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FUNCTIONAL SERVICING REPORT

Corseed Subdivision

West Side of County Road 25, South of Melody Lane
Town of Grand Valley
County of Dufferin
22T-201601

March 2016
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Prepared For: **Corseed Inc.**

CORTEL GROUP

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VALDOR WATER RESOURCES

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1.0 INTRODUCTION

Valdor Engineering Inc. has been retained by Corseed Inc. to provide consulting engineering services for the proposed Corseed Subdivision located on a 14.91 hectare parcel on the west side of County Road 25, south of Melody Lane, in the Town of Grand Valley, County of Dufferin as illustrated in **Figure 1**.

The proponent of the subject development also owns the lands to the southeast which are referred to as the Moco Subdivision (22T-201502) and a separate draft plan application and functional servicing report was submitted. The Moco Subdivision has been granted Draft Plan Approval and detailed engineering design has commenced.

1.1 Existing Conditions

The subject site is bounded to the north by an abandoned railway corridor, to the east County Road 25 and to the south and west by existing agricultural lands. Boyne Creek passes to the southwest of the subject site as it flows to the Grand River in a southeasterly direction. The majority of the subject site is presently a vacant field with two small stands of trees. The geotechnical and topographical conditions of the site are summarized as follows:

1.1.1 Geotechnical

A Geotechnical Investigation Report for the subject site was prepared by V.A. Wood Inc. and consisted of nine (9) total boreholes at 5.0m in depth. The investigation determined that the site is mostly covered by a surficial deposit of topsoil ranging between 100mm and 250mm, underlain by a deposit of brown clay and silt ranging between 0.8m to 4.6m below grade. Only 2 boreholes (BH 6 and BH 8) yielded a sandy silt fill at the surface (BH 6) and beneath the topsoil (BH 8) at 0.8m and 0.9m below grade.

With regards to groundwater, the report indicates that only one of the boreholes encountered cave-in at 0.8m below grade with free water surfaces noted for 6 of the boreholes at 0.9m to 4.1m below grade. An examination of the soil samples revealed a moist to wet observation. The report indicates that provisions should be made for the control of any surface water run-off and minor groundwater seepage by pumping from local sumps, where required. The Report recommends that a side slope of 1:1 be cut back or supported using adequately braced sheeting for excavations exceeding 1.2m below grade. The borehole and test pit logs are included in **Appendix "G"**.

1.1.2 Topography

The surface condition of the subject site can be generally described having gently sloped topography. Based on the topographic survey of the site, the east part of the property slopes from County Road 25 down in a westerly direction towards Boyne Creek. Boyne Creek passes by the southwest corner of the subject site while flowing to the southeast. Based on an existing elevation of 471.90 m near County Road 25 and an existing elevation of 466.50 m at the edge of the environmental protection buffer, the differential of 5.40 m equates to an overall average slope of approximately 1.3% for the development area which is considered to be relatively moderate. The valley area of the site within the environmental protection block slopes downwards towards Boyne Creek at a shallower slope typically ranging between approximately 0.35% and 0.50%.

1.2 Proposed Development

The proposed development consists of a mix of lots for detached dwellings as well as blocks for street townhouses, mixed use development and commercial space. The lot frontages for the detached dwellings will typically range from 42 to 50 feet. The subdivision will include a road connection to County Road 25 and consist of an internal network of looping streets.

A block of land in the north west part of the development has been established for a stormwater management facility to treatment for stormwater runoff. The remainder of the lands consist of blocks along County Road 25 for a sidewalk, an environmental protection area containing the valley lands associated with the adjacent Boyne Creek and a buffer block designated as open space. A reduced copy of the proposed Draft Plan of Subdivision is contained in **Figure 2**. The development statistics and the equivalent population data are summarized in **Table 1**.

Table 1. Development Statistics

Criteria:		
Single Residential Dwelling Population Density:	4.0	Persons / unit
Mixed Use Population Density* *value retrieved from similar developments within nearby municipalities	75	Persons / ha

Land Use	**Area** (Ha)	**Residential Units** (No.)	**Equivalent Population** (persons)
Residential Units	5.14	115	**460**
Mixed Use	0.45	10	**35**
Commercial	0.85		**24**
SWM Pond	0.91		
Street ROW	2.45		
Open Space	0.32		
Environmental Protection Lands	4.79		
TOTAL	**14.91**	**125**	**519**

1.3 Purpose of Report

This report has been prepared in support of the application for draft plan approval for the subject property. The primary intent of the report is to demonstrate the viability of water and wastewater servicing, storm drainage and stormwater management, grading as well as vehicular and pedestrian access for the proposed development with respect to applicable guidelines, policies and design criteria.

This report has been prepared based on a review of the topographic survey and background studies and a visit to the site. The conceptual design is documented on a series of large size functional servicing plans which are contained in a pocket at the rear of this report. This document provides guidance for detailed engineering design of the subdivision.

1.4 Approving Authorities

This report will be circulated for review, comment and approval to:

1. The Town of Grand Valley;
2. The County of Dufferin; and
3. The Grand River Conservation Authority (GRCA).

2.0 WATER SERVICING

The Town of Grand Valley retained R.J. Burnside & Associates Limited (RJB) to complete an update to the Water and Wastewater Master Servicing Plan. This Technical Memo completed in May 2014 reflects recent historical water demands and wastewater flows, incorporate amendments undertaken to the Town's Official Plan, and adds to a previous Memo completed by RJB in 2010 with regards to the water and wastewater infrastructure's ability to meet future demands.

The report outlines the existing water supply system consisting of 3 wells; Cooper Street Pumphouse wells (PW1 and PW2) and the Melody Lane Pumphouse well (PW3). PW1 and PW2 do not operate at the same time, limiting operating capacity. An elevated water tower with a storage capacity of 1,600m^3 and high water level of 519.3m located off County Road 25, north of Fife Road functions as part of the distribution system water storage and supplements the well supply during high demand periods. Based on the Memo's analysis of existing and future condition water service demands it was determined that the existing infrastructure would not be able to meet the future demand and that additional water supply, treatment and storage be implemented to meet the impending requirement. Of particular note is the Memo's recommendation to construct a new water tower, with similar capacity and storage to the existing tower, at the south end of the Town to accommodate the demand imposed on the system from the forthcoming southern developments where the subject site is located. This recommendation also adds that a Schedule B Class Environmental Assessment (EA) be undertaken to investigate the additional water capacity and storage requirements when the serviced population increases from 1,482 persons to 2,300 persons, or 3 to 5 years in advance of the need for the water supply, according to the Memo.

Further details with regards to the existing and future water supply and distribution can be found within the mentioned Technical Memo. The following is a summary of the water servicing requirements for the subject site.

2.1 Domestic Demand

The domestic water demand is to be calculated using the Town and Ministry of the Environment design standards which includes the following parameters:

Residential Average Day Demand:	450 L/person/day
Maximum Day Factor:	2.75
Peak Hour Factor	4.13

A detailed tabulation of the domestic water demand calculation is detailed in **Table A1** of **Appendix "A"**. The demands are summarized in **Table 2** below.

Table 2. Domestic Water & Fire Flow Demand

Land Use	Equivalent Population (Persons)	Domestic Demand (L/min)	Maximum Day Demand (L/min)	Peak Hour Demand (L/min)	Fire Flow (L/min)	Maximum Day Plus Fire Flow (L/min)	Maximum Day Plus Fire Flow (L/s)
Residential	460	144	395	594	6,000		
Mixed Use	35	11	30	45	-		
Commercial	24	8	21	31	-		
TOTAL	**519**	**162**	**446**	**670**	**6,000**	**6,466**	**108**

2.2 External Watermains

In accordance with the recommendations of the Technical Memo, a trunk watermain is proposed to be extended from its current terminus southerly from the existing WPCP along County Road 25 and across the frontage of the subject site. The proposed schematic extends the watermain to the sole entrance of the subject site which will facilitate the loop as required by the Town standards. This watermain is anticipated to connect to the proposed water storage tank which will be constructed at the south end of town, with an exact location of the facility to be determined after a Class EA stated in the Memo has been initiated. This system will feed a local distribution network which will provide water supply to the subject lands. The configuration of the water distribution system is illustrated on **Dwg. FSP-1**.

2.3 Local Watermains & Service Connections

The local water distribution system within the subdivision will consist of watermains ranging in diameter from 150mm to 200mm. This water system will connect to the trunk watermain aforementioned in the preceding section.

In accordance with Town standards the individual detached dwellings are each to have separate water connections. Based on Ontario Building Code (OBC 2012) regulations (7.6.3.4.(1) and (5) and Table 7.6.3.4), the single residential unit dwellings will be serviced with 25mm diameter water connections. The size of service to be provided for the mixed use units is to be determined during detailed design, as the details of the building to be constructed has not been yet established. Water meters shall be equipped as specified within Town standards.

2.4 Fire Protection

The fire flow required for the proposed detached dwelling units and commercial buildings was calculated using the criteria indicated in the *Water Supply for Public Fire Protection Manual*, 1999, by the Fire Underwriters Survey (FUS). The calculation incorporates various parameters such as coefficient for fire-resistant construction, an area reduction accounting for a fire-resistant (one hour rating) protection, a reduction for low-hazard occupancies, and a factor for neighbouring building proximity.

The calculation was completed to reflect the governing conditions which are the largest detached dwelling and the largest interior multi-use unit. Based on the calculations, the minimum fire suppression flow required for the residential units is 6,000 L/min. The calculation for minimum fire suppression flow for the mixed use unit and commercial building is to be determined during detailed design, as the details of the building to be constructed has not been yet established. The detailed fire flow calculations are provided in **Table A-2** of **Appendix "A"**. In accordance with the Town standards, this flow must be available at a minimum pressure of 140 KPa.

Fire hydrants will be provided along the private road such that a fire hydrant will be available approximately within 100m of one another and not be spaced exceeding 120m, as set out in the Town standards.

3.0 WASTEWATER SERVICING

The Town is currently serviced by the existing Grand Valley Wastewater Pollution Control Plant (WPCP) located at the east end of Industrial Road and just east of the subject site. This WPCP was commissioned in July 2011 with an average daily flow rating of 1,244m^3, designed for a population of 2,950 persons.

In addition to the Technical Memo composed by RJB as described in the previous section, a letter was completed to the Town by RJB in May 2015 updating the latter report's assessment of available capacity at the WPCP. The update also provided details on the population demands, wastewater flows and the capability of the WPCP to accommodate future planned developments. Both the 2014 Memo and 2015 Letter determined that the existing plant will need to be upgraded to manage future flow and capacity requirements. An Assimilative Capacity Study for the WPCP was completed in 2013 by XCG Environmental Engineers and Scientists (XCG) in conjunction with RJB, and concluded that a Class EA Study be undertaken to further examine the need to increase capacity for the future scenario at the WPCP facility. The XCG report findings were included as part of the RJB Technical Memo conclusions.

The subject site was part of the study area considered and was partitioned into a separate sanitary drainage area (Area E3) within the Technical Memo. This area was recommended to convey wastewater flow to the existing system via connection to Leeson Street or Emma Street South that would then relay the flow to the WPCP. The Memo provides an assessment and analysis of the wastewater flows by formulating an estimate of the expected population to settle on these lands. Upon a more detailed review of the 2014 Memo, 2015 Letter and given the proposed plans presented within this Report, it appears that there is a minor variance between the estimations made within the Technical Memo and the proposed plans set forth as part of this Report. Ultimately, utilizing the Town population density values within the 2015 Letter, the Memo's population value for Area E3 were at a lower value than that currently anticipated, yielding variance in the projected wastewater flow rates to the existing system and to the WPCP. An alternative strategy would need to be conceptualized in order to address the differences between the proposed development and the baseline information available.

A wastewater management strategy has been optimized for the Corseed Subdivision that considers the variances, as well as the recommendations provided within the Technical Memo. This strategy includes conveying flow southerly along County Road 25 to the Moco Subdivision, located southeast of the Corseed site, and eventually to a Sanitary Pumping Station (SPS-A) located at the northeast corner of the Moco site within Town lands that pumps the wastewater to the WPCP. The wastewater flow generated from the Corseed Subdivision has been considered in the generation of SPS-A on the Moco Lands, with details on SPS-A found within the Functional Servicing Report for the Moco Subdivision submitted to the Town under a separate cover. It is anticipated that SPS-A will adequately service both the Corseed and Moco Subdivisions within the flow limit allocated in the Technical Memo. The following are further details of the wastewater servicing analysis for the subject site.

3.1 Wastewater Loading

The wastewater loading is to be calculated using the Township engineering design standards which include the following parameters:

Residential Average Daily Flow: 450 L/person/day

Residential Peaking Factor: $K_H = 1 + \frac{14}{4 + \sqrt{P}}$

Where: K_H = Harmon Peaking Factor (Max. 4.0, Min. 2.0)
p = Population in thousands

Extraneous Flow, *I*: 0.20 L/ha/s (Infiltration)

Design Flow, Q = $Q_{RES} \times K_H + I$

Based on the above criteria the sewage flow calculations are provided in **Table B1** contained in **Appendix "B"** and the total flow is summarized in **Table 3**.

Table 3. Wastewater Loading Summary

Land Use	Area (Ha)	Equivalent Population (Persons)	Average Daily Flow (L/s)	Harmon Peaking Factor	Peak Daily Flow (L/s)	Infiltration Rate (L/s)	Total Flow (L/s)
Residential	5.14	460	2.40	3.99	9.57	1.03	10.59
Mixed Use	0.46	35	0.18	4.00	0.72	0.09	0.81
Commercial	0.87	24	0.09	4.00	0.38	0.17	0.55
Parks & Open Space	0.32					0.06	0.06
R.O.W	2.42					0.48	0.48
TOTAL	**9.20**	**519**	**2.67**		**10.66**	**1.84**	**12.50**

3.2 External Sanitary Sewers

In accordance with the proposed initiatives stated within Section 3.0, it is being proposed to convey the Corseed sanitary flow to SPS-A, within Town owned lands, northeast of the Moco Subdivision that also contains the WPCP. Given the existing topography of the area, an analysis has been conducted to select a route which minimizes the depth of the gravity sewer for the Corseed Lands conveyed to SPS-A. This consideration of conveying the E3 land southerly instead of northerly as set within the RJB Memo to SPS-A reduces the wastewater load of E3 to the existing system. It has been calculated in **Table 3** that approximately 12.5 L/s will be conveyed from E3 to SPS-A. Combined with the Moco Subdivision wastewater flow to SPS-A, the total sanitary outflow of SPS-A to WPCP is 35.7 L/s.

In order to facilitate the wastewater conveyance of the Corseed Subdivision to SPS-A, a new sanitary sewer will be required to be constructed within the existing road allowance along County Road 25, but not within the travelled portion of the roadway. This proposed sewer is anticipated to be 120 m in length with 2 manholes to be installed on County Road 25, eventually connecting to the system at the Moco Subdivision.

The preliminary layout of the sanitary sewers has been included on **Dwg. FSP-1** which includes sanitary obvert elevations to illustrate the depth of the sewer along the alignment.

3.3 Local Sanitary Sewers & Service Connections

The subject site will be serviced by a local sanitary system consisting of sewers which will discharge to County Road 25 and eventually to SPS-A located on Town lands north of the Moco Subdivision SWM Block. The local sanitary drainage system will be by gravity and follow road grade slopes where possible. In accordance with standard practice and Town standards, manholes will be provided for maintenance access at a maximum spacing of 100m and individual sanitary service connections will be provided.

4.0 STORM CONVEYANCE SYSTEM

The subject site is located in the Boyne Creek watershed which is part of the larger Grand River watershed under the jurisdiction of the Grand River Conservation Authority (GRCA). Boyne Creek originates from the Luther Marsh Wildlife Management Area and generally flows in an easterly direction before discharging into the Grand River. Boyne Creek meets the Grand River approximately 235 km upstream of Lake Erie. A map illustrating the Grand River watershed is contained in **Appendix "C"**.

In accordance with Town standards, a major / minor system storm conveyance concept has been incorporated into the functional servicing design for the subject development. The following sections provide a brief summary of the storm drainage components:

4.1 Minor System Design

As per the Town engineering design criteria, the proposed development is to be serviced with a minor storm sewer system that is designed to convey runoff from the 5 year storm event on local streets, and runoff from the 10 year storm on collectors. The rainfall intensity values, *I*, are calculated in accordance with the 1961-2007 rainfall intensity duration frequency (IDF) data for the Fergus Shand Dam weather station which was obtained from Environment Canada. Based on this data the rainfall intensity for the 5 and 100 year rainfall events is calculated as follows:

$$I_5 = \frac{1525.827}{(t+12.117)^{0.862}}$$

$$I_{10} = \frac{2179.495}{(t+15.119)^{0.890}}$$

$$I_{100} = \frac{4789.414}{(t+21.844)^{0.949}}$$

The peak flows are calculated using the following formula:

$Q = R \times A \times I \times 2.778$ where: Q = peak flow (L/s)
A = area in hectares (Ha)
I = rainfall intensity (mm/hr)
R = composite runoff coefficient
t = time of concentration (min)

The proposed storm sewer will discharge to the environmental protection lands near Boyne Creek at the southwest corner of the subject site as per the pre-development condition.

The IDF curve data is included in **Appendix "C"**. A schematic design of the minor system is illustrated in on **Dwg. FSP-1** and the catchment areas are delineated on **Figure 4.**

4.2 Major System Design

The major system will generally be comprised of an overland flow route along the municipal road network directing drainage to a safe outlet. This major system will convey flows which are in excess of the capacity of the minor storm sewer system. The major system flow route is illustrated in **Dwg. FSP-1**.

4.3 Foundation Drainage

Due to the high elevation of the SWM pond relative to the rest of the site, and in an effort to minimize the required fill, it is not possible to provide direct gravity-draining storm service connections from each lot to the storm sewer. Sump pumps will therefore be required for each unit to ensure no basement flooding as a result of the high water level in the SWM pond. A detailed hydraulic grade line (HGL) analysis is to be completed at the detailed design stage to confirm that the 100-year HGL is no more than 1.0 m above the top of the pipe, as per the Town's standards.

4.4 Roof Drainage

It is anticipated that the proposed dwellings will have conventional peaked roof with eaves troughs and downspouts. As per standard practice the downspouts are to discharge to grade over splash pads, preferably towards sodded areas. Roof downspouts are not to be connected to the storm sewer.

4.5 Flood Plain

A HEC-RAS model was prepared in order to delineate the extent of flooding through the subject site. Cross-section data, as well as bridge and culvert data, and was entered into the model based on a detailed survey of the site.

The Boyne Creek Regional (Hurricane Hazel) flow (102 cms where it joins the Grand River) was obtained from the Grand River Conservation Authority (GRCA), along with the GRCA's HEC-RAS model of the Grand River. Five flow nodes were established between the upstream and downstream boundaries of the HEC-RAS model. The upstream bounding flow node is located just upstream of the subject site, while the downstream flow node is located where Boyne Creek joins the Grand River (RS 396.9 in the GRCA's Grand River HEC-RAS model). Three additional flow nodes were established within these limits where smaller tributaries join Boyne Creek.

The flow at each flow node was calculated based on the corresponding upstream drainage area by using the transposition of flood discharges method (MTO Drainage Management Manual, 1997, Eq. 8.31):

$$Q_2 = Q_1 \cdot \left(\frac{A_2}{A_1}\right)^{0.75}$$

Where:

Q_1 = known peak discharge
Q_2 = unknown peak discharge
A_1 = known basin area
A_2 = unknown basin area

The flow at each cross-section was calculated by prorating the flow between the two bounding flow nodes based on the channel length.

The downstream Regional water surface elevation boundary condition, 454.23 m, used in the HEC-RAS model was based on the Regional water surface elevation at the corresponding location, RS 396.6, of the GRCA's Grand River HEC-RAS model.

The location of the existing floodplain based on the HEC-RAS model is shown on **Figure 6** and **Figure 7**. All proposed development, grading and pond outlet structures will be located outside of the floodplain and the area regulated by the GRCA.

Supporting HEC-RAS model output is provided in **Appendix "D"**.

5.0 STORMWATER MANAGEMENT

5.1 Storm Drainage Areas

Based on the topographic survey and the proposed draft plan of subdivision, the following is a summary of the pre and post development drainage areas.

5.1.1 Pre-Development

There is a tributary of the Grand River (Boyne Creek) that passes to the southwest of the proposed site before it ultimately flows beneath an abandoned railway corridor and into the Grand River. The overall site topography generally falls southwesterly towards Boyne Creek. Site elevations vary from 471.90 m near County Road 25 to approximately 466.50 m in the environmental protection lands near Boyne Creek. The existing slopes range from approximately 0.35% to 9%.

The existing site land use is primarily agricultural with two small wooded areas. **Figure 3** shows the drainage patterns for existing conditions.

5.1.2 Post-Development

The subject site will be developed into a mixed-use development including medium-density residential, a neighbourhood park, a SWM pond block, commercial and mixed-use (commercial and residential) areas. Drainage patterns will generally follow existing conditions, with all development area drainage to be directed through the proposed SWM facility before it discharges to the valley near Boyne Creek. The proposed SWM pond will collect drainage from the proposed development and direct it to the outlet near the south-west corner of the subject site. **Figure 4** shows the details of the proposed drainage plan for the subject site.

5.2 Stormwater Management Design Criteria

The proposed SWM facility shall be designed to provide the following levels of control as per the requirements of the Ministry of the Environment (MOE), Grand River Conservation Authority (GRCA) and Town of Grand Valley:

- **Quality control**: The permanent pool shall be sized to provide Enhanced (Level 1) treatment of stormwater runoff for the proposed development.
- **Erosion control**: Stormwater runoff from the 25 mm storm event shall be stored and released over a minimum 24 hour period.
- **Flood control**: Flood storage and control shall be provided to maintain peak outflows from the pond at or below pre-development levels for the critical of the 12 & 24-hour SCS and 1, 6 & 12-hour AES, and the 3-hour Chicago storm distributions for the 2-yr through 100-yr design storm events.

5.3 Stormwater Management Pond Design

A SWM facility is proposed to serve the subject development area. This SWM facility will discharge through a level spreader outfall located near the south-west corner of the development area. The total service area for the SWM facility is approximately 9.41 ha. The proposed SWM facility is located to the east of the proposed *Street "A"* collector road, to the northeast of Boyne Creek as illustrated in **Figure 4**.

Per the Town standards and MOE SWM pond criteria, the SWM facility design includes 5H:1V side slopes above and below the permanent pool level. This also meets the MOE requirement to provide a 5H:1V safety shelf for 3.0m on either side of the permanent pool elevation (NWL) of 467.30 m. A 5.0 m wide access road with maximum 10% slope has been provided to the bottom of the forebay and access to the facility is provided from the subdivision. The details of the proposed SWM facility are provided on **Dwg. SWM-1** and **Dwg. SWM-2**.

5.3.1 Quality Control

Various source controls, conveyance and end-of-pipe SWM facilities were considered to provide the appropriate level of stormwater quality control. Reduced lot grades, rear and side yard swales, and discharge of roof leaders to pervious surfaces will augment the control provided by the SWM facility and promote infiltration where possible. Based on a preliminary review of available controls, it appears that the primary and most effective option to provide water quality control for runoff from the contributing drainage areas is a SWM facility. The options reviewed are as follows:

- Roof Leader to Ponding Areas or Soakaway Pits (Lot Level): The Town design criteria do not address the use of ponding areas or soakaway pits in the rear yards. Roof leaders will discharge directly to pervious surfaces to encourage infiltration and filtration on the lots. Soakaway pits can be an effective means of improving infiltration of stormwater, but require a large area in comparison to typical residential rear yard dimensions. As a result, soakaway pits and ponding areas are not recommended.
- Grassed Swales (Conveyance): Rear and side yard swales will be incorporated into the grading plan. The swales will convey runoff to rear lot catch basins. The number of rear lot catch basins will be minimized in order to encourage infiltration via swales.
- Stormwater Management Facilities (End-of-Pipe): Based on discussions with the GRCA, SWM facilities are required to provide water quality, extended detention and flood control of stormwater runoff. Stormwater management facilities will be constructed within the subject property.
- Oil/Grit Separation Technologies (End-of-Pipe): These SWM facilities can be effective for smaller, high impervious sites where spill protection is desired and when area for a stormwater pond is unavailable. The construction of the stormwater pond will eliminate the need for any oil/grit separation units.
- Infiltration Trenches/Basins (End-of-Pipe): These SWM facilities are most effective in areas with highly pervious soils and large areas.

In accordance with the GRCA requirements for development within the Boyne Creek watershed, a minimum of Enhanced (Level 1) water quality protection shall be provided by the proposed SWM facility.

The developed drainage area to the SWM facility consists of approximately 9.07 ha. The total assumed imperviousness of the drainage area to the SWM facility is 70%. The required permanent pool volume for the SWM facility based on a wet pond design is provided below.

SWM Facility (Wetland) Permanent Pool Volume Calculation

Volume required for catchment with 68% imperviousness:	225.0	m^3/ha
Less 40 m^3/ha of extended detention storage zone:	- 40.0	m^3/ha
Permanent pool volume required:	185.0	m^3/ha

The permanent pool storage volume required for the wetland SWM facility is therefore 185.0 m^3/ha x 9.07 ha = 1,678 m^3.

The requirement for a pond liner will be confirmed at detailed design in order to maintain a permanent pool of water in the pond and to prevent the mixing of surface water with ground water.

The normal water level of the permanent pool for the pond is set at an elevation of 467.30 m. The bottom of the pond is set at an elevation of 465.30 m. This provides a permanent pool depth of 2.00 m.

The actual permanent pool storage volume provided is approximately 3,303 m^3 which is greater than the minimum required volume to meet the Enhanced (Level 1) quality control requirement. The required and provided quality control volume together with the elevation of the normal water level are summarized in **Table 5.**

The forebay has been sized based on MOE design criteria and supporting calculations are provided below.

Forebay Sizing Calculations

The proposed forebay is approximately 43 m in length and 21 m in width, on average. The resultant length-to-width ratio is therefore 2:1. Using the methodology provided in the Stormwater Management Planning and Design Manual, the recommended forebay length based on particulate settling is calculated using the following expression:

$$Dist = \sqrt{\frac{r \cdot Q_p}{V_s}} \qquad [1]$$

where: *Dist* is the forebay length (m)
r is the length-to-width ratio of the forebay (2:1 or *r* = 2)

Q_p	is the pond's peak discharge (0.013 m^3/s, VO2 modelling of 25 mm storm)
V_s	is the settling velocity (0.0003 m/s for 150 μm particles)

Solving [1] gives:

$$Dist = \sqrt{\frac{2 \times 0.013}{0.0003}} = 9.3\ m$$

The recommended forebay length based on flow dispersion calculations is calculated using the following expression:

$$Dist = \frac{8 \cdot Q}{d \cdot V_f} \qquad [2]$$

where: *Dist*	is the forebay length (m)
Q	is the peak inlet flow (1.926 m^3/s, VO2 modeling of 5-year storm for *Catchments 202*, and 10-year storm for *Catchments 102 & 201*)
d	is the depth of the permanent pool in the forebay, assuming 1.00 m depth of sediment accumulation (1.00 m)
V_f	is the desired velocity in the forebay (0.50 m/s)

Solving [2] gives:

$$Dist = \frac{8 \times 1.926}{1.00 \times 0.50} = 30.8\ m$$

The distance from the headwall (HW.1) to the forebay weir is 43 m. The proposed design therefore satisfies the minimum forebay length recommendations.

The minimum recommended forebay bottom width is calculated as follows, based on the maximum distance from the calculations above:

$$Width = \frac{Dist}{8} = \frac{30.8}{8} = 3.9\ m \qquad [3]$$

The design proposes an average forebay bottom width of approximately 7.0 m, which satisfies this criterion.

In accordance with the SWMP Manual, it is recommended that the maximum average velocity in the forebay is 0.15 m/s. This velocity corresponds the maximum permissible velocity that can be achieved before erosion will start to occur. The minor system flow into the forebay is 1.926 cms. The average cross-sectional area of the forebay (assuming 1.00 m depth) is approximately 18.5 m^2. The average velocity is therefore 0.104 m/s (1.926 m^3/s ÷ 18.5 m^2 = 0.104 m/s), which is less than the maximum permissible velocity of 0.15 m/s.

Sediment Loading and Forebay Cleanout Calculations

In accordance with the SWMP Manual, it is recommended that the frequency of sediment removal be determined based on a 5% reduction in the total suspended solids (TSS) removal efficiency of the permanent pool, or once the forebay reaches 80% of its capacity for sediment below the normal water level.

Based on a request by the GRCA, the forebay is to maintain a minimum depth of 1.00 m before sediment cleanout is required in order to satisfy the sediment settling requirements, as per the calculations above. The proposed forebay has been sized to provide a sediment storage volume of 224 m^3 below elevation 466.30 m, such that the forebay has a minimum depth of 1.00 m below the normal water level before sediment removal is required. The forebay sediment storage volume 1.00 m below the normal water level (224 m^3) therefore corresponds to 25.9% of the total forebay volume below the normal water level (864 m^3).

In order to achieve an enhanced (80%) level of TSS removal efficiency, the required pond permanent pool volume is 1,678 m^3, as calculated above. A TSS removal efficiency of 75% (a 5% decrease from 80%) would require a permanent pool volume of 1,247 m^3. The proposed pond has a permanent pool volume of 3,303 m^3 with no sediment loading, and a permanent pool volume of 3,079 m^3 with 224 m^3 of sediment storage. Based on this the proposed pond will maintain a minimum of 80% TSS removal efficiency even with the provided forebay sediment storage volume being utilized.

As per *Table 6.3* from the *MOE Stormwater Management Planning and Design Manual*, the annual sediment loading for a catchment with 70% imperviousness is 2.8 m^3/ha. The annual sediment loading for the pond is therefore 2.8 m^3/ha x 9.07 ha = 25.4 m^3. The forebay sediment storage volume corresponds to approximately the 9-year sediment loading volume (224 m^3 ÷ 25.4 m^3/year = 8.8 years).

Based on the above calculations, the estimated forebay cleanout period is 9 years.

5.3.2 Erosion Control

In accordance with the GRCA guidelines, erosion control shall be provided using an extended detention active storage zone sized to capture the runoff resulting from a 25 mm rainfall event and to release the runoff over a period of at least 24 hours. Based on results using the Visual OTTHYMO 2.0 (VO2) model, the required erosion volume for the SWM facility is 1,485 m^3, based on a runoff volume of 14.88 mm over a total drainage area of 9.98 ha. The VO2 model parameters and the results are included in **Appendix "D"**.

Based on the design for the SWM pond, the erosion control volume provided is 1,641 m^3 at an elevation of 467.80 m. This meets and/or exceeds the respective erosion volume requirement of 1,485 m^3 for the pond. The proposed extended detention depth is 0.50 m, which is less than the maximum recommended extended detention depth of 1.00 m.

The required detention time and release rate will be achieved using an orifice plate installed within the pond outlet control structure.

The extended detention active storage zone will capture the runoff volume resulting from a 25 mm rainfall event and release it over a period exceeding the required 24-hour detention. A 4-hour, 25 mm Chicago distribution storm was used for this analysis. Based on the calculations below, the drawdown time for the proposed SWM facility is approximately 53.8 hours with a 100 mm diameter orifice, which meets the minimum 24-hour release criteria (48 hours is considered preferable). More detailed calculations are provided in **Table D.8** in **Appendix "D"**.

The orifice size, erosion control release rate, draw down time, extended detention volume and water level are summarized in **Table 5**.

5.3.3 Quantity Control

Per the GRCA's requirements, the SWM facility shall be designed to control the post-development peak flow to pre-development levels for the 2-year through 100-year design storms and to safely convey the Regional flow. The SWM facility will be sized to control post-development peak flows to pre-development levels up to and including the 100-year storm using the VO2 model and the 1-hour AES storm distribution, created using the latest Fergus Shand Dam IDF data obtained from Environment Canada as specified in the Town of Grand Valley standards. The 1-hour AES storm distribution was determined to be critical based on a critical storm analysis completed for the proposed SWM facility. The pre-development flow targets are provided in **Table 4**. The critical storm analysis is provided in **Table D.9** which is included in **Appendix "D"** together with the VO2 model schematic, catchments and pre-development flow calculations.

Table 4 shows the peak flows calculated in VO2 for each return period. **Table 5** shows the SWM facility performance characteristics for each return period event based on the preliminary outlet structure design and rating curve. The rating curve includes quality and quantity control structures and an emergency spillway. The actual pond performance, outlet structure design and rating curve will be confirmed at detailed design.

The SWM pond has been designed with a total active storage volume of 4,643 m^3 at an elevation of 468.50 m. The expected maximum storage required during 100 year storm conditions is approximately 4,606 m^3. The provided active storage for the pond is therefore sufficient. As shown in **Table 4**, the peak discharge rates are equal to or less than the target release rates. The preliminary rating curve is presented in **Table D.5** which is included in **Appendix "D"** together with the output from the VO2 modeling of the SWM pond.

Table 4. Summary of Storm Drainage Peak Flows

Return Period	Existing Peak Flows (m^3/s)	Proposed Peak Flow (m^3/s)
2-yr 1-hr AES	0.115	0.045
5-yr 1-hr AES	0.315	0.262
10-yr 1-hr AES	0.486	0.459
25-yr 1-hr AES	0.731	0.647
50-yr 1-hr AES	0.933	0.783
100-yr 1-hr AES	1.145	0.916

5.3.4 Thermal Mitigation Measures

Mitigation measures shall be incorporated into the SWM pond design to minimize thermal impacts to the receiving watercourse. These measures include a bottom draw pipe and a planting strategy to promote shading along the pond perimeter.

Bottom Draw Pipe

Instead of the common perforated riser configuration, a bottom draw pipe will be implemented for the extended detention component to discharge water from the deepest section of the pond where the water temperature is lowest. This outlet consists of a submerged intake headwall and a bottom draw pipe which discharges via an orifice plate in the quality control structure. Given that this pipe is sized for frequent rainfall events (25mm storm), it will provide the greatest benefit to the thermal regime of the receiving watercourse.

Planting Strategy

In accordance with the Town and GRCA requirements the SWM facility will be planted to provide a natural appearance and to provide environmental benefits. The landscape plan will specify shade producing species to minimize solar heating of the permanent pool during summer months. The forebay design provides additional pond perimeter where shade producing vegetation can be planted.

5.3.5 SWM Pond Inspection & Maintenance

The stormwater management facility should be inspected periodically to determine the frequency of maintenance activities. As such, maintenance activities will be performed on an as-required basis. During the first two years of operation, it is recommended that the stormwater management facility be inspected following significant storm events to determine if and when maintenance activities are required. Subsequently, inspections should be carried out twice per year. The following items should be considered when inspecting the pond:

- Sediment accumulation to determine cleanout requirements;
- Erosion of side slopes and outfall channel;
- Safety hazards;
- Hydraulic operation of the pond;
- Drawdown time following a rainfall event (extended drawdown time greater than 50 hours may indicate a blocked orifice or intake);
- Condition of terrestrial and aquatic vegetation;
- Trash accumulation near hydraulic structures; and
- Surface sheen indicating possible oil contamination.

