Revised Stormwater Management Design Brief

Nautical Lands

Wellings of Picton

March 24, 2021

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1 Background

The 2.6 ha site is located along the west side of County Road 49 in Prince Edward County, approximately 2 km north of Picton. The site is bound by the Millennium Trail to the west, Picton Golf and Country Club to the north, Picton Bay to the east, and the completed Phase 1 development to the south (see Figure 1-1). Phase 1 of the development was completed in 2014 and stormwater management was implemented following the approval of the stormwater management report prepared by WaterPlan Associates in August 2014. The purpose of this SWM design brief is to describe the SWM solution for Phase 3 of the development to address the quality and quantity treatment objectives described below.

1.1 Review of Relevant Documents

The following documents were reviewed to assist with the stormwater management solution proposed for the Wellings of Picton - Phase 3 development. Previous reports were reviewed to understand previous work that has been completed at the site. Guidance documents were referenced to develop SWM to meet the treatment objectives identified in Section 2.

- **HYDROLOGY & HYDRAULICS REPORT** prepared by WaterPlan Associates for the Wellings of Picton Retirement Residence Complex (Phase 1) and submitted to the County of Prince Edward in August of 2014.
- **Stormwater Management Report** prepared by Jewell Engineering Inc. for the Wellings of Picton Retirement Residence Complex – Phase 3 in April of 2016. *Note: The site layout for the proposed Phase 3 development has changed since submission of Jewell's 2016 report. This updated report has been completed to address the updated site layout as of March 2021.*
- **Quinte Conservation Stormwater Management Submission Guidelines** prepared by Quinte Conservation dated May of 2012.
- **Bay of Quinte Implementation Area Stormwater Management Design Guidelines** revised in March of 2006**.**
- **2003 Stormwater Management Planning and Design Manual** prepared by the Ministry of the Environment.
- **1997 Drainage Management Manual** prepared by the Ministry of Transportation.

1.2 Overview of Phase 1 Development (Completed)

The Hydrology & Hydraulics Report prepared by WaterPlan Associates in 2014 for Phase 1 of the Wellings of Picton development addressed stormwater management for this phase of development. Phase 1 included the development of a retirement building, parking areas, and vehicle access routes within a 1.62 ha limit.

The 2014 report confirms that the site is outside of the Hospital Creek watershed and states that Level 1 (Enhanced) quality treatment objectives were required by Quinte Conservation. On-site quantity control was also required by the conservation authority.

Due to land availability constraints, the SWM solution in the 2014 report proposed oil-grit separator (OGS) units for quality control and an underground superpipe storm network system for quantity control.

1.3 Overview of Phase 3 Development (Proposed)

Jewell completed a SWM report in 2016 for an original site plan for Phase 3. In the 2016 report, Jewell proposed parking lot storage to control post-development peak flows to the pre-development condition. An STC 3000 model OGS unit by Stormceptor was proposed to provide 81% particulate removal at a 12-month cleanout frequency. Since the 2016 report, the site layout for Phase 3 has been modified. Therefore, the SWM controls are revised in this report since the parking lot storage that was utilized in the 2016 report is not available with the proposed changes.

The updated site layout for Phase 3 is provided in the design drawings.

