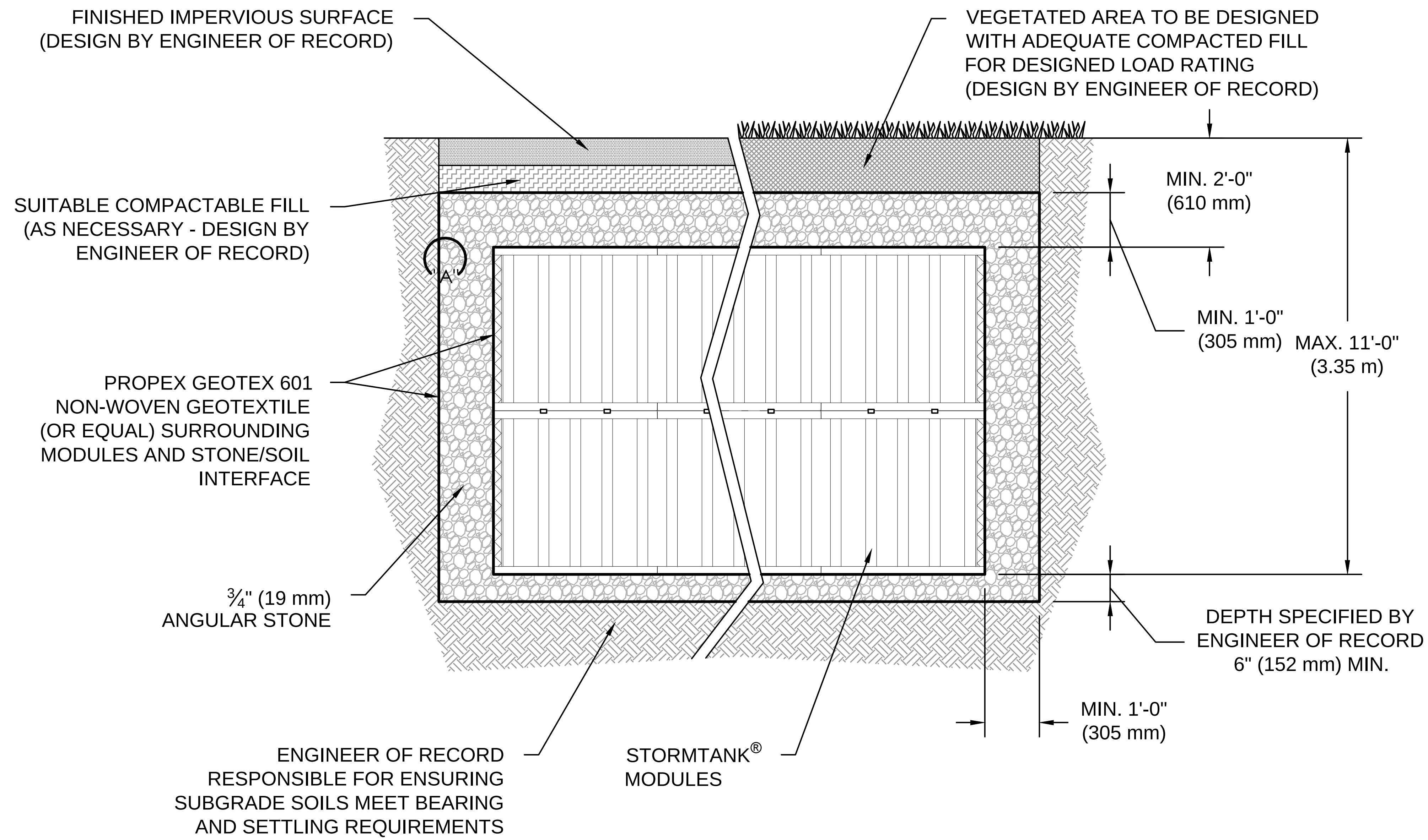
Basin Detail

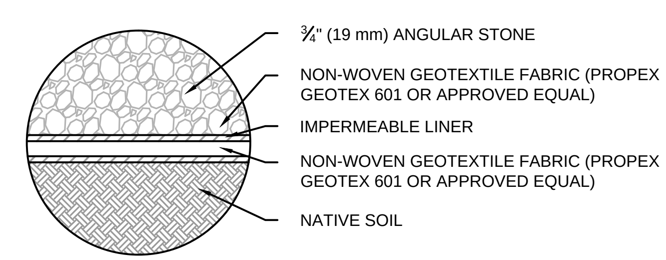
Component Quantities:

	Bottom Layer	Top Layer	Total
Height	762.0	N/A	762.0
# of Modules	167	N/A	167
# of Platens	335	N/A	335
# of Side Panels	74	N/A	74
# of Columns	1,339	N/A	1,339
# of Stacking Pins	0	N/A	0

Cross-Section:







DETAIL "A"

NOTES:

a. REFERENCE CURRENT INSTALLATION INSTRUCTIONS FOR PROPER INSTALLATION PRACTICES.

b. IMPERMEABLE LINER IS REQUIRED TO BE INSTALLED AROUND BOTTOM AND SIDES OF EXCAVATION ONLY

REV.	DATE	RECORD OF CHANGES	BY	APPRV.
D	11/10/14	GEOTEXTILE PRODUCT SPECIFIED	CGB	
C	9/9/13	NOTE REVISION, FORMATTING UPDATE & DWG. NO. UPDATE	JKB	JKB
B	7/6/12	FORMATTING & DWG. NO. UPDATE	JKB	FK
A	1/10/12	INITIAL RELEASE	BLL	FK

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Phone: (610) 374-5109
Fax: (610) 376-6022
www.brentwoodindustries.com

Project Name
TYPICAL DOUBLE STK. DETENTION BASIN CROSS-SECTION DETAIL

Title
STORMTANK® MODULE

Drawn By	Date
B.LINE	1/10/12

Drawing No.	Sheet	Scale
STM-001-03	1 of 1	NTS

DESIGN GUIDE

STORMTANK® Module

BRENTWOOD®

Contents

General Notes

1. Brentwood recommends that the installing contractor contact either Brentwood or the local distributor prior to installation of the system to schedule a pre-construction meeting. This meeting will ensure that the installing contractor has a firm understanding of the installation instructions.
2. All systems must be designed and installed to meet or exceed Brentwood's minimum requirements. Although Brentwood offers support during the design, review, and construction phases of the Module system, it is the ultimate responsibility of the Engineer of Record to design the system in full compliance with all applicable engineering practices, laws, and regulations.
3. Brentwood requires a minimum cover of 24" (610 mm) and/or a maximum Module invert of 11' (3.35 m). Additionally, a minimum 6" (152 mm) leveling bed, 12" (305 mm) side backfill, and 12" (305 mm) top backfill are required on every system.
4. Brentwood recommends a minimum bearing capacity and subgrade compaction for all installations. If site conditions are found not to meet any design requirements during installation, the Engineer of Record must be contacted immediately.
5. All installations require a minimum two layers of geotextile fabric. One layer is to be installed around the Modules, and another layer is to be installed between the stone/soil interfaces.
6. Stone backfilling is to follow all requirements of the most current installation instructions.
7. The installing contractor must apply all protective measures to prevent sediment from entering the system during and after installation per local, state, and federal regulations.
8. The StormTank® Module carries a Limited Warranty, which can be accessed at www.brentwoodindustries.com.

1.0 Introduction

About Brentwood

Brentwood is a global manufacturer of custom and proprietary products and systems for the construction, consumer, medical, power, transportation, and water industries. A focus on plastics innovation, coupled with diverse production capabilities and engineering expertise, has allowed Brentwood to build a strong reputation for thermoplastic molding and solutions development.

Brentwood's product and service offerings continue to grow with an ever-increasing manufacturing presence. By emphasizing customer service and working closely with clients throughout the design, engineering, and manufacturing phases of each project, Brentwood develops forward-thinking strategies to create targeted, tailored solutions.

StormTank® Module

The StormTank Module is a strong, yet lightweight, alternative to other subsurface systems and offers the largest void space (up to 97%) of any subsurface stormwater storage unit on the market. The Modules are simple to assemble on site, limiting shipping costs, installation time, and labor. Their structural PVC columns pressure fit into the polypropylene top/bottom platens, with side panels inserted around the perimeter of the system. This open design and lack of internal walls make the Module system easy to clean compared to other subsurface box structures. When properly designed, applied, installed, and maintained, the Module system has been engineered to achieve a 50-year lifespan.

Technical Support

Brentwood's knowledgeable distributor network and in-house associates emphasize customer service and support by parterning with customers to extend the process beyond physical material supply. These trained specialists are available to assist in the review of proposed systems, conversions of alternatively designed systems, or to resolve any potential concerns before, during, and after the design process. To provide the best assistance, it is recommended that associates be provided with a site plan and cross-sections that include grading, drainage structures, dimensions, etc.

2.0 Product Information

Applications

The Module system can be utilized for detention, infiltration, capture and reuse, and specialty applications across a wide range of industries, including the commercial, residential, and recreational segments. The product's modular design allows the system to be configured in almost any shape (even around utilities) and to be located under almost any pervious or impervious surface.