Table 5. Stormwater Facility Performance Summary

Quality Control		
	Protection Level	Level 1 (Enhanced)
	Permanent Pool Required (m^3)	1,678
	Permanent Pool Provided (m^3)	3,303
	Normal Water Level, NWL (m)	**467.30**

Erosion Control		
25-mm 4-hour Chicago	Orifice Size (mm)	100
	Draw Down Time (hrs)	53.8
	Flow In (m^3/s)	0.566
	Flow Out (m^3/s)	0.013
	Storage Used (m^3)	1,352
	Pond W.S. Elevation (m)	**467.72**

Quantity Control		
2 Year Storm Event	Flow in (m^3/s)	1.111
	Flow Out (m^3/s)	0.013
	Storage Used (m^3)	1,463
	Pond W.S. Elevation (m)	**467.75**
5 Year Storm Event	Flow in (m^3/s)	1.865
	Flow Out (m^3/s)	0.170
	Storage Used (m^3)	2,286
	Pond W.S. Elevation (m)	**467.97**
10 Year Storm Event	Flow in (m^3/s)	2.382
	Flow Out (m^3/s)	0.313
	Storage Used (m^3)	2,778
	Pond W.S. Elevation (m)	**468.09**
25 Year Storm Event	Flow in (m^3/s)	3.054
	Flow Out (m^3/s)	0.422
	Storage Used (m^3)	3,471
	Pond W.S. Elevation (m)	**468.25**
50 Year Storm Event	Flow in (m^3/s)	3.573
	Flow Out (m^3/s)	0.491
	Storage Used (m^3)	4,025
	Pond W.S. Elevation (m)	**468.37**
100 Year Storm Event	Flow in (m^3/s)	4.098
	Flow Out (m^3/s)	0.553
	Storage Used (m^3)	4,606
	Pond W.S. Elevation (m)	**468.49**
Regional Storm (Hurricane Hazel)	Flow in (m^3/s)	1.506
	Flow Out (m^3/s)	1.486
	Storage Used (m^3)	4,928
	Pond W.S. Elevation (m)	**468.56**

5.4 Site Water Balance

In accordance with the requirements of the GRCA, a site water balance assessment was completed for the subject development area to determine the overall infiltration deficit under proposed conditions and to design infiltration facilities as part of an overall mitigation strategy to maintain pre-development infiltration volumes. Data for the assessment was obtained from soil mapping obtained from the Ontario Soil Survey mapping for Dufferin County, satellite imagery and the *Stormwater Management Planning and Design Manual* (Ministry of the Environment, March 2003). These documents provide information with respect to the soil types and soil infiltration rates. The following sections detail the methodology, volume calculations and proposed infiltration mitigation measures necessary to achieve a post-development site infiltration balance.

5.4.1 Methodology

The approach for estimating water balance volumes is based on the method described in the Stormwater Management Planning and Design Manual (MOE, 2003). The assessment was completed for the site using soils and land use information to calculate weighted evapotranspiration values. Weighted water surplus volumes were then calculated and a weighted infiltration factor was calculated. Surplus volumes were then split into runoff and infiltration components for existing and proposed conditions.

In order to perform the water balance analysis, the site (14.89 ha) was divided into two areas; the area to remain undeveloped (5.09 ha) and the area to be developed (9.80 ha). With regards to land use, the analysis reflects existing conditions which is described as a combination of agricultural, meadow, and forest land cover. The proposed land use is residential and mixed-use (commercial-residential) with the pervious component being limited to the lawn areas.

The assumed hydrologic soil group (HSG) for the site was based on a review of soils mapping, which showed the predominant soil type within the subject development to be HSG "BC". Under proposed conditions, it is assumed that existing soils will be used in the grading of the proposed development and therefore HSG "BC" soils were also assumed for the site under proposed conditions. The existing site soils were assumed to have a 15mm/hr percolation rate for the calculation of the infiltration trench maximum depth. It is recommended that a percolation rate be provided by the geotechnical consultant at detailed design to confirm the maximum allowable infiltration trench depth.

The water balance calculations including water holding capacity assessment, infiltration factor selection, rainfall analysis and evapotranspiration analysis are provided in **Table E.1** to **Table E.5** which are contained in **Appendix "E"**.

5.4.2 Existing Conditions Water Balance Volumes

The pre-development baseline site infiltration condition was calculated using the Toronto Pearson Airport Climate Normal 1971 – 2000 data from Environment Canada and the current land cover and land use pattern. Based on the MOE Infiltration Factor Method, the calculated infiltration factor for the site under existing conditions was 0.545 for the area to remain undeveloped, and 0.515 for the area to be developed. For the area to remain undeveloped, the analysis indicates that the existing annual surplus is 10,375 m^3 and the annual infiltration capacity is 5,654 m^3. For the area to be developed, the analysis indicates that the existing annual surplus is 20,135 m^3 and the annual infiltration capacity is 10,377 m^3. The results of the annual water balance analysis for the existing conditions are presented in the first (area to not be developed) and third row (area to be developed) of **Table E.1**.

5.4.3 Post-Development Unmitigated Water Balance Volumes

For the 5.09 ha area that is to remain undeveloped, the proposed annual surplus and annual infiltration capacity will remain unchanged, as shown in the second row of **Table E.1**.

For the 9.80 ha area to be developed, it is estimated that approximately 6,306 m^3 of water will infiltrate the ground under post-development conditions without implementing any infiltration mitigation measures. This represents 60.8% of the existing infiltration volume for this area. The notable reduction in infiltration volume is the result of an increase in the impervious area associated with the proposed development. The results of the annual water balance analysis for the proposed condition, with no infiltration best management practices, are presented in the fourth row of **Table E.1**. Therefore, mitigation measures are necessary to achieve the site infiltration water balance.

5.4.4 Site Infiltration Mitigation Measures

In order to minimize the impact of development on the future water balance for the site, infiltration mitigation measures will be promoted and incorporated within the proposed development. These measures include basic and enhanced best management practices (BMPs) as follows:

Basic Best Management Practices

The following basic BMPs are to be implemented on the subject site:

- Roof down spouts of the dwellings will be directed to pervious lawn areas and grassed swales where feasible to promote infiltration;
- Where applicable, grassed swales will be constructed along side and rear lot lines;
- For lots abutting existing valley areas, all roof drainage and rear yard drainage is to sheet flow across the buffer, where possible, to encourage infiltration; and

- Where possible, the fine grading of lots will be completed with an extra depth of topsoil to encourage infiltration and absorption.

For the 9.80 ha area to be developed, it is estimated that approximately 7,531 m^3 of water will infiltrate the ground under post-development conditions with the implementation of the above-mentioned infiltration BMPs. This represents 72.6% of the existing infiltration volume for this area.

It is assumed that each of the approximately 95 proposed lots has an average roof area of 150 m^2, which will need to be confirmed at detailed design. The fifth row of **Table E.1** provides the summary of the calculations for the post-development condition with basic infiltration BMPs.

Enhanced Best Management Practices

In an effort to better match the existing infiltration volumes, enhanced infiltration BMPs in the form of infiltration trenches is required. These measures will serve to further promote the infiltration of runoff from the proposed development.

Through the implementation of the proposed infiltration trenches, the annual infiltration capacity can increase by 2,875 m^3. As a result, the post-development infiltration volumes for the site will be 10,407 m^3, which is 100.3% of the pre-development volume.

The areas directed to the infiltration trenches will include the roof areas of the commercial and mixed use blocks (Block 5 & Block 6), and the rear yard areas of lots backing onto the SWM block or open space block (Lot 57 to Lot 72). A summary of the infiltration trench sizing is provided in **Table E.7** and **Table E.8** which are included in **Appendix "E".**

The location of the infiltration trenches are indicated in **Figure 4**. It is recommended that infiltration trenches be designed with a provision for over-flow. Specific sizing details for the proposed infiltration trenches will be provided at detailed design.

6.0 VEHICULAR & PEDESTRIAN ACCESS

The layout of the proposed subdivision has been developed with consideration for efficient and safe access and circulation of both vehicular and pedestrian traffic.

6.1 Municipal Roads

The subject site has frontage on County Road 25 which is under the jurisdiction of the County of Dufferin. This road consists of a rural cross section having two lanes with gravel shoulders and road site ditches. The vehicular access to the subdivision will be facilitated by a proposed collector road (Street 'A') which will intersect County Road 25 at Industrial Drive and extend north westerly through the subdivision. This collector road will have a 26.0m wide road allowance and is planned to eventually extend northerly through planned developments north of Melody Lane. The balance of the proposed roads within the subdivision will have 20.0m wide road allowances. All of the roads will be constructed with 2% surface cross fall and edged with concrete curb and gutter. The longitudinal slope of the road will generally be 0.5% with some length of road ranging up to 5.0% slope. A copy of a typical road cross section is included in **Appendix "F"**.

Based on the Town standards, the minimum pavement structure for the proposed roads is as follows:

Municipal Roads

Material	Local Road	Collector Road
HL3 Asphalt	40mm	50mm
HL8 Asphalt	50mm	60mm
Granular "A"	150mm	150mm
Granular "B"	450mm	600mm

6.2 Driveways & Parking

Units will likely require parking by way of driveways or surface parking lots for the mixed use units. The recommended pavement structure for passenger car parking is as follows:

Passenger Car Parking

Material	Compacted Depth
Asphalt Concrete	50mm
Granular "A"	150mm
Granular "B"	200mm

The slope of driveways and parking is to be within the range of 2.0% to 6.0% in accordance with Town criteria.

6.3 Sidewalks, Walkways & Trails

Internal pedestrian access will be provided by standard 1.5m wide concrete sidewalks to safely guide residents through the subdivision for access to the proposed units and the adjacent existing road allowance. Sidewalks will be generally be constructed on one side of each road.

The configuration of the proposed sidewalks are illustrated on **Dwg. FSP-1**. A copy of the standard sidewalk detail is included in **Appendix "F"**.

7.0 GRADING

As is typical will all subdivision, earthmoving is required, to varying degrees, in order to achieve the municipal design criteria and accommodate the development form.

7.1 Grading Criteria

The subject site is to be graded in accordance with the Town grading criterion which dictates that road grades are to range from 0.5% to 8.0% and that sodded yard areas are to range from 2.0% to 4.0%. For large grade differentials, a maximum slope 4H : 1V can be used for sodded embankments. In areas where space is limited, retaining walls can be utilized to accommodate grade differentials, however, their use should be minimized.

7.2 Preliminary Design

Based on the topographic survey, the proposed subdivision configuration and the Township's criteria, a preliminary grading design has been prepared. The preliminary grading design, considered the following factors:

- Achieve the Town's lot grading criteria.
- Meet the Town's vertical road design parameters.
- Minimize the requirement for retaining walls.
- Match existing grades along the adjacent properties and road allowances.
- Grading along existing road allowances is to have consideration for their future urbanization and grades are to be established to accommodate future boulevard slopes in the range of 2 to 4%.
- Provide an overland flow route to direct drainage to a safe outlet.
- Provide sufficient cover over the sanitary sewer and storm sewer.

The preliminary grading design for the subdivision is presented in **Dwg PGR-1**. A preliminary analysis of the earthworks was conducted using digital terrain modelling software to determine the magnitude of the volumes and it was determined that approximately 18,000 m^3 of fill is required. This fill will be available as surplus material from the planned earthworks operations for the proposed Moco Subdivision which is in close proximity to the subject site. Further analysis will be conducted at the detailed design stage to optimize and verify the quantities. Based on the preliminary design, no significant difficulties are anticipated in achieving the municipal grading design standards.

7.3 Permitting

A review of the Regulation Mapping indicates that the subject site is located within an area that is regulated by the GRCA. A grading permit is therefore required from their office under Ontario Regulation 166/06 prior to commencing topsoil stripping and earthworks. The permit application should be submitted in conjunction with the detailed design at the subdivision engineering stage.

In addition, a clearance letter from the Ministry of Tourism, Culture and Sport (MTSC) is required prior to commencing topsoil stripping and earthworks. In this regard and as per standard practice for subdivisions, an investigation is to be conducted by a licensed archaeologist and a report is to be submitted to the MTSC for approval. Such investigations typically consists of background research and a visual inspection of the lands after it has been ploughed and weathered by two rainfall events which will assist in exposing any archaeological resources that may be present.

8.0 EROSION & SEDIMENT CONTROL DURING CONSTRUCTION

Construction activity, especially operations involving the handling of earthen material, dramatically increases the availability of particulate matter for erosion and transport by surface drainage. In order to mitigate the adverse environmental impacts caused by the release of silt-laden stormwater runoff into receiving watercourses, measures for erosion and sediment control are required for construction sites. This is an extremely important component of land development that plays a large role in the protection of downstream watercourses and aquatic habitat. It is of particular concern for this site given the proximity of the site to a watercourse and environmental protection block.

The impact of construction on the environment is recognized by the Greater Golden Horseshoe Area Conservation Authorities. In December 2006 they released their document titled Erosion & Sediment Control Guidelines for Urban Construction (ESC Guideline). This document provides guidance for the preparation of effective erosion and sediment control plans.

Control measures must be selected that are appropriate for the erosion potential of the site and it is important that they be implemented and modified on a staged basis to reflect the site activities. Furthermore, their effectiveness decreases with sediment loading and therefore inspection and maintenance is required. The selection, implementation, inspection and maintenance of the control features are summarized as follows:

8.1 Control Measures

On relatively large sites, measures for erosion and sediment control typically include the use of sediment control basins, silt fencing, a mud mat and sediment traps. The following is a description of the sediment controls to be implemented on the subject site:

- **Temporary Sediment Control Basins** are commonly used to clarify silt-laden stormwater runoff by promoting sedimentation of the suspended particles in the runoff through long detention times. The proposed SWM pond will be utilized as temporary sediment control basins during construction. The basin is to be sized in accordance with the ESC Guideline based on a required storage volume of 250 m^3 per hectare of disturbed area (125 m^3/ha of permanent pool and 125 m^3/ha of active storage). The basin's outlet is to have a Hickenbottom riser and a minimum 75mm diameter orifice plate sized to provide a drawdown time in the order of 48 hours.
- **Silt Fences** are to be installed adjacent to all property limits subject to drainage from the development area prior to topsoil stripping and in other locations, such as at the bases of topsoil stockpiles. It is recommended that earthworks not extend immediately adjacent to the silt fence and instead 1m to 2m vegetated buffer be maintained for additional protection. The silt fences are to be constructed with 150 x 150mm wire farm fence fabric to properly support the geotextile. Heavy duty silt fence is recommended to be installed adjacent the valley and watercourse to the east of the development area, consisting of two rows of fence with a row of staked straw bales between.
- **Mud Mat** is to be installed at the construction entrance prior to commencing earthworks to minimize the tracking of mud onto municipal roads.

- **Sediment Traps** are to be installed at all catchbasin locations once the storm sewer system has been constructed to prevent silt laden runoff from entering.
- **Rock Check Dams** are to be constructed in swales and ditches to reduce velocities and trap sediment.
- **Erosion Protection** in the form of a level spreader or vegetative buffers are be provided immediately downstream pond outlets to ensure that sediment is not released and / or created as a result of the concentrated discharge.

A set of Erosion and Sediment Control Plans are to be prepared at the detailed engineering design stage to reflect the various construction stages. Details of typical erosion and sediment control measures are included in **Appendix "H"**.

8.2 Construction Sequencing

The following is a summary of the scheduling of construction activities and the related implementation of sediment controls:

Stage 1 – Subdivision Earthworks

1. Construct mud mat for temporary construction access.
2. Install primary silt fencing around the limits of grading and secondary silt fencing along the south limit of the work area adjacent the existing wetland.
3. Install temporary swales and rock check dams.
4. Excavate and construct the temporary sediment basins including installation of hickenbottom drain and spillway and connect to temporary swales.
5. Strip any remaining topsoil, stockpile where indicated and install silt fence around the perimeter.
6. Rough grade the site by placing cut material in fill areas and spreading and compacting of imported fill. Maintain the mud mat to minimize the tracking of silt onto the municipal road and provide street sweeping as necessary.

Stage 2 – Subdivision Servicing & Road Construction

1. Install underground servicing, covering the end of the pipe at the end of each work day to ensure that silt does not enter the storm sewer.
2. Construct roads, install sediment controls on catchbasins and install temporary hickenbottom drains at low point of lot blocks.

Stage 3 – House Construction

1. Construct houses and maintain all sediment controls including regular street sweeping and catchbasin cleaning.
2. Stabilize all lot surfaces as soon as possible after completion of the houses.
3. Remove silt fencing on a phased basis as areas are stabilized.

8.3 ESC Inspection & Maintenance

In order to ensure that the erosion and sediment control measures operate effectively, they are to be regularly monitored and they will require periodic cleaning (e.g., removal of accumulated silt), maintenance and/or re-construction.

Inspections of all of the erosion and sediment controls on the construction site should be undertaken with the following frequency:

- On a weekly basis
- After every rainfall event
- After significant snow melt events
- Prior to forecasted rainfall events

If damaged control measures are found they should be repaired and/or replaced within 48 hours. Site inspection staff and construction managers should refer to the Erosion and Sediment Control Inspection Guide (2008) prepared by the Greater Golden Horseshoe Area Conservation Authorities. This Inspection Guide provides information related to the inspection reporting, problem response and proper installation techniques.

9.0 UTILITIES

While some external upgrades may be necessary by the utility providers, it is anticipated that utilities such as hydro, natural gas, cable television, and telephone service will be available to service the subject development. As per standard practice in subdivisions, utilities will be installed underground. Co-ordination with the local hydro authority and the various utility companies will be undertaken at the detailed engineering design stage to determine appropriate locations for pedestals, transformers and street lights.

It is recommended that the utility installation be in the form of a joint trench as outlined in the Town's Design Standards. The process of joint trenching allows all of the utility companies to co-ordinate the placement of their lines in a common trench excavated by a single utility contractor. Joint trenching maximizes the efficiency of the available area in the utility corridor and provides for a safe installation. A detail of the typical utility corridor location is included in the road cross-section details within **Appendix "F"**.

10.0 SUMMARY

Based on the analysis contained herein, the proposed residential subdivision can be adequately serviced with full municipal services (watermain, wastewater and storm) in accordance with the standards of the Town of Grand Valley, the County of Dufferin and the Grand River Conservation Authority design criteria and consists of the following:

Water

- The existing water supply system in the Town of Grand Valley consists of 3 wells with an elevated water tower located off County Road 25, north of Fife Road functioning as part of the water distribution system and supplementing the well supply during high demand periods.
- The existing water infrastructure is not be able to meet the future demand and that an additional water tower at the south end of the Town to accommodate the demand be investigated by Class EA study to determine the ability meet the impending requirement.
- A trunk watermain is proposed to be extended from its current terminus southerly from the existing WPCP along County Road 25 and across the frontage to the southern entrance of the subject site, facilitating a loop per Town standards.
- A local water distribution system will be constructed along the roads to provide domestic supply and fire protection for the proposed dwellings. This local system will connect to the trunk watermain. Based on the Ontario Building Code (OBC 2012) requirements, the water service connections for the individual townhouse units are to be 25mm diameter.

Waste Water

- The Town is currently serviced by the existing Grand Valley Wastewater Pollution Control Plant (WPCP) located at the east end of Industrial Road. A 2013 Capacity Study completed for the WPCP concluded that a Class EA Study be undertaken to further examine the need to increase capacity to accommodate the impending developments.
- Variances in the data between baseline reports completed for this area and the proposed development presented as part of this Report has necessitated revisions to the wastewater strategy mainly conveying the Corseed wastewater flow south to the proposed Sanitary Pumping Station (SPS-A) north of the Moco Lands to alleviate impacts to the existing system.
- A sanitary sewer system will be constructed along the roads to provide service to the proposed dwellings. The local system will connect to a proposed sewer along County Road 25 to SPS-A and will convey flow to the WPCP as initially recommended by the baseline reports. In accordance with Town standards, the dwellings will be serviced with individual sanitary connections.

Storm Drainage

- The subject site is located in the Boyne Creek subwatershed. Boyne Creek drains to the Grand River which discharges to Lake Erie.
- In accordance with Town criteria, the subject site will be serviced by minor system comprised of a municipal storm sewer sized for the 5-year storm event for local roads and 10-year storm event for collector roads. This storm sewer will outlet to environmental

protection lands adjacent Boyne Creek near the west side of the subject site as per the pre-development condition.

- The major system will be comprised of an overland flow route which will convey runoff from rainfall events in excess of the capacity of the municipal storm sewer to a safe outlet.
- The flood plain of Boyne Creek is contained entirely within the valley lands and therefore the proposed residential lots and the stormwater management pond are outside the Regulatory flood plain.

<u>Stormwater Management</u>

- A stormwater management facility will be constructed to service the subject property. This facility has been designed as a wet pond to provide a minimum of Enhanced (Level 1) water quality treatment, extended detention for erosion control and flood control using the calculated pre-development flow targets up to and including the 100-year storm event. The wet pond consists of a sediment forebay and a main cell separated by a forebay berm.
- Thermal mitigation measures are to be incorporated in the design of the pond including bottom draw pipe and a planting strategy to provide shading around the pond perimeter.
- A site water balance assessment has been undertaken to ensure that pre-development infiltration volumes are maintained. Based on the analysis it was determined that mitigation measures are required in the form of infiltration trenches.

<u>Vehicular & Pedestrian Access</u>

- Vehicular access to the subject site will be provided by one road connection to County Road 25.
- The proposed local roads will be constructed to urban standards having 20m and 26m wide road allowances where appropriate.
- Pedestrian access will be provided by 1.5m wide concrete sidewalks which are to be generally located on one side of each road.

<u>Grading</u>

- As is typical with large subdivision projects, earthmoving will be required to achieve the proposed subdivision grading necessary to meet the criteria of the Town. A detailed analysis of the earthworks will be conducted at the detailed design stage to optimize the cut and fill volumes. Based on the preliminary design, no significant difficulties are anticipated in achieving the municipal grading design standards.
- Since the subject site is located in an area which regulated by the GRCA, a permit will be required from their office prior to commencing earthworks. In addition, an archaeological clearance letter will be required from the Ministry of Tourism, Culture and Sport

<u>Erosion & Sediment Control During Construction</u>

- Erosion and sediment control (ESC) measures are to be implemented during construction to prevent silt laden runoff downstream in accordance with the Erosion & Sediment Control Guidelines for Urban Construction (December 2006). The ESC plans are to be prepared at the detailed engineering design stage and are to reflect the various construction stages.

Subdivision Engineering Design

- Detailed design for the proposed development is to be prepared at the subdivision engineering stage. This detailed design is to include servicing and grading plans as well as a stormwater management report based on the criteria established in this Functional Servicing Report.

11.0 REFERENCES & BIBLIOGRAPHY

- R.J. Burnside & Associates Ltd., **Grand Valley Master Servicing Plan (MSP) Update – Technical Memorandum**, 30 May 2014.
- XCG Consultants Ltd., **Assimilative Capacity Study of the Grand River for the Grand Valley WPCP**, 21 October 2013.
- V.A. Wood (Guelph) Inc., **Geotechnical Investigation G3524-4-11**, November 2014.
- Innovative Planning Solutions, **Draft Plan of Subdivision**, 10 September 2018.
- Town of Grand Valley, Engineering Standards, November 2013.
- Town of Grand Valley, Official Plan, February 2014.
- Ontario Ministry of Environment, **Stormwater Management Planning and Design Manual,** March 2003.
- Ontario Ministry of Transportation, **Drainage Management Manual**, 1997.
- Greater Golden Horseshoe Area Conservation Authorities, **Erosion & Sediment Control Guidelines for Urban Construction**, December 2006.
- Fire Underwriters Survey, Water Supply for Public Fire Protection, 1999.
- Ministry of Municipal Affairs & Housing, **Ontario Building Code**, 2012.

Respectfully Submitted,
VALDOR ENGINEERING INC.

LICENSED PROFESSIONAL ENGINEER
Oct 19, 2018
D. A. GIUGOVAZ
PROVINCE OF ONTARIO

David Giugovaz, P.Eng.
Senior Project Manager

LICENSED PROFESSIONAL ENGINEER
Oct. 19, 2018
P. S. ZOURNTOS
PROVINCE OF ONTARIO

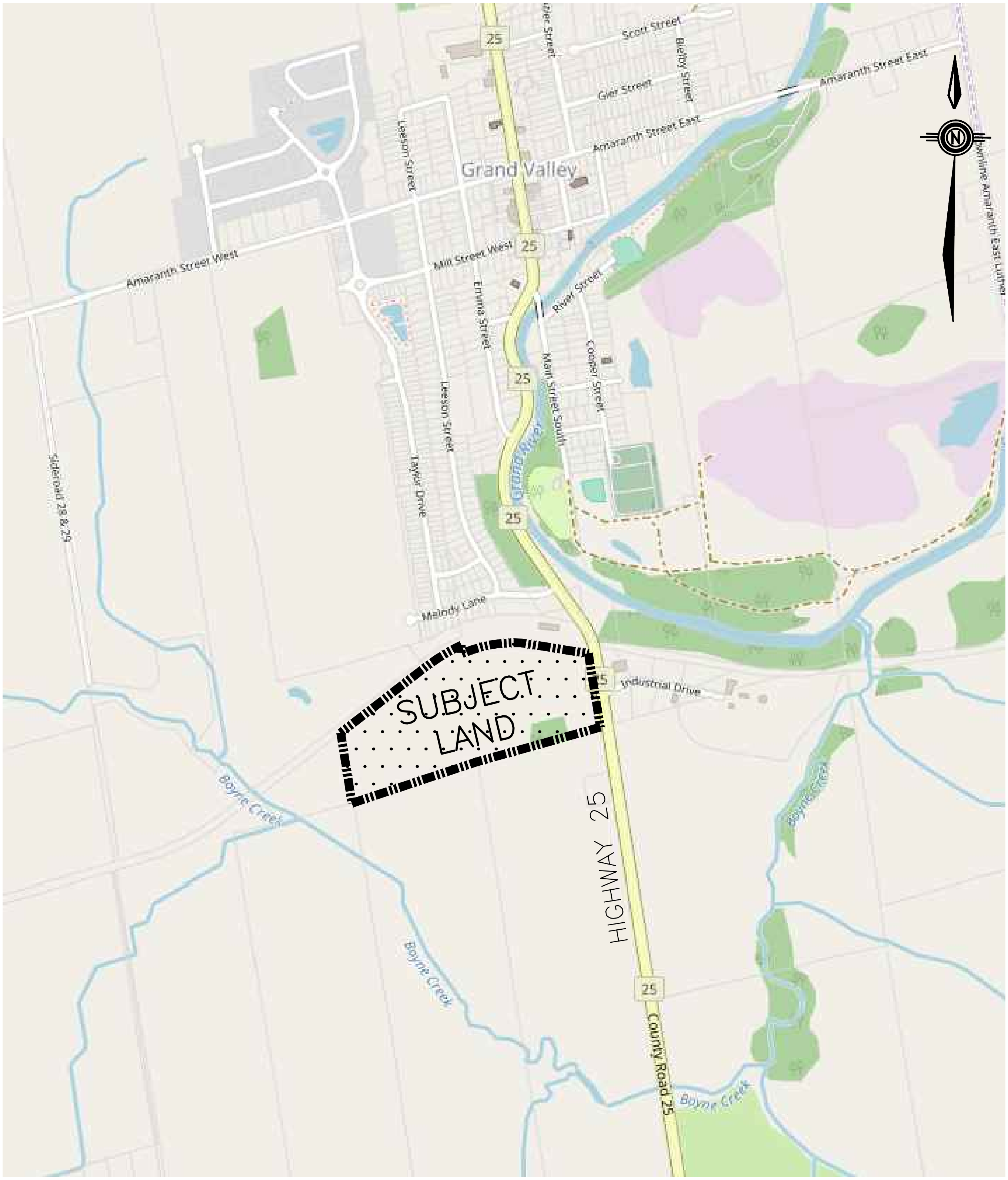
Peter Zourntos, P.Eng., C.Eng.
Head of Municipal Design

LICENSED PROFESSIONAL ENGINEER
Oct 19, 2018
O. P. H. BEAUDIN
100522363
PROVINCE OF ONTARIO

Oliver Beaudin, P.Eng.
Project Manager, Water Resources

LICENSED PROFESSIONAL ENGINEER
Oct 19, 2018
W. L. P. COFFEY
PROVINCE OF ONTARIO

Bill Coffey, M.Sc., P.Eng.
Head of Water Resources



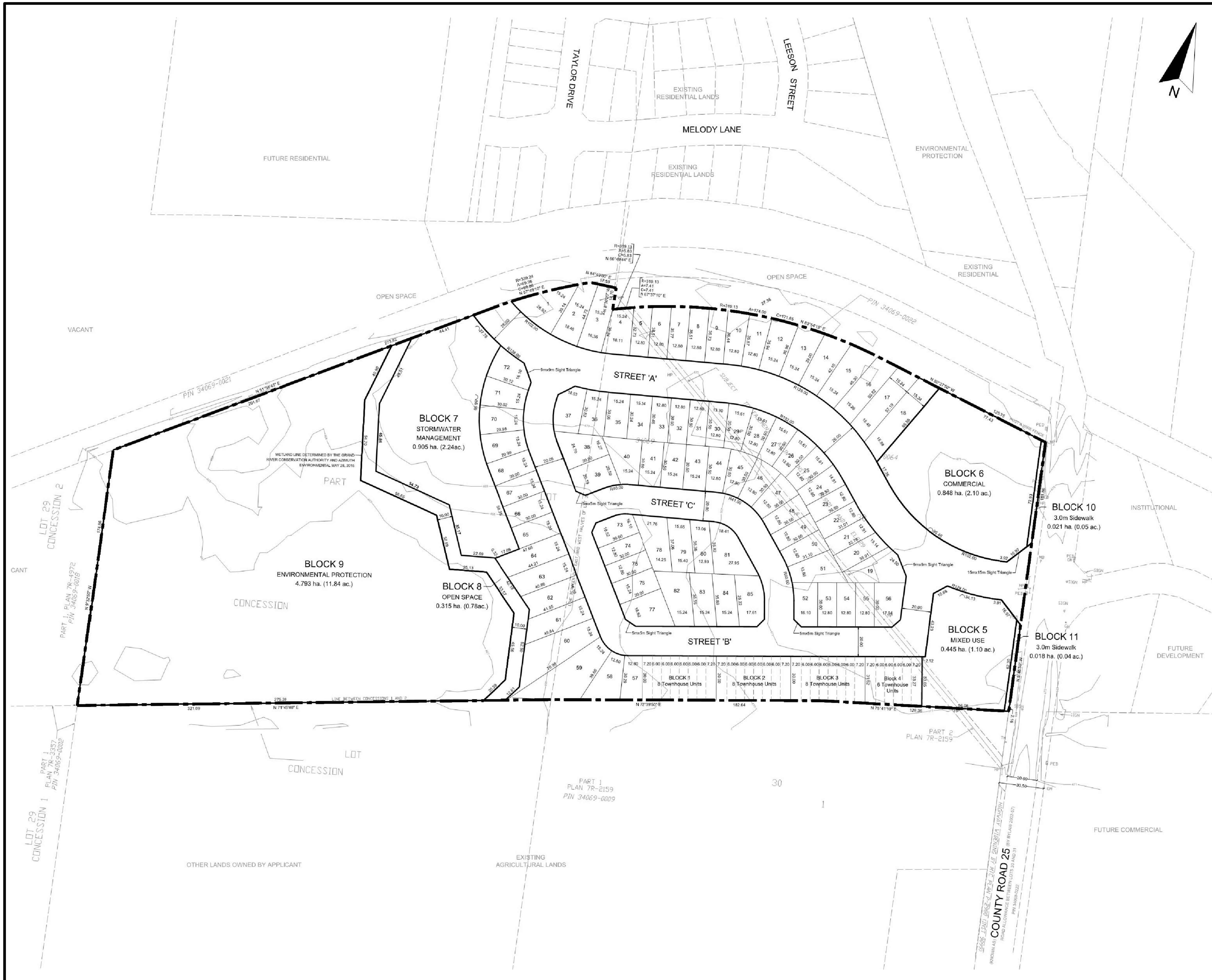
CORSEED SUBDIVISION

LOCATION MAP

VALDOR ENGINEERING INC.
Consulting Engineers - Project Managers
741 ROWNTREE DAIRY ROAD, SUITE 2, WOODBRIDGE, ONTARIO, L4L 5T9
TEL (905)264-0054, FAX (905)264-0069
E-MAIL: info@valdor-engineering.com
www.valdor-engineering.com

SCALE	N.T.S.	PROJECT	14118
DATE	MARCH 2018	DRAWN BY	G.D.

FIGURE 1



KEY MAP Scale 1:20,000

LEGEND
Subject Lands
Other Lands Owned By Applicant

DRAFT PLAN OF SUBDIVISION

CORSEED FARM

PART OF LOT 30, CONCESSION 2
FORMERLY IN THE TOWNSHIP OF EAST LUTHER
NOW IN THE
TOWNSHIP OF EAST EAST LUTHER - GRAND VALLEY
COUNTY OF DUFFERIN

Scale 1:1,250

0 25 50 75 100 125 150m

LAND USE SCHEDULE

	LOTS/BLOCKS	UNITS	ha	ac	%
RESIDENTIAL LOTS (50')	1-4, 12-18, 34-43, 59-71, 76-79, 82-84	41	2.552	6.31	17.12
RESIDENTIAL LOTS (42')	5-11, 19-33, 44-58, 72-75, 80, 81, 85	44	2.010	4.97	13.49
RESIDENTIAL UNITS (19.7')	Blocks 1-4	30	0.581	1.44	3.90
MIXED USE	Block 5	10	0.445	1.10	2.98
COMMERCIAL	Block 6		0.848	2.10	5.69
STORMWATER MANAGEMENT	Block 7		0.905	2.24	6.07
OPEN SPACE	Block 8		0.315	0.78	2.12
ENVIRONMENTAL PROTECTION	Block 9		4.793	11.84	32.16
3.0m SIDEWALK	Blocks 10 & 11		0.039	0.10	0.26
STREETS			2.416	5.97	16.21
TOTAL		125	14.906	36.83	100

ADDITIONAL INFORMATION REQUIRED UNDER **SECTION 51(17)** OF THE PLANNING ACT

OWNER'S CERTIFICATE

I HEREBY AUTHORIZE INNOVATIVE PLANNING SOLUTIONS TO PREPARE THIS DRAFT PLAN OF SUBDIVISION AND SUBMIT THIS DRAFT PLAN OF SUBDIVISION FOR APPROVAL.

DATE CORSEED INC.