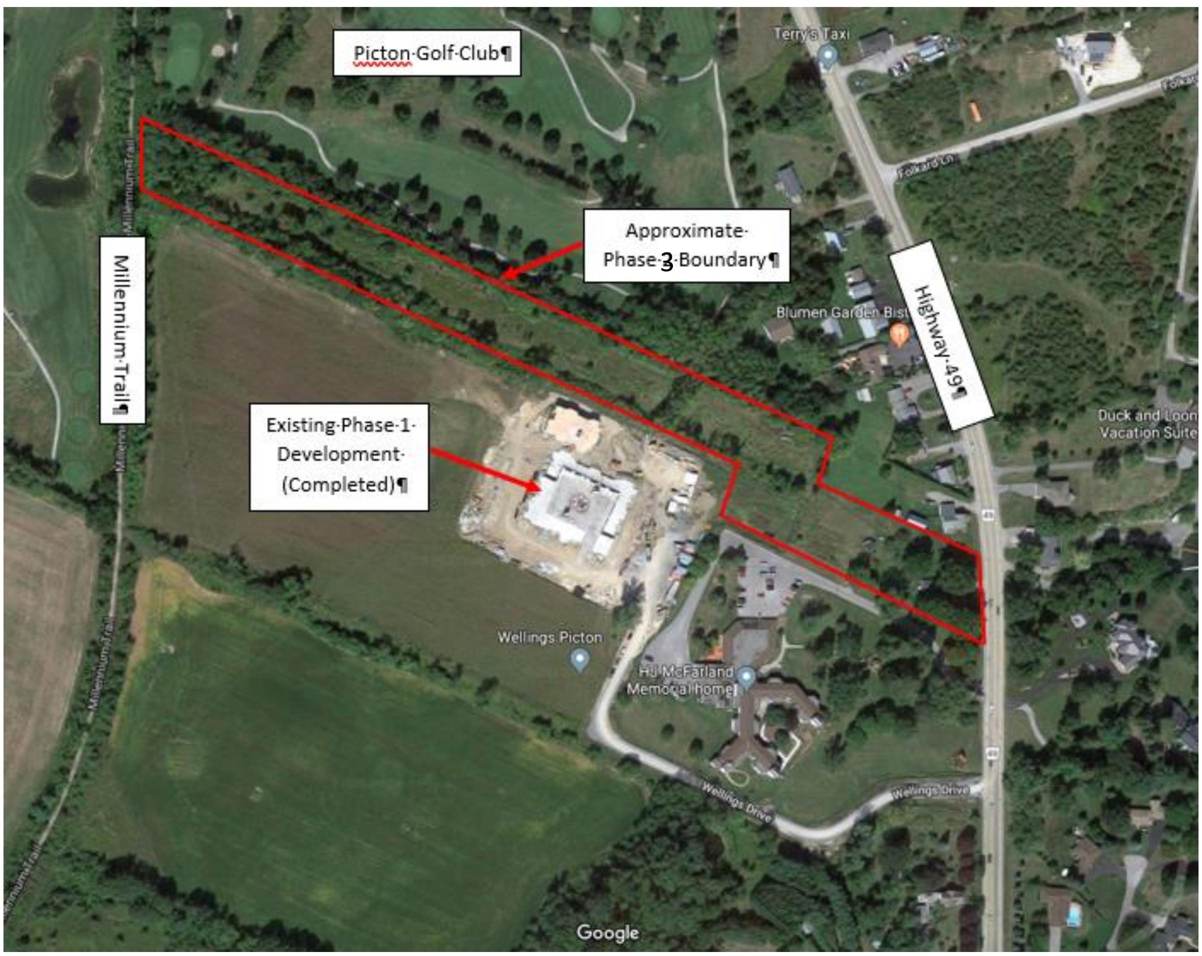


Figure 1-1: Site Location

2 SWM Objectives

By meeting quantity control objectives and providing SWM practices that have water quality benefits, the potential impact on stormwater runoff can be effectively mitigated with the proposed SWM solution. Jewell coordinated with Quinte Conservation in 2018 for assistance in identifying the treatment objectives for the site. The stormwater objectives are summarized below.

Quality Control Objectives

Quality control should be provided to meet Enhanced treatment objectives. Therefore, a minimum of 80% of total suspended solids should be removed from site runoff.

Quantity Control Objectives

For quantity control, post-development peak flows are to be controlled to pre-development conditions. Jewell completed hydrologic simulations with varying return periods and storm durations to ensure quantity control is effectively managed in the proposed SWM solution.

Sediment and Erosion Control during Construction

- Minimize the potential for erosion of soils and construction materials
- Mitigate the release of sediment offsite

3 Methodology

The stormwater management solution was prepared with the understanding of:

- the site hydrology to estimate the peak flows as well as
- hydraulic calculations to determine storage requirements, swale dimensions, and outlet structures.

The methodologies followed for each of the hydrology and hydraulic calculations are provided in this section. The analysis is provided in Section 4.

3.1.1 Precipitation

Rainfall data was obtained from the MTO IDF Look-Up Tool. Coordinates that correspond to the site location are 44˚ 1’ 45” N, 77˚ 8’ 15” W (44.029167, -77137500). A feature of the MTO Look-up Tool is that it allows the user to select anticipated future rainfall data. This data was selected to adjust the sizing of the SWM facilities to accommodate anticipated future rainfall data for the year 2071.