Module Selection

Brentwood manufactures the Module in five different heights (Table 1) that can be stacked uniformly up to two Modules high. This allows for numerous height configurations up to 6' (1.83 m) tall. The Modules can be buried up to a maximum invert of 11' (3.35 m) and require a minimum cover of 24" (610 mm) for load rating. When selecting the proper Module, it is important to consider the minimum required cover, any groundwater or limiting zone restrictions, footprint requirements, and all local, state, and federal regulations.

Table 1: Nominal StormTank® Module Specificiations

	ST-18	ST-24	ST-30	ST-33	ST-36
Height	18" (457 mm)	24" (610 mm)	30" (762 mm)	33" (838 mm)	36" (914 mm)
Void Space	95.5%	96.0%	96.5%	96.9%	97.0%
Module Storage Capacity	6.54 ft^3 (0.18 m^3)	8.64 ft^3 (0.24 m^3)	10.86 ft^3 (0.31 m^3)	11.99 ft^3 (0.34 m^3)	13.10 ft^3 (0.37 m^3)
Min. Installed Capacity*	9.15 ft^3 (0.26 m^3)	11.34 ft^3 (0.32 m^3)	13.56 ft^3 (0.38 m^3)	14.69 ft^3 (0.42 m^3)	15.80 ft^3 (0.45 m^3)
Weight	22.70 lbs (10.30 kg)	26.30 lbs (11.93 kg)	29.50 lbs (13.38 kg)	31.3 lbs (14.20 kg)	33.10 lbs (15.01 kg)

Min. Installed Capacity includes the leveling bed, Module, and top backfill storage capacity for one Module. Stone storage capacity is based on 40% void space.* ***Side backfill storage is not included.*

3.0 Manufacturing Standards

Brentwood selects material based on long-term performance needs. To ensure long-term performance and limit component deflection over time (creep), Brentwood selected polyvinyl chloride (PVC) for the Module's structural columns and a virgin polypropylene (PP) blend for the top/bottom and side panels. PVC provides the largest creep resistance of commonly available plastics, and therefore, provides the best performance under loading conditions. Materials like polyethylene (HDPE) and recycled PP have lower creep resistance and are not recommended for load-bearing products and applications.

Materials:

Brentwood's proprietary PVC and PP copolymer resins have been chosen specifically for utilization in the StormTank® Module. The PVC is blended in house by experts and is a 100% blend of post-manuacturing/pre-consumer recycled material. Both materials exhibit structural resilience and naturally resist the chemicals typically found in stormwater runoff.

Methods:

Injection Molding

The Module's top/bottom platens and side panels are injection molded, using proprietary molds and materials. This allows Brentwood to manufacture a product that meets structural requirements while maintaining dimensional control, molded-in traceability, and quality control.

Extrusion

Brentwood's expertise in PVC extrusion allows the structural columns to be manufactured in house. The column extrusion includes the internal structural ribs required for lateral support.

Quality Control

Brentwood maintains strict quality control in order to ensure that materials and the final product meet design requirments. This quality assurance program includes full material property testing in accordance with American Society for Testing and Materials (ASTM) standards, full-part testing, and process testing in order to quantify product performance during manufacturing. Additionally, Brentwood conducts secondary finshed-part testing to verify that design requirements continue to be met post-manufacturing.

All Module parts are marked with traceability information that allows for tracking of manufacturing. Brentwood maintains equipment at all manufacturing locations, as well as at its corporate testing lab, to ensure all materials and products meet all requirements.

4.0 Structural Response

Structural Design

The Module has been designed to resist loads calculated in accordance with the American Association of State Highway and Transportation Official's (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design manual. This fully factored load includes a multiple presence factor, dynamic load allowance, and live load factor to account for real-world situations. This loading was considered when Brentwood developed both the product and installation requirements. The developed minimum cover ensures the system maintains an adequate resistance factor for the design truck (HS-20) and HS-25 loads.

Full-Scale Product Testing

Engineers at Brentwood's in-house testing facility have completed full-scale vertical and lateral tests on the Module to evaluate product response. To date, Brentwood continues in-house testing in order to evaluate long-term creep effects.

Fully Installed System Testing

Brentwood's dedication to providing a premier product extends to fully installed testing. Through a partnership with Queen's University's GeoEngineering Centre in Kingston, Ontario, Brentwood has conducted full-scale installation tests of single- and double-stacked Module systems to analyze short- and long-term performance. Testing includes short-term ultimate limit state testing under fully factored AASHTO loads and minimum installation cover, lateral load testing, long-term performance and lifecycle testing utilizing time-temperature superposition, and load resistance development. Side backfill material tests were also performed to compare the usage of sand, compacted stone, and uncompacted stone.

5.0 Foundation

The foundation (subgrade) of the subsurface storage structure may be the most important part of the Module system installation as this is the location where the system applies the load generated at the surface. If the subgrade lacks adequate support or encounters potential settlement, the entire system could be adversely affected. Therefore, when implementing an underground storage solution, it is imperative that a geotechnical investigation be performed to ensure a strong foundation.

Considerations & Requirements:

Bearing Capacity

The bearing capacity is the ability of the soil to resist settlement. In other words, it is the amount of weight the soil can support. This is important versus the native condition because the system is replacing earth, and even though the system weighs less than the earth, the additional load displacement of the earth is not offset by the difference in weight.

Using the Loading and Resistance Factor Design (LRFD) calculation for bearing capacity, Brentwood has developed a conservative minimum bearing capacity table (see Appendix). The Engineer of Record shall reference this table to assess actual cover versus the soil bearing required for each unit system.

Soil Profile

Limiting Zones

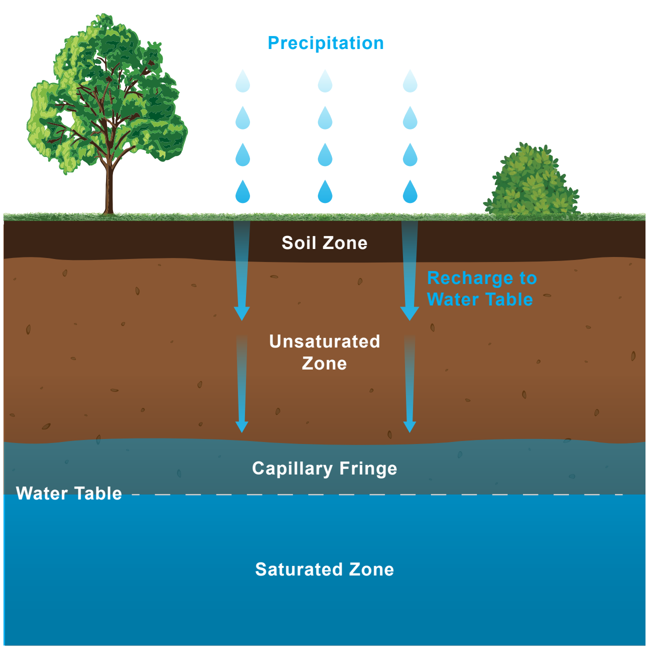
Limiting zones are conditions in the underlying soils that can affect the maximum available depth for installation and can reduce the strength and stability of the underlying subgrade. The three main forms of limiting zones are water tables, bedrock, and karst topography. It is recommended that a system be offset a minimum of 12" (305 mm) from any limiting zones.

Compaction

Soil compaction occurs as the soil particles are pressed together and pore space is eliminated. By compacting the soils to 95% (as recommended by Brentwood), the subgrade strength will increase, in turn limiting both the potential for the soil to move once installed and for differential settlement to occur throughout the system. If designing the specific compaction requirement, settlement should be limited to less than 1" (25 mm) through the entire subgrade and should not exceed a 1/2" (13 mm) of differential settlement between any two adjacent units within the system over time.

Mitigation

If a minimum subgrade bearing capacity cannot be achieved because of weak soil, a suitable design will need to be completed by a Geotechnical Engineer. This design may include the over-excavation of the subgrade and an engineered fill or slurry being placed. Additional material such as geogrid or other products may also be required. Please contact a Geotechnical Engineer prior to selecting products or designing the subgrade.



Water Table Zones

6.0 System Materials

Geotextile Fabric

The 6-ounce geotextile fabric is recommended to be installed between the soil and stone interfaces around the Modules to prevent soil migration.

Leveling Bed

The leveling bed is constructed of 6"-thick (152 mm) angular stone (Table 2). The bed has not been designed as a structural element but is utilized to provide a level surface for the installation of the system and provide an even distribution of load to the subgrade.

Stone Backfill

The stone backfill is designed to limit the strain on the product through displacement of load and ensure the product's longevity. Therefore, a minimum of 12"-wide (305 mm) angular stone must be placed around all sides of the system. In addition, a minimum layer of 12" (305 mm) angular stone is required on top of the system. All material is to be placed evenly in 12" (305 mm) lifts around and on top of the system and aligned with a vibratory plate compactor.