SURVEYOR'S CERTIFICATE

I CERTIFY THAT THE BOUNDARIES OF THE LANDS TO BE SUBDIVIDED AND THEIR RELATIONSHIP TO ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

DATE PIER DE ROSA, O.L.S

SCHEDULE OF REVISIONS

No.	Date	Description	By

IPS INNOVATIVE PLANNING SOLUTIONS
PLANNERS • PROJECT MANAGERS • LAND DEVELOPERS

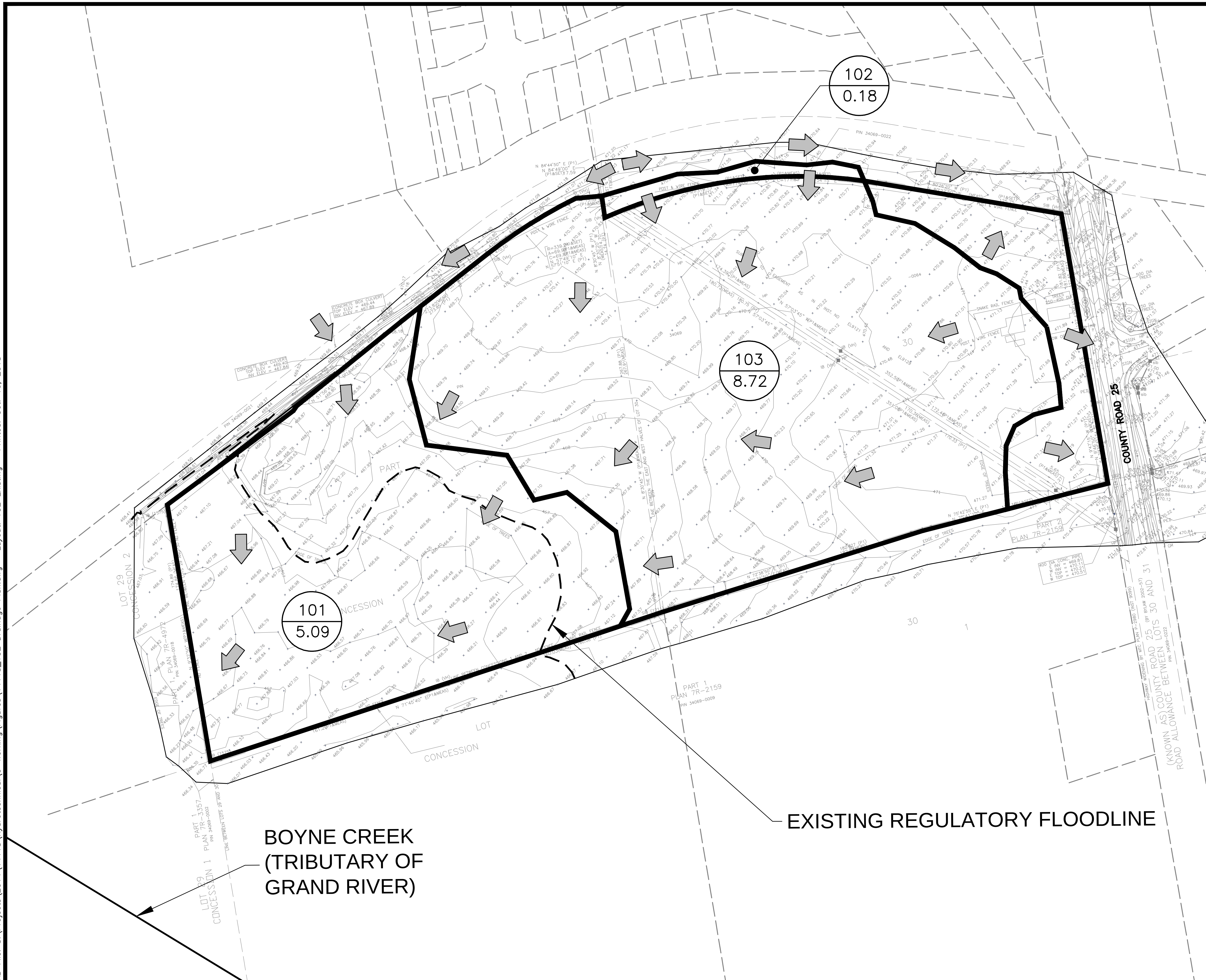
Date: October 16, 2018 Drawn By: AM
File: 10-301 - Corsel Grand Valley Checked By: CS

PROJECT
CORSEED SUBDIVISION
TOWN OF GRAND VALLEY

TITLE
PROPOSED DEVELOPMENT

VALDOR ENGINEERING INC.
Consulting Engineers - Project Managers
741 ROWNTREE DAIRY ROAD, SUITE 2, WOODBRIDGE, ONTARIO, L4L 5T9
TEL (905)264-0054, FAX (905)264-0069
E-MAIL: info@valdor-engineering.com
www.valdor-engineering.com

PREPARED BY: D.Z.	CKD. BY: D.G.
SCALE: N.T.S.	DATE: October 19, 2018
PROJECT: 14118	FIGURE 2



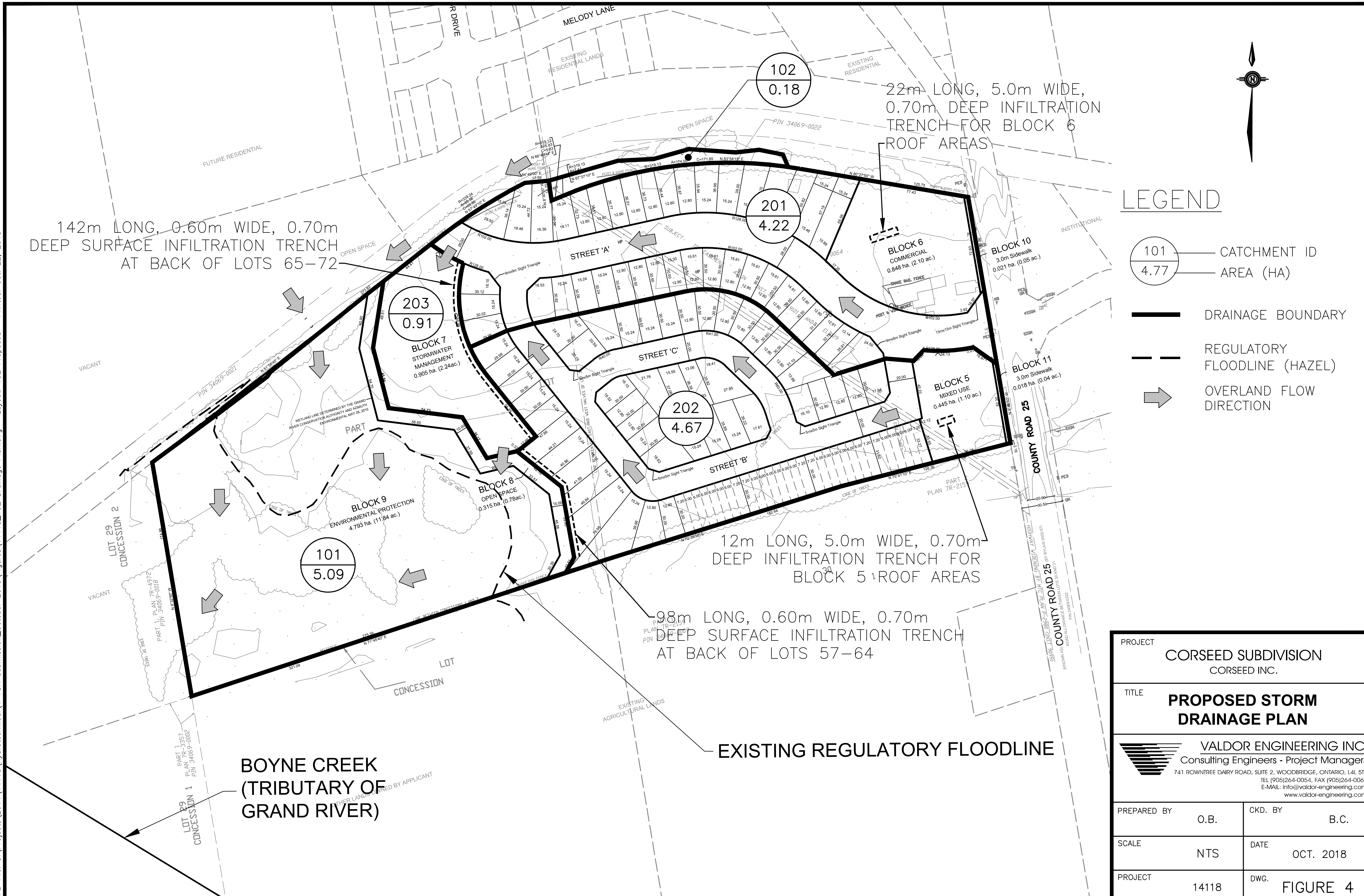
PROJECT
CORSEED SUBDIVISION
CORSEED INC.

TITLE
EXISTING STORM DRAINAGE PLAN

VALDOR ENGINEERING INC.
Consulting Engineers - Project Managers
741 ROWNTREE DAIRY ROAD, SUITE 2, WOODBRIDGE, ONTARIO, L4L 5T9
TEL (905)264-0054, FAX (905)264-0069
E-MAIL: info@valdor-engineering.com
www.valdor-engineering.com

PREPARED BY	O.B.	CKD. BY	B.C.
SCALE	NTS	DATE	OCT. 2018
PROJECT	14118	DWG.	FIGURE 3

ACAD File: S:\Projects\2014\14118\Hydrotechnical\0-Working\Figures\14118_V02 Drainage Plan.dwg Layout: V02 Existing Printed: Oct. 16, 2018



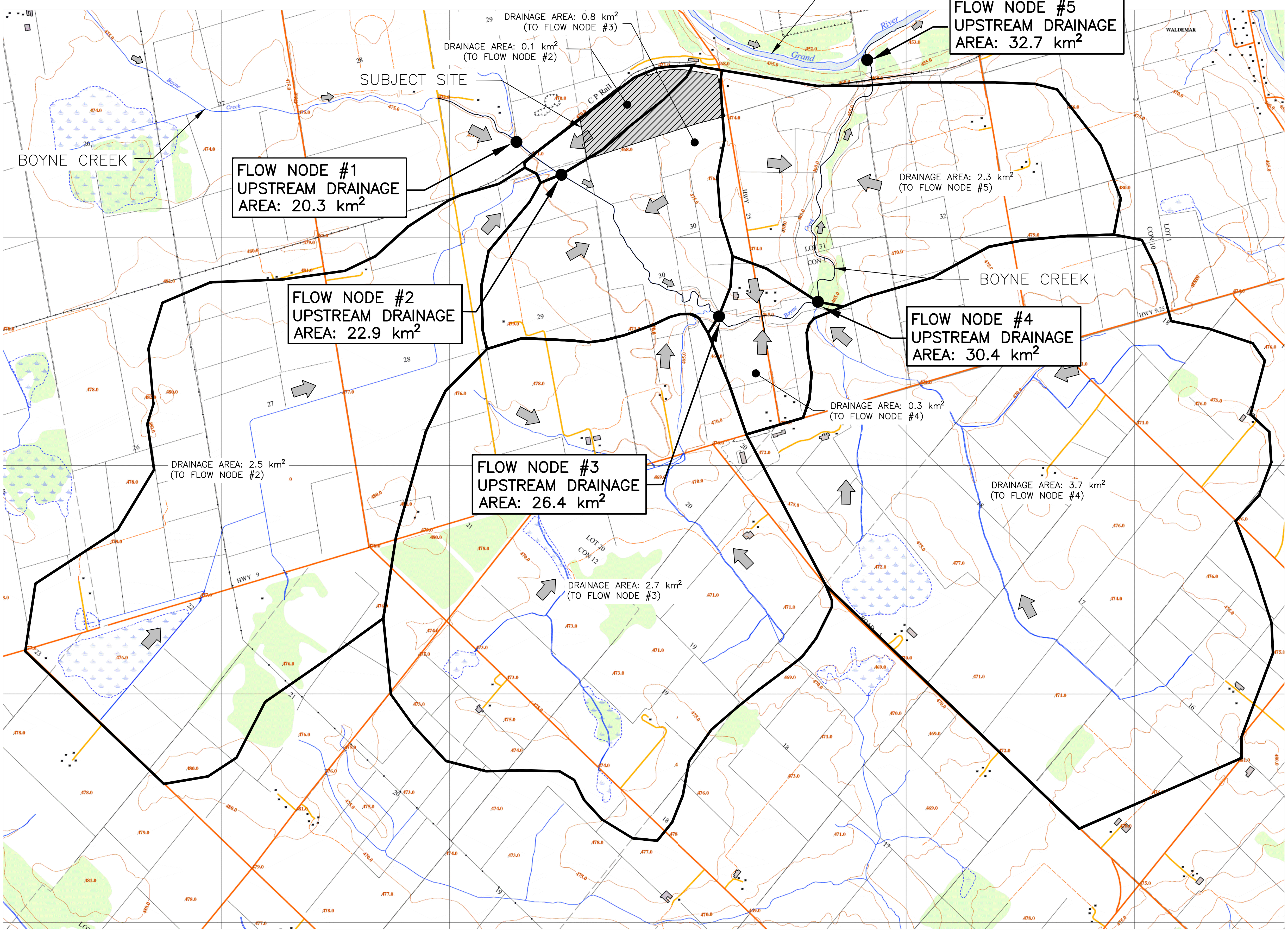
PROJECT
CORSEED SUBDIVISION
CORSEED INC.

TITLE
PROPOSED STORM DRAINAGE PLAN

VALDOR ENGINEERING INC.
Consulting Engineers - Project Managers
741 ROWNTREE DAIRY ROAD, SUITE 2, WOODBRIDGE, ONTARIO, L4L 5T9
TEL (905)264-0054, FAX (905)264-0069
E-MAIL: info@valdor-engineering.com
www.valdor-engineering.com

PREPARED BY	O.B.	CKD. BY	B.C.
SCALE	NTS	DATE	OCT. 2018
PROJECT	14118	DWG.	FIGURE 4

ACAD File: S:\Projects\2014\14118\Hydrotechnical\4-FSR Submission_October 2018\Figures\14118_V02 Drainage Plan.dwg Layout: V02 Proposed Printed: Oct. 22, 2018



N

LEGEND

DRAINAGE BOUNDARY

SUBJECT SITE

OVERLAND FLOW DIRECTION

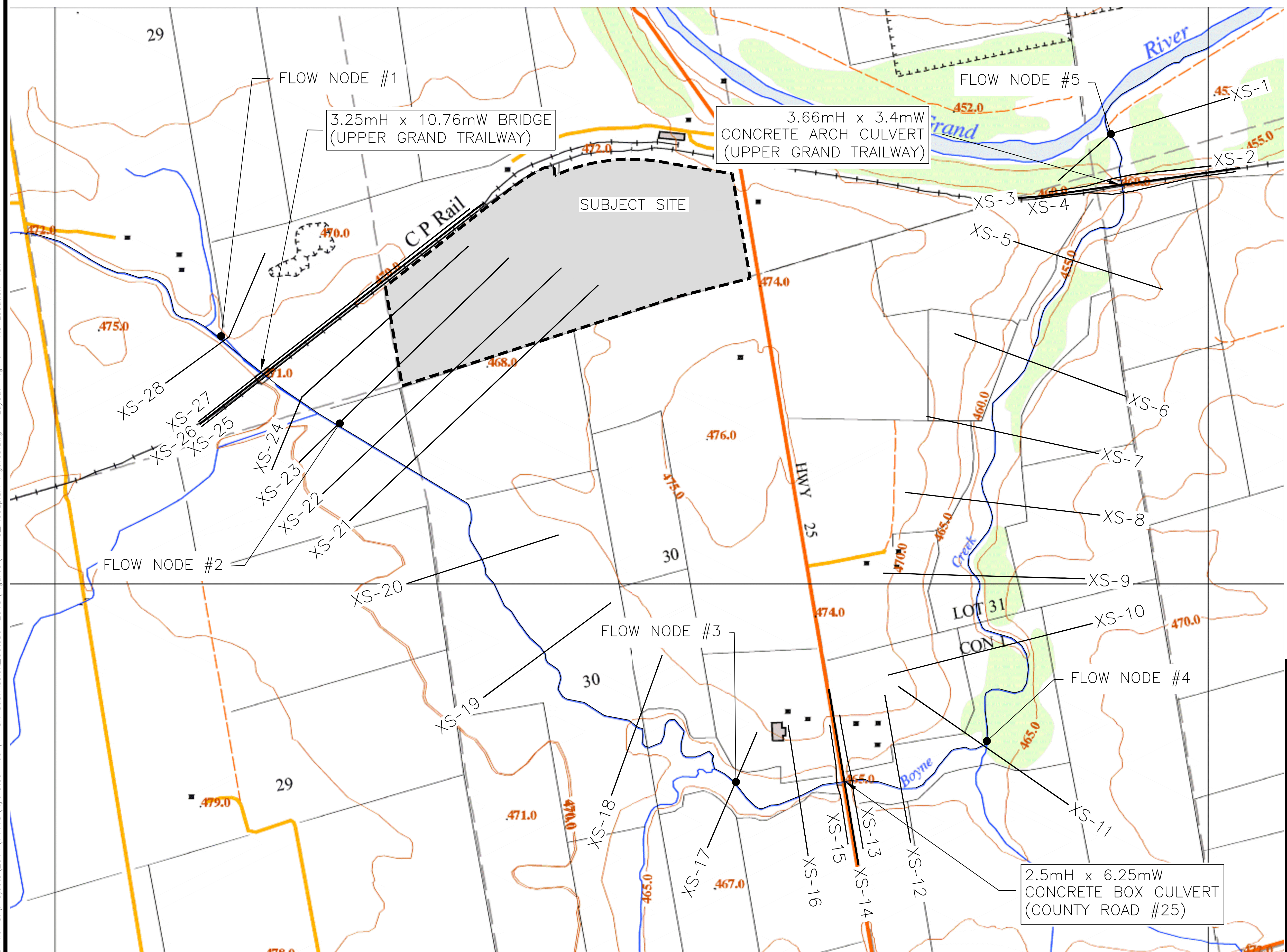
PROJECT	CORSEED SUBDIVISION TOWN OF GRAND VALLEY
TITLE	FLOODPLAIN MAPPING DRAINAGE PLAN

VALDOR ENGINEERING INC.
Consulting Engineers - Project Managers
741 ROWNTREE DAIRY ROAD, SUITE 2, WOODBRIDGE, ONTARIO, L4L 5T9
TEL (905)264-0054, FAX (905)264-0069
E-MAIL: info@valdor-engineering.com
www.valdor-engineering.com

PREPARED BY W.Z./O.B.	CKD. BY B.C.
SCALE NTS	DATE OCT. 2018
PROJECT 14118	FIGURE 5

Acad File: S:\Projects\2014\14118\Hydrotechnical\4-FSR Submission_October 2018\Figures\14118_Floodplain Figures.dwg Layout: Fig.5 - Drainage Plan

Printed: Oct. 19, 2018



LEGEND

HEC–RAS CROSS–SECTION

SITE BOUNDARY

PROJECT
CORSEED SUBDIVISION
TOWN OF GRAND VALLEY

TITLE
HEC-RAS CROSS-SECTION LOCATION PLAN

VALDOR ENGINEERING INC.
Consulting Engineers - Project Managers
741 ROWNTREE DAIRY ROAD, SUITE 2, WOODBRIDGE, ONTARIO, L4L 5T9
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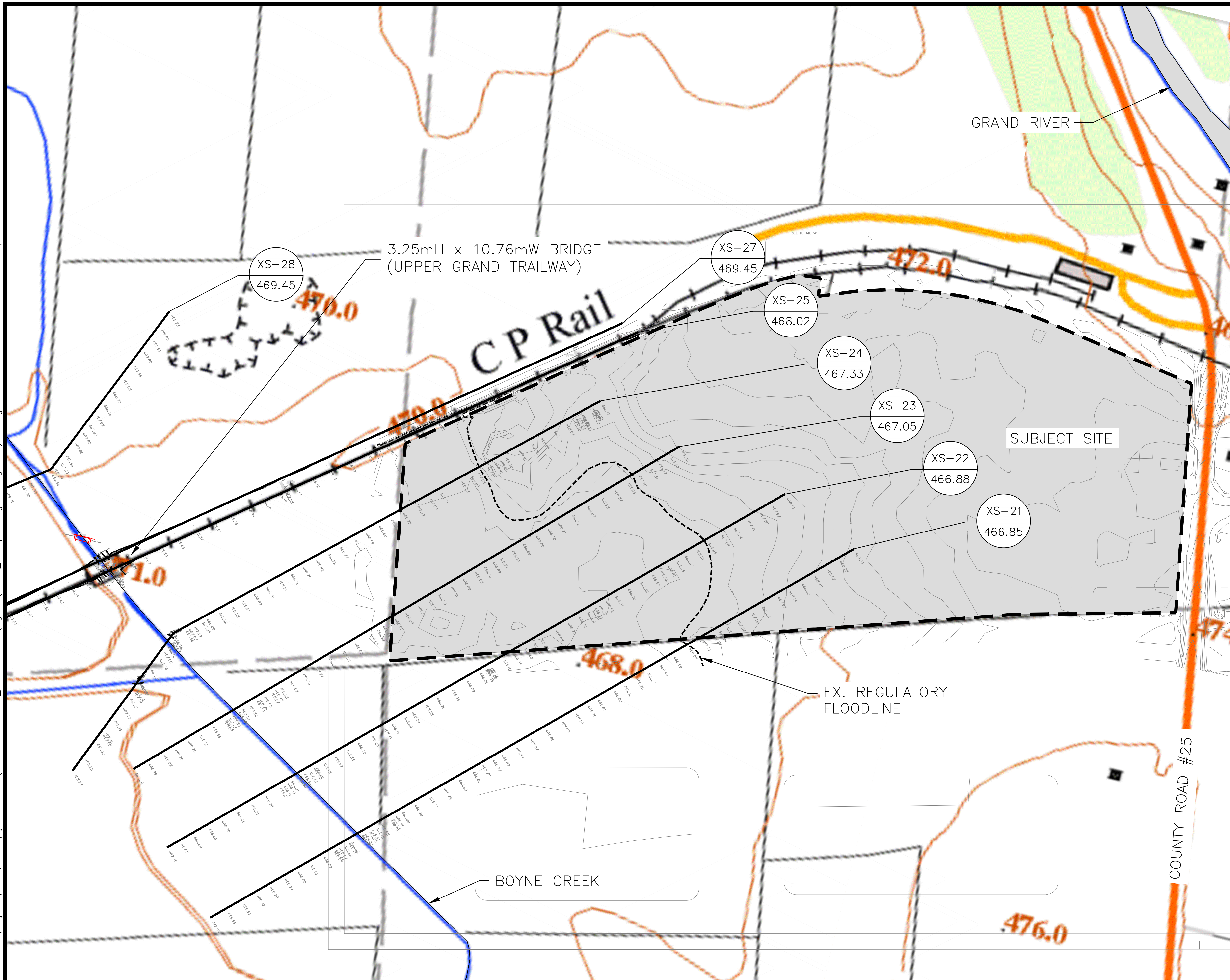
E-MAIL: info@valdor-engineering.com
www.valdor-engineering.com

PREPARED BY W.Z./O.B.	CKD. BY B.C.
SCALE NTS	DATE OCT. 2018
PROJECT 14118	FIGURE 6

Acad File: S:\Projects\2014\14118\Hydrotechnical\4-FSR Submission_October 2018\Figures\14118_Floodplain Figures.dwg Layout: Fig. 6 – XS Location Plan

Printed: Oct. 19, 2018



LEGEND

- HEC-RAS CROSS-SECTION
- SITE BOUNDARY
- EX. REGULATORY FLOODLINE
- XS-21 — HEC-RAS CROSS-SECTION
- 466.85 — EX. REGULATORY (REGIONAL) WATER SURFACE ELEVATION (m)

NOTES ON TOPOGRAPHIC DATA USED:

THE SITE SURVEY WAS COMPLETED BY J.D. BARNES LIMITED ON NOVEMBER 10, 2010. (PLAN OF TOPOGRAPHIC SURVEY OF PART OF LOT 30, CONCESSION 2, TOWNSHIP OF EAST LUTHER – GRAND VALLEY, COUNTY OF DUFFERIN, REFERENCE NUMBER: 10-11-245-00-B (WEST)). CONTOURS WERE GENERATED FROM THIS SITE SURVEY BY J.D. BARNES LIMITED.

AN ADDITIONAL CROSS-SECTION SURVEY IN SUPPORT OF THE HEC-RAS MODEL WAS COMPLETED BY J.D. BARNES LIMITED ON JANUARY 12, 2015; (REFERENCE NUMBER: 10-11-245-01. TOWNSHIP OF EAST LUTHER – GRAND VALLEY COUNTY OF DUFFERIN).

PROJECT
CORSEED SUBDIVISION
TOWN OF GRAND VALLEY

TITLE
EXISTING REGULATORY FLOODLINE MAPSHEET

VALDOR ENGINEERING INC.
Consulting Engineers - Project Managers
741 ROWNTREE DAIRY ROAD, SUITE 2, WOODBRIDGE, ONTARIO, L4L 5T9
TEL (905)264-0054, FAX (905)264-0069
E-MAIL: info@valdor-engineering.com
www.valdor-engineering.com

PREPARED BY W.Z./O.B.	CKD. BY B.C.
SCALE 1:3000	DATE OCT. 2018
PROJECT 14118	FIGURE 7

APPENDIX "A"

Water Demand Calculations & Details

VALDOR ENGINEERING INC.
741 Rowntree Dairy Road, Suite 2, Woodbridge, ON L4L 5T9
Tel: 905-264-0054 Fax: 905-264-0069 info@valdor-engineering.com
www.valdor-engineering.com

TABLE A1: DOMESTIC WATER CONSUMPTION DEMAND CALCULATION

Project Name: **Corseed Subdivision, Town of Grand Valley**
File: 14118
Date: March 2018

Conditions:		
Average Day Demand	450	L/person/day
Maximum Day Factor	2.75	
Peak Hour Factor	4.13	

Consumption Demand:

	Equivalent Population (persons)	Domestic Demand (L/min)	Maximum Day Demand (L/min)	Peak Hour Demand (L/min)
Residential Units	380	119	327	490
Mixed Use	50	16	43	65
Commercial	22	7	19	28
Total	**452**	**141**	**388**	**583**

VALDOR ENGINEERING INC.
741 Rowntree Dairy Road, Suite 2, Woodbridge, ON L4L 5T9
Tel: 905-264-0054 Fax: 905-264-0069 info@valdor-engineering.com
www.valdor-engineering.com

TABLE A2: REQUIRED FIRE FLOW CALCULATION

In accordance to Water Supply for Public Fire Protection, Fire Underwriters Survey 1999

Project Name: **Corseed Subdivision**
File: 14118
Date: March 2018

Notes: **DETACHED DWELLING**
Assume:
- 3,500 sq.ft total floor area
- interior unit for max exposure

Type of Construction - Ordinary Construction

C = 1.0

Total Floor Area: 325 sq.m

A = 325 sq.m

(Total Floor Area includes all storeys, but excludes basements at least 50 percent below grade)

$F = 220\,C\,\sqrt{A}$

F = 3,966 L/min

F = 4,000 (to nearest 1,000 Lmin)

Occupancy Factor

		Charge
Type:	Limited Combustible	-15%
	f_1 =	-15%

$F' = F \times (1+f_1)$

F' = 3,400 L/min

Sprinkler Credit

		Charge
NFPA 13 Sprinkler Standard:	NO	0%
Standard Water Supply:	NO	0%
Fully Supervised System:	NO	0%
Total Charge to Fire Flow:	f_2 =	0%

Exposure Factor

		Charge
Side 1 - Distance to Building (m):	0 to 3m	25%
Side 2 - Distance to Building (m):	0 to 3m	25%
Side 3 - Distance to Building (m):	3.1 to 10m	20%
Side 4 - Distance to Building (m):	3.1 to 10m	20%
	f_3 =	75% (maximum of 75%)

$F'' = F' + F' \times f_2 + F' \times f_3$

F'' = 5,950 L/min

REQUIRED FIRE FLOW

F'' = **6,000** **L/min** (to nearest 1,000 L/min)

APPENDIX "B"

Wastewater Calculations & Details

VALDOR ENGINEERING INC.
741 Rowntree Dairy Road, Suite 2, Woodbridge, ON L4L 5T9
Tel: 905-264-0054 Fax: 905-264-0069 info@valdor-engineering.com
www.valdor-engineering.com

TABLE B1: SEWAGE FLOW CALCULATIONS

Project Name: **Corseed Subdivision, Town of Grand Valley**
File: 14118
Date: October 2018

Conditions:

Average Daily Flow:	450	L/person/day
Residential Peaking Factor:	$K_H = 1 + \frac{14}{4+\sqrt{P}}$	where K_H = Harmon Peaking Factor (max. 4.0, min. 2.0); p = population in thousands
Extraneous Flow (I):	0.20	L/ha/s. (infiltration)
Design Flow (Q_D):	$Q \times K_H + I$	
Commercial Flow Rate*:	3.75	L/day/sq.m.Floor Area
Commercial Floor Area**:	2,170.00	sq.m
Commercial Flow:	8,137.50	L/day
	0.09	L/s
Per capita Rate:	343.00	L/person/day
Equivalent Population:	24	People

*average as per the 2008 MOE Guideline, Table 5-3
**assume 25% of lot area

Consumption Demand:

Land Use	Area (ha.)	Equivalent Population (persons)	Average Daily Flow (L/s)	Harmon Peaking Factor	Peak Daily Flow (L/s)	Extraneous Flow (L/s)	Total Flow (L/s)
Residential Units	5.14	460	2.40	3.99	9.57	1.03	10.59
Mixed Use Units	0.46	35	0.18	4.00	0.72	0.09	0.81
Commercial units	0.87	24	0.09	4.00	0.38	0.17	0.55
Parks & Open Space	0.32					0.06	0.06
Road Allowance	2.42					0.48	0.48
Total	**9.20**	**519**	**2.67**		**10.66**	**1.84**	**12.50**

APPENDIX "C"

Storm Drainage Details

Consultant:

VALDOR ENGINEERING INC.

741 Rowntree Dairy Road, Suite 2, Woodbridge, Ontario, L4L 5T9
Tel: 905-264-0054 Fax: 905-264-0069 info@valdor-engineering.com

Town of Grand Valley

Engineering and Public Works Department

STORM SEWER DESIGN SHEET

Project Name: Corseed Subdivision

Project No: 14118

Design: O. Beaudin, P.Eng.
Checked: D. Giugovaz, P.Eng.
Approved: P.Zourntos, P.Eng
Date: October 2018

NOTE: All flows are provided by the VO2 model.

Street	FROM MH	TO MH	A (ha)	R	A x R	Accum. A x R	Tc (min)	5 Year I (mm/hr)	Design Flow Qd (m^3/s)	Size of Pipe (mm)	Grade (%)	Nominal Capacity Qc (m^3/s)	Full Flow Velocity (m/s)	Length (m)	Time in Sect. (min)	Total Time (min)	Qd / Qc	Remarks
MINOR SYSTEM FLOW TO SWM POND FOREBAY INLET **Note:** Pipe sized to convey the 5-year flow from local streets (Catchment 202: 0.887 cms) and the 10-year flow from the collector road (Catchment 102: 0.010 cms, Catchment 201: 1.029 cms). Total minor system flow is 1.926 cms. Flows obtained from VO2 model results.	CATCHMENTS 102, 201 & 202	MH 101	9.07						1.926									
	MH 101	HW 1							1.926	1200	0.50	2.757	2.46	58.8	0.40	0.40	70%	

RUNOFF COEFFICIENTS (R)

0.30 : PARK - OPEN SPACES - CEMETARIES
0.45 : SINGLE FAMILY RESIDENTIAL
0.65 : TOWN HOUSES
0.50 : APARTMENTS & MEDIUM DENSITY

No.	REVISION	DATE	AUTH
3			
2			
1			

Town of Grand Valley
Engineering and Public Works Department

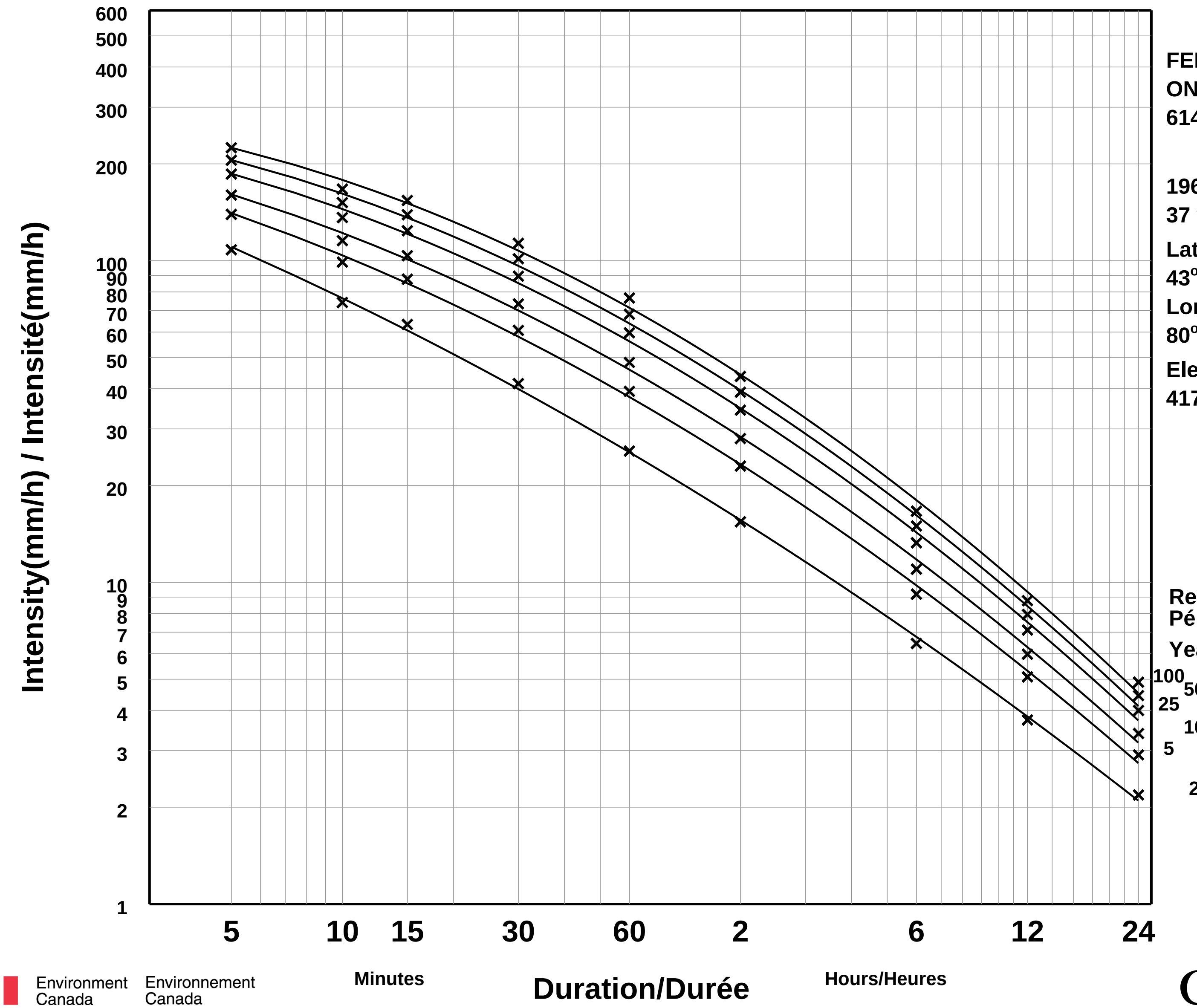
STORM SEWER DESIGN SHEET

SCALE:	N.T.S.		DATE: October 2018
DRAWN BY:	--		DWG. No.