3.1.2 Catchment Area

Catchment areas (A) are determined using topographic data obtained from Jewell survey data and LiDAR information. Catchment areas are specified areas of land that drain to a designated location based on land topography. The land use within the catchment areas define runoff coefficient values. Catchment areas are shown in Appendix A.

In pre-development conditions, runoff drains from the site in three directions before ultimately discharging to the Bay of Quinte. Catchment 100 drains westward towards the Millennium Trail and receives runoff from the external catchment labelled Catchment 301. Catchment 102 drains eastward towards the existing roadside ditch along County Road 49 and receives runoff from an external catchment labelled Catchment 302. Catchment 101 drains northeast towards an existing 800mm circular pipe that crosses County Road 49.

The post-development drainage pattern is discussed in Section 4. With the exception of Catchment 101, the overall drainage pattern is generally maintained with the proposed Phase 3 development. Catchment 101 in the pre-development drawing is directed westward in the post-development catchment drawing as there is no suitable drainage outlet to the north.

3.1.3 Soil Characteristics

The *Geotechnical Investigation* report prepared by Inspec-Sol in 2014 provided soil information for boreholes within the vicinity of the Phase 1 boundaries. Since Phase 1 is adjacent to Phase 3, Jewell used this information to investigate soil characteristics.

Borehole information from the 2014 Inspec-Sol report show that the soils are generally comprised of sandy clay, silty clay, or clayey silt. Several boreholes were noted to have practical auger refusal between depths of 1-3m. *Design Chart 1.08* of the MTO DMM suggests that these soil types would be categorized as Hydrologic Soils Group (HSG) C or D. Additionally, Jewell’s 2016 SWM report noted that the land cover at the site is undeveloped although it would have been in agricultural use in the not too distant past.

3.1.4 Runoff Coefficient

Runoff coefficients (C) are determined by a ratio of the depth of runoff from a drainage basin to the depth of rainfall, and indicating the runoff potential of particular topography/soil type/ land use combination (MTC).

The time of concentration varies with runoff coefficient. The runoff coefficient is calculated using a weighted average and the values provided in MTO *Design Chart 1.07* (Ontario Ministry of Transportation, 1997). Equation 4 is used to calculate the weighted runoff coefficients shown in Tables 3-5 and 3-6. A runoff coefficient of 0.6 was applied for multiple, detached units as per *MTO Design Chart 1.07*.

Equation 1: Weighted Runoff Coefficient

$$C_w = \frac{C_1\, x\, A_1 + \; C_2\, x\, A_2 + \; \ldots\; C_n\, x\, A_n}{A_1 + \; A_2 + \; \ldots\; A_n}$$

Where:

C_i = Runoff Coefficient for A_i
A_i = Land Area (ha) of Cover Type

As per Chapter 8, P. 19 of the MTO DMM, the runoff coefficient was increased for major storm events (i.e. 25, 50, and 100-yr) by 10-25%. This provides conservatism in sizing of conveyance facilities as well as the stormwater storage basin.

3.1.5 Time of Concentration

The Airport Method was selected to determine the time of concentration (Tc) for pre-development and external catchments since the runoff coefficient is less then 0.4 (Ontario Ministry of Transportation, 1997). A time of concentration of 15 minutes was assumed for post-development catchment areas (see Tables 3-1 and 3-2.

Table 3-1: Pre-Development Time of Concentration and Lag Time Summary

Catchment	Area (ha)	Watershed Length (m)	Elevation at 85% (m)	Elevation at 10% (m)	Slope (%)	RC	T_c (min)
100	1.12	175	95.00	93.00	1.5	0.25	31.8
101	1.04	185	95.50	94.00	1.1	0.25	36.7
102	0.65	125	94.50	91.00	3.7	0.25	20.1
300	0.54	118	96.25	94.60	1.9	0.30	23.1
301	0.24	105	94.50	93.25	1.6	0.33	22.1

Table 3-2: Post-Development Time of Concentration and Lag Time Summary

Catchment	Area (ha)	Watershed Length (m)	Elevation at 85% (m)	Elevation at 10% (m)	Slope (%)	RC	T_c (min)
100	0.47	-	-	-	-	0.60	15.0
101	1.42	-	-	-	-		
102	0.82	-	-	-	-		
103	0.04	-	-	-	-		
300	0.54	118	96.25	94.60	1.9	0.30	23.1
301	0.24	105	94.50	93.25	1.6	0.33	22.1

3.1.6 Hydrology Input Summary

The hydrology inputs discussed in this section are summarized in Table 3-3 for pre-development conditions and Table 3-4 for post-development conditions.