Table 2: Approved Backfill Material

Material Location	Description	AASHTO M43 Designation	ASTM D2321 Class	Compaction/Density
Finished Surface	Topsoil, hardscape, stone, concrete, or asphalt per Engineer of Record	N/A	N/A	Prepare per engineered plans
Suitable Compactable Fill	Well-graded granular soil/aggregate, typically road base or earthen fill (maximum 4" particle size)	56, 57, 6, 67, 68	I & II III (Earth Only)	Place in maximum 12" lifts to a minimum 90% standard proctor density
Top Backfill	Crushed angular stone placed between Modules and road base or earthen fill	56, 57, 6, 67, 68	I & II	Plate vibrate to provide evenly distributed layers
Side Backfill	Crushed angular stone placed between earthen wall and Modules	56, 57, 6, 67, 68	I & II	Place and plate vibrate in uniform 12" lifts around the system
Leveling Bed	Crushed angular stone placed to provide level surface for installation of Modules	56, 57, 6, 67, 68	I & II	Plate vibrate to achieve level surface

Impermeable Liner

In designs that prevent runoff from infiltrating into the surrounding soil (detention or reuse applications) or groundwater from entering the system, an impermeable liner is required. When incorporating a liner as part of the system, Brentwood recommends using a manufactured product such as a PVC liner. This can be installed around the Modules themselves or installed around the excavation (to gain the benefit of the void space in the stone) and should include an underdrain system to ensure the basin fully drains. This liner is installed with a layer of geotextile fabric on both sides to prevent puncture, in accordance with manufacturer recommendations.

7.0 Connections

Stormwater runoff must be able to move readily in and out of the StormTank® Module system. Brentwood has developed numerous means of connecting to the system, including inlet/outlet ports and direct abutment to a catch basin or endwall. All methods of connection should be evaluated as each one may offer a different solution. Brentwood has developed drawings to assist with specific installation methods, and these are available at www.brentwoodindustries.com.

Inlet/Outlet and Pipe Connections

To facilitate easy connection to the system, Brentwood manufactures two inlet/outlet ports. They are 12" (305 mm) and 14" (356 mm), respectfully, and utilize a flexible coupling connection to the adjoining pipe.

Another common installation method is to directly connect the pipe to the system. In order to do this, an opening is cut into the side panels, the pipe is inserted, and then the system is wrapped in geotextile fabric. When utilizing this connection method, the pipe must be located a minimum of 3" (76 mm) from the bottom of the system. This provides adequate clearance for the bottom platen and the required strength in the remaining side panel. To maintain the required clearances or reduce pipe size, it may be necessary to connect utilizing a manifold system.

Direct Abutment

The system can also be connected by directly abutting Modules to a concrete catch basin or endwall. This allows for a seamless connection of structures in close proximity to the system and eliminates the need for numerous pipe connections. When directly abutting one of these structures, remove any side panels that fully abut the structure, and make sure it is flush with the system to prevent material migration into the structure.

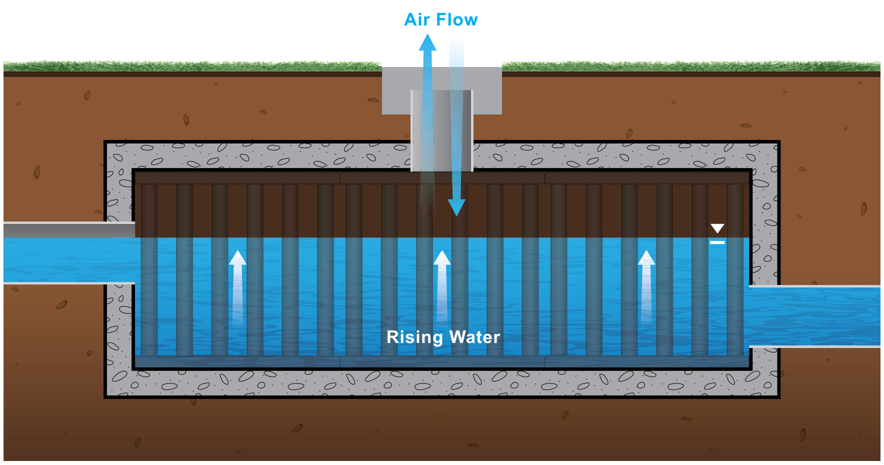
Underdrain

Underdrains are typically utilized in detention applications to ensure the system fully drains since infiltration is limited or prohibited. The incorporation of an underdrain in a detention application will require an impermeable liner between the stone-soil interface.

Cleanout Ports

Brentwood understands the necessity to inspect and clean a subsurface system and has designed the Module without any walls to allow full access. Brentwood offers three different cleanout/observation ports for utilization with the system. The ports are made from PVC, provide an easy means of connection, and are available in 6" (152 mm), 8" (203 mm) and 10" (254 mm) diameters. The 10" (254 mm) port is sized to allow access to the system by a vacuum truck suction hose for easy debris removal.

It is recommended that ports be located a maximum of 30' (9.14 m) on center to provide adequate access, ensure proper airflow, and allow the system to completely fill.



Ventilation and Air Flow

8.0 Pretreatment

Removing pollutants from stormwater runoff is an important component of any stormwater management plan. Pretreatment works to prevent water quality deterioration and also plays an integral part in allowing the system to maintain performance over time and increase longevity. Treatment products vary in complexity, design, and effectiveness, and therefore, should be selected based on specific project requirements.

Typical Stormwater System

Catch Basin → **Inlet Piping** → **Pretreatment** → **Storage Basin** → **Outlet Structure**

Pretreatment: STORMTANK® *Shield*

Storage Basin: STORMTANK® *Module*, STORMTANK® *Pack*

StormTank® Shield

Brentwood's StormTank Shield provides a low-cost solution for stormwater pretreatment. Designed to improve sumped inlet treatment, the Shield reduces pollutant discharge through gross sediment removal and oil/water separation. For more information, please visit www.brentwoodindustries.com.

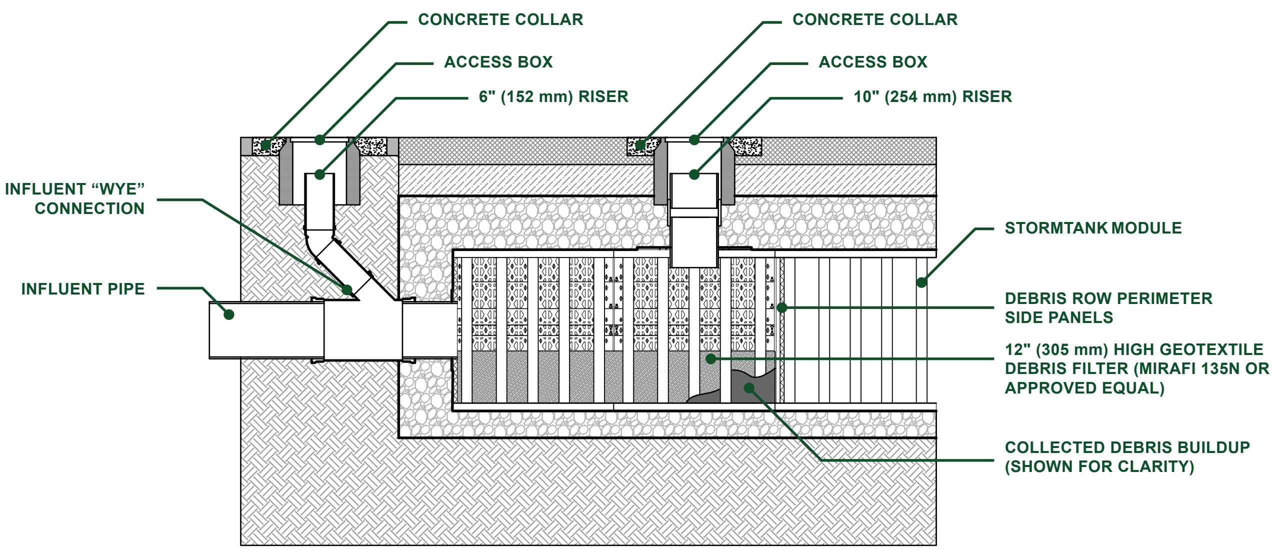
Debris Row (Easy Cleanout)

An essential step of designing, installing, and maintaining a subsurface system is preventing debris from entering the storage. This can be done by incorporating debris rows (or bays) at the inlets of the system to prevent debris from entering the rest of the system.

The debris row is built into the system utilizing side panels with a 12" (305 mm) segment of geotextile fabric. This allows for the full basin capacity to be utilized while storing any debris in an easy-to-remove location. To calculate the number of side panels required to prevent backing up, the opening area of the side panels on the area above the geotextile fabric has been calculated and compared to the inflow pipe diameter.

Debris row cleanout is made easy by including 10" (254 mm) suction ports, based on the length of the row, and a 6" (152 mm) saddle connection to the inflow pipe. If the system is directly abutting a catch basin, the saddle connection is not required, and the flush hose can be inserted through the catch basin. Debris is then flushed from the inlet toward the suction ports and removed.

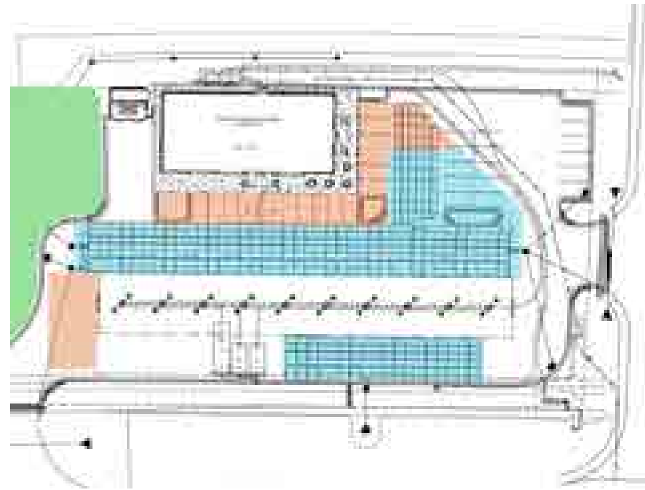
Brentwood has developed drawings and specifications that are available at www.brentwoodindustries.com to illustrate the debris row configuration and layouts.