Short Duration Rainfall Intensity−Duration−Frequency Data

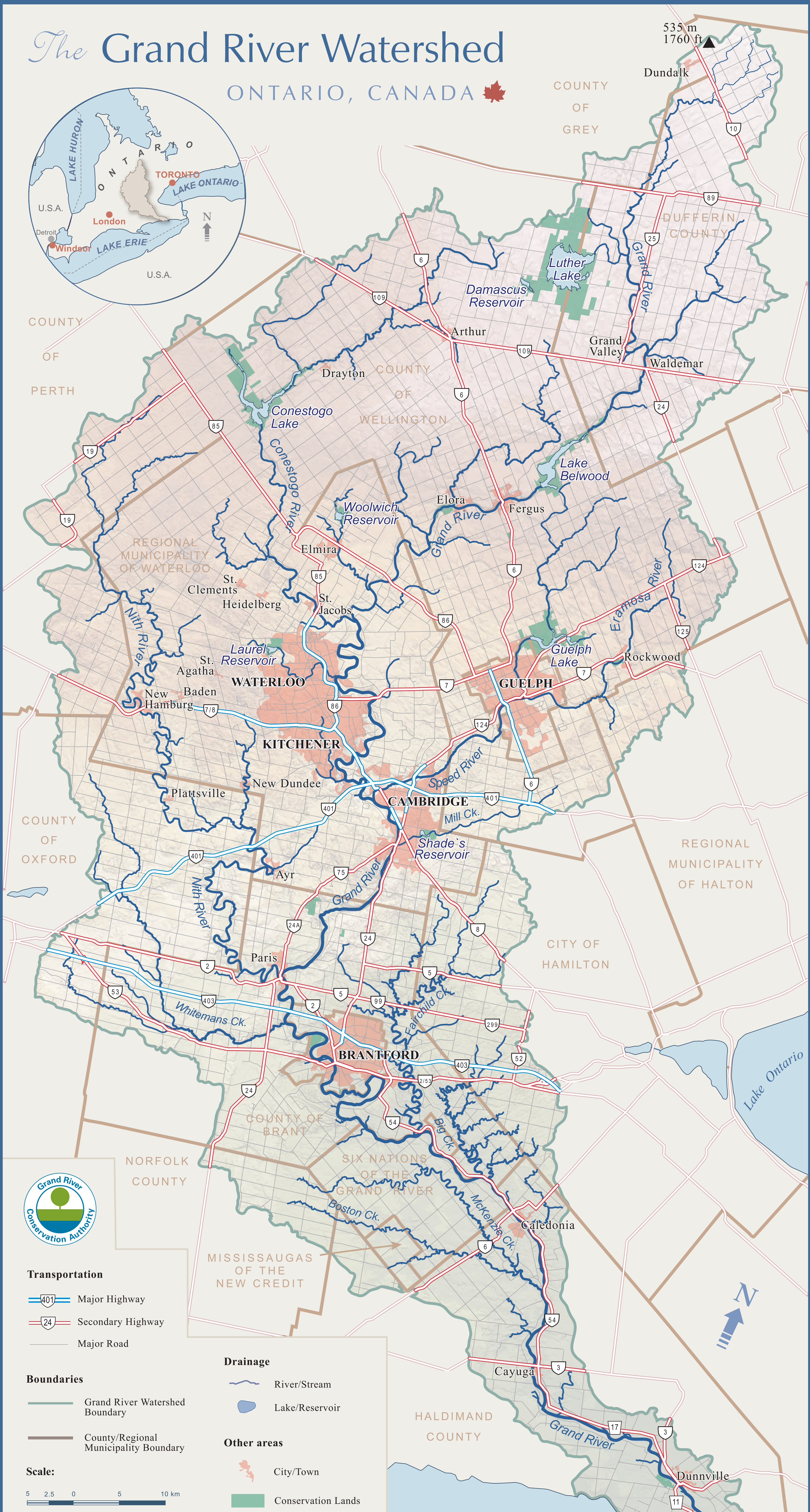
2014/12/21

Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée



FERGUS SHAND DAM
ON
6142400

1961 − 2007
37 years / ans
Latitude
43° 44'N
Longitude
80° 20'W
Elevation / Altitude
417 m


The Grand River Watershed
ONTARIO, CANADA
LAKE HURON
ONTARIO
TORONTO
LAKE ONTARIO
U.S.A.
London
Detroit
Windsor
LAKE ERIE
U.S.A.
N
535 m
1760 ft
Dundalk
COUNTY OF GREY
DUFFERIN COUNTY
Luther Lake
Damascus Reservoir
Grand River
Arthur
Grand Valley
Waldemar
COUNTY OF PERTH
Drayton
COUNTY OF WELLINGTON
Conestogo Lake
Conestogo River
Lake Belwood
Woolwich Reservoir
Elora
Fergus
Grand River
REGIONAL MUNICIPALITY OF WATERLOO
Elmira
St. Clements
Heidelberg
St. Jacobs
Eramosa River
Nith River
Laurel Reservoir
St. Agatha
Guelph Lake
Rockwood
WATERLOO
GUELPH
New Hamburg
Baden
KITCHENER
Speed River
New Dundee
Plattsville
CAMBRIDGE
Mill Ck.
COUNTY OF OXFORD
Shade`s Reservoir
Ayr
Grand River
Nith River
REGIONAL MUNICIPALITY OF HALTON
CITY OF HAMILTON
Paris
Fairchild Ck.
Whitemans Ck.
BRANTFORD
Lake Ontario
COUNTY OF BRANT
Big Ck.
SIX NATIONS OF THE GRAND RIVER
NORFOLK COUNTY
Boston Ck.
McKenzie Ck.
Caledonia
MISSISSAUGAS OF THE NEW CREDIT
Grand River Conservation Authority
Transportation
Major Highway
Secondary Highway
Major Road
Boundaries
Grand River Watershed Boundary
County/Regional Municipality Boundary
Drainage
River/Stream
Lake/Reservoir
Other areas
City/Town
Conservation Lands
Scale:
5 2.5 0 5 10 km
N
Cayuga
HALDIMAND COUNTY
Grand River
Dunnville
Lake Erie
Port Maitland
175 m
574 ft

APPENDIX "D"

Stormwater Management Calculations

VALDOR ENGINEERING INC.
Project: Corseed Subdivision
File: 14118
Date: October 2018

Table D.1: Existing VO2 Model Parameters

Subcatchment	Area (ha)	DT (min)	CN Number	IA (mm)	Tp (hr)
101	5.09	5	65	8.0	0.42
102	0.18	5	65	8.0	0.06
103	8.72	5	77	7.5	0.50
Total	**13.99**				

VALDOR ENGINEERING INC.
Project: Corseed Subdivision
File: 14118
Date: October 2018

Table D.2: Proposed VO2 Model Parameters

Subcatchment	Area (ha)	DT (min)	TIMP	XIMP	CN	IA (mm)
101	5.09	5	-	-	65	8.0
102	0.18	5	-	-	65	8.0
201	4.22	5	0.70	0.55	68	5.0
202	4.67	5	0.70	0.55	68	5.0
203	0.91	5	0.50	0.50	68	5.0
Total	**15.07**					

VALDOR ENGINEERING INC.
Project: Corseed Subdivision
File: 14118
Date: October 2018

Table D.3: Calculation of CN Values, Initial Abstractions and Runoff Coefficients

Watershed	Area (ha)	Land Use and Land Cover		CN	Area Weighted CN	IA (mm)	Area Weighted IA (mm)	C-Value	Area Weighted C-Value
		Type	Area (ha)						
101	**5.09**	Row Crops (HSG 'BC')	0.000	85	**65**	7	**8.0**	0.35	**0.280**
		Meadow (HSG 'BC')	5.090	65		8		0.28	
		Forest (HSG 'BC')	0.000	63		10		0.25	
102	**0.18**	Row Crops (HSG 'BC')	0.000	85	**65**	7	**8.0**	0.35	**0.280**
		Meadow (HSG 'BC')	0.180	65		8		0.28	
		Forest (HSG 'BC')	0.000	63		10		0.25	
103	**8.72**	Row Crops (HSG 'BC')	5.497	85	**77**	7	**7.5**	0.35	**0.322**
		Meadow (HSG 'BC')	2.591	65		8		0.28	
		Forest (HSG 'BC')	0.632	63		10		0.25	

VALDOR ENGINEERING INC.
Project: Corseed Subdivision
File: 14118
Date: October 2018

Table D.4: Calculation of Time to Peak

Subcatchment	C Runoff Coefficient (Area Weighted)	L(m) Catchment Length	Highest Elevation (m)	Lowest Elevation (m)	S(%) Catchment Slope	T_c (min)	T_p (hr)
101	0.28	200	468.21	466.21	1.00	37.9	0.42
102	0.28	11	471.55	470.98	5.00	5.3	0.06
103	0.32	365	471.61	467.05	1.25	45.1	0.50

Note:

1) T_p calculation is based on Airport Method $T_c = 3.26 \times (1.1 - C) \times L^{0.5} / S_w^{0.33}$ and $T_P = 0.67 T_c$

Table D.5
SWM POND STAGE-STORAGE TABLE

Project Name: Corseed Subdivision
Municipality: Town of Grand Valley
Project No.: 14118
Date: October 2018

Stage Storage Curve						Outlet Structure							Comments:
Elevation (m)	Sec Area (m^2)	Avg Area (m^2)	Sec Volume (m^3)	Cumulative Volume (m^3)	Volume Above NWL (m^3)		Stage Active (m)	[1]Discharge m^3/s Orifice #1	Orifice #2 (Weir Flow)	Orifice #2 (Orifice Flow)	Spillway	Total	
						Invert Elevation (m)		467.30	467.80	467.80	468.50	Flow	
						Diameter (mm)/Length (m)		100	1.30	1.30	30.00		
						Height (m)		-	0.20	0.20			
						Orifice Area (m^2)		0.0079	0.2600	0.2600	-		
													Weir Equation: $Q=1.837xLxH^{1.5}$
Forebay Below NWL													Orifice Eq'n: $Q = 0.6A(2gH)^{0.5}$
465.30	**55**	**-**	**-**	**0**		**Bottom of Forebay**							Spillway Design: $Q=1.67xLxH^{1.5}$
466.30	**393**	**224**	**224**	**224**		**-**							
467.30	**886**	**640**	**640**	**864**		**NWL**							
Main Cell Below NWL													
465.30	**566**	**-**	**-**	**0**		**Bottom of Main Cell**							
466.30	**1,162**	**864**	**864**	**864**		**-**							
467.30	**1,989**	**1,576**	**1,576**	**2,440**		**NWL**							
Forebay & Main Cell Above NWL													
467.30	**2,875**	**-**	**-**	**3,303**	**0**	**NWL**	0.00	0.000				**0.000**	**Permanent Pool Provided**
467.60	3,364	3,119	936	4,239	936		0.30	0.010				**0.010**	
467.65	3,445	3,404	170	4,409	1,106		0.35	0.011				**0.011**	
467.70	3,526	3,486	174	4,583	1,280		0.40	0.012				**0.012**	
467.75	3,608	3,567	178	4,762	1,459		0.45	0.013				**0.013**	
467.80	3,689	3,648	182	4,944	1,641	**Extended Detention**	0.50	0.014	0.000	-		**0.014**	**Extended Detention Provided**
467.85	3,771	3,730	186	5,131	1,828		0.55	0.015	0.024	-		**0.039**	
467.90	**3,852**	**3,811**	**191**	**5,321**	**2,018**		0.60	0.015	0.069	-		**0.084**	
468.00	4,028	3,940	394	5,715	2,412		0.70	0.017	0.194	-		**0.211**	
468.10	4,205	4,116	412	6,127	2,824		0.80	0.018	-	0.309		**0.327**	
468.30	**4,557**	**4,381**	**876**	**7,003**	**3,700**		1.00	0.020	-	0.437		**0.457**	
468.50	4,870	4,713	943	7,946	4,643	**Spillway**	1.20	0.022	-	0.535	0.000	**0.558**	**100-year Storage Provided**
468.60	**5,026**	**4,948**	**495**	**8,440**	**5,137**		1.30	0.023	-	0.578	1.584	**2.186**	
468.70	5,184	5,105	510	8,951	5,648		1.40	0.024	-	0.618	4.481	**5.123**	
469.00	**5,658**	**5,421**	**1,626**	**10,577**	**7,274**	**Top of Berm**	1.70	0.027	-	0.725	17.713	**18.465**	**Top of Berm**

Corseed Subdivision
SWM Facility (Wet Pond)
Town of Grand Valley
Project No.: 14118

VALDOR ENGINEERING INC.
741 Rowntree Dairy Road, Suite 2, Woodbridge, Ontario. L4L 5T9
Tel: 905-264-0054 Fax: 905-264-0069
www.valdor-engineering.com

TABLE D.6: SWM FACILITY SIZING FOR WATER QUALITY CONTROL

Source: Stormwater Management Planning and Design Manual (Table 3.2),
Ministry of the Environment, Ontario, March 2003

Protection Level	SWMP Type	Storage Volume (m^3/ha) for Impervious Level			
		35%	55%	70%	85%
Level 1	*Infiltration*	25	30	35	40
	Wetlands [2]	80	105	120	140
	Wet Pond [2]	140	190	225	250
	Hybrid Wet Pond/Wetland [4]	110	150	175	195
Level 2	*Infiltration*	20	20	25	30
	Wetlands	60	70	80	90
	Wet Pond	90	110	130	150
	Hybrid Wet Pond/Wetland	75	90	105	120
Level 3	*Infiltration*	20	20	20	20
	Wetlands	60	60	60	60
	Wet Pond	60	75	85	95
	Hybrid Wet Pond/Wetland	60	70	75	80
	Dry Pond	90	150	200	240

1. Table 3.2 was based on specific design parameters (depth, length to width ratio) for each type of end-of-pipe stormwater management facility. The values of these parameters are provided in Appendix I of the Manual. All values in Table 4.1 are based on a 24 hour detention.
2. For wetlands, wet ponds and hybrid ponds, all of the storage, except 40 m^3/ha, in Table 3.2 represents the permanent pool volume. The 40 m^3/ha represents the extended detention storage.
3. For hybrid ponds, 50% to 60% of the permanent pool volume shall be contained in deeper portions of the facility.

PERMANENT POOL CALCULATOR

SWMP Type:	WET POND	(IN - infiltration, WET - wetlands, WP - wet pond, HYB - hybrid wet pond/wetland, DP - dry pond)
Protection Level:	1	(1 - 80% TSS, 2 - 70% TSS, 3 - 60% TSS)
Average Imperviousness:	70.0 %	
Volume Level:	185.0 m^3/ha	Excluding Extended Detention
Area:	9.070 ha	
Total Required Volume:	**1,678** m^3	

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Project: Corseed Subdivision
File: 14118
Date: October 2018

Table D.7: Extended Detention Requirements

Event	Area (ha)	R.V. (mm)	Required Ext. Det. Volume (m^3)	Provided Ext. Det. Volume (m^3)
25mm 4-hour Chicago Storm	9.98	14.88	1,485	1,641

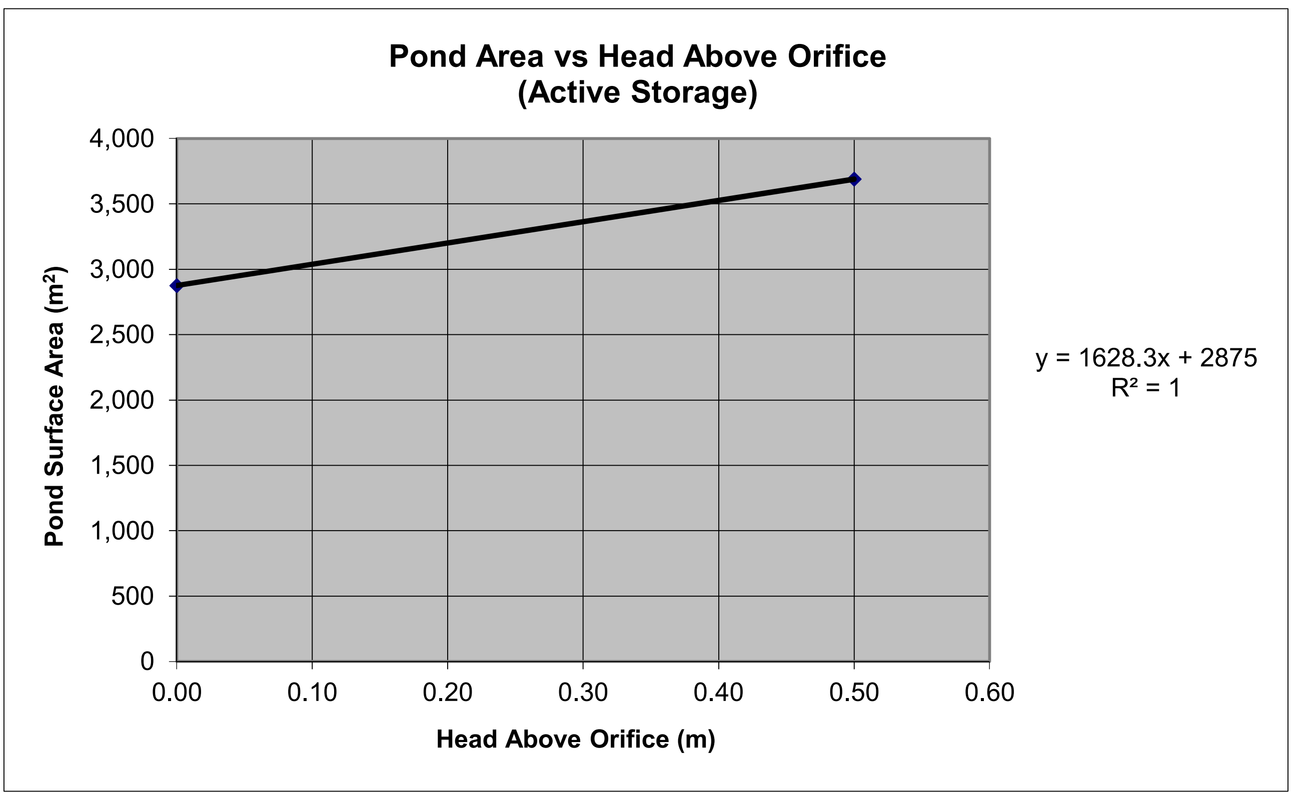
Table D.8: SWM Facility Operation - Extended Detention
Erosion Control Drawdown Time

Project Name: Corseed Subdivision
Municipality: Town of Grand Valley
Project No.: 14118
Date: October 2018

Extended Detention - SWM Pond

Orifice Sizing		
Orifice Size	100	mm
Orifice Invert	467.30	m
Orifice Area	0.007854	sq. m
[1]$EDL_{erosion}$	467.80	m
NWL	467.30	m
C_2	1628.3	
C_3	2875.0	
h	0.4500	m
Drawdown Time	53.8	hr

$y = mx + b$
$C_2 = m$
$C_3 = b$



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Project: Corseed Subdivision
File: 14118
Date: October 2018

Table D.9: Critical Storm Analysis

Storm Distribution	Theoretical 100-year Storage Volume Required (m^3)	Note
6-hour SCS	3,626	
12-hour SCS	3,241	
24-hour SCS	3,000	
1-hour AES	**3,902**	Critical Storm
6-hour AES	3,484	
12-hour AES	3,044	
24-hour AES	2,905	
3-hour Chicago	3,772	

SWM Pond: Forebay Weir

Project Description

Solve For	Discharge		

Input Data

Headwater Elevation		467.80	m
Crest Elevation		467.30	m
Tailwater Elevation		467.30	m
Crest Surface Type	Gravel		
Crest Breadth		6.00	m
Crest Length		4.00	m

Results

Discharge	2.294	m^3/s
Headwater Height Above Crest	0.50	m
Tailwater Height Above Crest	0.00	m
Weir Coefficient	1.62	SI
Submergence Factor	1.00	
Adjusted Weir Coefficient	1.62	SI
Flow Area	2.00	m^2
Velocity	1.15	m/s
Wetted Perimeter	5.00	m
Top Width	4.00	m

Culvert Calculator Report
SWM Pond: Bottom Draw Outlet Pipe

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	467.80	m	Headwater Depth/Height	6.56	
Computed Headwater Elevation	467.80	m	Discharge	0.0798	m³/s
Inlet Control HW Elev.	467.64	m	Tailwater Elevation	467.30	m
Outlet Control HW Elev.	467.80	m	Control Type	Outlet Control	

Grades					
Upstream Invert	465.80	m	Downstream Invert	467.30	m
Length	31.10	m	Constructed Slope	-0.048232	m/m

Hydraulic Profile					
Profile	CompositeA2PressureProfile		Depth, Downstream	0.22	m
Slope Type	Adverse		Normal Depth	0.00	m
Flow Regime	Subcritical		Critical Depth	0.22	m
Velocity Downstream	1.42	m/s	Critical Slope	0.007087	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	0.30	m
Section Size	300 mm		Rise	0.30	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	467.80	m	Upstream Velocity Head	0.06	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	467.64	m	Flow Control	Transition	
Inlet Type	Beveled ring, 33.7° bevels		Area Full	0.1	m²
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	B	
C	0.02430		Equation Form	1	
Y	0.83000				

Culvert Calculator Report
SWM Pond: Quantity Outlet Pipe - 100yr Controlled Flow

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	468.50 m	Headwater Depth/Height	0.61
Computed Headwater Elevation	467.45 m	Discharge	0.5530 m³/s
Inlet Control HW Elev.	467.41 m	Tailwater Elevation	467.35 m
Outlet Control HW Elev.	467.45 m	Control Type	Outlet Control

Grades

Upstream Invert	467.08 m	Downstream Invert	467.00 m
Length	15.60 m	Constructed Slope	0.005128 m/m

Hydraulic Profile

Profile	S1	Depth, Downstream	0.35 m
Slope Type	Steep	Normal Depth	0.19 m
Flow Regime	Subcritical	Critical Depth	0.21 m
Velocity Downstream	0.88 m/s	Critical Slope	0.003684 m/m

Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	1.80 m
Section Size	1800 x 600 mm	Rise	0.60 m
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	467.45 m	Upstream Velocity Head	0.07 m
Ke	0.50	Entrance Loss	0.04 m

Inlet Control Properties

Inlet Control HW Elev.	467.41 m	Flow Control	Unsubmerged
Inlet Type	90° headwall w 45° bevels	Area Full	1.1 m²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

SWM Pond: Level Spreader - 100yr Controlled Flow

Project Description

Solve For	Headwater Elevation		

Input Data

Discharge		0.553	m³/s
Crest Elevation		467.25	m
Tailwater Elevation		467.25	m
Crest Surface Type	Paved		
Crest Breadth		0.30	m
Crest Length		10.00	m

Results

Headwater Elevation	467.35	m
Headwater Height Above Crest	0.10	m
Tailwater Height Above Crest	0.00	m
Weir Coefficient	1.70	SI
Submergence Factor	1.00	
Adjusted Weir Coefficient	1.70	SI
Flow Area	1.02	m²
Velocity	0.54	m/s
Wetted Perimeter	10.20	m
Top Width	10.00	m

SWM Pond: Emergency Spillway - 100yr Uncontrolled Flow

Project Description

Solve For	Headwater Elevation	

Input Data

Discharge	4.098	m^3/s
Crest Elevation	468.50	m
Tailwater Elevation	468.50	m
Crest Surface Type	Gravel	
Crest Breadth	8.00	m
Crest Length	30.00	m

Results

Headwater Elevation	468.70	m
Headwater Height Above Crest	0.20	m
Tailwater Height Above Crest	0.00	m
Weir Coefficient	1.51	SI
Submergence Factor	1.00	
Adjusted Weir Coefficient	1.51	SI
Flow Area	6.04	m^2
Velocity	0.68	m/s
Wetted Perimeter	30.40	m
Top Width	30.00	m

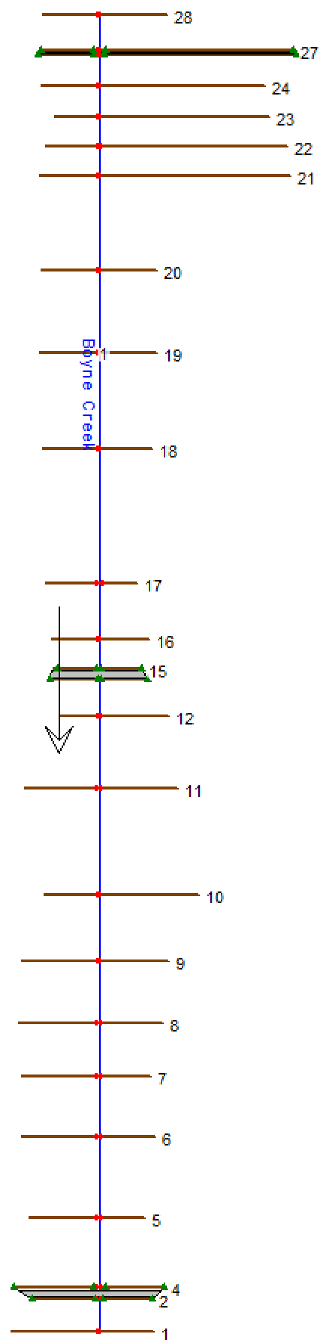

Figure D.1: HEC-RAS Model Schematic

VALDOR ENGINEERING INC.

Project: Corseed Subdivision

File: 14118

Date: March 2018

Table D.10: HEC-RAS FLOW DATA

Boyne Creek drainage area upstream of Grand River (km^2): **32.7**

Boyne Creek Regional flow at Grand River (cms): **102**

Transposition of Flood Discharges Method (MTO Drainage Management Manual, 1997, Eq. 8.31):

$$Q_2 = Q_1 \left(\frac{A_2}{A_1}\right)^{0.75}$$

Where:

Q_1 = known peak discharge

Q_2 = unknown peak discharge

A_1 = known basin area

A_2 = unknown basin area

Regional flow at flow nodes as per the Transposition of Flood Discharges Method:

Flow Node	[1]HEC-RAS XS	Upstream Drainage Area (km^2)	Regional Flow (cms)
1	-	20.3	**71.3**
2	28	22.9	**78.1**
3	23	26.4	**86.9**
4	17	30.4	**96.6**
5	11	32.7	**102.0**

Notes:

1-The flow at each flow node is applied to the HEC-RAS cross-sections upstream of that flow node.

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Project: Corseed Subdivision

File: 14118

Date: March 2018

Table D.11: EXISTING CONDITIONS HEC-RAS OUTPUT

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	28	Regulatory	78.10	465.66	469.45		469.47	0.00	1.18	211.82	150.29	0.2
1	27	Regulatory	78.10	465.29	469.45	468.39	469.45	0.00	0.48	692.27	564.91	0.08
1	26		Bridge									
1	25	Regulatory	78.10	465.55	468.02	468.02	468.18	0.00	2.52	138.66	395.02	0.52
1	24	Regulatory	78.10	464.94	467.33		467.38	0.00	1.90	189.87	362.08	0.41
1	23	Regulatory	86.90	464.62	467.05	467.05	467.18	0.00	2.78	162.40	447.68	0.59
1	22	Regulatory	86.90	464.53	466.88		466.90	0.00	1.41	273.68	466.95	0.3
1	21	Regulatory	86.90	464.03	466.85		466.86	0.00	1.03	352.05	427.29	0.2
1	20	Regulatory	86.90	463.67	466.66		466.71	0.00	1.83	182.88	196.87	0.34
1	19	Regulatory	86.90	463.09	465.58	465.58	466.17	0.01	4.29	45.73	46.52	0.9
1	18	Regulatory	86.90	462.39	465.23		465.31	0.00	2.01	106.78	69.94	0.39
1	17	Regulatory	96.60	461.82	465.01		465.09	0.00	1.49	127.41	82.27	0.27
1	16	Regulatory	96.60	461.06	464.86		464.98	0.00	2.34	108.83	57.87	0.39
1	15	Regulatory	96.60	459.58	464.80	461.69	464.93	0.00	1.64	77.59	124.97	0.23
1	14		Culvert									
1	13	Regulatory	96.60	459.62	462.50	462.35	463.71	0.01	4.90	20.15	27.65	0.93
1	12	Regulatory	96.60	459.93	462.55		462.79	0.00	2.92	79.38	63.50	0.59
1	11	Regulatory	102.00	459.44	461.52	461.52	462.00	0.01	3.51	57.13	73.66	0.81
1	10	Regulatory	102.00	458.26	460.79		460.92	0.00	2.55	115.57	105.06	0.53
1	9	Regulatory	102.00	457.24	459.64	459.63	460.23	0.01	4.25	52.78	47.27	0.89
1	8	Regulatory	102.00	456.56	459.84		459.89	0.00	1.32	163.96	99.09	0.24
1	7	Regulatory	102.00	455.70	459.81		459.84	0.00	1.15	226.68	102.82	0.18
1	6	Regulatory	102.00	454.22	459.80		459.82	0.00	0.78	350.64	138.02	0.11
1	5	Regulatory	102.00	452.53	459.80		459.81	0.00	0.44	709.28	206.56	0.05
1	4	Regulatory	102.00	450.67	459.77	452.78	459.80	0.00	0.86	301.77	342.75	0.09
1	3		Culvert									
1	2	Regulatory	102.00	450.65	454.10		454.38	0.00	2.60	54.68	95.50	0.45
1	1	Regulatory	102.00	449.23	454.23	452.29	454.23	0.00	0.50	699.43	308.10	0.07

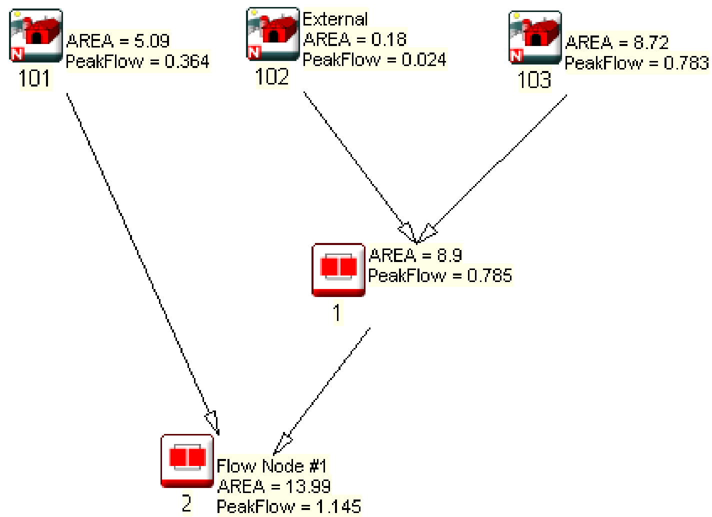

Figure D.2: VO2 Model Schematic – Existing Conditions

```
=========================================================================================
==============

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM, Version 2.0
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O   Licensed To: Valdor Engineering
        OOO     T      T    H   H    Y    M   M   OOO                 VO2-0156
```



```
                   *****  D E T A I L E D   O U T P U T *****


  Input   filename: C:\Program Files\Visual OTTHYMO v2.0\voin.dat
  Output  filename: S:\Projects\2014\14118\Hydrotechnical\0-
Working\VO2\VO2\14118\14118_Existing.out
  Summary filename: S:\Projects\2014\14118\Hydrotechnical\0-
Working\VO2\VO2\14118\14118_Existing.sum


DATE: 10/16/2018                           TIME: 2:13:10 PM

USER:
```

COMMENTS: **Existing Conditions VO2 Model Output**

```
-----------------------------------------------------------------------------------------
--------------
  ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************
```

2-year 1-hour AES

```
--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_2Y.STM
| Ptotal= 25.60 mm |    Comments: 2yr/1hr Fergus Shand Dam 2007 (AES Curve
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42   46.08 |   .75   24.58 |  1.08    3.07
                  .17    3.07 |   .50   86.02 |   .83   15.36 |
                  .25    9.22 |   .58   46.08 |   .92    9.22 |
                  .33   24.58 |   .67   36.86 |  1.00    3.07 |

-----------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=   8.72   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   7.50   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .50

     Unit Hyd Qpeak  (cms)=    .666

     PEAK FLOW       (cms)=    .084 (i)
     TIME TO PEAK    (hrs)=   1.167
     RUNOFF VOLUME    (mm)=   3.486
     TOTAL RAINFALL   (mm)=  25.601
     RUNOFF COEFFICIENT   =    .136

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .002 (i)
     TIME TO PEAK    (hrs)=    .667
     RUNOFF VOLUME    (mm)=   1.720
     TOTAL RAINFALL   (mm)=  25.601
     RUNOFF COEFFICIENT   =    .067

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0103):      8.72     .084     1.17     3.49
        + ID2= 2 (0102):       .18     .002      .67     1.72
          ==================================================
          ID = 3 (0001):      8.90     .084     1.17     3.45

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .032 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=   2.006
     TOTAL RAINFALL   (mm)=  25.601
     RUNOFF COEFFICIENT   =    .078

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0001):      8.90     .084     1.17     3.45
        + ID2= 2 (0101):      5.09     .032     1.08     2.01
          ==================================================
          ID = 3 (0002):     13.99     .115     1.08     2.93

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
```

```
------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   3 **  5-year 1-hour AES
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_5Y.STM
| Ptotal= 39.20 mm |    Comments: 5yr/1hr Fergus Shand Dam 2007 (AES Curve
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42   70.56 |   .75   37.63 |  1.08    4.70
                  .17    4.70 |   .50  131.71 |   .83   23.52 |
                  .25   14.11 |   .58   70.56 |   .92   14.11 |
                  .33   37.63 |   .67   56.45 |  1.00    4.70 |

------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=   8.72   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   7.50   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .50

     Unit Hyd Qpeak  (cms)=    .666

     PEAK FLOW       (cms)=    .222 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=   9.340
     TOTAL RAINFALL   (mm)=  39.198
     RUNOFF COEFFICIENT   =    .238

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .006 (i)
     TIME TO PEAK    (hrs)=    .667
     RUNOFF VOLUME    (mm)=   4.972
     TOTAL RAINFALL   (mm)=  39.198
     RUNOFF COEFFICIENT   =    .127

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0103):     8.72    .222     1.08     9.34
        + ID2= 2 (0102):      .18    .006      .67     4.97
          ===============================================
          ID = 3 (0001):     8.90    .223     1.08     9.25

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .092 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=   5.794
     TOTAL RAINFALL   (mm)=  39.198
     RUNOFF COEFFICIENT   =    .148

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0001):     8.90    .223     1.08     9.25
        + ID2= 2 (0101):     5.09    .092     1.08     5.79
          ===============================================
          ID = 3 (0002):    13.99    .315     1.08     7.99

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   4 **  10-year 1-hour AES
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_10Y.STM
| Ptotal= 48.30 mm |    Comments: 10yr/1hr Fergus Shand Dam 2007 (AES Curv
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42   86.94 |   .75   46.37 |  1.08    5.80
                  .17    5.80 |   .50  162.29 |   .83   28.98 |
                  .25   17.39 |   .58   86.94 |   .92   17.39 |
                  .33   46.37 |   .67   69.55 |  1.00    5.80 |

------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=   8.72   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   7.50   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .50

     Unit Hyd Qpeak  (cms)=    .666

     PEAK FLOW       (cms)=    .339 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=  14.268
     TOTAL RAINFALL   (mm)=  48.302
     RUNOFF COEFFICIENT   =    .295

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
```

```
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .010 (i)
     TIME TO PEAK    (hrs)=    .583
     RUNOFF VOLUME    (mm)=   7.870
     TOTAL RAINFALL   (mm)=  48.302
     RUNOFF COEFFICIENT   =    .163

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

-------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
-------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0103):     8.72    .339     1.08     14.27
        + ID2= 2 (0102):      .18    .010      .58      7.87
          ==================================================
          ID = 3 (0001):     8.90    .340     1.08     14.14

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
-------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .145 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=   9.172
     TOTAL RAINFALL   (mm)=  48.302
     RUNOFF COEFFICIENT   =    .190

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

-------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
-------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0001):     8.90    .340     1.08     14.14
        + ID2= 2 (0101):     5.09    .145     1.08      9.17
          ==================================================
          ID = 3 (0002):    13.99    .486     1.08     12.33

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   5 **   25-year 1-hour AES
  ****************************


-------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_25Y.STM
| Ptotal= 59.70 mm |    Comments: 25yr/1hr Fergus Shand Dam 2007 (AES Curv
-------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42  107.46 |   .75   57.31 |  1.08    7.16
                  .17    7.16 |   .50  200.59 |   .83   35.82 |
                  .25   21.49 |   .58  107.46 |   .92   21.49 |
                  .33   57.31 |   .67   85.97 |  1.00    7.16 |

------------------------------------------------------------------------------

-------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=   8.72   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   7.50   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=    .50

     Unit Hyd Qpeak  (cms)=    .666

     PEAK FLOW       (cms)=    .506 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=  21.274
     TOTAL RAINFALL   (mm)=  59.698
     RUNOFF COEFFICIENT   =    .356

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
-------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .015 (i)
     TIME TO PEAK    (hrs)=    .583
     RUNOFF VOLUME    (mm)=  12.168
     TOTAL RAINFALL   (mm)=  59.698
     RUNOFF COEFFICIENT   =    .204

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

-------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
-------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0103):     8.72    .506     1.08     21.27
        + ID2= 2 (0102):      .18    .015      .58     12.17
          ==================================================
          ID = 3 (0001):     8.90    .507     1.08     21.09

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
-------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .225 (i)
     TIME TO PEAK    (hrs)=   1.000
     RUNOFF VOLUME    (mm)=  14.180
     TOTAL RAINFALL   (mm)=  59.698
     RUNOFF COEFFICIENT   =    .238

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

```
-----------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
         ID1= 1 (0001):      8.90     .507     1.08    21.09
       + ID2= 2 (0101):      5.09     .225     1.00    14.18
         ================================================
         ID = 3 (0002):     13.99     .731     1.08    18.58

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   6 **   50-year 1-hour AES
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_50Y.STM
| Ptotal= 68.20 mm |    Comments: 50yr/1hr Fergus Shand Dam 2007 (AES Curv
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42  122.76 |   .75   65.47 |  1.08    8.18
                  .17    8.18 |   .50  229.15 |   .83   40.92 |
                  .25   24.55 |   .58  122.76 |   .92   24.55 |
                  .33   65.47 |   .67   98.21 |  1.00    8.18 |

-----------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=   8.72   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   7.50   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .50

    Unit Hyd Qpeak  (cms)=    .666

    PEAK FLOW       (cms)=    .641 (i)
    TIME TO PEAK    (hrs)=   1.083
    RUNOFF VOLUME    (mm)=  26.976
    TOTAL RAINFALL   (mm)=  68.198
    RUNOFF COEFFICIENT   =    .396

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

    Unit Hyd Qpeak  (cms)=    .115

    PEAK FLOW       (cms)=    .019 (i)
    TIME TO PEAK    (hrs)=    .583
    RUNOFF VOLUME    (mm)=  15.786
    TOTAL RAINFALL   (mm)=  68.198
    RUNOFF COEFFICIENT   =    .231

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------
```

```
--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
         ID1= 1 (0103):      8.72     .641     1.08    26.98
       + ID2= 2 (0102):       .18     .019      .58    15.79
         ================================================
         ID = 3 (0001):      8.90     .643     1.08    26.75