Table 3-3: Pre-Development Hydrology Input Summary

Catchment	Area (ha)	RC	T_c (min)
100	1.12	0.25	31.8
101	1.04	0.25	36.7
102	0.65	0.25	20.1
301	0.54	0.30	23.1
302	0.24	0.33	22.1

Table 3-4: Post-Development Hydrology Input Summary

Catchment	Area (ha)	RC	T_c (min)
100	0.47	0.60	15.0
101A & 101B	1.42		
102	0.82		
103	0.04		
301	0.54	0.30	23.1
302	0.24	0.33	22.1

3.2 Hydraulics

Hydraulic calculations were completed for the SWM facility outlets, overflow spillway, and grass swales.

3.2.1 Broad-Crested Weir Equation

The broad-crested weirs used for the overflow spillways were sized using Equation 2.

Equation 2: Broad-Crested Weir Formula

$$Q = 1.67LH^{3/2}$$

Where:

Q = Flow (m^3/s)
L = Length of Weir (m)
H = Depth of flow (m)

3.2.2 Orifice Equation

The outlet control structures for the SWM facilities were determined using Equation 3.

Equation 3: Orifice Equation

$$Q = CAo(2gh)^{0.5}$$

Where:

Q = Flow (m^3/s)
C = Coefficient of discharge (0.6)
Ao = Area of orifice opening (m^2)
g = acceleration due to gravity ($9.81 m/s^2$)
H = Head measured from centroid of orifice (m)

3.2.3 Manning's Open Channel Flow

JE sized the grassed swales using Manning's open channel flow (see Equation 4 & Appendix E).

Equation 4: Manning's Open Channel Flow

$$Q = 1/n\ AR^{2/3}S^{1/2}$$

Where:

n = roughness coefficient
A = area (m^2)
R = hydraulic Radius (m)
S = slope

4 Stormwater Management Solution

The following sections describe the proposed SWM solution for Phase 3 of the Wellings of Picton development.

4.1 Overview

The proposed SWM solution utilizes pre-treatment sumps, enhanced grassed swales, and storage basins to achieve the objectives identified in Section 2. The storage facilities are controlled by outlet structures with simulated outflows using the equations in Section 3. A relatively small storm sewer pipe network is used to convey a portion of runoff from catchments contributing to the east SWM facility (see Appendix B).

The purpose of the storage facilities is to provide **quantity control** by reducing post-development peak flows to the pre-development condition. Pre-treatment sumps and enhanced grassed swales are proposed to provide **quality control**.

The proposed SWM solution was selected after consideration of other SWM alternatives. Common SWM technologies include wet ponds, dry ponds, and infiltration facilities. Since this is a 2.6 ha site, a traditional wet pond or dry pond is not recommended based on MOE guidance and land availability constraints. OGS units were not selected due to the drainage divide that results in small drainage areas that would reduce their efficiency and sediment capture potential for this SWM solution.

Infiltration is often a preferred SWM technique for small sites. However, borehole results from the *Geotechnical Investigation* report prepared by Inspec-Sol in 2014 suggests bedrock exists at shallow depths. Since infiltration techniques require a minimum 1m buffer from the bottom of facility to the top of bedrock, infiltration should not be selected as the individual treatment method for this site.

4.2 Site Drainage (Existing vs. Proposed)

The site drainage in existing and proposed conditions is described below.

Site drainage in existing conditions is summarized in the pre-development catchment area drawing (see Appendix A). As described in Section 3.1.2, runoff drains from the site in three directions before ultimately discharging to the Bay of Quinte. Catchment 100 drains westward towards the Millennium Trail and receives runoff from the external catchment labelled Catchment 301. Catchment 102 drains eastward towards the existing roadside ditch along County Road 49 and receives runoff from an external catchment labelled Catchment 302. Catchment 101 drains northeast towards an existing 800mm circular pipe that crosses County Road 49.

After the development, runoff will drain to the two outlet locations as shown in Figure 4-1. Outlet 1 is located at the west end of the site and drains to the ditch alongside the existing Millennium Trail. Outlet 2 is located at the east end of the site and drains to the roadside ditch at County Road 49.