Debris Row Section Detail

9.0 Additional Considerations

Many variable factors, such as the examples below, must be taken into consideration when designing a StormTank® Module system. As these considerations require complex calculations and proper planning, please contact Brentwood or your local distributor to discuss project-specific requirements.



Site Plan Module Layout Adaptability
(StormTank Modules shown in blue)

Adaptability

The Modules can be arranged in custom configurations to meet tight site constraints and to provide different horizontal and edge configurations. Modules can also be stacked, to a maximum 2 units tall, to meet capacity needs and can be buried to a maximum invert of 11' (3.35 m) to allow for a stacked system or deeper burial.

Adjacent Structures

The location of adjacent structures, especially the location of footings and foundations, must be taken into consideration as part of system design. The foundation of a building or retaining wall produces a load that is transmitted to a footing and then applied to the surface below. The footing is intended to distribute the line load of the wall over a larger area without increasing the larger wall's thickness. The reason this is important is because the load the footing is applying to the earth is distributed through the earth and could potentially affect a subsurface system as either a vertical load to the top of the Module or a lateral load to the side of the Module.

Based on this increased loading, it is recommended that the subsurface system either maintain a distance away from the foundation, footing equal to the height between the Module invert and structure invert of the system, or the foundation or footing extend at a minimum to the invert of the subsurface system. By locating the foundation away from the system or equal to the invert, the loading generated by the structure does not get transferred onto the system. It is recommended that all adjacent structures be completed prior to the installation of the Modules to prevent construction loads from being imparted on the system.

Adjacent Excavation

The subsurface system must be protected before, during, and after the installation. Once a system is installed, it is important to remember that excavation adjacent to the system could potentially cause the system to become unstable. The uniform backfilling will evenly distribute the lateral loads to the system and prohibit the system from becoming unstable and racking from unequal loads. However, it is recommended that any excavation adjacent to a system remain a minimum distance away from the system equal to the invert. This will provide a soil load that is equal to the load applied by the opposite side of the installation. If the excavation is to exceed the invert of the system, additional analysis may be necessary.

Sloped Finished Grade

Much like adjacent excavation, a finished grade with a differential cover could potentially cause a subsurface system to become disproportionately loaded. For example, if one side of the system has 10' (3.05 m) of cover and the adjacent side has 24" (610 mm) of cover, the taller side will generate a higher lateral load, and the opposite side may not have an equal amount of resistance to prevent a racking of the system. Additional evaluation may be required when working on sites where the final grade around a system exceeds 5%.

10.0 Inspection & Maintenance

Description

Proper inspection and maintenance of a subsurface stormwater storage system are vital to ensuring proper product functioning and system longevity. It is recommended that during construction the contractor takes the necessary steps to prevent sediment from entering the subsurface system. This may include the installation of a bypass pipe around the system until the site is stabilized. The contractor should install and maintain all site erosion and sediment per Best Management Practices (BMP) and local, state, and federal regulations.

Once the site is stabilized, the contractor should remove and properly dispose of erosion and sediment per BMP and all local, state, and federal regulations. Care should be taken during removal to prevent collected sediment or debris from entering the stormwater system. Once the controls are removed, the system should be flushed to remove any sediment or construction debris by following the maintenance procedure outlined below.

During the first service year, a visual inspection should be completed during and after each major rainfall event, in addition to semi-annual inspections, to establish a pattern of sediment and debris buildup. Each stormwater system is unique, and multiple criteria can affect maintenance frequency. For example, whether or not a system design includes inlet protection or a pretreatment device has a substantial effect on the system's need for maintenance. Other factors include where the runoff is coming from (hardscape, gravel, soil, etc.) and seasonal changes like autumn leaves and winter salt.

During and after the second year of service, an established annual inspection frequency, based on the information collected during the first year, should be followed. At a minimum, an inspection should be performed semi-annually. Additional inspections may be required at the change of seasons for regions that experience adverse conditions (leaves, cinders, salt, sand, etc).

Maintenance Procedures

Inspection:

1. Inspect all observation ports, inflow and outflow connections, and the discharge area.
2. Identify and log any sediment and debris accumulation, system backup, or discharge rate changes.
3. If there is a sufficient need for cleanout, contact a local cleaning company for assistance.

Cleaning:

1. If a pretreatment device is installed, follow manufacturer recommendations.
2. Using a vacuum pump truck, evacuate debris from the inflow and outflow points.
3. Flush the system with clean water, forcing debris from the system.
4. Repeat steps 2 and 3 until no debris is evident.

11.0 System Sizing

System Sizing Calculation

This section provides a brief description of the process required to size the StormTank® Module system. If you need additional assistance in determining the required number of Modules or assistance with the proposed configuration, it is recommended that you contact Brentwood or your local distributor. Additionally, Brentwood's volume calculator can help you to estimate the available storage volumes with and without stone storage. This tool is available at www.brentwoodindustries.com.

1. Determine the required storage volume (Vs):
It is the sole responsibility of the Engineer of Record to calculate the storage volume in accordance with all local, state, and federal regulations.

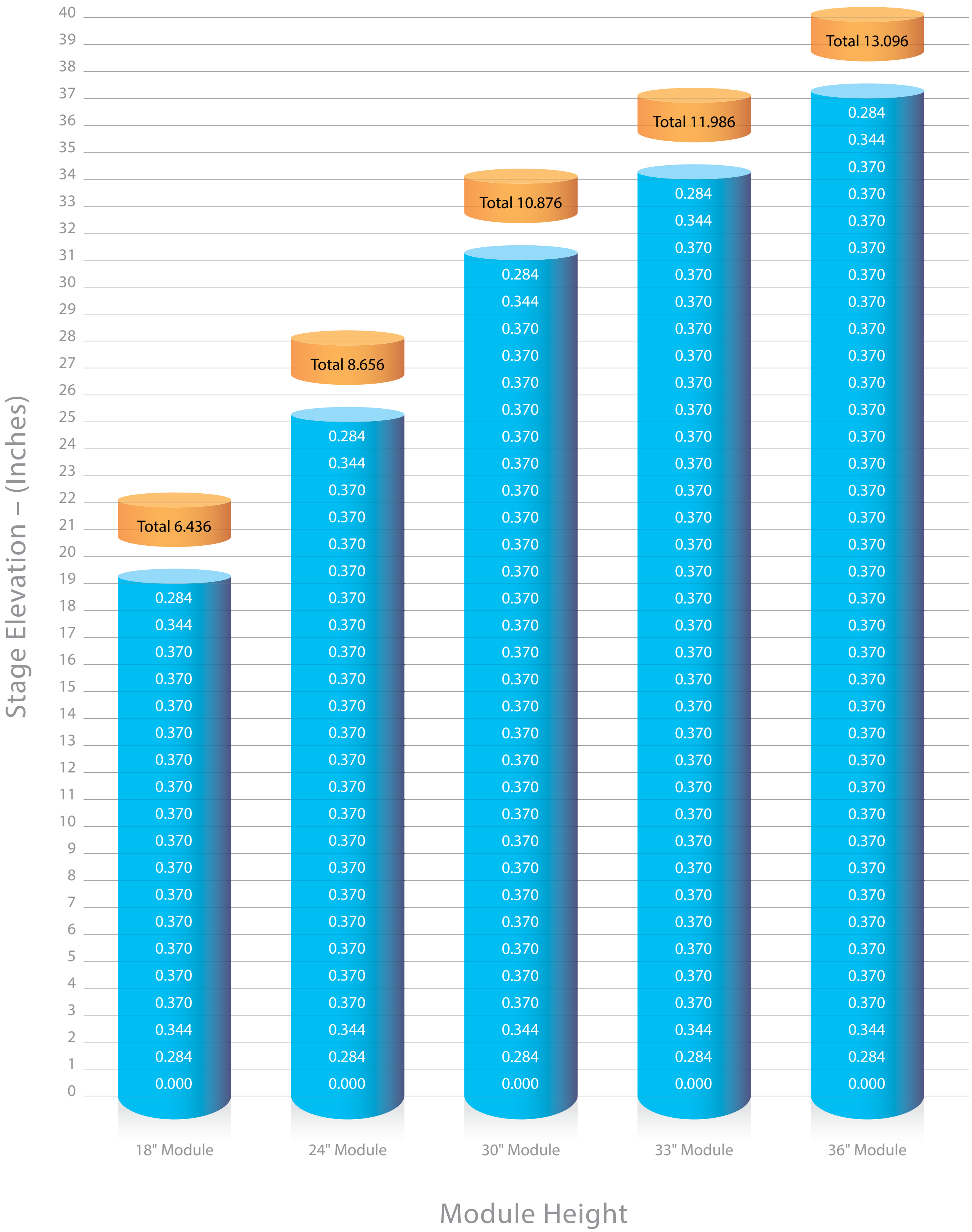
2. Determine the required number of Modules (N):
If the storage volume does not include stone storage, take the total volume divided by the selected Module storage volume. If the stone storage is to be included, additional calculations will be required to determine the available stone storage for each configuration.