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

    Unit Hyd Qpeak  (cms)=    .463

    PEAK FLOW       (cms)=    .292 (i)
    TIME TO PEAK    (hrs)=   1.000
    RUNOFF VOLUME    (mm)=  18.396
    TOTAL RAINFALL   (mm)=  68.198
    RUNOFF COEFFICIENT   =    .270

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
         ID1= 1 (0001):      8.90     .643     1.08    26.75
       + ID2= 2 (0101):      5.09     .292     1.00    18.40
         ================================================
         ID = 3 (0002):     13.99     .933     1.08    23.71

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   7 **   100-year 1-hour AES
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_100Y.STM
| Ptotal= 76.60 mm |    Comments: 100yr/1hr Fergus Shand Dam 2007 (AES Cur
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42  137.88 |   .75   73.54 |  1.08    9.19
                  .17    9.19 |   .50  257.38 |   .83   45.96 |
                  .25   27.58 |   .58  137.88 |   .92   27.58 |
                  .33   73.54 |   .67  110.30 |  1.00    9.19 |

-----------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=   8.72   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   7.50   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .50
```

```
     Unit Hyd Qpeak  (cms)=    .666

     PEAK FLOW       (cms)=    .783 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=  32.935
     TOTAL RAINFALL   (mm)=  76.601
     RUNOFF COEFFICIENT   =    .430

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .024 (i)
     TIME TO PEAK    (hrs)=    .583
     RUNOFF VOLUME    (mm)=  19.661
     TOTAL RAINFALL   (mm)=  76.601
     RUNOFF COEFFICIENT   =    .257

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0103):     8.72    .783     1.08    32.94
        + ID2= 2 (0102):      .18    .024      .58    19.66
          ===============================================
          ID = 3 (0001):     8.90    .785     1.08    32.67

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .364 (i)
     TIME TO PEAK    (hrs)=   1.000
     RUNOFF VOLUME    (mm)=  22.913
     TOTAL RAINFALL   (mm)=  76.601
     RUNOFF COEFFICIENT   =    .299

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0001):     8.90    .785     1.08    32.67
        + ID2= 2 (0101):     5.09    .364     1.00    22.91
          ===============================================
          ID = 3 (0002):    13.99   1.145     1.08    29.12

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

 FINISH
===============================================================================================
===============
```

Valdor Engineering Inc.
File: 14118
Date: October 2018

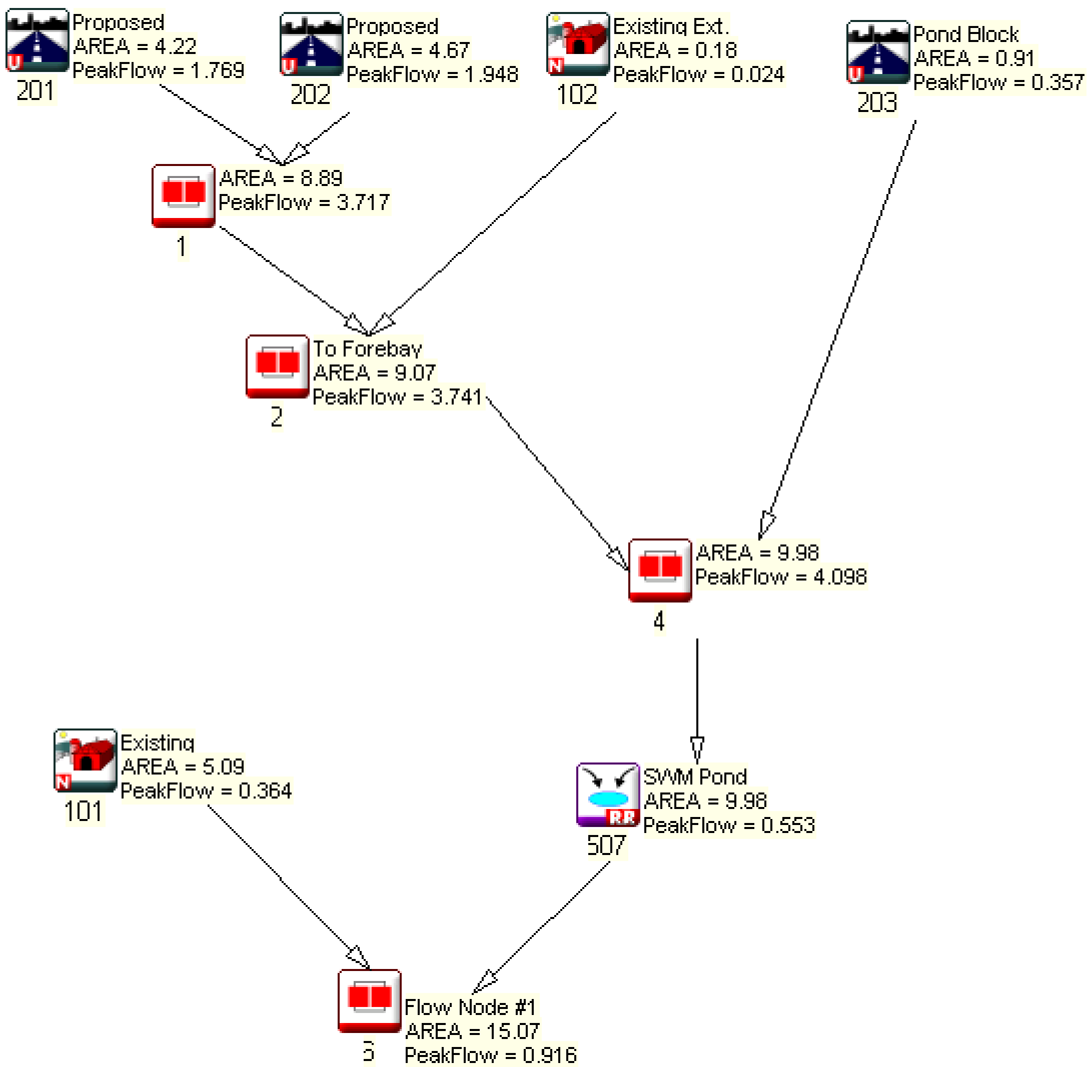

Figure D.3: VO2 Model Schematic – Proposed Conditions

```
=========================================================================================
===============
       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM, Version 2.0
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O   Licensed To: Valdor Engineering
        OOO     T      T    H   H    Y    M   M   OOO                 VO2-0156
```

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```
                   *****  D E T A I L E D   O U T P U T *****


  Input   filename: C:\Program Files\Visual OTTHYMO v2.0\voin.dat
  Output  filename: S:\Projects\2014\14118\Hydrotechnical\0-
Working\VO2\VO2\14118\14118_Proposed.out
  Summary filename: S:\Projects\2014\14118\Hydrotechnical\0-
Working\VO2\VO2\14118\14118_Proposed.sum


DATE: 10/16/2018                           TIME: 2:15:35 PM

USER:
```

COMMENTS: **Proposed Conditions VO2 Model Output**

```
-----------------------------------------------------------------------------------------
---------------
  ****************************
  ** SIMULATION NUMBER:   1 **  25mm Chicago
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              25mmchi.stm
| Ptotal= 25.02 mm |    Comments: 25mm CHICAGO Storm
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .17    2.17 |  1.17    6.20 |  2.17    5.62 |  3.17    2.95
                  .33    2.38 |  1.33   12.18 |  2.33    4.80 |  3.33    2.76
                  .50    2.66 |  1.50   41.67 |  2.50    4.21 |  3.50    2.62
                  .67    3.03 |  1.67   15.28 |  2.67    3.78 |  3.67    2.47
                  .83    3.58 |  1.83    9.22 |  2.83    3.45 |  3.83    2.35
                 1.00    4.47 |  2.00    6.88 |  3.00    3.18 |  4.00    2.23

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.

                          ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                .083    2.17 | 1.083    6.20 | 2.083    5.62 |  3.08    2.95
                .167    2.17 | 1.167    6.20 | 2.167    5.62 |  3.17    2.95
                .250    2.38 | 1.250   12.18 | 2.250    4.80 |  3.25    2.76
                .333    2.38 | 1.333   12.18 | 2.333    4.80 |  3.33    2.76
                .417    2.66 | 1.417   41.67 | 2.417    4.21 |  3.42    2.62
                .500    2.66 | 1.500   41.67 | 2.500    4.21 |  3.50    2.62
                .583    3.03 | 1.583   15.28 | 2.583    3.78 |  3.58    2.47
                .667    3.03 | 1.667   15.28 | 2.667    3.78 |  3.67    2.47
                .750    3.58 | 1.750    9.22 | 2.750    3.45 |  3.75    2.35
                .833    3.58 | 1.833    9.22 | 2.833    3.45 |  3.83    2.35
                .917    4.47 | 1.917    6.88 | 2.917    3.18 |  3.92    2.23
               1.000    4.47 | 2.000    6.88 | 3.000    3.18 |  4.00    2.23

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW      (cms)=    .001 (i)
     TIME TO PEAK   (hrs)=   1.500
     RUNOFF VOLUME   (mm)=   1.616
     TOTAL RAINFALL  (mm)=  25.023
     RUNOFF COEFFICIENT  =    .065

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0202) |   Area    (ha)=   4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=      41.67         6.26
                over (min)       5.00        30.00
     Storage Coeff.  (min)=       5.10 (ii)   26.47 (ii)
     Unit Hyd. Tpeak (min)=       5.00        30.00
     Unit Hyd. peak  (cms)=        .21          .04
                                                          *TOTALS*
     PEAK FLOW      (cms)=        .27          .01           .269 (iii)
     TIME TO PEAK   (hrs)=       1.50         2.08          1.50
     RUNOFF VOLUME   (mm)=      24.02         4.64         15.30
     TOTAL RAINFALL  (mm)=      25.02        25.02         25.02
     RUNOFF COEFFICIENT  =        .96          .19           .61


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0201) |   Area    (ha)=   4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
```

```
     Length           (m)=     167.70        40.00
     Mannings n          =       .013         .250

     Max.Eff.Inten.(mm/hr)=      41.67         6.26
                over (min)       5.00        30.00
     Storage Coeff.  (min)=       4.94 (ii)   26.32 (ii)
     Unit Hyd. Tpeak (min)=       5.00        30.00
     Unit Hyd. peak  (cms)=        .22          .04
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .24          .01          .245 (iii)
     TIME TO PEAK    (hrs)=       1.50         2.08          1.50
     RUNOFF VOLUME    (mm)=      24.02         4.64         15.30
     TOTAL RAINFALL   (mm)=      25.02        25.02         25.02
     RUNOFF COEFFICIENT   =        .96          .19           .61

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67    .269     1.50    15.30
        + ID2= 2 (0201):     4.22    .245     1.50    15.30
          ==================================================
          ID = 3 (0001):     8.89    .514     1.50    15.30

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18    .001     1.50     1.62
        + ID2= 2 (0001):     8.89    .514     1.50    15.30
          ==================================================
          ID = 3 (0002):     9.07    .515     1.50    15.03

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0203) |   Area    (ha)=    .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      77.90        25.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=      41.67         2.35
                over (min)       5.00        30.00
     Storage Coeff.  (min)=       3.12 (ii)   27.00 (ii)
     Unit Hyd. Tpeak (min)=       5.00        30.00
     Unit Hyd. peak  (cms)=        .27          .04
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .05          .00          .051 (iii)
     TIME TO PEAK    (hrs)=       1.50         2.08          1.50
     RUNOFF VOLUME    (mm)=      24.02         2.87         13.43
     TOTAL RAINFALL   (mm)=      25.02        25.02         25.02
     RUNOFF COEFFICIENT   =        .96          .11           .54

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     9.07    .515     1.50    15.03
        + ID2= 2 (0203):      .91    .051     1.50    13.43
          ==================================================
          ID = 3 (0004):     9.98    .566     1.50    14.88

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          .0000      .0000    |    .0841      .2018
                          .0104      .0936    |    .2110      .2412
                          .0114      .1106    |    .3271      .2824
                          .0123      .1280    |    .4574      .3700
                          .0132      .1459    |    .5576      .4643
                          .0140      .1641    |   2.1858      .5137
                          .0390      .1828    |   5.1234      .5648

                             AREA     QPEAK     TPEAK       R.V.
                             (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0004)    9.98       .57      1.50      14.88
     OUTFLOW: ID= 1 (0507)    9.98       .01      4.25      14.65

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.24
                  TIME SHIFT OF PEAK FLOW        (min)=165.00
                  MAXIMUM  STORAGE   USED      (ha.m.)=  .1352

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .012 (i)
     TIME TO PEAK    (hrs)=   2.333
     RUNOFF VOLUME    (mm)=   1.884
     TOTAL RAINFALL   (mm)=  25.023
     RUNOFF COEFFICIENT   =    .075

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
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```
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):     9.98    .013     4.25    14.65
        + ID2= 2 (0101):     5.09    .012     2.33     1.88
          ==================================================
          ID = 3 (0006):    15.07    .023     2.42    10.34

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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  ****************************
  ** SIMULATION NUMBER:   2 **  2-year 1-hour AES
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_2Y.STM
| Ptotal= 25.60 mm |    Comments: 2yr/1hr Fergus Shand Dam 2007 (AES Curve
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42   46.08 |   .75   24.58 |  1.08    3.07
                  .17    3.07 |   .50   86.02 |   .83   15.36 |
                  .25    9.22 |   .58   46.08 |   .92    9.22 |
                  .33   24.58 |   .67   36.86 |  1.00    3.07 |

--------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .002 (i)
     TIME TO PEAK    (hrs)=    .667
     RUNOFF VOLUME    (mm)=   1.720
     TOTAL RAINFALL   (mm)=  25.601
     RUNOFF COEFFICIENT   =    .067

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| STANDHYD  (0202) |   Area    (ha)=   4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n          =       .013         .250

     Max.Eff.Inten.(mm/hr)=      86.02        18.30
                over (min)       5.00        20.00
     Storage Coeff.  (min)=       3.81 (ii)   17.74 (ii)
     Unit Hyd. Tpeak (min)=       5.00        20.00
     Unit Hyd. peak  (cms)=        .25          .06
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .52          .04         .527 (iii)
     TIME TO PEAK    (hrs)=        .50          .92          .50
     RUNOFF VOLUME    (mm)=      24.60         4.86        15.72
     TOTAL RAINFALL   (mm)=      25.60        25.60        25.60
     RUNOFF COEFFICIENT   =        .96          .19          .61

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0201) |   Area    (ha)=   4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     167.70        40.00
     Mannings n          =       .013         .250

     Max.Eff.Inten.(mm/hr)=      86.02        18.30
                over (min)       5.00        20.00
     Storage Coeff.  (min)=       3.70 (ii)   17.62 (ii)
     Unit Hyd. Tpeak (min)=       5.00        20.00
     Unit Hyd. peak  (cms)=        .25          .06
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .48          .04         .480 (iii)
     TIME TO PEAK    (hrs)=        .50          .92          .50
     RUNOFF VOLUME    (mm)=      24.60         4.86        15.72
     TOTAL RAINFALL   (mm)=      25.60        25.60        25.60
     RUNOFF COEFFICIENT   =        .96          .19          .61

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67    .527      .50    15.72
        + ID2= 2 (0201):     4.22    .480      .50    15.72
          ==================================================
          ID = 3 (0001):     8.89   1.007      .50    15.72

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18    .002      .67     1.72
        + ID2= 2 (0001):     8.89   1.007      .50    15.72
          ==================================================
          ID = 3 (0002):     9.07   1.008      .50    15.44

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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| CALIB             |
| STANDHYD  (0203) |   Area    (ha)=    .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
-------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      77.90        25.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=      86.02         7.01
                over (min)        5.00        20.00
     Storage Coeff.  (min)=       2.34 (ii)   17.75 (ii)
     Unit Hyd. Tpeak (min)=       5.00        20.00
     Unit Hyd. peak  (cms)=        .30          .06
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .10          .01          .103 (iii)
     TIME TO PEAK    (hrs)=        .50          .92           .50
     RUNOFF VOLUME    (mm)=      24.60         3.03         13.80
     TOTAL RAINFALL   (mm)=      25.60        25.60         25.60
     RUNOFF COEFFICIENT   =        .96          .12           .54

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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-------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
-------------------           (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):      9.07   1.008      .50    15.44
        + ID2= 2 (0203):       .91    .103      .50    13.80
          ===============================================
          ID = 3 (0004):      9.98   1.111      .50    15.29

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
-------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |      OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
-------------------        (cms)     (ha.m.)   |   (cms)     (ha.m.)
                           .0000      .0000    |    .0841      .2018
                           .0104      .0936    |    .2110      .2412
                           .0114      .1106    |    .3271      .2824
                           .0123      .1280    |    .4574      .3700
                           .0132      .1459    |    .5576      .4643
                           .0140      .1641    |   2.1858      .5137
                           .0390      .1828    |   5.1234      .5648

                                  AREA     QPEAK     TPEAK       R.V.
                                  (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0004)      9.98      1.11       .50      15.29
     OUTFLOW: ID= 1 (0507)      9.98       .01      1.58      15.06

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.19
                   TIME SHIFT OF PEAK FLOW        (min)= 65.00
                   MAXIMUM  STORAGE   USED      (ha.m.)=  .1463

------------------------------------------------------------------------------
-------------------
| CALIB             |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .032 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=   2.006
     TOTAL RAINFALL   (mm)=  25.601
     RUNOFF COEFFICIENT   =    .078

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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-------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
-------------------           (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):      9.98    .013     1.58    15.06
        + ID2= 2 (0101):      5.09    .032     1.08     2.01
          ===============================================
          ID = 3 (0006):     15.07    .045     1.08    10.65

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   3 **   5-year 1-hour AES
  ****************************


-------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_5Y.STM
| Ptotal= 39.20 mm |    Comments: 5yr/1hr Fergus Shand Dam 2007 (AES Curve
-------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42   70.56 |   .75   37.63 |  1.08    4.70
                  .17    4.70 |   .50  131.71 |   .83   23.52 |
                  .25   14.11 |   .58   70.56 |   .92   14.11 |
                  .33   37.63 |   .67   56.45 |  1.00    4.70 |

------------------------------------------------------------------------------

-------------------
| CALIB             |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .006 (i)
     TIME TO PEAK    (hrs)=    .667
     RUNOFF VOLUME    (mm)=   4.972
     TOTAL RAINFALL   (mm)=  39.198
     RUNOFF COEFFICIENT   =    .127

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
-------------------
| CALIB             |
| STANDHYD  (0202) |   Area    (ha)=   4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
```

```
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=     131.71        44.95
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       3.22 (ii)    8.18 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .27          .13
                                                            *TOTALS*
     PEAK FLOW       (cms)=        .83          .13           .887 (iii)
     TIME TO PEAK    (hrs)=        .50          .67            .50
     RUNOFF VOLUME    (mm)=      38.20        11.13          26.02
     TOTAL RAINFALL   (mm)=      39.20        39.20          39.20
     RUNOFF COEFFICIENT   =        .97          .28            .66

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD  (0201) |   Area    (ha)=    4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     167.70        40.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=     131.71        44.95
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       3.12 (ii)    8.08 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .27          .13
                                                            *TOTALS*
     PEAK FLOW       (cms)=        .76          .12           .807 (iii)
     TIME TO PEAK    (hrs)=        .50          .67            .50
     RUNOFF VOLUME    (mm)=      38.20        11.13          26.02
     TOTAL RAINFALL   (mm)=      39.20        39.20          39.20
     RUNOFF COEFFICIENT   =        .97          .28            .66

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67     .887      .50    26.02
        + ID2= 2 (0201):     4.22     .807      .50    26.02
          ==================================================
          ID = 3 (0001):     8.89    1.693      .50    26.02

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18     .006      .67     4.97
        + ID2= 2 (0001):     8.89    1.693      .50    26.02
          ==================================================
          ID = 3 (0002):     9.07    1.698      .50    25.60

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD  (0203) |   Area    (ha)=     .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      77.90        25.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=     131.71        19.79
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       1.97 (ii)    6.74 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .31          .14
                                                            *TOTALS*
     PEAK FLOW       (cms)=        .16          .02           .167 (iii)
     TIME TO PEAK    (hrs)=        .50          .75            .50
     RUNOFF VOLUME    (mm)=      38.20         7.61          22.90
     TOTAL RAINFALL   (mm)=      39.20        39.20          39.20
     RUNOFF COEFFICIENT   =        .97          .19            .58

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     9.07    1.698      .50    25.60
        + ID2= 2 (0203):      .91     .167      .50    22.90
          ==================================================
          ID = 3 (0004):     9.98    1.865      .50    25.35

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          .0000      .0000    |   .0841      .2018
```

```
                           .0104      .0936  |    .2110      .2412
                           .0114      .1106  |    .3271      .2824
                           .0123      .1280  |    .4574      .3700
                           .0132      .1459  |    .5576      .4643
                           .0140      .1641  |   2.1858      .5137
                           .0390      .1828  |   5.1234      .5648

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0004)      9.98      1.87       .50      25.35
     OUTFLOW: ID= 1 (0507)      9.98       .17      1.08      25.12

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  9.11
                   TIME SHIFT OF PEAK FLOW         (min)= 35.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  .2286

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .092 (i)
     TIME TO PEAK    (hrs)=   1.083
     RUNOFF VOLUME    (mm)=   5.794
     TOTAL RAINFALL   (mm)=  39.198
     RUNOFF COEFFICIENT   =    .148

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):     9.98     .170     1.08    25.12
        + ID2= 2 (0101):     5.09     .092     1.08     5.79
          ==================================================
          ID = 3 (0006):    15.07     .262     1.08    18.60

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   4 **   10-year 1-hour AES
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_10Y.STM
| Ptotal= 48.30 mm |    Comments: 10yr/1hr Fergus Shand Dam 2007 (AES Curv
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42   86.94 |   .75   46.37 |  1.08    5.80
                  .17    5.80 |   .50  162.29 |   .83   28.98 |
                  .25   17.39 |   .58   86.94 |   .92   17.39 |
                  .33   46.37 |   .67   69.55 |  1.00    5.80 |

--------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .010 (i)
     TIME TO PEAK    (hrs)=    .583
     RUNOFF VOLUME    (mm)=   7.870
     TOTAL RAINFALL   (mm)=  48.302
     RUNOFF COEFFICIENT   =    .163

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0202) |   Area    (ha)=   4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n           =       .013         .250

     Max.Eff.Inten.(mm/hr)=     162.29        66.40
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       2.96 (ii)    7.52 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .28          .13
                                                            *TOTALS*
     PEAK FLOW       (cms)=       1.05          .19           1.132 (iii)
     TIME TO PEAK    (hrs)=        .50          .67             .50
     RUNOFF VOLUME    (mm)=      47.30        16.22           33.31
     TOTAL RAINFALL   (mm)=      48.30        48.30           48.30
     RUNOFF COEFFICIENT   =        .98          .34             .69

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0201) |   Area    (ha)=   4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     167.70        40.00
     Mannings n           =       .013         .250

     Max.Eff.Inten.(mm/hr)=     162.29        66.40
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       2.87 (ii)    7.43 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .28          .13
                                                            *TOTALS*
     PEAK FLOW       (cms)=        .95          .18           1.029 (iii)
     TIME TO PEAK    (hrs)=        .50          .67             .50
     RUNOFF VOLUME    (mm)=      47.30        16.22           33.31
     TOTAL RAINFALL   (mm)=      48.30        48.30           48.30
```

```
     RUNOFF COEFFICIENT   =        .98          .34            .69

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67   1.132      .50    33.31
        + ID2= 2 (0201):     4.22   1.029      .50    33.31
          ===============================================
          ID = 3 (0001):     8.89   2.162      .50    33.31

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18    .010      .58     7.87
        + ID2= 2 (0001):     8.89   2.162      .50    33.31
          ===============================================
          ID = 3 (0002):     9.07   2.170      .50    32.81

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0203) |   Area    (ha)=     .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      77.90        25.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=     162.29        30.53
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       1.81 (ii)    6.20 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .32          .15
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .20          .03          .211 (iii)
     TIME TO PEAK    (hrs)=        .50          .67           .50
     RUNOFF VOLUME    (mm)=      47.30        11.52         29.40
     TOTAL RAINFALL   (mm)=      48.30        48.30         48.30
     RUNOFF COEFFICIENT   =        .98          .24           .61

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     9.07   2.170      .50    32.81
        + ID2= 2 (0203):      .91    .211      .50    29.40
          ===============================================
          ID = 3 (0004):     9.98   2.382      .50    32.50

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          .0000      .0000    |    .0841      .2018
                          .0104      .0936    |    .2110      .2412
                          .0114      .1106    |    .3271      .2824
                          .0123      .1280    |    .4574      .3700
                          .0132      .1459    |    .5576      .4643
                          .0140      .1641    |   2.1858      .5137
                          .0390      .1828    |   5.1234      .5648

                               AREA     QPEAK     TPEAK       R.V.
                               (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0004)      9.98      2.38       .50      32.50
     OUTFLOW: ID= 1 (0507)      9.98       .31      1.00      32.27

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 13.16
                   TIME SHIFT OF PEAK FLOW        (min)= 30.00
                   MAXIMUM  STORAGE   USED      (ha.m.)=  .2778

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW      (cms)=    .145 (i)
     TIME TO PEAK   (hrs)=   1.083
     RUNOFF VOLUME    (mm)=   9.172
     TOTAL RAINFALL   (mm)=  48.302
     RUNOFF COEFFICIENT   =    .190

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):     9.98    .313     1.00    32.27
        + ID2= 2 (0101):     5.09    .145     1.08     9.17
          ===============================================
          ID = 3 (0006):    15.07    .459     1.00    24.47

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
```

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------------------------------------------------------------------------------
  ***************************
  ** SIMULATION NUMBER:   5 **  25-year 1-hour AES
  ***************************

--------------------
|    READ STORM     |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                   |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                   |              AES_1H_25Y.STM
| Ptotal= 59.70 mm |    Comments: 25yr/1hr Fergus Shand Dam 2007 (AES Curv
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42  107.46 |   .75   57.31 |  1.08    7.16
                  .17    7.16 |   .50  200.59 |   .83   35.82 |
                  .25   21.49 |   .58  107.46 |   .92   21.49 |
                  .33   57.31 |   .67   85.97 |  1.00    7.16 |

------------------------------------------------------------------------------

--------------------
| CALIB             |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .015 (i)
     TIME TO PEAK    (hrs)=    .583
     RUNOFF VOLUME    (mm)=  12.168
     TOTAL RAINFALL   (mm)=  59.698
     RUNOFF COEFFICIENT   =    .204

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| CALIB             |
| STANDHYD  (0202) |   Area    (ha)=   4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n          =       .013         .250

     Max.Eff.Inten.(mm/hr)=     200.59        96.75
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       2.72 (ii)    6.91 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .29          .14
                                                          *TOTALS*
     PEAK FLOW       (cms)=       1.32          .29         1.452 (iii)
     TIME TO PEAK    (hrs)=        .50          .67           .50
     RUNOFF VOLUME    (mm)=      58.70        23.35         42.79
     TOTAL RAINFALL   (mm)=      59.70        59.70         59.70
     RUNOFF COEFFICIENT   =        .98          .39           .72

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| CALIB             |
| STANDHYD  (0201) |   Area    (ha)=   4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     167.70        40.00
     Mannings n          =       .013         .250

     Max.Eff.Inten.(mm/hr)=     200.59        96.75
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       2.64 (ii)    6.83 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .29          .14
                                                          *TOTALS*
     PEAK FLOW       (cms)=       1.19          .26         1.320 (iii)
     TIME TO PEAK    (hrs)=        .50          .67           .50
     RUNOFF VOLUME    (mm)=      58.70        23.35         42.79
     TOTAL RAINFALL   (mm)=      59.70        59.70         59.70
     RUNOFF COEFFICIENT   =        .98          .39           .72

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|  1 +  2 =  3     |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67   1.452      .50    42.79
        + ID2= 2 (0201):     4.22   1.320      .50    42.79
          ===============================================
          ID = 3 (0001):     8.89   2.772      .50    42.79

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|  1 +  2 =  3     |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18    .015      .58    12.17
        + ID2= 2 (0001):     8.89   2.772      .50    42.79
          ===============================================
          ID = 3 (0002):     9.07   2.786      .50    42.18

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD  (0203) |   Area    (ha)=    .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
```

```
     Length           (m)=      77.90        25.00
     Mannings n          =       .013         .250

     Max.Eff.Inten.(mm/hr)=     200.59        46.27
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.66 (ii)    5.69 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .32          .15
                                                          *TOTALS*
     PEAK FLOW       (cms)=        .25          .05           .269 (iii)
     TIME TO PEAK    (hrs)=        .50          .67            .50
     RUNOFF VOLUME    (mm)=      58.70        17.17          37.93
     TOTAL RAINFALL   (mm)=      59.70        59.70          59.70
     RUNOFF COEFFICIENT   =        .98          .29            .64

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     9.07   2.786      .50    42.18
        + ID2= 2 (0203):      .91    .269      .50    37.93
          ===============================================
          ID = 3 (0004):     9.98   3.054      .50    41.80

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          .0000      .0000    |    .0841      .2018
                          .0104      .0936    |    .2110      .2412
                          .0114      .1106    |    .3271      .2824
                          .0123      .1280    |    .4574      .3700
                          .0132      .1459    |    .5576      .4643
                          .0140      .1641    |   2.1858      .5137
                          .0390      .1828    |   5.1234      .5648

                                 AREA     QPEAK     TPEAK       R.V.
                                 (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0004)       9.98      3.05       .50      41.80
     OUTFLOW: ID= 1 (0507)       9.98       .42      1.00      41.57

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 13.82
                   TIME SHIFT OF PEAK FLOW         (min)= 30.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  .3471

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=    5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=    8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=     .42

     Unit Hyd Qpeak  (cms)=     .463

     PEAK FLOW       (cms)=     .225 (i)
     TIME TO PEAK    (hrs)=    1.000
     RUNOFF VOLUME    (mm)=   14.180
     TOTAL RAINFALL   (mm)=   59.698
     RUNOFF COEFFICIENT   =     .238

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):     9.98    .422     1.00    41.57
        + ID2= 2 (0101):     5.09    .225     1.00    14.18
          ===============================================
          ID = 3 (0006):    15.07    .647     1.00    32.32

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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  ****************************
  ** SIMULATION NUMBER:   6 **   50-year 1-hour AES
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_50Y.STM
| Ptotal= 68.20 mm |    Comments: 50yr/1hr Fergus Shand Dam 2007 (AES Curv
--------------------
                 TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                  .08     .00 |   .42  122.76 |   .75   65.47 |  1.08    8.18
                  .17    8.18 |   .50  229.15 |   .83   40.92 |
                  .25   24.55 |   .58  122.76 |   .92   24.55 |
                  .33   65.47 |   .67   98.21 |  1.00    8.18 |

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=     .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=    8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=     .06

     Unit Hyd Qpeak  (cms)=     .115

     PEAK FLOW       (cms)=     .019 (i)
     TIME TO PEAK    (hrs)=     .583
     RUNOFF VOLUME    (mm)=   15.786
     TOTAL RAINFALL   (mm)=   68.198
     RUNOFF COEFFICIENT   =     .231

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0202) |   Area    (ha)=    4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n          =       .013         .250
```

```
     Max.Eff.Inten.(mm/hr)=     229.15       121.42
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.58 (ii)    6.55 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .29          .14
                                                            *TOTALS*
     PEAK FLOW      (cms)=       1.52          .36           1.699 (iii)
     TIME TO PEAK    (hrs)=        .50          .67             .50
     RUNOFF VOLUME    (mm)=      67.20        29.11           50.06
     TOTAL RAINFALL   (mm)=      68.20        68.20           68.20
     RUNOFF COEFFICIENT   =        .99          .43             .73

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD  (0201) |   Area    (ha)=   4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     167.70        40.00
     Mannings n           =       .013         .250

     Max.Eff.Inten.(mm/hr)=     229.15       121.42
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.50 (ii)    6.48 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .29          .14
                                                            *TOTALS*
     PEAK FLOW      (cms)=       1.38          .33           1.543 (iii)
     TIME TO PEAK    (hrs)=        .50          .67             .50
     RUNOFF VOLUME    (mm)=      67.20        29.11           50.06
     TOTAL RAINFALL   (mm)=      68.20        68.20           68.20
     RUNOFF COEFFICIENT   =        .99          .43             .73

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67   1.699      .50    50.06
        + ID2= 2 (0201):     4.22   1.543      .50    50.06
          ================================================
          ID = 3 (0001):     8.89   3.242      .50    50.06

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18    .019      .58    15.79
        + ID2= 2 (0001):     8.89   3.242      .50    50.06
          ================================================
          ID = 3 (0002):     9.07   3.260      .50    49.38

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD  (0203) |   Area    (ha)=    .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      77.90        25.00
     Mannings n           =       .013         .250

     Max.Eff.Inten.(mm/hr)=     229.15        59.42
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.58 (ii)    5.40 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .33          .16
                                                            *TOTALS*
     PEAK FLOW      (cms)=        .28          .06            .313 (iii)
     TIME TO PEAK    (hrs)=        .50          .67             .50
     RUNOFF VOLUME    (mm)=      67.20        21.86           44.52
     TOTAL RAINFALL   (mm)=      68.20        68.20           68.20
     RUNOFF COEFFICIENT   =        .99          .32             .65

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     9.07   3.260      .50    49.38
        + ID2= 2 (0203):      .91    .313      .50    44.52
          ================================================
          ID = 3 (0004):     9.98   3.573      .50    48.93

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          .0000      .0000    |    .0841      .2018
                          .0104      .0936    |    .2110      .2412
                          .0114      .1106    |    .3271      .2824
                          .0123      .1280    |    .4574      .3700
                          .0132      .1459    |    .5576      .4643
                          .0140      .1641    |   2.1858      .5137
                          .0390      .1828    |   5.1234      .5648

                               AREA     QPEAK     TPEAK       R.V.
```

```
                              (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0004)      9.98      3.57       .50      48.93
     OUTFLOW: ID= 1 (0507)      9.98       .49      1.00      48.70

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 13.74
                   TIME SHIFT OF PEAK FLOW         (min)= 30.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  .4025

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .292 (i)
     TIME TO PEAK    (hrs)=   1.000
     RUNOFF VOLUME    (mm)=  18.396
     TOTAL RAINFALL   (mm)=  68.198
     RUNOFF COEFFICIENT   =    .270

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):     9.98     .491     1.00    48.70
        + ID2= 2 (0101):     5.09     .292     1.00    18.40
          ==================================================
          ID = 3 (0006):    15.07     .783     1.00    38.47

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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  ****************************
  ** SIMULATION NUMBER:   7 **
  ****************************
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100-year 1-hour AES

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--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydrotechnical\
|                  |              3-FSR Submission_March 2018\VO2\VO2\Storms\
|                  |              AES_1H_100Y.STM
| Ptotal= 76.60 mm |    Comments: 100yr/1hr Fergus Shand Dam 2007 (AES Cur
--------------------
                  TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                   .08     .00 |   .42  137.88 |   .75   73.54 |  1.08    9.19
                   .17    9.19 |   .50  257.38 |   .83   45.96 |
                   .25   27.58 |   .58  137.88 |   .92   27.58 |
                   .33   73.54 |   .67  110.30 |  1.00    9.19 |

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .06

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .024 (i)
     TIME TO PEAK    (hrs)=    .583
     RUNOFF VOLUME    (mm)=  19.661
     TOTAL RAINFALL   (mm)=  76.601
     RUNOFF COEFFICIENT   =    .257

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0202) |   Area    (ha)=   4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n           =       .013         .250

     Max.Eff.Inten.(mm/hr)=     257.38       147.19
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       2.46 (ii)    6.25 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .30          .15
                                                           *TOTALS*
     PEAK FLOW       (cms)=       1.72          .44          1.948 (iii)
     TIME TO PEAK    (hrs)=        .50          .67            .50
     RUNOFF VOLUME    (mm)=      75.60        35.10          57.37
     TOTAL RAINFALL   (mm)=      76.60        76.60          76.60
     RUNOFF COEFFICIENT   =        .99          .46            .75

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0201) |   Area    (ha)=   4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     167.70        40.00
     Mannings n           =       .013         .250

     Max.Eff.Inten.(mm/hr)=     257.38       147.19
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       2.39 (ii)    6.18 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .30          .15
                                                           *TOTALS*
     PEAK FLOW       (cms)=       1.56          .40          1.769 (iii)
     TIME TO PEAK    (hrs)=        .50          .67            .50
     RUNOFF VOLUME    (mm)=      75.60        35.10          57.37
     TOTAL RAINFALL   (mm)=      76.60        76.60          76.60
     RUNOFF COEFFICIENT   =        .99          .46            .75

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
```

```
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67   1.948      .50    57.37
        + ID2= 2 (0201):     4.22   1.769      .50    57.37
          ==================================================
          ID = 3 (0001):     8.89   3.717      .50    57.37

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18    .024      .58    19.66
        + ID2= 2 (0001):     8.89   3.717      .50    57.37
          ==================================================
          ID = 3 (0002):     9.07   3.741      .50    56.62

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| STANDHYD  (0203) |   Area    (ha)=    .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      77.90        25.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=     257.38        73.44
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       1.51 (ii)    5.15 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .33          .16
                                                                *TOTALS*
     PEAK FLOW       (cms)=        .32          .08               .357 (iii)
     TIME TO PEAK    (hrs)=        .50          .67                .50
     RUNOFF VOLUME    (mm)=      75.60        26.82              51.21
     TOTAL RAINFALL   (mm)=      76.60        76.60              76.60
     RUNOFF COEFFICIENT   =        .99          .35                .67

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  68.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     9.07   3.741      .50    56.62
        + ID2= 2 (0203):      .91    .357      .50    51.21
          ==================================================
          ID = 3 (0004):     9.98   4.098      .50    56.13

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          .0000      .0000    |    .0841      .2018
                          .0104      .0936    |    .2110      .2412
                          .0114      .1106    |    .3271      .2824
                          .0123      .1280    |    .4574      .3700
                          .0132      .1459    |    .5576      .4643
                          .0140      .1641    |   2.1858      .5137
                          .0390      .1828    |   5.1234      .5648

                               AREA     QPEAK     TPEAK        R.V.
                               (ha)     (cms)     (hrs)        (mm)
     INFLOW : ID= 2 (0004)     9.98      4.10       .50       56.13
     OUTFLOW: ID= 1 (0507)     9.98       .55      1.00       55.90

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 13.49
                   TIME SHIFT OF PEAK FLOW        (min)= 30.00
                   MAXIMUM  STORAGE   USED      (ha.m.)=  .4606

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 65.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW      (cms)=    .364 (i)
     TIME TO PEAK   (hrs)=   1.000
     RUNOFF VOLUME   (mm)=  22.913
     TOTAL RAINFALL  (mm)=  76.601
     RUNOFF COEFFICIENT  =    .299

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):     9.98    .553     1.00    55.90
        + ID2= 2 (0101):     5.09    .364     1.00    22.91
          ==================================================
          ID = 3 (0006):    15.07    .916     1.00    44.76

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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  ****************************
  ** SIMULATION NUMBER:   8 **   Regional Storm (Hurricane Hazel)
  ****************************


--------------------
|    READ STORM    |    Filename: S:\Projects\2014\14118\Hydro
|                  |              technical\0-Working\VO2\VO2\Storms\Hazel.stm
| Ptotal=212.00 mm |    Comments: * Regional Storm - 12 Hour HAZEL
```

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-------------------
                TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                 .50    4.00 |  3.50   12.00 |  6.50   22.00 |  9.50   50.00
                1.00    8.00 |  4.00   12.00 |  7.00   26.00 | 10.00   56.00
                1.50    4.00 |  4.50   16.00 |  7.50   12.00 | 10.50   38.00
                2.00    4.00 |  5.00   18.00 |  8.00   12.00 | 11.00   38.00
                2.50    6.00 |  5.50   12.00 |  8.50   12.00 | 11.50   14.00
                3.00    8.00 |  6.00   14.00 |  9.00   14.00 | 12.00   12.00

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-------------------
| CALIB             |
| NASHYD    (0102) |   Area    (ha)=    .18   Curve Number   (CN)= 82.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------    U.H. Tp(hrs)=    .06

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                .083    4.00 | 3.083   12.00 | 6.083   22.00 |  9.08   50.00
                .167    4.00 | 3.167   12.00 | 6.167   22.00 |  9.17   50.00
                .250    4.00 | 3.250   12.00 | 6.250   22.00 |  9.25   50.00
                .333    4.00 | 3.333   12.00 | 6.333   22.00 |  9.33   50.00
                .417    4.00 | 3.417   12.00 | 6.417   22.00 |  9.42   50.00
                .500    4.00 | 3.500   12.00 | 6.500   22.00 |  9.50   50.00
                .583    8.00 | 3.583   12.00 | 6.583   26.00 |  9.58   56.00
                .667    8.00 | 3.667   12.00 | 6.667   26.00 |  9.67   56.00
                .750    8.00 | 3.750   12.00 | 6.750   26.00 |  9.75   56.00
                .833    8.00 | 3.833   12.00 | 6.833   26.00 |  9.83   56.00
                .917    8.00 | 3.917   12.00 | 6.917   26.00 |  9.92   56.00
               1.000    8.00 | 4.000   12.00 | 7.000   26.00 | 10.00   56.00
               1.083    4.00 | 4.083   16.00 | 7.083   12.00 | 10.08   38.00
               1.167    4.00 | 4.167   16.00 | 7.167   12.00 | 10.17   38.00
               1.250    4.00 | 4.250   16.00 | 7.250   12.00 | 10.25   38.00
               1.333    4.00 | 4.333   16.00 | 7.333   12.00 | 10.33   38.00
               1.417    4.00 | 4.417   16.00 | 7.417   12.00 | 10.42   38.00
               1.500    4.00 | 4.500   16.00 | 7.500   12.00 | 10.50   38.00
               1.583    4.00 | 4.583   18.00 | 7.583   12.00 | 10.58   38.00
               1.667    4.00 | 4.667   18.00 | 7.667   12.00 | 10.67   38.00
               1.750    4.00 | 4.750   18.00 | 7.750   12.00 | 10.75   38.00
               1.833    4.00 | 4.833   18.00 | 7.833   12.00 | 10.83   38.00
               1.917    4.00 | 4.917   18.00 | 7.917   12.00 | 10.92   38.00
               2.000    4.00 | 5.000   18.00 | 8.000   12.00 | 11.00   38.00
               2.083    6.00 | 5.083   12.00 | 8.083   12.00 | 11.08   14.00
               2.167    6.00 | 5.167   12.00 | 8.167   12.00 | 11.17   14.00
               2.250    6.00 | 5.250   12.00 | 8.250   12.00 | 11.25   14.00
               2.333    6.00 | 5.333   12.00 | 8.333   12.00 | 11.33   14.00
               2.417    6.00 | 5.417   12.00 | 8.417   12.00 | 11.42   14.00
               2.500    6.00 | 5.500   12.00 | 8.500   12.00 | 11.50   14.00
               2.583    8.00 | 5.583   14.00 | 8.583   14.00 | 11.58   12.00
               2.667    8.00 | 5.667   14.00 | 8.667   14.00 | 11.67   12.00
               2.750    8.00 | 5.750   14.00 | 8.750   14.00 | 11.75   12.00
               2.833    8.00 | 5.833   14.00 | 8.833   14.00 | 11.83   12.00
               2.917    8.00 | 5.917   14.00 | 8.917   14.00 | 11.92   12.00
               3.000    8.00 | 6.000   14.00 | 9.000   14.00 | 12.00   12.00

     Unit Hyd Qpeak  (cms)=    .115

     PEAK FLOW       (cms)=    .022 (i)
     TIME TO PEAK    (hrs)=  10.000
     RUNOFF VOLUME    (mm)= 137.473
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =    .648

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

```
-------------------------------------------------------------------------------
-------------------
| CALIB            |
| STANDHYD  (0202) |   Area    (ha)=   4.67
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
-------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.27         1.40
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     176.40        40.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=      56.00        81.45
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.53 (ii)   12.19 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=        .23          .09
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .40          .31           .708 (iii)
     TIME TO PEAK    (hrs)=      10.00        10.00          10.00
     RUNOFF VOLUME    (mm)=     211.00       180.73         197.38
     TOTAL RAINFALL   (mm)=     212.00       212.00         212.00
     RUNOFF COEFFICIENT   =       1.00          .85            .93

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  84.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
-------------------
| CALIB            |
| STANDHYD  (0201) |   Area    (ha)=   4.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  70.00   Dir. Conn.(%)=  55.00
-------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       2.95         1.27
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     167.70        40.00
     Mannings n          =        .013         .250

     Max.Eff.Inten.(mm/hr)=      56.00        81.45
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.39 (ii)   12.05 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=        .23          .09
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .36          .28           .640 (iii)
     TIME TO PEAK    (hrs)=      10.00        10.00          10.00
     RUNOFF VOLUME    (mm)=     211.00       180.73         197.38
     TOTAL RAINFALL   (mm)=     212.00       212.00         212.00
     RUNOFF COEFFICIENT   =       1.00          .85            .93

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  84.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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```
| ADD HYD   (0001) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
-------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0202):     4.67     .708    10.00   197.38
        + ID2= 2 (0201):     4.22     .640    10.00   197.38
          ==================================================
          ID = 3 (0001):     8.89    1.347    10.00   197.38

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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-------------------
| ADD HYD   (0002) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
-------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):      .18     .022    10.00   137.47
        + ID2= 2 (0001):     8.89    1.347    10.00   197.38
          ==================================================
          ID = 3 (0002):     9.07    1.369    10.00   196.19

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
-------------------
| CALIB            |
| STANDHYD  (0203) |   Area    (ha)=    .91
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.00   Dir. Conn.(%)=  50.00
-------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .46          .46
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      77.90        25.00
     Mannings n           =       .013         .250

     Max.Eff.Inten.(mm/hr)=      56.00        52.71
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.77 (ii)    9.65 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=        .28          .11
                                                            *TOTALS*
     PEAK FLOW       (cms)=        .07          .07            .137 (iii)
     TIME TO PEAK    (hrs)=      10.00        10.00           10.00
     RUNOFF VOLUME    (mm)=     211.00       167.78          189.39
     TOTAL RAINFALL   (mm)=     212.00       212.00          212.00
     RUNOFF COEFFICIENT   =       1.00          .79             .89

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  84.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------

-------------------
| ADD HYD   (0004) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
-------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):     9.07    1.369    10.00   196.19
        + ID2= 2 (0203):      .91     .137    10.00   189.39
          ==================================================
          ID = 3 (0004):     9.98    1.506    10.00   195.57

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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-------------------
| RESERVOIR (0507) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
-------------------       (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          .0000      .0000    |    .0841      .2018
                          .0104      .0936    |    .2110      .2412
                          .0114      .1106    |    .3271      .2824
                          .0123      .1280    |    .4574      .3700
                          .0132      .1459    |    .5576      .4643
                          .0140      .1641    |   2.1858      .5137
                          .0390      .1828    |   5.1234      .5648

                               AREA     QPEAK     TPEAK       R.V.
                               (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0004)     9.98      1.51     10.00     195.57
     OUTFLOW: ID= 1 (0507)     9.98      1.49     10.00     195.34

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 98.66
                   TIME SHIFT OF PEAK FLOW        (min)=   .00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  .4928

-------------------------------------------------------------------------------
-------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=   5.09   Curve Number   (CN)= 82.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.00   # of Linear Res.(N)= 3.00
-------------------    U.H. Tp(hrs)=    .42

     Unit Hyd Qpeak  (cms)=    .463

     PEAK FLOW       (cms)=    .642 (i)
     TIME TO PEAK    (hrs)=  10.167
     RUNOFF VOLUME    (mm)= 160.196
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =    .756

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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-------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
-------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0507):     9.98    1.486    10.00   195.34
        + ID2= 2 (0101):     5.09     .642    10.17   160.20
          ==================================================
          ID = 3 (0006):    15.07    2.102    10.00   183.47

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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APPENDIX "E"

Site Water Balance Calculations

VALDOR ENGINEERING INC.
File: 14118
Date: October 2018

Table E.1: Site Water Balance Calculations (Annual)
Corseed Subdivision, Town of Grand Valley

Condition	Site Area (ha)	Water Balance Components	Pervious Area Without Infiltration BMP's	Impervious Area Without Infiltration BMP's	Impervious Area With Basic Infiltration BMP's	TOTAL SITE VOLUMES Precipitation (m^3)	Evapotranspiration (m^3)	Surplus (m^3)	Runoff (m^3)	Infiltration (m^3)	Percent of Existing Infiltration (%)
		Area (ha)	5.090	0.000	0.000						
		HSG	BC	n/a	BC						
		Weighted WHC (mm)	200	n/a	200						
		Infiltration Factor	0.545	0.00	0.000						
Existing (Not to be developed)	**5.09**	Precipitation (mm)	792.7	792.7	792.7	40,348	29,850	10,375	4,721	5,654	100.0
		Evapotranspiration (mm)	586	0.0	586						
		Surplus (mm)	204	792.7	204						
		Infiltration (mm)	111.1	0.0	0.0						
		Runoff (mm)	92.7	792.7	203.8						
		Area (ha)	5.090	0.000	0.000						
		HSG	BC	n/a	BC						
		Weighted WHC (mm)	200	n/a	200						
		Infiltration Factor	0.545	0.00	0.000						
Proposed (Undeveloped)	**5.09**	Precipitation (mm)	792.7	792.7	792.7	40,348	29,850	10,375	4,721	5,654	100.0
		Evapotranspiration (mm)	586	0.0	586						
		Surplus (mm)	204	792.7	204						
		Infiltration (mm)	111.1	0.0	0.0						
		Runoff (mm)	92.7	792.7	203.8						
		Area (ha)	9.800	0.000	0.000						
		HSG	BC	n/a	BC						
		Weighted WHC (mm)	195	n/a	195						
		Infiltration Factor	0.515	0.00	0.000						
Existing (To be developed)	**9.80**	Precipitation (mm)	792.7	792.7	792.7	77,685	57,312	20,135	9,758	10,377	100.0
		Evapotranspiration (mm)	585	0.0	585						
		Surplus (mm)	205	792.7	205						
		Infiltration (mm)	105.9	0.0	0.0						
		Runoff (mm)	99.6	792.7	205.5						
		Area (ha)	4.514	5.286	0.000						
		HSG	BC	n/a	BC						
		Weighted WHC (mm)	100	n/a	100						
		Infiltration Factor	0.545	0.00	0.431						
Proposed (Developed) (No Infiltration BMPs)	**9.80**	Precipitation (mm)	792.7	792.7	792.7	77,685	24,060	53,475	47,168	6,306	60.8
		Evapotranspiration (mm)	533	0.0	533						
		Surplus (mm)	256	792.7	256						
		Infiltration (mm)	139.7	0.0	110.4						
		Runoff (mm)	116.6	792.7	146.0						
		Area (ha)	4.514	4.176	1.110						
		HSG	BC	n/a	BC						
		Weighted WHC (mm)	100	n/a	100						
		Infiltration Factor	0.545	0.00	0.431						
Proposed (Developed) (With Basic Infiltration BMPs)	**9.80**	Precipitation (mm)	792.7	792.7	792.7	77,685	29,977	47,521	39,990	7,531	72.6
		Evapotranspiration (mm)	533	0.0	533						
		Surplus (mm)	256	792.7	256						
		Infiltration (mm)	139.7	0.0	110.4						
		Runoff (mm)	116.6	792.7	146.0						
Proposed (Developed) (With Enhanced Infiltration BMP's)	**9.80**		**See Table E.6**						7531 + 2875	10,407	100.3

Notes:
1. Site water balance calculations based on methodology per *Stormwater Management Planning and Design Manual* (MOE, March 2003).
2. Basic Infiltration BMP's consist of roof leaders that discharge to pervious areas.
3. Enhanced Infiltration BMP's consist of the proposed infiltration trenches.

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Date: October 2018

Table E.2: Water Holding Capacity (WHC) Calculations

Per MOE Methodology (SWM Planning & Design Manual, MOE, March 2003)

Existing Conditions (Pervious Area) (Not to be developed)

BC	HSG
Moderately Rooted Crops	
0	Area (ha)
175	WHC (mm)
Pasture and Shrubs	
5.09	Area (ha)
200	WHC (mm)
Mature Forests	
0	Area (ha)
350	WHC (mm)
Area-Weighted WHC	
200.0	WHC (mm)

Proposed Conditions (Pervious Area) (Not to be developed)

BC	HSG
Lawn	
0	Area (ha)
100	WHC (mm)
Pasture and Shrubs	
5.09	Area (ha)
200	WHC (mm)
Area-Weighted WHC	
200.0	WHC (mm)

Existing Conditions (Pervious Area) (To be developed)

BC	HSG
Moderately Rooted Crops	
5.597	Area (ha)
175	WHC (mm)
Pasture and Shrubs	
3.588	Area (ha)
200	WHC (mm)
Mature Forests	
0.615	Area (ha)
350	WHC (mm)
Area-Weighted WHC	
195.1	WHC (mm)

Proposed Conditions (Pervious Area) (To be developed)

BC	HSG
Lawn	
3.124	Area (ha)
100	WHC (mm)
Pasture and Shrubs	
0	Area (ha)
200	WHC (mm)
Area-Weighted WHC	
100.0	WHC (mm)


Table 3.1: Hydrologic Cycle Component Values

	Water Holding Capacity mm	Hydrologic Soil Group	Precipitation mm	Evapo-transpiration mm	Runoff mm	Infiltration mm
Urban Lawns/Shallow Rooted Crops (spinach, beans, beets, carrots)						
Fine Sand	50	A	[illegible]	[illegible]	[illegible]	[illegible]
Fine Sandy Loam	75	B	[illegible]	[illegible]	[illegible]	[illegible]
Silt Loam	125	C	[illegible]	[illegible]	[illegible]	[illegible]
Clay Loam	100	CD	[illegible]	[illegible]	[illegible]	[illegible]
Clay	75	D	[illegible]	[illegible]	[illegible]	[illegible]
Moderately Rooted Crops (corn and cereal grains)						
Fine Sand	75	A	[illegible]	[illegible]	[illegible]	[illegible]
Fine Sandy Loam	150	B	[illegible]	[illegible]	[illegible]	[illegible]
Silt Loam	[illegible]	C	[illegible]	[illegible]	[illegible]	[illegible]
Clay Loam	[illegible]	CD	[illegible]	[illegible]	[illegible]	[illegible]
Clay	[illegible]	D	[illegible]	[illegible]	[illegible]	[illegible]
Pasture and Shrubs						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mature Forests						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Urban Lawns/Shallow Rooted Crops

Fine Sand	**A**	**50**
	AB	**63**
Fine Sandy Loam	**B**	**75**
	BC	**100**
Silt Loam, Muck	**C**	**125**
Clay Loam	**CD**	**100**
Clay	**D**	**75**

Moderately Rooted Crops

Fine Sand	**A**	**75**
	AB	**113**
Fine Sandy Loam	**B**	**150**
	BC	**175**
Silt Loam,Muck	**C**	**200**
Clay Loam	**CD**	**200**
Clay	**D**	**150**

Pasture and Shrubs

Fine Sand	**A**	**100**
	AB	**125**
Fine Sandy Loam	**B**	**150**
	BC	**200**
Silt Loam, Muck	**C**	**250**
Clay Loam	**CD**	**250**
Clay	**D**	**200**

Mature Forests

Fine Sand	**A**	**250**
	AB	**275**
Fine Sandy Loam	**B**	**300**
	BC	**350**
Silt Loam, Muck	**C**	**400**
Clay Loam	**CD**	**400**
Clay	**D**	**350**

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Table E.3: Infiltration Factor Calculation
Per MOE Methodology (SWM Planning & Design Manual, MOE, March 2003)

Topography	
0.3	Flat Land (avg slope < 0.06%)
0.225	0.06% to 0.27%
0.15	Rolling Land (avg slope between 0.28% and 0.38%)
0.125	0.39% to 2.7%
0.1	Hilly Land (avg slope between 2.8% and 4.7%)

Soils	
0.4	HSG A - open sandy loam
0.35	HSG AB
0.3	HSG B
0.27	HSG BC
0.23	HSG C
0.2	HSG CD - medium combinations of clay and loam
0.1	HSG D - tight impervious clay

Cover	
0.1	cultivated land (crops)
0.15	pasture, lawns
0.2	woodland (forest)

Infiltration Factor Calculations

Existing Conditions (Not to be Developed)

0.125		Topography	
0.270		Soils	
0.150		Cover (Area-Weighted)	
Land Use	Area (ha)	Cover	Area*Cover
Pasture and Shrubs	5.09	0.15	0.7635
Forest	0	0.2	0
Mod. Rooted Crops	0	0.1	0
0.545		Total Infiltration Factor (Existing Conditions)	

Existing Conditions (To be Developed)

0.125		Topography	
0.270		Soils	
0.120		Cover (Area-Weighted)	
Land Use	Area (ha)	Cover	Area*Cover
Pasture and Shrubs	2.198	0.15	0.3297
Forest	0.615	0.2	0.123
Mod. Rooted Crops	5.597	0.1	0.5597
0.515		Total Infiltration Factor (Existing Conditions)	

Proposed Conditions

0.125	Topography
0.270	Soils

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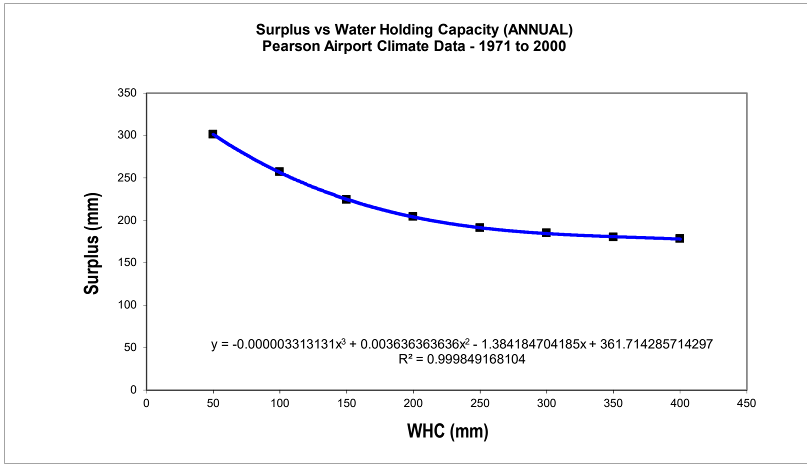
Table E.4: Surplus and Actual Evapotranspiration vs Water Holding Capacity (WHC) Regression Analysis

AES Water Balance Model Results for a Range of WHC
Pearson Airport Climate Data (1971 - 2000)

Existing Condition

Trendline			AES Model Results	
Surplus	AE	WHC	Surplus	AE
(mm)	(mm)	(mm)	(mm)	(mm)
301	486	50	301	487
256	533	100	257	531
225	565	150	224	567
204	586	200	204	587
191	599	250	191	598
184	605	300	185	605
181	609	350	180	609
178	612	400	178	612
203.8	586.4	200.0	TOTAL SITE	



Proposed Condition

Trendline			AES Model Results	
Surplus	AE	WHC	Surplus	AE
(mm)	(mm)	(mm)	(mm)	(mm)
301	486	50	301	487
256	533	100	257	531
225	565	150	224	567
204	586	200	204	587
191	599	250	191	598
184	605	300	185	605
181	609	350	180	609
178	612	400	178	612
256.3	533.0	100.0	TOTAL SITE	

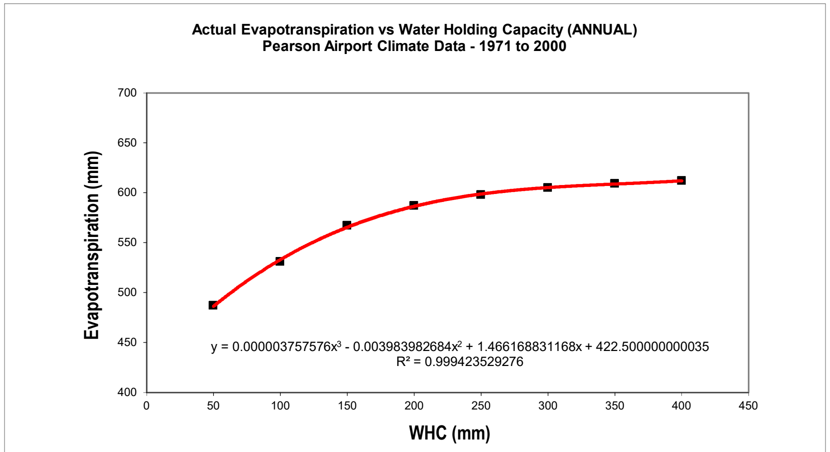


Table E.5: Rainfall Analysis - Initial Abstraction = 0.0 mm

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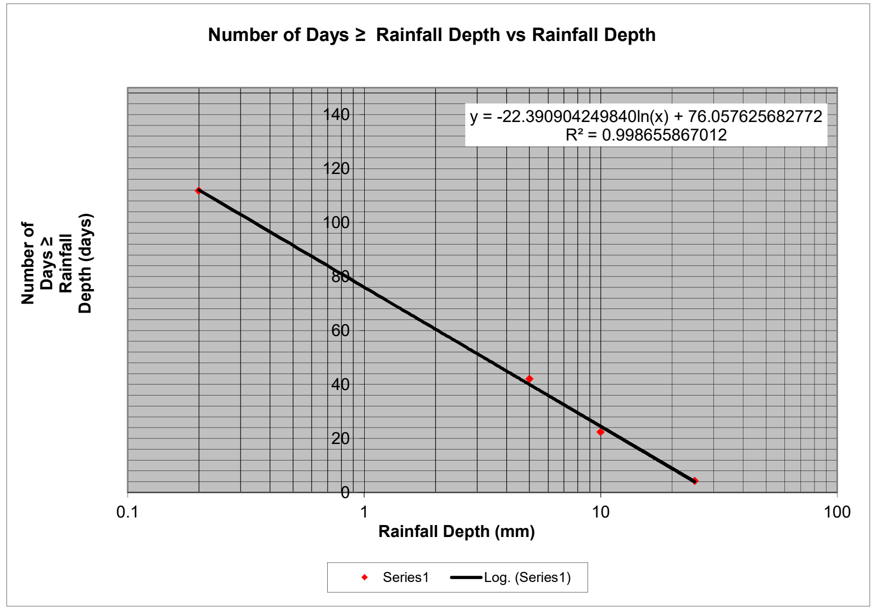


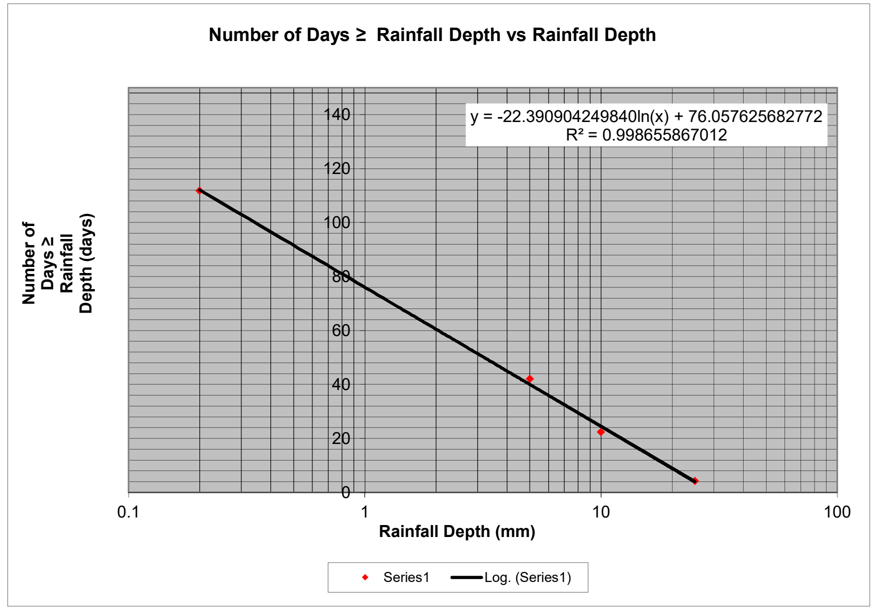
Normal Rainfall Depth (mm)	Normal Days ≥ Rainfall Depth (days)
0.2	111.8
5	42.1
10	22.4
25	4.3

Toronto Pearson Airport Climate Normals (1971 - 2000)
684.6 Normal Annual Rainfall Depth (mm)
111.8 Normal Annual Days with Rainfall (≥ 0.2 mm)
792.7 Normal Annual Precipitation Depth (mm)

Simulated Depth (mm)	Simulated Days ≥ Sim Depth (days)	Average Event Depth (mm)	Simulated Days Equal to Avg Depth (days)	Assumed IA (mm)	Runoff (Rain - IA) (mm)	INF Design Storm (mm)	Event Based Maximum Design INF Depth (mm)	Event Based Design INF Depth (mm)	Annual Incremental Design INF Depth (mm)	Annual Cumulative Design INF Depth (mm)	Annual Incremental Total Rain Depth (mm)	Annual Percent of Total Rain (%)	Annual Cumulative Total Rain Depth (mm)	Annual Cumulative Percent of Total Depth (%)
0.2	120.19													
0.5	98.04	0.2 - 0.5	22.15	0.00	0.00	15.00	15.00	0.00	0.00	**0.00**		0.000	0.0	0.000
1.5	71.49	1	26.55	0.00	1.00	15.00	15.00	1.00	26.55	**26.55**	26.55	0.039	26.6	0.039
2.5	59.14	2	12.35	0.00	2.00	15.00	15.00	2.00	24.69	**51.25**	24.69	0.036	51.2	0.075
3.5	51.01	3	8.13	0.00	3.00	15.00	15.00	3.00	24.40	**75.64**	24.40	0.036	75.6	0.110
4.5	44.93	4	6.07	0.00	4.00	15.00	15.00	4.00	24.30	**99.94**	24.30	0.035	99.9	0.146
5.5	40.08	5	4.85	0.00	5.00	15.00	15.00	5.00	24.25	**124.19**	24.25	0.035	124.2	0.181
6.5	36.05	6	4.04	0.00	6.00	15.00	15.00	6.00	24.23	**148.42**	24.23	0.035	148.4	0.217
7.5	32.59	7	3.46	0.00	7.00	15.00	15.00	7.00	24.21	**172.63**	24.21	0.035	172.6	0.252
8.5	29.56	8	3.03	0.00	8.00	15.00	15.00	8.00	24.20	**196.83**	24.20	0.035	196.8	0.288
9.5	26.87	9	2.69	0.00	9.00	15.00	15.00	9.00	24.20	**221.03**	24.20	0.035	221.0	0.323
10.5	24.46	10	2.42	0.00	10.00	15.00	15.00	10.00	24.19	**245.22**	24.19	0.035	245.2	0.358
11.5	22.26	11	2.20	0.00	11.00	15.00	15.00	11.00	24.19	**269.41**	24.19	0.035	269.4	0.394
12.5	20.24	12	2.02	0.00	12.00	15.00	15.00	12.00	24.18	**293.59**	24.18	0.035	293.6	0.429
13.5	18.38	13	1.86	0.00	13.00	15.00	15.00	13.00	24.18	**317.77**	24.18	0.035	317.8	0.464
14.5	16.65	14	1.73	0.00	14.00	15.00	15.00	14.00	24.18	**341.95**	24.18	0.035	342.0	0.499
15.5	15.04	15	1.61	0.00	15.00	15.00	15.00	15.00	24.18	**366.13**	24.18	0.035	366.1	0.535
16.5	13.53	16	1.51	0.00	16.00	15.00	15.00	15.00	22.67	**388.80**	24.18	0.035	390.3	0.570
17.5	12.11	17	1.42	0.00	17.00	15.00	15.00	15.00	21.33	**410.13**	24.18	0.035	414.5	0.605
18.5	10.77	18	1.34	0.00	18.00	15.00	15.00	15.00	20.15	**430.28**	24.18	0.035	438.7	0.641
19.5	9.49	19	1.27	0.00	19.00	15.00	15.00	15.00	19.09	**449.36**	24.18	0.035	462.8	0.676
20.5	8.28	20	1.21	0.00	20.00	15.00	15.00	15.00	18.13	**467.50**	24.18	0.035	487.0	0.711
21.5	7.13	21	1.15	0.00	21.00	15.00	15.00	15.00	17.27	**484.76**	24.17	0.035	511.2	0.747
22.5	6.03	22	1.10	0.00	22.00	15.00	15.00	15.00	16.48	**501.25**	24.17	0.035	535.4	0.782
23.5	4.98	23	1.05	0.00	23.00	15.00	15.00	15.00	15.77	**517.01**	24.17	0.035	559.5	0.817
24.5	3.98	24	1.01	0.00	24.00	15.00	15.00	15.00	15.11	**532.12**	24.17	0.035	583.7	0.853
25.5	3.01	25	0.97	0.00	25.00	15.00	15.00	15.00	14.50	**546.62**	24.17	0.035	607.9	0.888
26.5	2.08	26	0.93	0.00	26.00	15.00	15.00	15.00	13.95	**560.57**	24.17	0.035	632.1	0.923
27.5	1.18	27	0.90	0.00	27.00	15.00	15.00	15.00	13.43	**574.00**	24.17	0.035	656.2	0.959
28.5	0.32	28	0.86	0.00	28.00	15.00	15.00	15.00	12.95	**586.95**	24.17	0.035	680.4	0.994
29	0.00	≥ 29	0.00	0.00	29.00	15.00	15.00	15.00	0.00	**586.95**	4.20	0.006	684.6	1.000

Table E.6: Rainfall Analysis Initial Abstraction = 5.0 mm

VALDOR ENGINEERING INC.
File: 14118
Date: October 2018



Normal Rainfall Depth (mm)	Normal Days ≥ Rainfall Depth (days)
0.2	111.8
5	42.1
10	22.4
25	4.3

Toronto Pearson Airport Climate Normals (1971 - 2000)
684.6 Normal Annual Rainfall Depth (mm)
111.8 Normal Annual Days with Rainfall (≥ 0.2 mm)
792.7 Normal Annual Precipitation Depth (mm)