3. Determine the required volume of stone (Vstone):
The system requires a minimum 6" (152 mm) leveling bed, 12" (305 mm) backfill around the system, and 12" (305 mm) top backfill utilizing 3/4" (19 mm) angular clean stone. Therefore, take the area of the system times the leveling bed and the top backfill. Once that value is determined, add the volume based on the side backfill width times the height from the invert of the Modules to the top of the Modules.

4. Determine the required excavation volume (Vexcv):
Utilizing the area of the system, including the side backfill, multiply by the depth of the system including the leveling bed. It is noted that this calculation should also include any necessary side pitch or benching that is required for local, state, or federal safety standards.

5. Determine the required amount of geotextile (G):
The system utilizes a multiple layer system of geotextile fabric. Therefore, two calculations are required to determine the necessary amount of geotextile. The first layer surrounds the entire system (including all backfill), and the second layer surrounds the Module system only. It is recommended that an additional 20% be included for waste and overlap.

11.1 Storage Volume



11.2 Material Quantity Worksheet

Project Name:	By:

Location:	Date:

System Requirements

Required Storage		ft^3 (m^3)
Number of Modules		Each
Module Storage		ft^3 (m^3)
Stone Storage		ft^3 (m^3)
Module Footprint		ft^2 (m^2) Number of Modules x 4.5 ft^2 (0.42 m^2)
System Footprint w/ Stone		ft^2 (m^2) Module Footprint + 1 ft (0.3048 m) to each edge
Stone		Tons (kg) Leveling Bed + Side Backfill + Top Backfill
Volume of Excavation		yd^3 (m^3) System Footprint w/ Stone x Total Height
Area of Geotextile		yd^2 (m^2) Wrap around Modules + Wrap around Stone/Soil Interface

System Cost

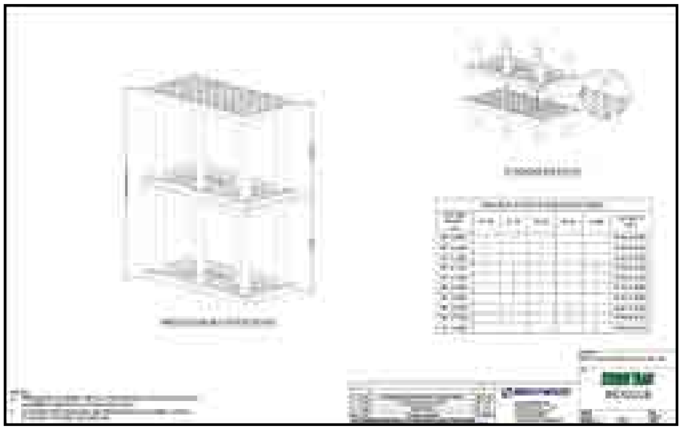
	Quantity			**Unit Price**			**Total**
Modules		ft^3 (m^3)	**X**	$	ft^3 (m^3)	=	$
Stone		Tons (kg)	**X**	$	Tons (kg)	=	$
Excavation		yd^3 (m^3)	**X**	$	yd^3 (m^3)	=	$
Geotextile		yd^2 (m^2)	**X**	$	yd^2 (m^2)	=	$
						Subtotal =	$
						Tons =	$

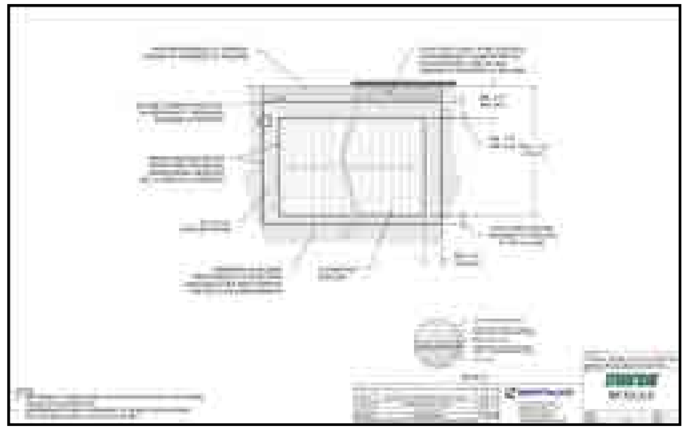
Material costs may not include freight.

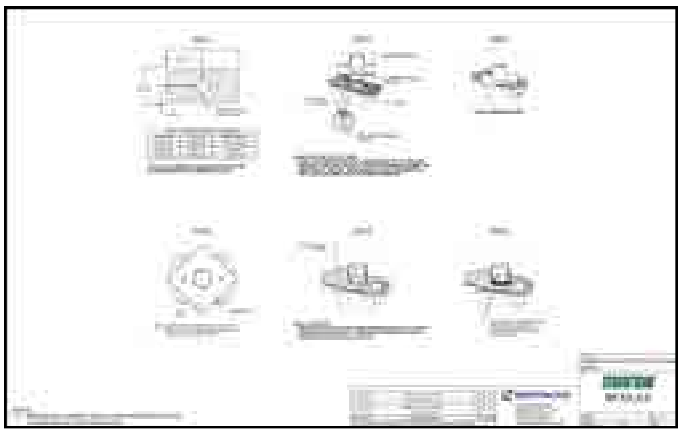
Please contact Brentwood or your local distributor for this information.

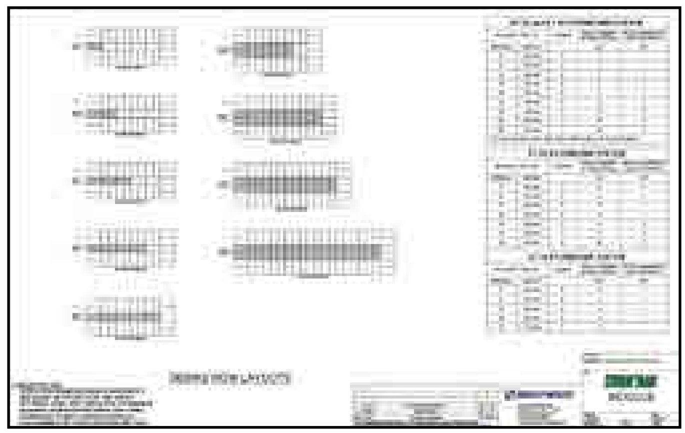
12.0 Detail Drawings

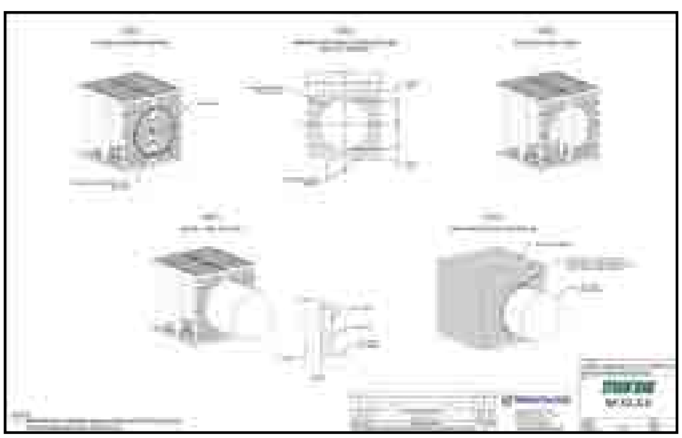
Brentwood has developed numerous drawings for utilization when specifying a StormTank® Module system. Below are some examples of drawings available at [www.brentwoodindustries.com.](http://www.brentwoodindustries.com)

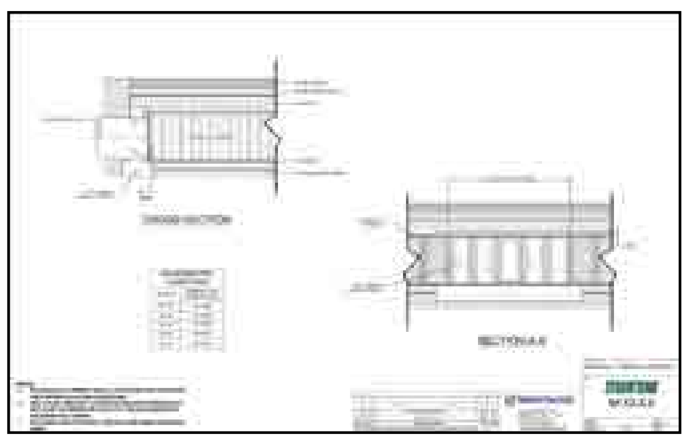












13.0 Specifications

1) General

a) This specification shall govern the implementation, performance, material, and fabrication pertaining to the subsurface stormwater storage system. The subsurface stormwater storage system shall be manufactured by Brentwood Industries, Inc., 500 Spring Ridge Drive, Reading, PA 19610 (610.374.5109), and shall adhere to the following specification at the required storage capacities.

b) All work is to be completed per the design requirements of the Engineer of Record and to meet or exceed the manufacturer's design and installation requirements.

2) Subsurface Stormwater Storage System Modules

a) The subsurface stormwater storage system shall be constructed from virgin polypropylene and 100% recycled PVC to meet the following requirements:

i) High-Impact Polypropylene Copolymer Material

(1) Injection molded, polypropylene, top/bottom platens and side panels formed to a dimension of 36" (914 mm) long by 18" (457 mm) wide [nominal].

ii) 100% Recycled PVC Material

(1) PVC conforming to ASTM D-1784 Cell Classification 12344 b-12454 B.