Simulated Depth (mm)	Simulated Days ≥ Sim Depth (days)	Average Event Depth (mm)	Simulated Days Equal to Avg Depth (days)	Assumed IA (mm)	Runoff (Rain - IA) (mm)	INF Design Storm (mm)	Event Based Maximum Design INF Depth (mm)	Event Based Design INF Depth (mm)	Annual Incremental Design INF Depth (mm)	Annual Cumulative Design INF Depth (mm)	Annual Incremental Total Rain Depth (mm)	Annual Percent of Total Rain (%)	Annual Cumulative Total Rain Depth (mm)	Annual Cumulative Percent of Total Depth (%)
0.2	120.19													
0.5	98.04	0.2 - 0.5	22.15	5.00	0.00	15.00	10.00	0.00	0.00	**0.00**		0.000	0.0	0.000
1.5	71.49	1	26.55	5.00	0.00	15.00	10.00	0.00	0.00	**0.00**	26.55	0.039	26.6	0.039
2.5	59.14	2	12.35	5.00	0.00	15.00	10.00	0.00	0.00	**0.00**	24.69	0.036	51.2	0.075
3.5	51.01	3	8.13	5.00	0.00	15.00	10.00	0.00	0.00	**0.00**	24.40	0.036	75.6	0.110
4.5	44.93	4	6.07	5.00	0.00	15.00	10.00	0.00	0.00	**0.00**	24.30	0.035	99.9	0.146
5.5	40.08	5	4.85	5.00	0.00	15.00	10.00	0.00	0.00	**0.00**	24.25	0.035	124.2	0.181
6.5	36.05	6	4.04	5.00	1.00	15.00	10.00	1.00	4.04	**4.04**	24.23	0.035	148.4	0.217
7.5	32.59	7	3.46	5.00	2.00	15.00	10.00	2.00	6.92	**10.96**	24.21	0.035	172.6	0.252
8.5	29.56	8	3.03	5.00	3.00	15.00	10.00	3.00	9.08	**20.03**	24.20	0.035	196.8	0.288
9.5	26.87	9	2.69	5.00	4.00	15.00	10.00	4.00	10.75	**30.78**	24.20	0.035	221.0	0.323
10.5	24.46	10	2.42	5.00	5.00	15.00	10.00	5.00	12.10	**42.88**	24.19	0.035	245.2	0.358
11.5	22.26	11	2.20	5.00	6.00	15.00	10.00	6.00	13.19	**56.07**	24.19	0.035	269.4	0.394
12.5	20.24	12	2.02	5.00	7.00	15.00	10.00	7.00	14.11	**70.18**	24.18	0.035	293.6	0.429
13.5	18.38	13	1.86	5.00	8.00	15.00	10.00	8.00	14.88	**85.06**	24.18	0.035	317.8	0.464
14.5	16.65	14	1.73	5.00	9.00	15.00	10.00	9.00	15.54	**100.61**	24.18	0.035	342.0	0.499
15.5	15.04	15	1.61	5.00	10.00	15.00	10.00	10.00	16.12	**116.72**	24.18	0.035	366.1	0.535
16.5	13.53	16	1.51	5.00	11.00	15.00	10.00	10.00	15.11	**131.84**	24.18	0.035	390.3	0.570
17.5	12.11	17	1.42	5.00	12.00	15.00	10.00	10.00	14.22	**146.06**	24.18	0.035	414.5	0.605
18.5	10.77	18	1.34	5.00	13.00	15.00	10.00	10.00	13.43	**159.49**	24.18	0.035	438.7	0.641
19.5	9.49	19	1.27	5.00	14.00	15.00	10.00	10.00	12.72	**172.21**	24.18	0.035	462.8	0.676
20.5	8.28	20	1.21	5.00	15.00	15.00	10.00	10.00	12.09	**184.30**	24.18	0.035	487.0	0.711
21.5	7.13	21	1.15	5.00	16.00	15.00	10.00	10.00	11.51	**195.81**	24.17	0.035	511.2	0.747
22.5	6.03	22	1.10	5.00	17.00	15.00	10.00	10.00	10.99	**206.80**	24.17	0.035	535.4	0.782
23.5	4.98	23	1.05	5.00	18.00	15.00	10.00	10.00	10.51	**217.31**	24.17	0.035	559.5	0.817
24.5	3.98	24	1.01	5.00	19.00	15.00	10.00	10.00	10.07	**227.38**	24.17	0.035	583.7	0.853
25.5	3.01	25	0.97	5.00	20.00	15.00	10.00	10.00	9.67	**237.05**	24.17	0.035	607.9	0.888
26.5	2.08	26	0.93	5.00	21.00	15.00	10.00	10.00	9.30	**246.35**	24.17	0.035	632.1	0.923
27.5	1.18	27	0.90	5.00	22.00	15.00	10.00	10.00	8.95	**255.30**	24.17	0.035	656.2	0.959
28.5	0.32	28	0.86	5.00	23.00	15.00	10.00	10.00	8.63	**263.94**	24.17	0.035	680.4	0.994
29	0.00	≥ 29	0.00	5.00	24.00	15.00	10.00	10.00	0.00	**263.94**	4.20	0.006	684.6	1.000

Table E.7: Infiltration Trench Calculation - Commercial & Mixed Use Area Roof Drainage Areas to Infiltration Trenches

VALDOR ENGINEERING INC.
741 Rowntree Dairy Road, Suite 2, Woodbridge, Ontario L4L 5T9
Tel: 905-264-0054 Fax: 905-264-0069
info@valdor-engineering.com www.valdor-engineering.com

Project No: 14118
Date: October 2018

Total Req'd Annual Infiltration Volume to Achieve Target (m^3)	*Total Actual Annual Infiltration Volume per Design (m^3)*	*Soil Infiltration Rate (mm/h)*	*Drainage Area (ha)*	*Maximum Trench Length per Site Plan (m)*	*Initial Abstraction (Trench Drainage Area) (mm)*	*Retention Time (hr)*	*Total Annual Rainfall Depth (Per 1981-2010 Climate Normals for Pearson Airport) (mm)*	*Total Rainfall Depth Available for Infiltration Per Rainfall Analysis Assuming Ia=0.0mm (Refer to Table F.5) (mm)*	*Annual Rainfall Depth Needed to Achieve Target Infiltration (mm)*	*[1] Req'd Design Storm Depth to Achieve Annual Infiltration Requirements (Assuming Ia=5.0 mm) (mm)*	*Req'd Event-Based Runoff Volume to be Infiltrated (Based on Req'd Design Storm Depth) (m^3)*
2,846	1,820	15.0	0.31	-	0.0	48	684.6	586.95	918.0	15.0	46.5

Total annual infiltration volume provided (m^3/yr): 2,875

1,820 cu.m/yr (Roofs) + 1,056 cu.m/yr (Rear Lots) = 2,875 cu.m/yr

Maximum Allowable Depth	
P, Soil Infiltration Rate (mm/h):	**15.0**
T, Drawdown Time (hr):	**48**
d, Maximum Allowable Depth (m):	**0.72**

Minimum Bottom Area	
V, Runoff Volume to Infiltrated (m^3):	**46.5**
P, Soil Infiltration Rate (mm/h):	**15.0**
n, Void Ratio (clear stone):	**0.40**
Δt, Drawdown Time (hr):	**48**
A, Minimum Bottom Area (m^2):	**161**

$$d = \frac{P \cdot T}{1000} \quad \textit{Equation 4.2, Stormwater Management Planning and Design Manual, MOE, 2003}$$

$$A = \frac{1000 \cdot V}{P \cdot n \cdot \Delta t} \quad \textit{Equation 4.3, Stormwater Management Planning and Design Manual, MOE, 2003}$$

Infiltration Trench Design

Infiltration Trench Location	**Roof Drainage Area (ha)**	**Available Infiltration Volume (m^3)**	**Length (m)**	**Width (m)**	**[3]Design Depth (m)**	**Bottom Area (m^2)**	**Void Ratio**	**Storage Volume Provided (m^3)**	**Lesser of Available Infiltration Volume or Storage Volume Provided (m^3)**
Roof Drainage Infiltration Trench (Block 5)	0.11	16.5	12.0	5.0	0.70	60	0.40	16.8	16.5
Roof Drainage Infiltration Trench (Block 6)	0.20	30.0	22.0	5.0	0.70	110	0.40	30.8	30.0

Total Drainage Area (ha): 0.31
Total Bottom Area Provided (m^2): 170
Total Infiltration Volume Used (m^3): 46.5

Total: 46.50

Notes:

Infiltration facilities are sized based on the following criteria (SWMPDM, MOE, 2003) and/or assumptions:

(1) Infiltration trench volume should be sized based on the runoff generated by a 4-hr 15-mm event or smaller.
(2) The drainage area to each infiltration trench should be sufficient to provide required runoff quantity.
(3) The maximum allowable depth of the infiltration facility is based on the soil infiltrate rate and the retention time.
(4) It is feasible to convey the runoff to the infiltration facility.
(5) The seasonal high water table should be at least 1 m below the infiltration trench.

Table E.8: Infiltration Trench Calculation - Residential Rear Lot Areas to Infiltration Trenches

VALDOR ENGINEERING INC.
741 Rowntree Dairy Road, Suite 2, Woodbridge, Ontario L4L 5T9
Tel: 905-264-0054 Fax: 905-264-0069
info@valdor-engineering.com www.valdor-engineering.com

Project No: 14118
Date: October 2018

Total Req'd Annual Infiltration Volume to Achieve Target (m^3)	*Total Actual Annual Infiltration Volume per Design (m^3)*	*Soil Infiltration Rate (mm/h)*	*Drainage Area (ha)*	*Maximum Trench Length per Site Plan (m)*	*Initial Abstraction (Trench Drainage Area) (mm)*	*Retention Time (hr)*	*Total Annual Rainfall Depth (Per 1981-2010 Climate Normals for Pearson Airport) (mm)*	*Total Rainfall Depth Available for Infiltration Per Rainfall Analysis Assuming Ia=5.0mm (Refer to Table F.4) (mm)*	*Annual Rainfall Depth Needed to Achieve Target Infiltration (mm)*	*[1] Req'd Design Storm Depth to Achieve Annual Infiltration Requirements (Assuming Ia=5.0 mm) (mm)*	*Req'd Event-Based Runoff Volume to be Infiltrated (Based on Req'd Design Storm Depth) (m^3)*
2,846	1,056	15.0	0.40	-	5.0	48	684.6	263.94	711.5	15.0	40.0

Total annual infiltration volume provided (m^3/yr): **2,875**

1,820 cu.m/yr (Roofs) + 1,056 cu.m/yr (Rear Lots) = 2,875 cu.m/yr

Maximum Allowable Depth	
P, Soil Infiltration Rate (mm/h):	**15.0**
T, Drawdown Time (hr):	**48**
d, Maximum Allowable Depth (m):	**0.72**

Minimum Bottom Area	
V, Runoff Volume to Infiltrated (m³):	**40.0**
P, Soil Infiltration Rate (mm/h):	**15.0**
n, Void Ratio (clear stone):	**0.40**
Δt, Drawdown Time (hr):	**48**
A, Minimum Bottom Area (m²):	**139**

$$d = \frac{P \cdot T}{1000} \quad \textit{Equation 4.2, Stormwater Management Planning and Design Manual, MOE, 2003}$$

$$A = \frac{1000 \cdot V}{P \cdot n \cdot \Delta t} \quad \textit{Equation 4.3, Stormwater Management Planning and Design Manual, MOE, 2003}$$

Infiltration Trench Design

Infiltration Trench Location	Rear Lot Drainage Area (ha)	Available Infiltration Volume (m³)	Length (m)	Width (m)	[3]Design Depth (m)	Bottom Area (m²)	Void Ratio	Storage Volume Provided (m³)	Lesser of Available Infiltration Volume or Storage Volume Provided (m³)
Surface Infiltration Trench (Lots 57-72)	0.40	40.0	240.0	0.6	0.70	144	0.40	40.3	40.0

Total Drainage Area (ha): **0.40**
Total Bottom Area Provided (m²): **144**
Total Infiltration Volume Used (m³): **40.0**

Total: 40.0

Notes:

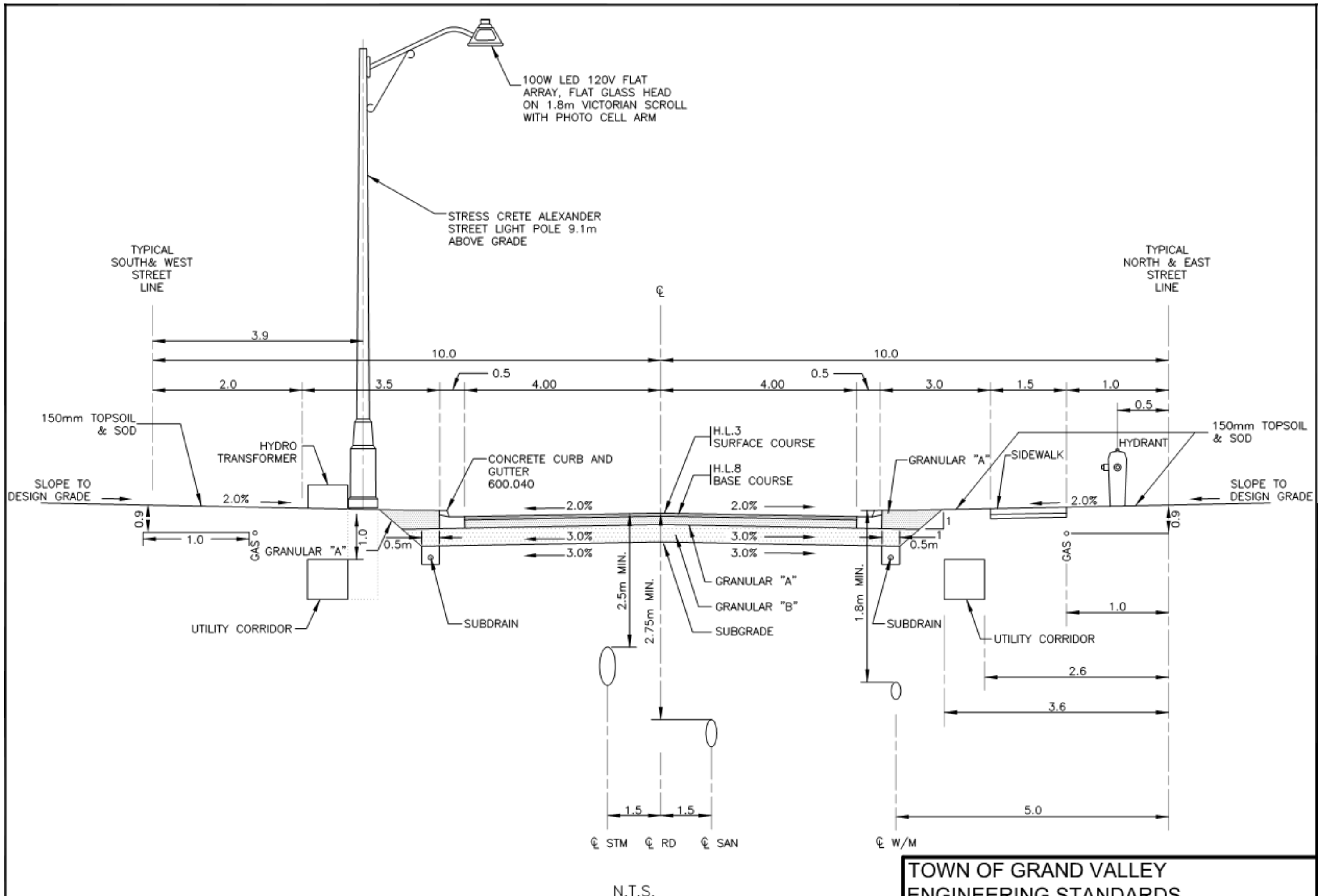
Infiltration facilities are sized based on the following criteria (SWMPDM, MOE, 2003) and/or assumptions:

(1) Infiltration trench volume should be sized based on the runoff generated by a 4-hr 15-mm event or smaller.
(2) The drainage area to each infiltration trench should be sufficient to provide required runoff quantity.
(3) The maximum allowable depth of the infiltration facility is based on the soil infiltrate rate and the retention time.
(4) It is feasible to convey the runoff to the infiltration facility.
(5) The seasonal high water table should be at least 1 m below the infiltration trench.

APPENDIX "F"

Standard Road Cross Sections

Revision Date: November, 2013



TOWN OF GRAND VALLEY
ENGINEERING STANDARDS

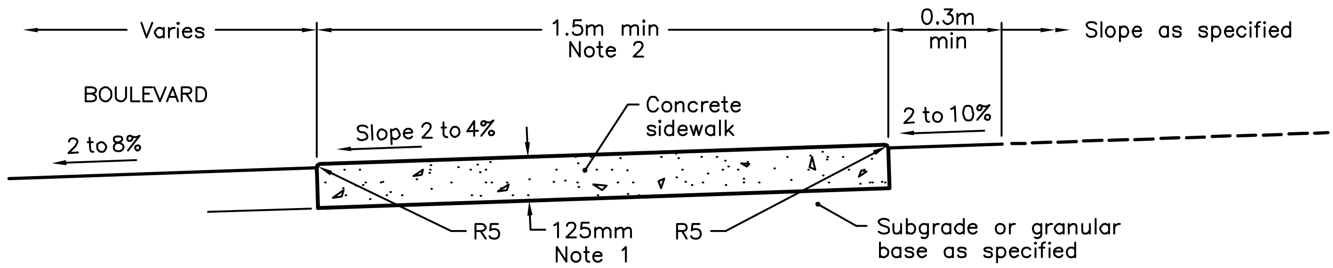
STANDARD ROAD

CROSS-SECTION - 20m R.O.W.

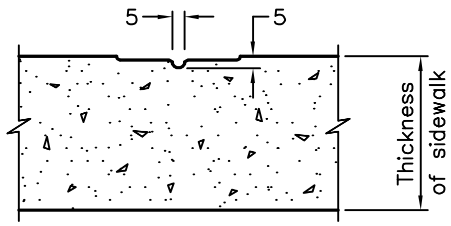
DRAFTED BY: VAN HARTEN SURVEYING INC.

REVISION NO.: 0 | DATE: AUGUST 2013

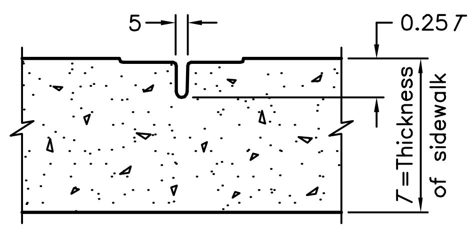
Cross-Section 8.0m Road.dwg



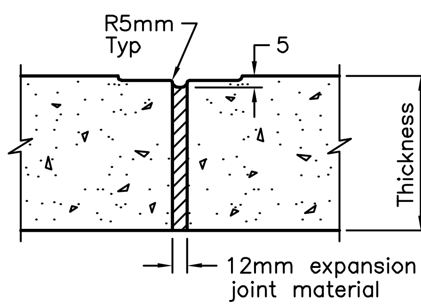
TYPICAL SECTION



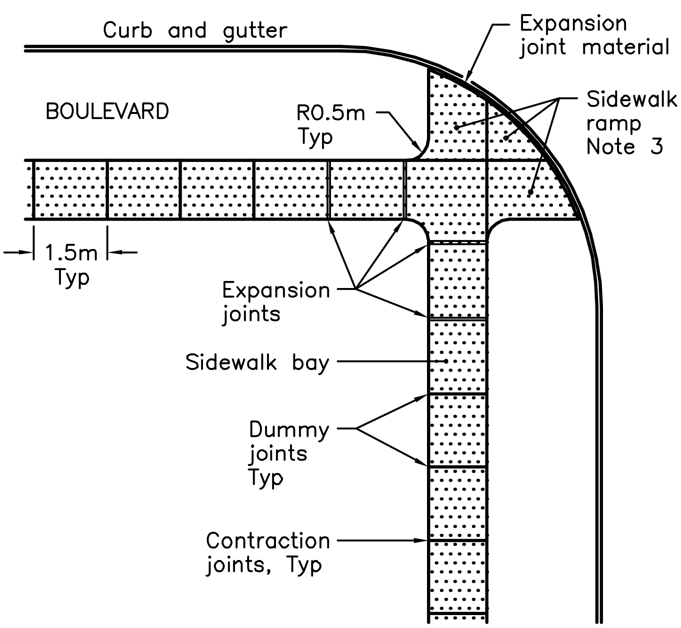
DUMMY JOINT (OPTIONAL)



CONTRACTION JOINT



EXPANSION JOINT



JOINT LAYOUT

NOTES:

1 Sidewalk thickness at residential driveways and adjacent to curb shall be 150mm. At commercial and industrial driveways, the thickness shall be 200mm.

2 Sidewalk width shall be wider when specified.

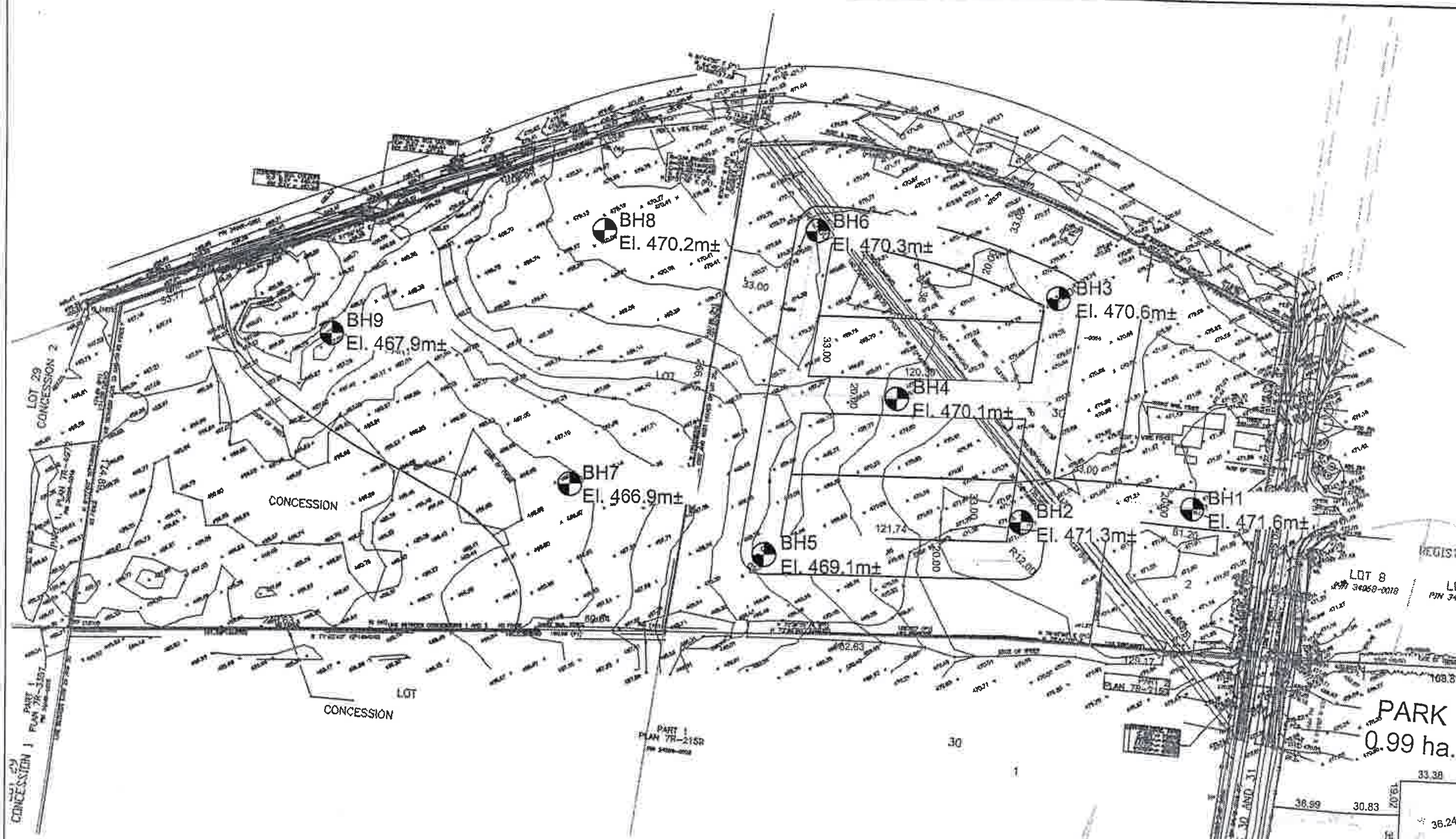
3 This OPSD shall be read in conjunction with OPSD 310.030, 310.031, 310.032, 310.033 and 310.039.

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2015	Rev 2
CONCRETE SIDEWALK		
	OPSD 310.010	

APPENDIX "G"

Geotechnical Bore Hole / Test Pit Logs



V.A. WOOD (GUELPH) INC.

Consulting Geotechnical Engineers

405 York Road, Guelph, Ontario N1E 3H3
Ph. (519) 763-3101 Fax. (519) 763-5912

Borehole Location Plan
Part of Lot 30, Concession 2
Grand Valley, Ontario

Scale: NTS	Ref. No. G3524-4-11
Date: November 19, 2014	Enclosure 1

REFERENCE No: G3524-4-11

CLIENT: Corseed Inc.

PROJECT: Proposed Subdivision

LOCATION: Grand Valley, ON

BOREHOLE No: 1

ENCLOSURE No: 2

SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

405 YORK ROAD, GUELPH, ONTARIO N1E 3H3
PH. (519) 763-3101 FAX (519) 763-5912

SUBSURFACE PROFILE					SAMPLE			PENETRATION RESISTANCE BLOWS/0.3m (20, 40, 60, 80)	WATER CONTENT % (5, 10, 15, 20, 25)	UNIT WEIGHT
DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m			
0.0	Ground Surface	471.6								
0.3	250mm Topsoil	471.4			1	SS	2			
	brown, medium to hard CLAY AND SILT trace sand, trace gravel, occasional wet sand seams, moist			W.L. @ El. 470.4m± (12-Nov-14)	1	SS	7			
					2	SS	19			
					3	SS	19			
					4	SS	29			
					5	SS	35			
5.0		466.6			6	SS	70			
	End of Borehole									

DRILLED BY: London Soil Test Ltd.

DRILL METHOD: Solid Stem Auger

DRILL DATE: November 12, 2014

HOLE DIAMETER: 110mm

DATUM: Geodetic

SHEET: 1 of 1

REFERENCE No: G3524-4-11

CLIENT: Corseed Inc.

PROJECT: Proposed Subdivision

LOCATION: Grand Valley, ON

BOREHOLE No: 2

ENCLOSURE No: 3

SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

405 YORK ROAD, GUELPH, ONTARIO N1E 3H3
PH. (519) 763-3101 FAX (519) 763-5912

DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m	PENETRATION RESISTANCE BLOWS/0.3m (20 40 60 80)	WATER CONTENT % (5 10 15 20 25)	UNIT WEIGHT
0.0	Ground Surface	471.3								
0.2	175mm Topsoil	471.1			1	SS	4			
1.0	brown, stiff CLAY AND SILT trace sand, trace gravel, occasional wet sand seams, moist	470.3			1	SS	13			
2.3	brown, compact SAND trace gravel, trace silt, trace clay, moist	469.0		W.L. @ El. 470.1m± (12-Nov-14)	2	SS	22			
					3	SS	22			
3.1	brown, compact GRAVEL wet	468.2			4	SS	19			
3.3	brown, hard CLAY AND SILT trace sand, trace gravel, moist	468.0			5	SS	53	125mm		
5.0	grey, hard SILTY CLAY some sand, trace gravel, moist	466.3			6	SS	50			
	End of Borehole									

DRILLED BY: London Soil Test Ltd.

DRILL METHOD: Solid Stem Auger

DRILL DATE: November 12, 2014

HOLE DIAMETER: 110mm

DATUM: Geodetic

SHEET: 1 of 1

REFERENCE No: G3524-4-11

CLIENT: Corseed Inc.

PROJECT: Proposed Subdivision

LOCATION: Grand Valley, ON

BOREHOLE No: 3

ENCLOSURE No: 4

SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

405 YORK ROAD, GUELPH, ONTARIO N1E 3H3
PH. (519) 763-3101 FAX (519) 763-5912

DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m
0.0	Ground Surface	470.6					
0.2	225mm Topsoil	470.4			1	SS	3
	brown, stiff to hard CLAY AND SILT trace sand, trace gravel, occasional wet sand seams, moist				1	SS	12
					2	SS	17
					3	SS	18
					4	SS	38
					5	SS	40
				W.L. @ El. 466.5m± (12-Nov-14)			
4.6		466.0					
5.0	grey, hard SILTY CLAY some sand, trace gravel, moist	465.6			6	SS	33
	End of Borehole						

PENETRATION RESISTANCE BLOWS/0.3m: 20 40 60 80

WATER CONTENT %: 5 10 15 20 25

UNIT WEIGHT

DRILLED BY: London Soil Test Ltd.

DRILL METHOD: Solid Stem Auger

DRILL DATE: November 12, 2014

HOLE DIAMETER: 110mm

DATUM: Geodetic

SHEET: 1 of 1

REFERENCE No: G3524-4-11	**BOREHOLE No: 4**
CLIENT: Corseed Inc.	
PROJECT: Proposed Subdivision	ENCLOSURE No: 5
LOCATION: Grand Valley, ON	SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

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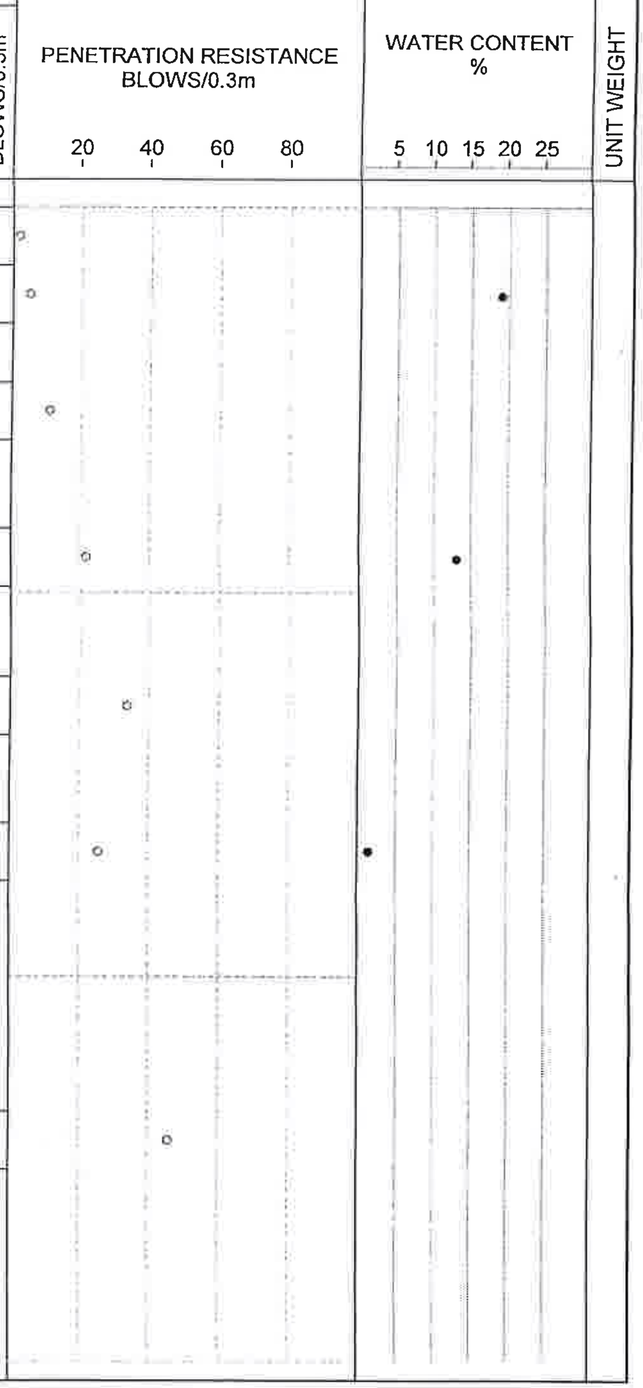
SUBSURFACE PROFILE					SAMPLE		
DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m
0.0	Ground Surface	470.1					
0.1	125mm Topsoil	470.0			1	SS	2
	brown, medium to hard CLAY AND SILT trace sand, trace gravel, moist to wet				1	SS	5
					2	SS	11
				W.L. @ El. 468.1m± (12-Nov-14)	3	SS	22
2.7		467.4			4	SS	34
	brown, compact SAND						
3.1	trace gravel, trace silt, trace clay, moist	467.0					
	grey, very stiff to hard SILTY CLAY some sand, trace gravel, moist				5	SS	26
5.0		465.1			6	SS	46
	End of Borehole						



DRILLED BY: London Soil Test Ltd.	HOLE DIAMETER: 110mm
DRILL METHOD: Solid Stem Auger	DATUM: Geodetic
DRILL DATE: November 12, 2014	SHEET: 1 of 1

REFERENCE No: G3524-4-11

CLIENT: Corseed Inc.

PROJECT: Proposed Subdivision

LOCATION: Grand Valley, ON

BOREHOLE No: 5

ENCLOSURE No: 6

SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

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PH. (519) 763-3101 FAX (519) 763-5912

SUBSURFACE PROFILE					SAMPLE			PENETRATION RESISTANCE BLOWS/0.3m (20, 40, 60, 80)	WATER CONTENT % (5, 10, 15, 20, 25)	UNIT WEIGHT
DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m			
0.0	Ground Surface	469.1								
0.2	150mm Topsoil	469.0			1	SS	6			
0.8	brown, medium CLAY AND SILT trace sand, trace gravel, moist	468.3			1	SS	11			
1.5	brown, compact SAND trace gravel, trace silt, trace clay, wet	467.6		Wet Cave-In @ El. 468.3m± (12-Nov-14)	2	SS	16			
2.3	brown, very stiff CLAY AND SILT trace sand, trace gravel, occasional wet sand seams, moist	466.8			3	SS	20			
5.0	grey, very stiff SILTY CLAY some sand, trace gravel, occasional wet sand seams, moist	464.1			4	SS	22			
					5	SS	26			
					6	SS	22			
	End of Borehole									

DRILLED BY: London Soil Test Ltd.

DRILL METHOD: Solid Stem Auger

DRILL DATE: November 12, 2014

HOLE DIAMETER: 110mm

DATUM: Geodetic

SHEET: 1 of 1

REFERENCE No: G3524-4-11

CLIENT: Corseed Inc.

PROJECT: Proposed Subdivision

LOCATION: Grand Valley, ON

BOREHOLE No: 6

ENCLOSURE No: 7

SUPERVISOR: J.D.

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DEPTH (m)	DESCRIPTION	ELEVATION	GROUND WATER	SAMPLE NUMBER	TYPE	'N' BLOWS/0.3m
0.0	Ground Surface	470.3	Dry (12-Nov-14)			
	brown, loose to compact Sandy Silt FILL trace gravel, moist			1	SS	5
				1	SS	21
0.8		469.5				
	100mm Topsoil					
	brown, very stiff to hard CLAY AND SILT trace sand, trace gravel, occasional cobble, moist			2	SS	17
				3	SS	23
				4	SS	37
3.2		467.1				
	grey, very stiff SILTY CLAY some sand, trace gravel, moist			5	SS	15
				6	SS	18
5.0		465.3				
	End of Borehole					

PENETRATION RESISTANCE BLOWS/0.3m: 20 40 60 80

WATER CONTENT %: 5 10 15 20 25

UNIT WEIGHT

DRILLED BY: London Soil Test Ltd.

DRILL METHOD: Solid Stem Auger

DRILL DATE: November 12, 2014

HOLE DIAMETER: 110mm

DATUM: Geodetic

SHEET: 1 of 1

REFERENCE No: G3524-4-11	BOREHOLE No: 7
CLIENT: Corseed Inc.	
PROJECT: Proposed Subdivision	ENCLOSURE No: 8
LOCATION: Grand Valley, ON	SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

405 YORK ROAD, GUELPH, ONTARIO N1E 3H3
PH. (519) 763-3101 FAX (519) 763-5912

DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m	PENETRATION RESISTANCE BLOWS/0.3m (20 40 60 80)	WATER CONTENT % (5 10 15 20 25)	UNIT WEIGHT
0.0	Ground Surface	466.9								
0.2	200mm Topsoil	466.7			1	SS	3			
	grey, medium CLAY AND SILT some sand, trace gravel, wet				1	SS	4			
1.0		465.9								
	brown, compact SAND trace gravel, trace silt, trace clay, wet				2	SS	12			
1.5		465.4								
	brown, stiff CLAY AND SILT trace sand, trace gravel, moist			W.L. @ El. 465.1m± (12-Nov-14)	3	SS	13			
2.3		464.6								
	grey, very stiff SILTY CLAY some sand, trace gravel, moist				4	SS	22			
					5	SS	26			
					6	SS	18			
5.0		461.9								
	End of Borehole									

DRILLED BY: London Soil Test Ltd.	HOLE DIAMETER: 110mm
DRILL METHOD: Solid Stem Auger	DATUM: Geodetic
DRILL DATE: November 12, 2014	SHEET: 1 of 1

REFERENCE No: G3524-4-11

CLIENT: Corseed Inc.

PROJECT: Proposed Subdivision

LOCATION: Grand Valley, ON

BOREHOLE No: 8

ENCLOSURE No: 9

SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

405 YORK ROAD, GUELPH, ONTARIO N1E 3H3
PH. (519) 763-3101 FAX (519) 763-5912

DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m	PENETRATION RESISTANCE BLOWS/0.3m (20 40 60 80)	WATER CONTENT % (5 10 15 20 25)	UNIT WEIGHT
0.0	Ground Surface	470.2		Dry (12-Nov-14)						
	100mm Topsoil brown, loose to compact Sandy Silt FILL trace gravel, moist				1	SS	6			
					1	SS	10			
0.9		469.3								
	75mm Topsoil brown, stiff to very stiff CLAY AND SILT trace sand, trace gravel, occasional wet sand seams, moist				2	SS	16			
					3	SS	12			
					4	SS	20			
					5	SS	23			
4.6		465.6								
	grey, very stiff SILTY CLAY some sand, trace gravel, moist				6	SS	18			
5.0		465.2								
	End of Borehole									

DRILLED BY: London Soil Test Ltd.

DRILL METHOD: Solid Stem Auger

DRILL DATE: November 12, 2014

HOLE DIAMETER: 110mm

DATUM: Geodetic

SHEET: 1 of 1

REFERENCE No: G3524-4-11

CLIENT: Corseed Inc.

PROJECT: Proposed Subdivision

LOCATION: Grand Valley, ON

BOREHOLE No: 9

ENCLOSURE No: 10

SUPERVISOR: J.D.

V.A. WOOD (GUELPH) INC.
CONSULTING GEOTECHNICAL ENGINEERS

405 YORK ROAD, GUELPH, ONTARIO N1E 3H3
PH. (519) 763-3101 FAX (519) 763-5912

SUBSURFACE PROFILE					SAMPLE					
DEPTH (m)	DESCRIPTION	ELEVATION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' BLOWS/0.3m	PENETRATION RESISTANCE BLOWS/0.3m (20 40 60 80)	WATER CONTENT % (5 10 15 20 25)	UNIT WEIGHT
0.0	Ground Surface	467.9								
0.2	150mm Topsoil	467.8			1	SS	3			
	brown, medium CLAY AND SILT trace sand, trace gravel, moist				1	SS	5			
0.9		467.0		W.L. @ El. 467.0m± (12-Nov-14)						
	brown, compact GRAVELLY SAND trace silt, wet to saturated				2	SS	9			
					3	SS	16			
					4	SS	13			
3.1		464.8								
	brown, compact SAND trace gravel, trace silt, trace clay, wet				5	SS	18			
4.7		463.2								
	brown, very stiff CLAY AND SILT trace sand, trace gravel, moist				6	SS	16			
5.0		462.9								
	End of Borehole									

DRILLED BY: London Soil Test Ltd.

DRILL METHOD: Solid Stem Auger

DRILL DATE: November 12, 2014

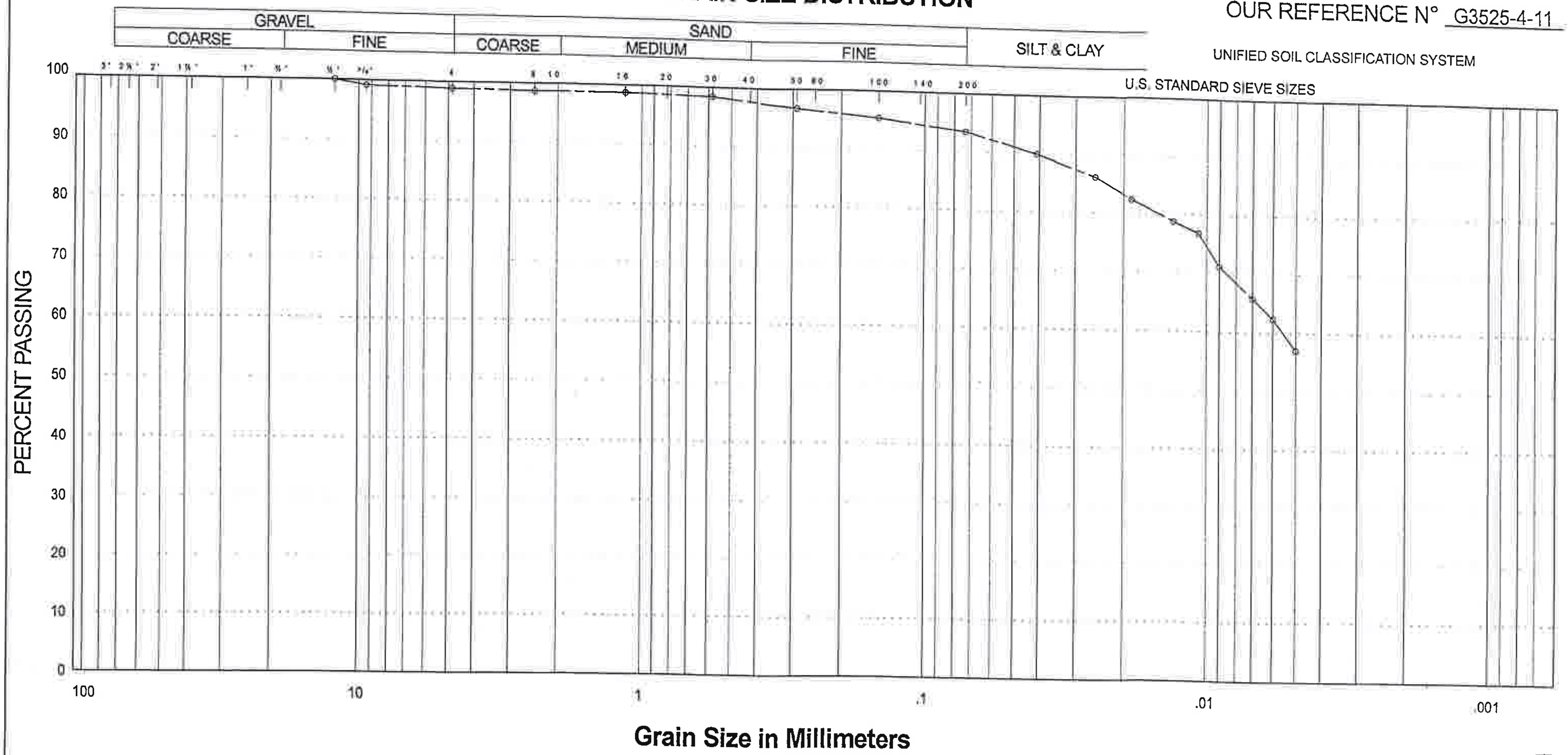
HOLE DIAMETER: 110mm

DATUM: Geodetic

SHEET: 1 of 1

GRAIN SIZE DISTRIBUTION

OUR REFERENCE N° G3525-4-11



PROJECT: Proposed Residential Development
LOCATION: North Half of Lot 31, Conc. 1, Grand Valley ON
BOREHOLE N°: 3
SAMPLE N°: 4
DEPTH: 2.3 - 2.7m±
ELEVATION: 463.2 - 462.8m±

COEFFICIENT OF UNIFORMITY:
COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

CLAY AND SILT, trace sand, trace gravel, (ML - OL)

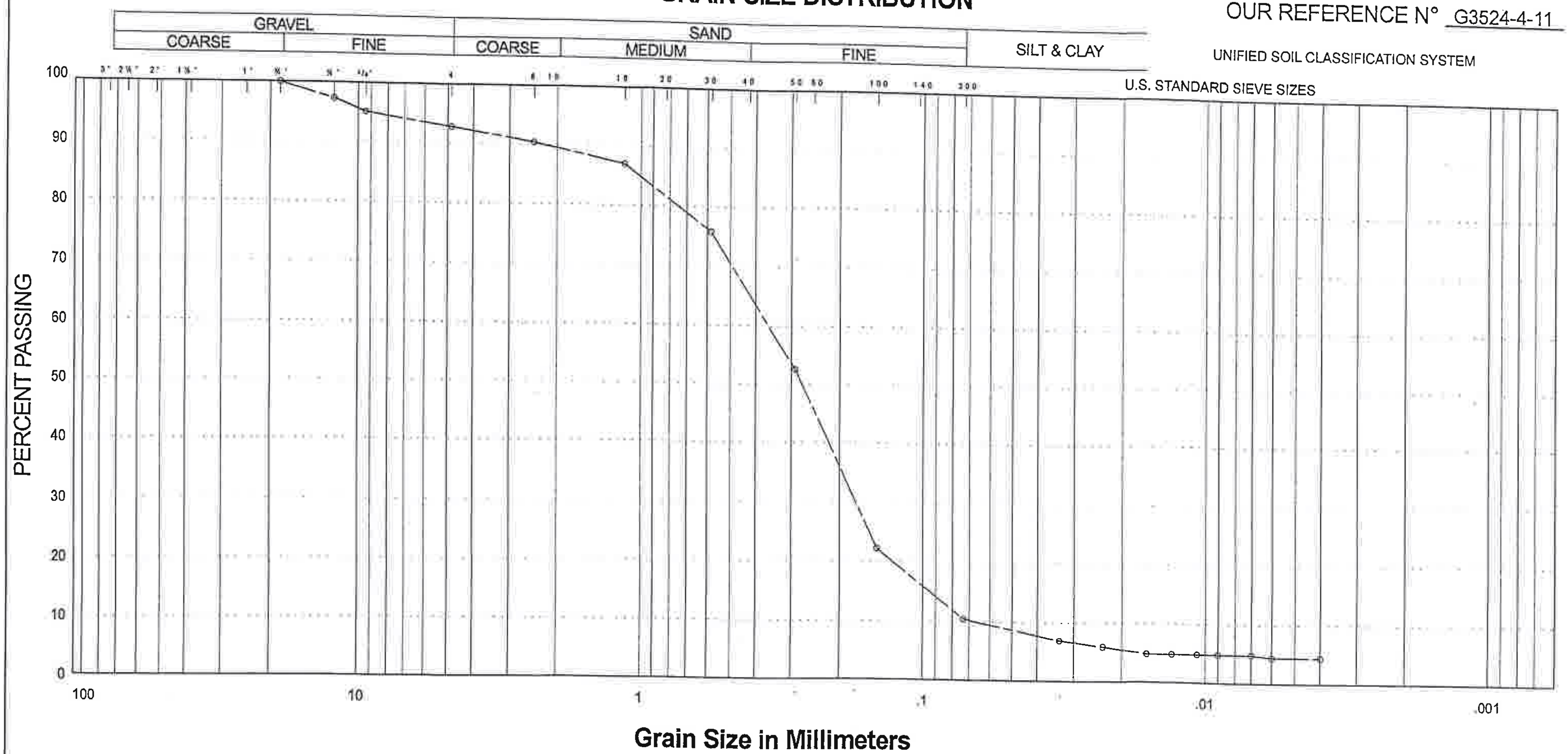
PLASTIC PROPERTIES	
LIQUID LIMIT	% = 33.7
PLASTIC LIMIT	% = 28.3
PLASTICITY INDEX	% = 5.4
MOISTURE CONTENT	% = 20.0

ENCLOSURE N° 11

V. A. WOOD (GUELPH) INCORPORATED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE N° G3524-4-11



PROJECT: Proposed Subdivision
LOCATION: Part of Lot 30, Conc. 2, Grand Valley ON
BOREHOLE N°: 9
SAMPLE N°: 5
DEPTH: 3.0 - 3.5m±
ELEVATION: 464.9 - 464.4m±

COEFFICIENT OF UNIFORMITY:
COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SAND, trace gravel, trace silt, trace clay, (SP - SM)

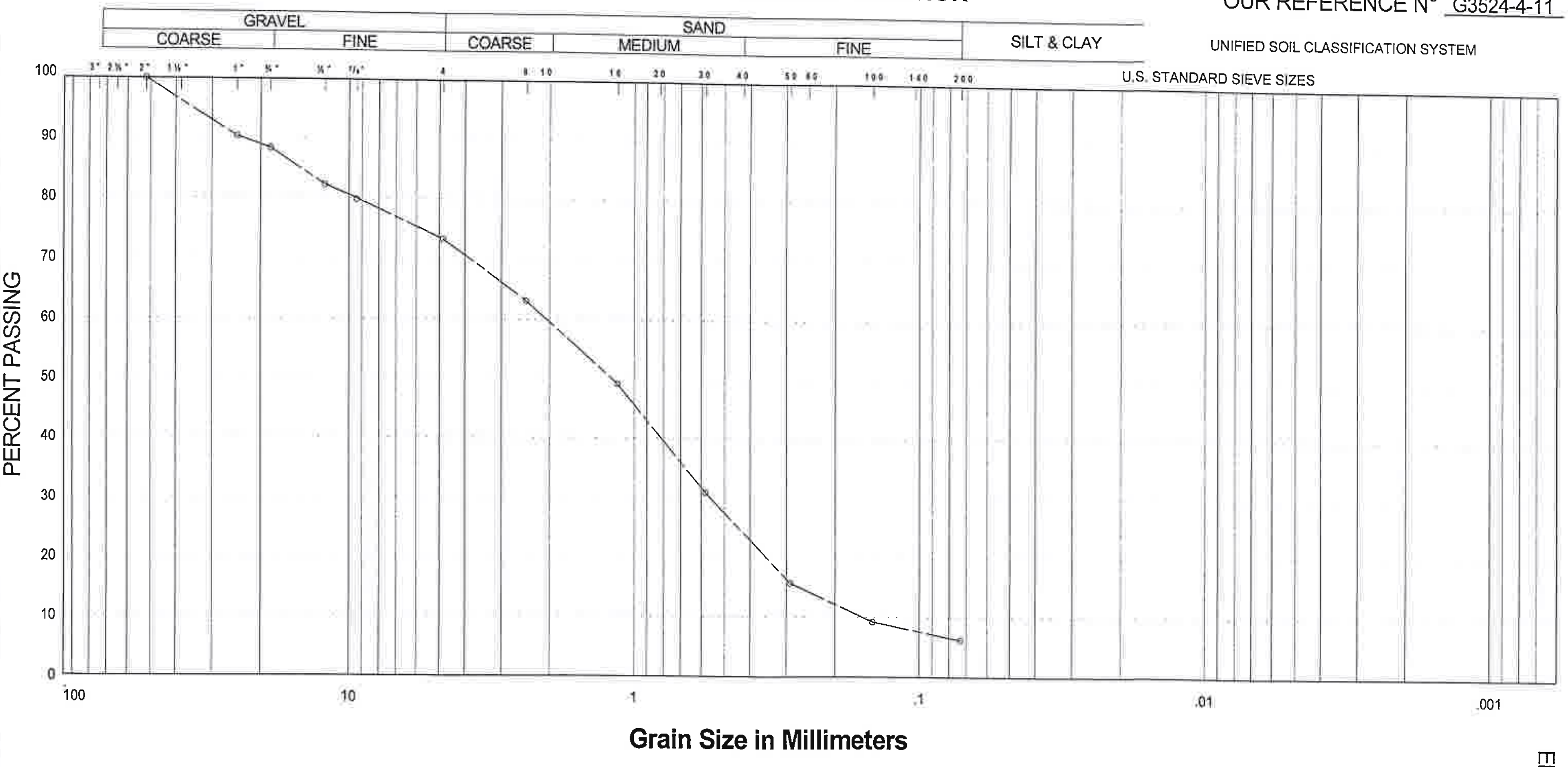
PLASTIC PROPERTIES
LIQUID LIMIT % =
PLASTIC LIMIT % =
PLASTICITY INDEX % =
MOISTURE CONTENT % = 18.3

ENCLOSURE N° 12

V. A. WOOD (GUELPH) INCORPORATED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE N° G3524-4-11



PROJECT: Proposed Residential Development
LOCATION: North Half of Lot 31, Con 1, ELGV, ON
BOREHOLE N°: 9
SAMPLE N°: 4
DEPTH: 2.3 - 2.7m±
ELEVATION: 465.6 - 465.2m±

COEFFICIENT OF UNIFORMITY: 12.4
COEFFICIENT OF CURVATURE: 0.9

Classification of Sample and Group Symbol:

GRAVELLY SAND, trace silt (SP-SM)

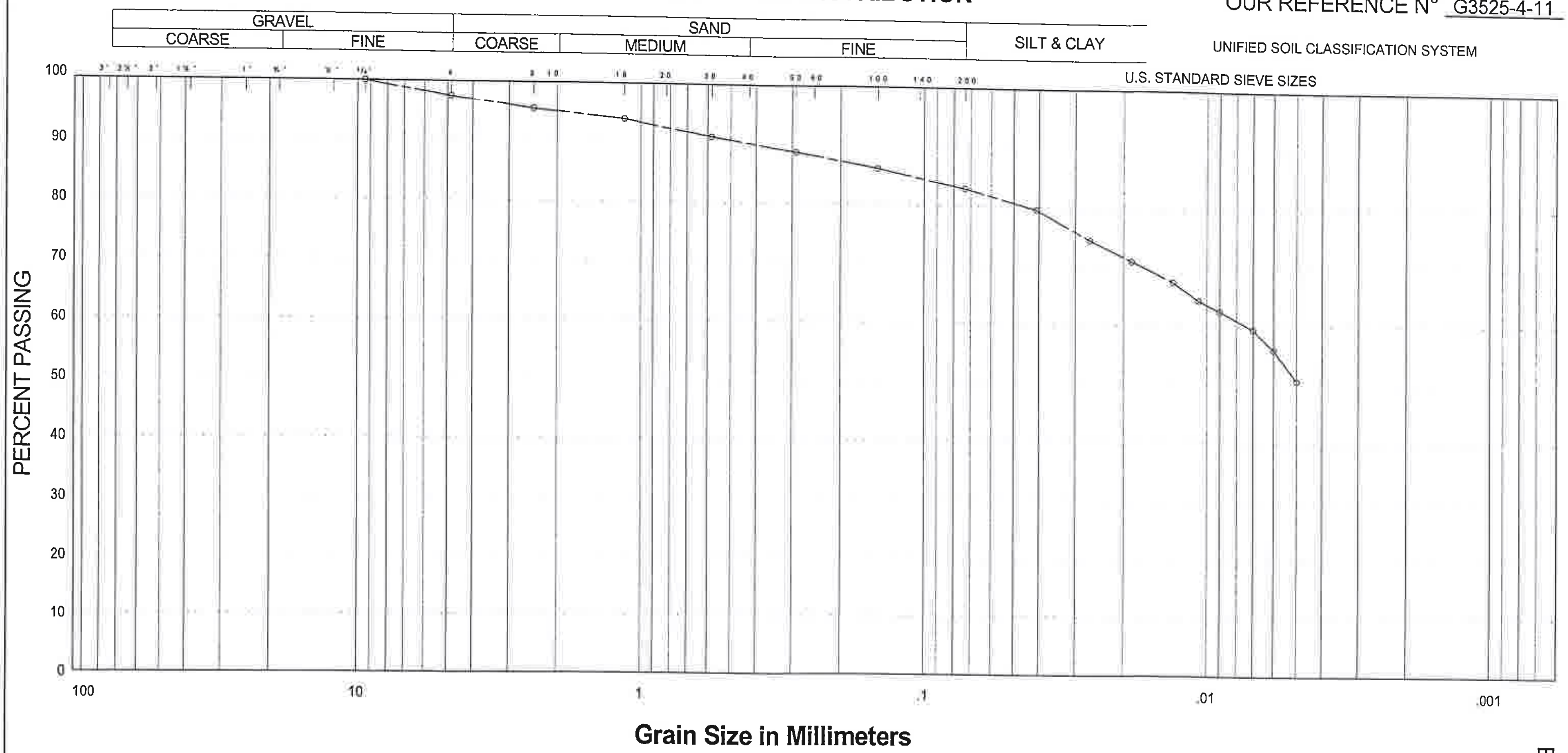
PLASTIC PROPERTIES
LIQUID LIMIT % =
PLASTIC LIMIT % =
PLASTICITY INDEX % =
MOISTURE CONTENT % = 12.8

ENCLOSURE N° 13

V. A. WOOD (GUELPH) INCORPORATED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE N° G3525-4-11



PROJECT: Proposed Residential Development

LOCATION: North Half of of Lot 31, Conc. 1, Grand Valley ON

BOREHOLE N°: 10

SAMPLE N°: 6

DEPTH: 4.6 - 5.0m±

ELEVATION: 464.4 - 464.0m±

COEFFICIENT OF UNIFORMITY:

COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY CLAY, some sand, trace gravel, (CL)

PLASTIC PROPERTIES

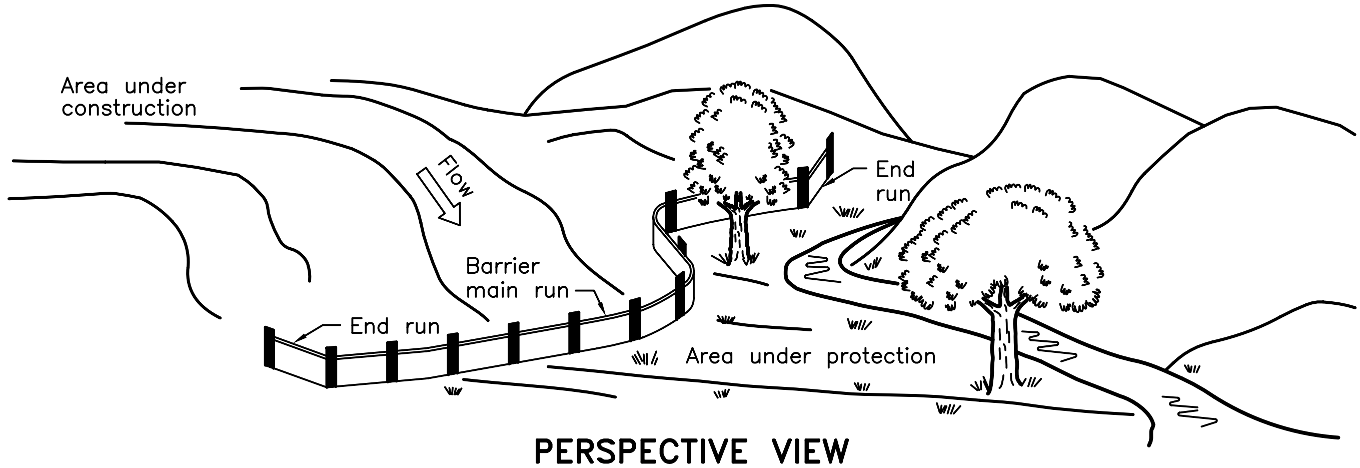
LIQUID LIMIT	% = 30.3
PLASTIC LIMIT	% = 16.9
PLASTICITY INDEX	% = 13.4
MOISTURE CONTENT	% = 5.7

ENCLOSURE N° 14

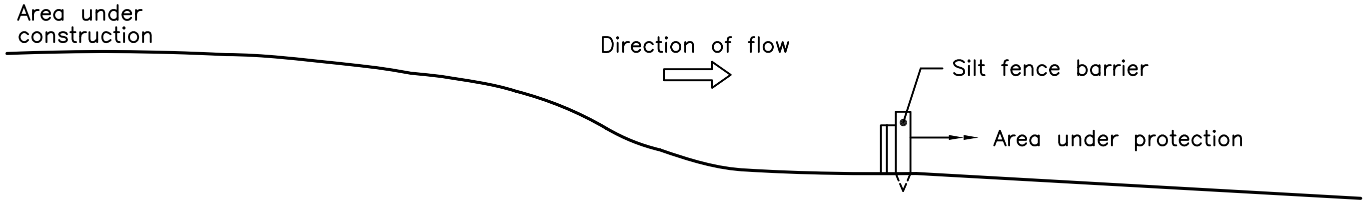
V. A. WOOD (GUELPH) INCORPORATED

APPENDIX "H"

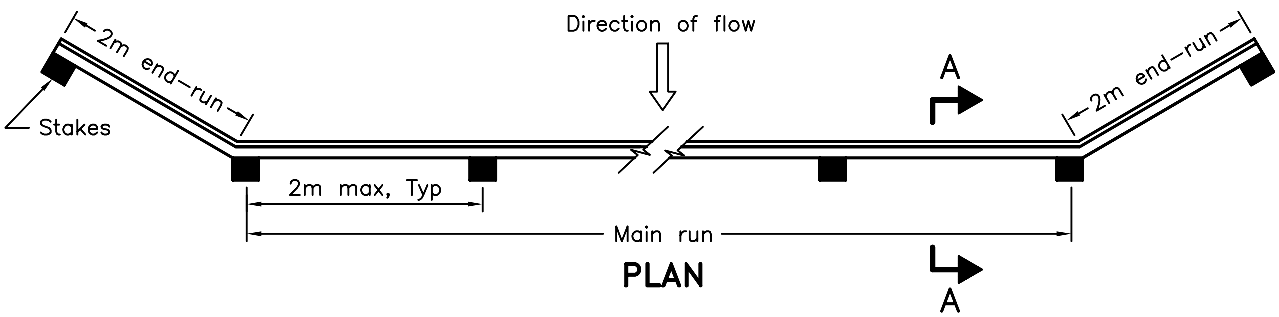
Erosion & Sediment Control Details



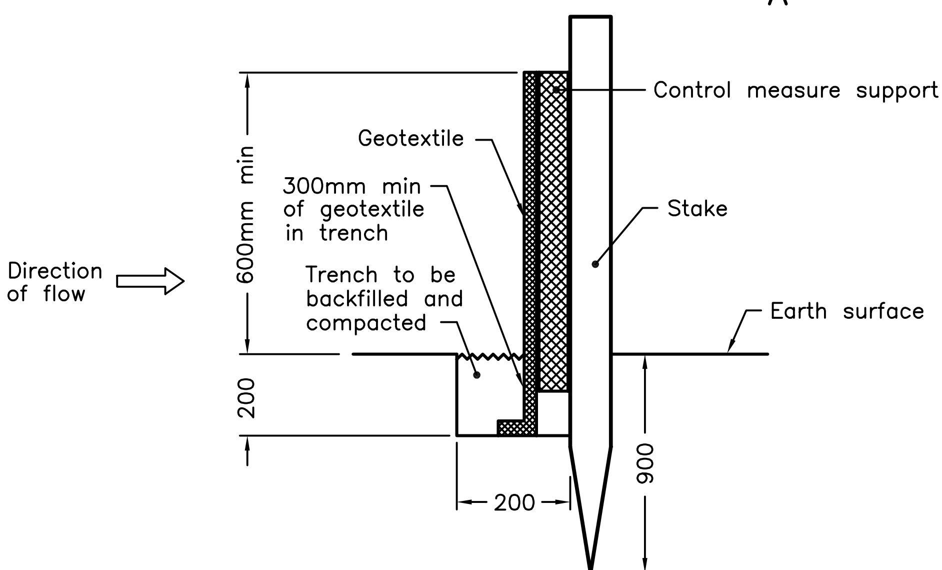
PERSPECTIVE VIEW



SECTION



PLAN

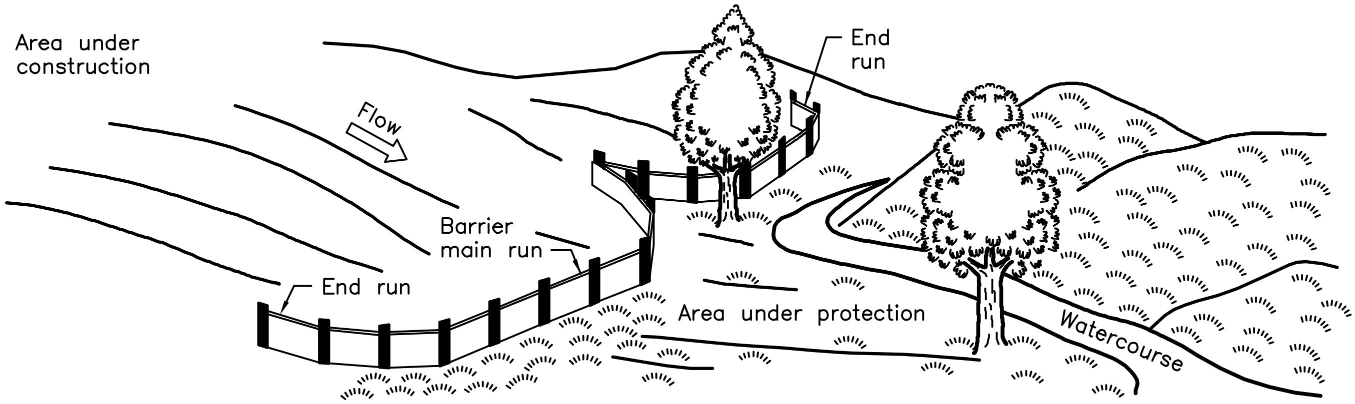


SECTION A-A

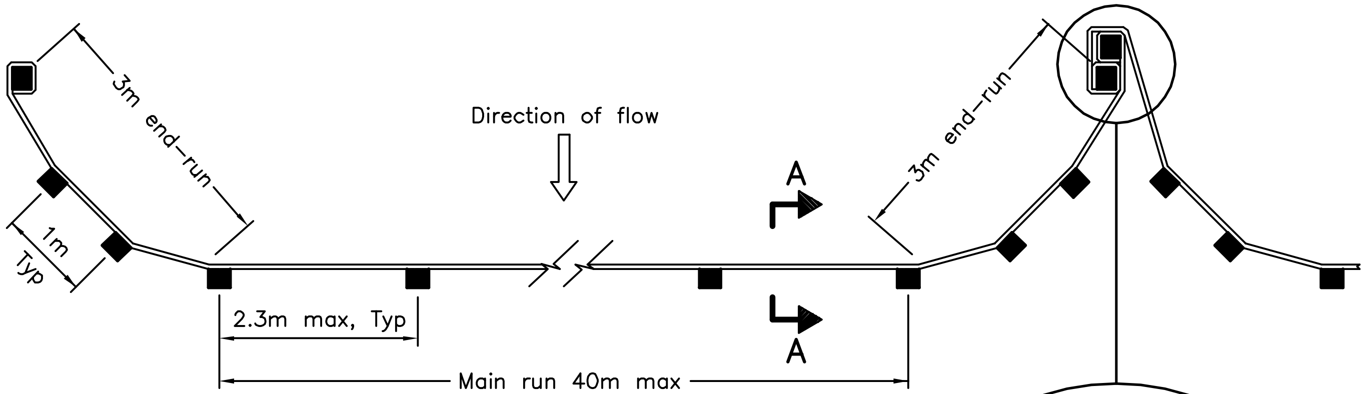
NOTE:

A All dimensions are in millimetres unless otherwise shown.

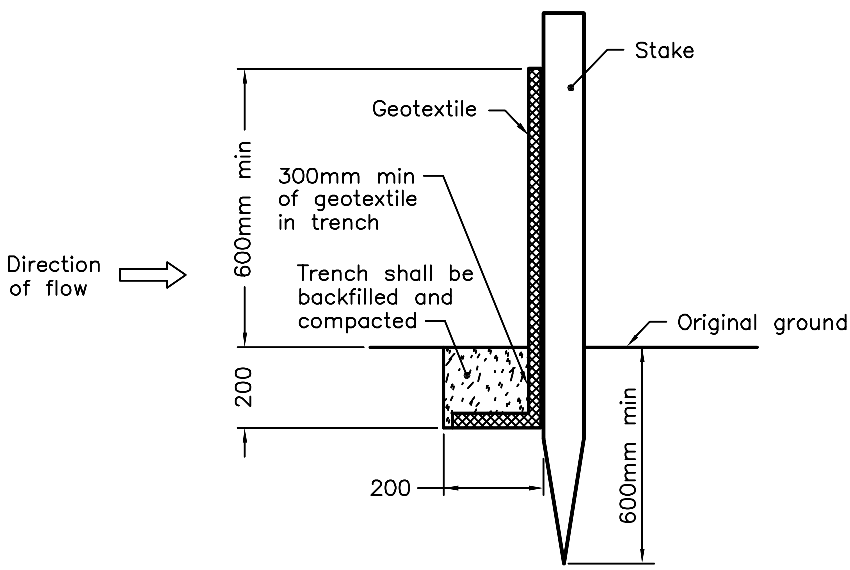
ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
HEAVY-DUTY SILT FENCE BARRIER		OPSD 219.130



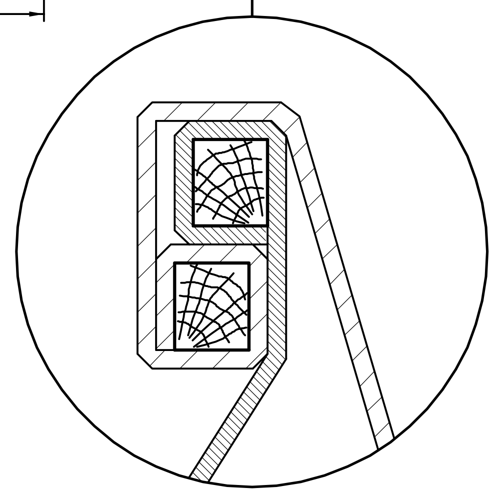
PERSPECTIVE VIEW



PLAN



SECTION A-A

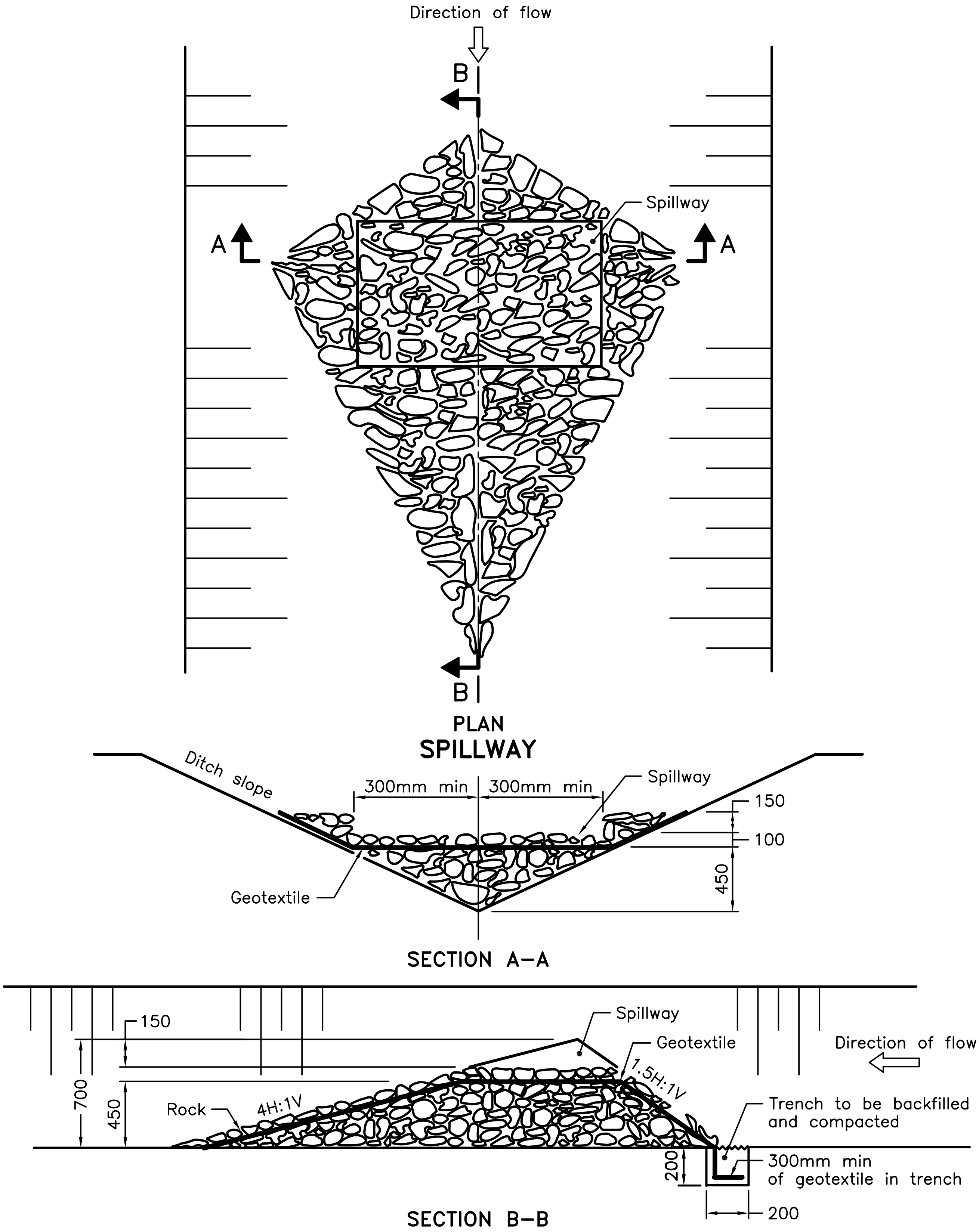


JOINT DETAIL

NOTE:

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2015	Rev 2
LIGHT-DUTY SILT FENCE BARRIER	OPSD 219.110	



NOTE:

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
ROCK FLOW CHECK DAM V–DITCH		
	OPSD 219.210	