(2) Extruded, rigid, and 100% recycled PVC columns sized for applicable loads as defined by Section 3 of the AASHTO LRFD Bridge Design Specifications and manufactured to the required length per engineer-approved drawings.

iii) Platens and columns are assembled on site to create Modules, which can be uniformly stacked up to two Modules high, in vertical structures of variable height (custom for each project).

iv) Modular stormwater storage units must have a minimum 95% void space and be continuously open in both length and width, with no internal walls or partitions.

3) Submittals

a) Only systems that are approved by the engineer will be allowed.

b) At least 10 days prior to bid, submit the following to the engineer to be considered for pre-qualification to bid:

i) A list of materials to be provided for work under this article, including the name and address of the materials producer and the location from which the materials are to be obtained.

ii) Three hard copies of the following:

(1) Shop drawings.

(2) Specification sheets.

(3) Installation instructions.

(4) Maintenance guidelines.

c) Subsurface Stormwater Storage System Component Samples for review:

i) Subsurface stormwater storage system Modules provide a single 36" (914 mm) long by 18" (457 mm) wide, height as specified, unit of the product for review.

ii) Sample to be retained by owner.

d) Manufacturers named as acceptable herein are not required to submit samples.

4) Structural Design

a) The structural design, backfill, and installation requirements shall ensure the loads and load factors specified in the AASHTO LRFD Bridge Design Specifications, Section 3 are met.

b) Product shall be tested under minimum installation criteria for short-duration live loads that are calculated to include a 20% increase over the AASHTO Design Truck standard with consideration for impact, multiple vehicle presences, and live load factor.

c) Product shall be tested under maximum burial criteria for long-term dead loads.

d) The engineer may require submission of third-party test data and results in accordance with items 4b and 4c to ensure adequate structural design and performance.

14.0 Appendix - Bearing Capacity Tables

Cover		HS-25 (Unfactored)		HS-25 (Factored)	
English (in)	Metric (mm)	English (ksf)	Metric (kPa)	English (ksf)	Metric (kPa)
24	610	1.89	90.45	4.75	227.43
25	635	1.82	86.96	4.53	216.90
26	660	1.75	83.78	4.34	207.80
27	686	1.69	80.88	4.16	199.18
28	711	1.63	78.24	3.99	191.04
29	737	1.58	75.82	3.84	183.86
30	762	1.54	73.62	3.70	177.16
31	787	1.50	71.60	3.57	170.93
32	813	1.46	69.75	3.45	165.19
33	838	1.42	68.06	3.34	159.92
34	864	1.39	66.51	3.24	155.13
35	889	1.36	65.10	3.14	150.34
36	914	1.33	63.80	3.05	146.03
37	940	1.31	62.62	2.97	142.20
38	965	1.29	61.54	2.90	138.85
39	991	1.26	60.55	2.83	135.50
40	1,016	1.25	59.65	2.76	132.15
41	1,041	1.23	58.54	2.70	129.28
42	1,067	1.21	58.09	2.67	127.84
43	1,092	1.20	57.42	2.60	124.49
44	1,118	1.19	56.81	2.55	122.09
45	1,143	1.18	56.26	2.50	119.70
46	1,168	1.16	55.77	2.46	117.79
47	1,194	1.16	55.33	2.42	115.87
48	1,219	1.15	54.94	2.39	114.43
49	1,245	1.14	54.59	2.36	113.00
50	1,270	1.13	54.29	2.33	111.56
51	1,295	1.13	54.03	2.30	110.12
52	1,321	1.12	53.80	2.27	108.69
53	1,346	1.12	53.62	2.25	107.73
54	1,372	1.12	53.46	2.23	106.77
55	1,397	1.11	53.34	2.21	105.82
56	1,422	1.11	53.24	2.19	104.86
57	1,448	1.11	53.18	2.17	103.90
58	1,473	1.11	53.14	2.16	103.42
59	1,499	1.11	53.12	2.14	102.46
60	1,524	1.11	53.13	2.13	101.98
61	1,549	1.11	53.16	2.12	101.51
62	1,575	1.11	53.21	2.11	101.03
63	1,600	1.11	53.28	2.10	100.55
64	1,626	1.11	53.37	2.09	100.07
65	1,651	1.12	53.48	2.08	99.59
66	1,676	1.12	53.61	2.08	99.59
67	1,702	1.12	53.75	2.07	99.11
68	1,727	1.13	53.91	2.07	99.11
69	1,753	1.13	54.08	2.06	98.63

Cover		HS-25 (Unfactored)		HS-25 (Factored)	
English (in)	Metric (mm)	English (ksf)	Metric (kPa)	English (ksf)	Metric (kPa)
70	1,778	1.13	54.26	2.06	98.63
71	1,803	1.14	54.46	2.06	98.63
72	1,829	1.14	54.67	2.06	98.63
73	1,854	1.15	54.90	2.06	98.63
74	1,880	1.15	55.13	2.06	98.63
75	1,905	1.16	55.38	2.06	98.63
76	1,930	1.16	55.64	2.06	98.63
77	1,956	1.17	55.90	2.06	98.63
78	1,981	1.17	56.18	2.06	98.63
79	2,007	1.18	56.46	2.07	99.11
80	2,032	1.19	56.76	2.07	99.11
81	2,057	1.19	57.06	2.07	99.11
82	2,083	1.20	57.37	2.08	99.59
83	2,108	1.20	57.69	2.08	99.59
84	2,134	1.21	58.02	2.09	100.07
85	2,159	1.22	58.35	2.09	100.07
86	2,184	1.23	58.69	2.10	100.55
87	2,210	1.23	59.04	2.11	101.03
88	2,235	1.24	59.39	2.11	101.03
89	2,261	1.25	59.75	2.12	101.51
90	2,286	1.26	60.11	2.13	101.98
91	2,311	1.26	60.48	2.13	101.98
92	2,337	1.27	60.86	2.14	102.46
93	2,362	1.28	61.24	2.15	102.94
94	2,388	1.29	61.62	2.16	103.42
95	2,413	1.30	62.01	2.17	103.90
96	2,438	1.30	62.41	2.18	104.38
97	2,464	1.31	62.81	2.19	104.86
98	2,489	1.32	63.21	2.20	105.34
99	2,515	1.33	63.62	2.21	105.82
100	2,540	1.34	64.03	2.22	106.29
101	2,565	1.35	64.45	2.23	106.77
102	2,591	1.35	64.87	2.24	107.25
103	2,616	1.36	65.29	2.25	107.73
104	2,642	1.37	65.72	2.27	108.69
105	2,667	1.38	66.15	2.28	109.17
106	2,692	1.39	66.58	2.29	109.65
107	2,718	1.40	67.02	2.30	110.12
108	2,743	1.41	67.45	2.31	110.60
109	2,769	1.42	67.90	2.33	111.56
110	2,794	1.43	68.34	2.34	112.04
111	2,819	1.44	68.79	2.35	112.52
112	2,845	1.45	69.24	2.36	113.00
113	2,870	1.46	69.69	2.38	113.96
114	2,896	1.47	70.15	2.39	114.43

BRENTWOOD INDUSTRIES, INC.
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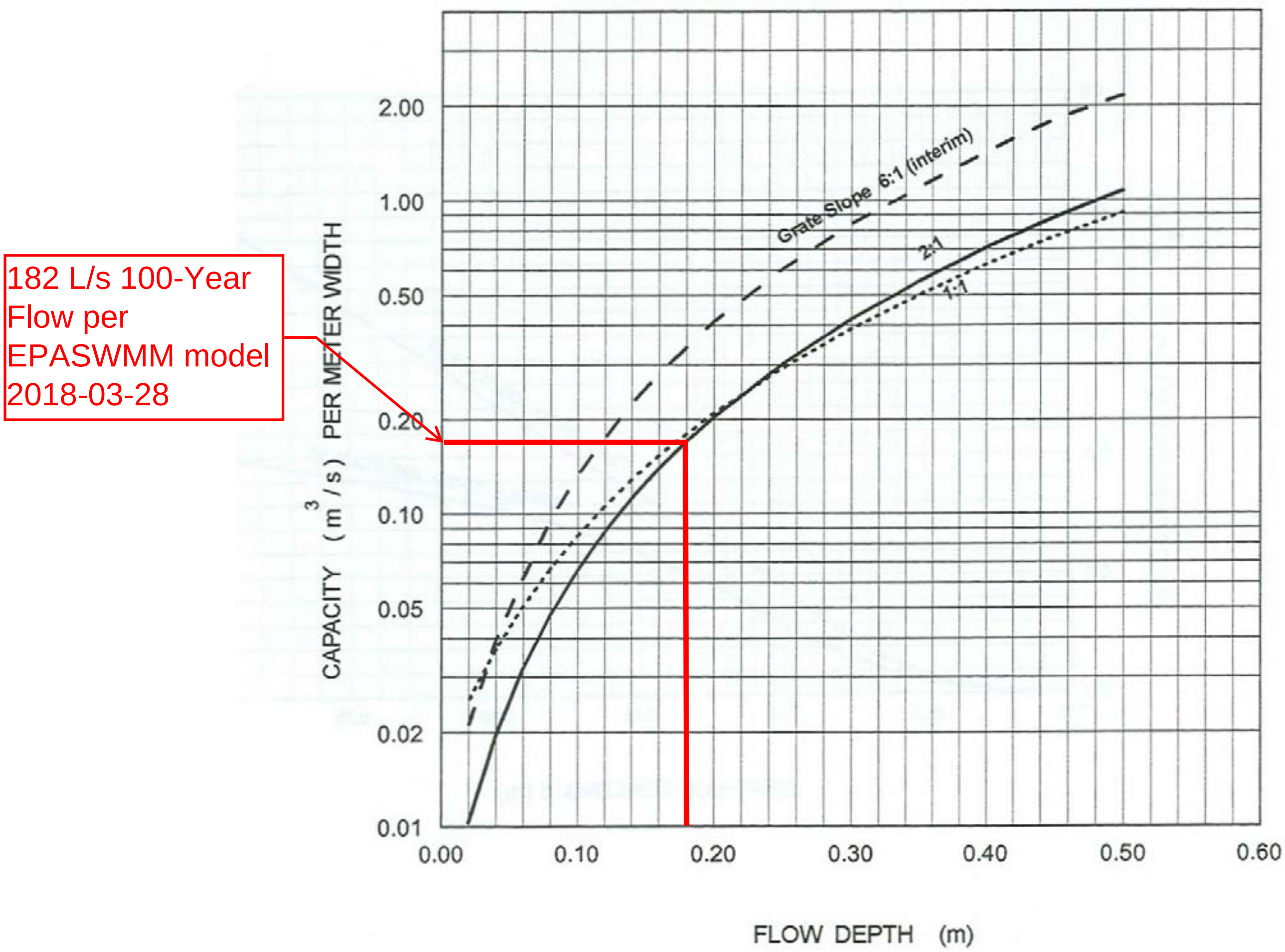
Design Chart 4.20: Ditch Inlet Capacity

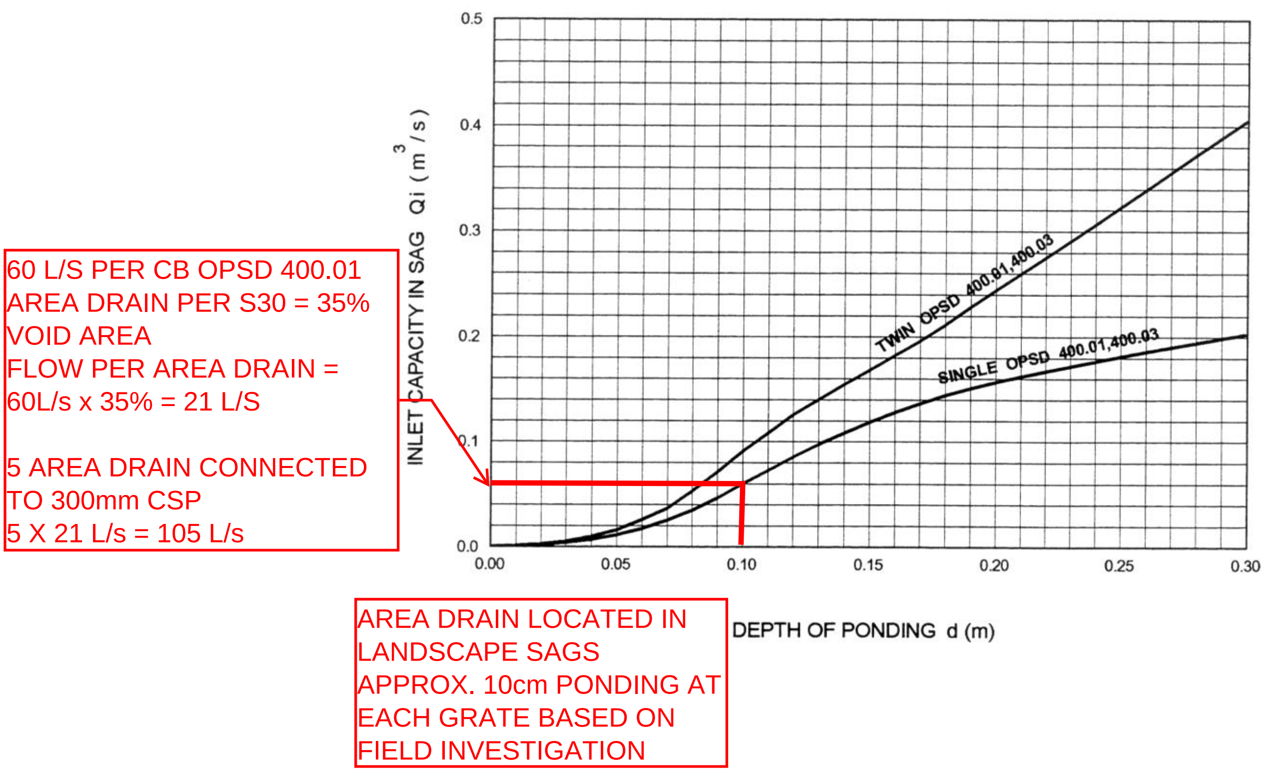


Notes:

1. Curves apply to grate Type 403.01, but may be used for straight - bar inlets without significant loss of accuracy.
2. Capacities given by curves are for unobstructed grates only. For design use working capacity ≯ 0.5 x unobstructed capacity.
3. Capacities of grates operating in high velocity flows are less than indicated.

Surface Inlet Capacity At Road Sags[8]

Design Chart 4.19: Inlet Capacity at Road Sag



[8] From the *MTO Drainage Management Manual*

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... LPS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2000 00:01:00
Ending Date .............. JAN-02-2000 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:01:00
Dry Time Step ............ 00:01:00
Routing Time Step ........ 2.00 sec


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.150        82.291
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.075        41.494
Surface Runoff ...........         0.073        40.285
Final Surface Storage ....         0.001         0.573
Continuity Error (%) .....        -0.074


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.073         0.732
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.072         0.720
Internal Outflow .........         0.001         0.013
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....        -0.028
```

```
***************************
Time-Step Critical Elements
***************************
None


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.91 sec
Average Time Step           :     2.00 sec
Maximum Time Step           :     2.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.01


***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff LPS	Runoff Coeff
EX12	82.29	0.00	0.00	31.62	49.89	0.10	93.22	0.606
EX13	82.29	0.00	0.00	31.69	49.82	0.28	259.72	0.605
EX15	82.29	0.00	0.00	7.63	73.33	0.05	27.80	0.891
EX1-EX2-A1	82.29	0.00	0.00	51.76	30.26	0.24	89.61	0.368
A2	82.29	0.00	0.00	48.28	33.84	0.07	41.65	0.411

```
******************
Node Depth Summary
******************
```

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days	Time of Max Occurrence hr:min
AD	JUNCTION	0.01	0.40	96.80	0	01:57
STM12	JUNCTION	0.01	0.81	96.01	0	01:52
STM13	JUNCTION	0.02	0.91	95.99	0	01:58
STM15	OUTFALL	0.01	0.38	95.34	0	01:55

5	OUTFALL	0.00	0.00	0.00	0 00:00

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow LPS	Maximum Total Inflow LPS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr
AD	JUNCTION	93.21	93.21	0 01:59	0.099	0.099
STM12	JUNCTION	0.00	87.73	0 01:59	0.000	0.098
STM13	JUNCTION	259.71	296.33	0 01:59	0.278	0.365
STM15	OUTFALL	27.80	324.13	0 01:59	0.046	0.411
5	OUTFALL	127.21	127.21	0 01:59	0.309	0.309

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
AD	JUNCTION	0.04	0.100	0.000
STM12	JUNCTION	0.19	0.510	0.000
STM13	JUNCTION	0.19	0.524	0.261

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate LPS	Time of Max Occurrence days hr:min	Total Flood Volume 10^6 ltr	Maximum Ponded Depth Meters
AD	0.03	7.77	0 01:57	0.000	0.40
STM12	0.11	51.05	0 01:59	0.012	0.81

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow LPS	Max. Flow LPS	Total Volume 10^6 ltr
STM15	27.70	17.22	324.13	0.411

5	23.26	15.41	127.21	0.309
System	25.48	32.62	451.34	0.720

****
Link Flow Summary
****

Link	Type	Maximum |Flow| LPS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	87.73	0 01:59	1.28	0.81	1.00
2	CONDUIT	84.89	0 02:00	1.20	1.03	1.00
3	CONDUIT	296.33	0 01:59	2.68	2.24	1.00

****
Flow Classification Summary
****

		--- Fraction of Time in Flow Class ----								
Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
1	1.00	0.07	0.00	0.00	0.86	0.07	0.00	0.00	0.11	0.0000
2	1.00	0.07	0.00	0.00	0.93	0.00	0.00	0.00	0.06	0.0001
3	1.00	0.07	0.00	0.00	0.87	0.06	0.00	0.00	0.13	0.0001

****
Conduit Surcharge Summary
****

	--------- Hours Full --------				
Conduit	Both Ends	Upstream	Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
1	0.04	0.04	0.04	0.01	0.01
2	0.19	0.19	0.19	0.01	0.01
3	0.06	0.06	0.07	0.25	0.06

Analysis begun on: Thu Mar 29 18:54:53 2018
Analysis ended on: Thu Mar 29 18:54:53 2018
Total elapsed time: < 1 sec

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... LPS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2000 00:01:00
Ending Date .............. JAN-02-2000 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:01:00
Dry Time Step ............ 00:01:00
Routing Time Step ........ 2.00 sec


WARNING 03: negative offset ignored for Link 13

**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.146        82.292
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.060        33.569
Surface Runoff ...........         0.085        47.971
Final Surface Storage ....         0.001         0.829
Continuity Error (%) .....        -0.094


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.085         0.852
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.084         0.839
Internal Outflow .........         0.001         0.013
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.031
```

****
Time-Step Critical Elements
****
Link 14 (1.05%)

****
Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****

Minimum Time Step : 0.72 sec
Average Time Step : 2.00 sec
Maximum Time Step : 2.00 sec
Percent in Steady State : 0.00
Average Iterations per Step : 2.01

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff LPS	Runoff Coeff
EX12	82.29	0.00	0.00	31.62	49.89	0.10	93.22	0.606
EX13	82.29	0.00	0.00	31.69	49.82	0.28	259.72	0.605
EX15	82.29	0.00	0.00	7.63	73.33	0.05	27.80	0.891
D1-D6	82.29	0.00	0.00	34.58	46.90	0.33	172.95	0.570
EX2	82.29	0.00	0.00	42.92	39.00	0.02	17.33	0.474
EX1	82.29	0.00	0.00	39.16	42.62	0.06	62.32	0.518
U2	82.29	0.00	0.00	49.57	32.66	0.02	31.22	0.397

****
Node Depth Summary
****

	Average Depth	Maximum Depth	Maximum HGL	Time of Max Occurrence

Node	Type	Meters	Meters	Meters	days hr:min
AD	JUNCTION	0.02	0.40	96.80	0 01:59
STM12	JUNCTION	0.03	0.81	96.01	0 01:52
STM13	JUNCTION	0.04	0.91	95.99	0 01:58
STM15	OUTFALL	0.03	0.38	95.34	0 01:55
1	OUTFALL	0.00	0.00	0.00	0 00:00
DICB101	STORAGE	0.07	0.87	97.41	0 02:15

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow LPS	Maximum Total Inflow LPS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr
AD	JUNCTION	93.19	94.40	0 01:56	0.099	0.459
STM12	JUNCTION	0.00	90.75	0 02:01	0.000	0.457
STM13	JUNCTION	259.62	296.32	0 01:58	0.278	0.724
STM15	OUTFALL	27.78	324.09	0 01:58	0.046	0.770
1	OUTFALL	31.19	74.58	0 02:15	0.024	0.069
DICB101	STORAGE	246.73	252.28	0 01:59	0.404	0.405

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
AD	JUNCTION	0.07	0.100	0.000
STM12	JUNCTION	0.24	0.510	0.000
STM13	JUNCTION	0.22	0.524	0.261

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate LPS	Time of Max Occurrence days hr:min	Total Flood Volume 10^6 ltr	Maximum Ponded Depth Meters
AD	0.01	3.05	0 01:59	0.000	0.40
STM12	0.11	50.75	0 01:59	0.012	0.81

****
Storage Volume Summary

****

Storage Unit	Average Volume 1000 m3	Avg Pcnt Full	E&I Pcnt Loss	Maximum Volume 1000 m3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow LPS
DICB101	0.020	9	0	0.209	100	0 02:15	111.05

****

Outfall Loading Summary

****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow LPS	Max. Flow LPS	Total Volume 10^6 ltr
STM15	29.24	30.95	324.09	0.770
1	4.69	18.77	74.58	0.069
System	16.97	49.72	355.29	0.839

****

Link Flow Summary

****

Link	Type	Maximum |Flow| LPS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	90.75	0 02:01	1.36	0.84	1.00
2	CONDUIT	90.85	0 02:01	1.29	1.10	1.00
3	CONDUIT	296.31	0 01:58	2.68	2.24	1.00
14	CONDUIT	70.16	0 02:15	0.56	0.91	0.97
13	ORIFICE	40.88	0 02:15			1.00

****

Flow Classification Summary

****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
1	1.00	0.07	0.00	0.00	0.72	0.21	0.00	0.00	0.28	0.0000
2	1.00	0.07	0.00	0.00	0.76	0.06	0.00	0.12	0.24	0.0001
3	1.00	0.07	0.00	0.00	0.76	0.17	0.00	0.00	0.26	0.0001
14	1.00	0.98	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.0000

****

Conduit Surcharge Summary

****

Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
1	0.07	0.07	0.07	0.01	0.01
2	0.24	0.24	0.24	0.03	0.03
3	0.06	0.06	0.07	0.32	0.06

Analysis begun on: Thu Mar 29 19:31:55 2018
Analysis ended on: Thu Mar 29 19:31:55 2018
Total elapsed time: < 1 sec

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... LPS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2000 00:01:00
Ending Date .............. JAN-02-2000 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:01:00
Dry Time Step ............ 00:01:00
Routing Time Step ........ 2.00 sec


WARNING 04: minimum elevation drop used for Conduit 13

**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.146        82.291
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.071        39.944
Surface Runoff ...........         0.074        41.791
Final Surface Storage ....         0.001         0.620
Continuity Error (%) .....        -0.078


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.074         0.743
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.073         0.730
Internal Outflow .........         0.001         0.013
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.001
Continuity Error (%) .....        -0.015
```

****
Time-Step Critical Elements
****
Link 13 (31.23%)

****
Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****
Minimum Time Step : 0.50 sec
Average Time Step : 1.55 sec
Maximum Time Step : 2.00 sec
Percent in Steady State : 0.00
Average Iterations per Step : 2.02

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff LPS	Runoff Coeff
EX12	82.29	0.00	0.00	31.62	49.89	0.10	93.22	0.606
EX13	82.29	0.00	0.00	31.69	49.82	0.28	259.72	0.605
EX15	82.29	0.00	0.00	7.63	73.33	0.05	27.80	0.891
A2	82.29	0.00	0.00	48.28	33.84	0.07	41.65	0.411
A1,A3,EX1,EX2	82.29	0.00	0.00	48.68	33.25	0.25	101.62	0.404

****
Node Depth Summary
****

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min
AD	JUNCTION	0.01	0.40	96.80	0 01:58
STM12	JUNCTION	0.03	0.81	96.01	0 01:52

STM13	JUNCTION	0.05	0.91	95.99	0	01:59
STM15	OUTFALL	0.03	0.38	95.34	0	01:55
5	OUTFALL	0.06	0.30	0.30	0	02:11
1	STORAGE	0.07	0.30	0.30	0	02:11

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow LPS	Maximum Total Inflow LPS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr
AD	JUNCTION	93.21	93.21	0 01:59	0.099	0.099
STM12	JUNCTION	0.00	87.73	0 01:59	0.000	0.098
STM13	JUNCTION	259.70	296.33	0 01:59	0.279	0.365
STM15	OUTFALL	27.80	324.13	0 01:59	0.046	0.411
5	OUTFALL	41.63	112.24	0 02:09	0.066	0.319
1	STORAGE	101.62	101.62	0 02:01	0.254	0.254

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
AD	JUNCTION	0.04	0.100	0.000
STM12	JUNCTION	0.19	0.510	0.000
STM13	JUNCTION	0.19	0.524	0.261
1	STORAGE	0.10	0.004	0.096

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate LPS	Time of Max Occurrence days hr:min	Total Flood Volume 10^6 ltr	Maximum Ponded Depth Meters
AD	0.02	8.87	0 01:58	0.000	0.40
STM12	0.11	51.10	0 01:59	0.012	0.81

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 m3	Avg Pcnt Full	E&I Pcnt Loss	Maximum Volume 1000 m3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow LPS
1	0.008	13	0	0.046	69	0 02:11	89.62

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow LPS	Max. Flow LPS	Total Volume 10^6 ltr
STM15	44.12	27.46	324.13	0.411
5	61.88	17.56	112.24	0.319
System	53.00	45.03	383.35	0.730

****
Link Flow Summary
****

Link	Type	Maximum |Flow| LPS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	87.73	0 01:59	1.29	0.81	1.00
2	CONDUIT	84.99	0 02:00	1.20	1.03	1.00
3	CONDUIT	296.33	0 01:59	2.68	2.24	1.00
13	CONDUIT	89.62	0 02:11	1.20	4.24	1.00

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
1	1.00	0.05	0.00	0.00	0.75	0.20	0.00	0.00	0.31	0.0000
2	1.00	0.06	0.00	0.00	0.94	0.00	0.00	0.00	0.15	0.0001
3	1.00	0.06	0.00	0.00	0.77	0.17	0.00	0.00	0.32	0.0001
13	1.00	0.06	0.00	0.00	0.94	0.00	0.00	0.00	0.65	0.0002

****
Conduit Surcharge Summary
****

Conduit	--------- Hours Full -------- Both Ends	Upstream	Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited

---

1	0.04	0.04	0.04	0.01	0.01
2	0.19	0.19	0.19	0.01	0.01
3	0.05	0.05	0.06	0.25	0.05
13	0.01	0.01	0.01	1.08	0.01

Analysis begun on: Thu Mar 29 19:54:38 2018
Analysis ended on: Thu Mar 29 19:54:39 2018
Total elapsed time: 00:00:01

DRAWINGS / FIGURES