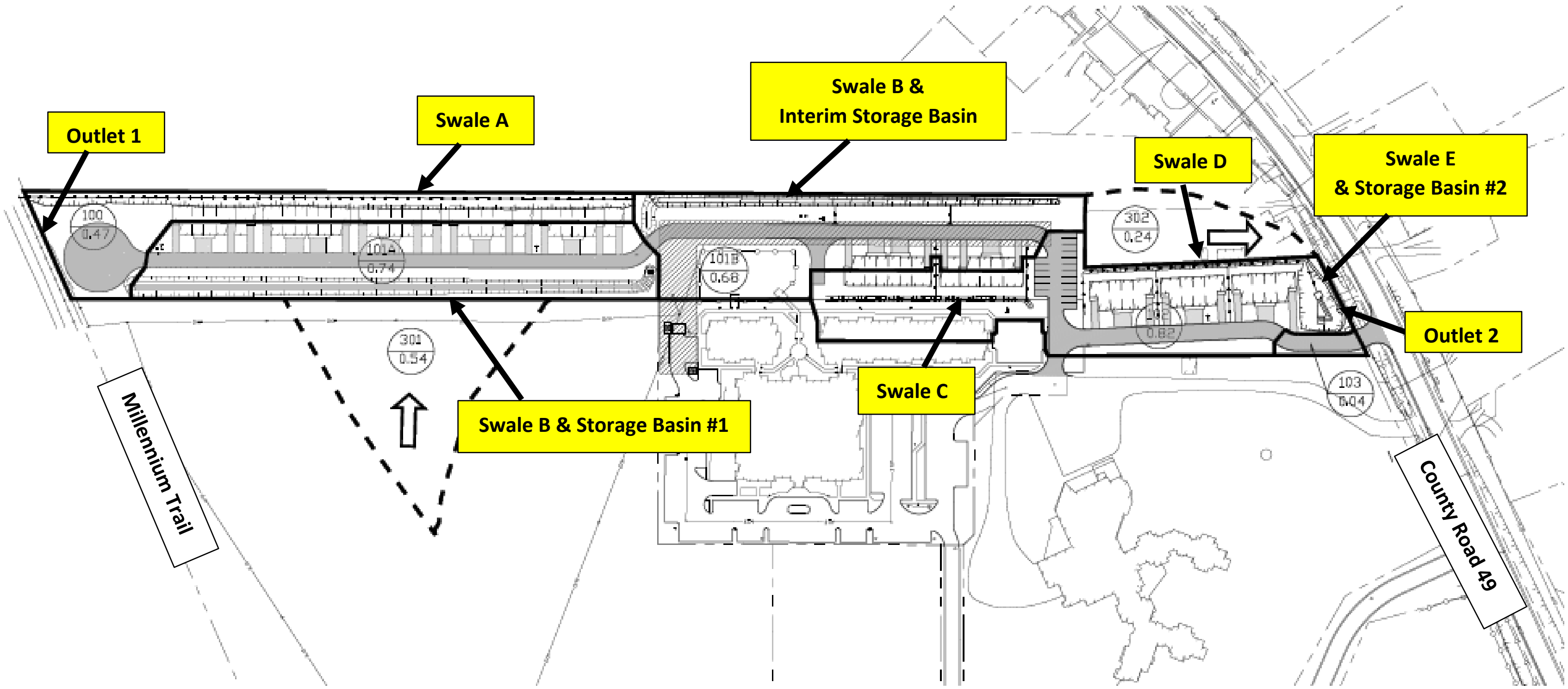


Figure 4-1: Summary of Grassed Swale and Outlet Locations with Proposed Phase 3 Development

4.3 Quality Control

Jewell selected pre-treatment sumps and enhanced grassed swales to provide quality control. Enhanced grassed swales are suitable as they provide filtration benefits and do not solely rely on infiltration. They are appropriate for this site based on the size of the receiving catchments and relatively low anticipated sediment loading rates.

Sumps that are 3m wide x 3m long x 0.5 m deep and filled with clearstone are recommended for pre-treatment. The sumps are located at the upstream end of Storage Basin #1 (West) and Storage Basin #2 (East). For Storage Basin #2, there are two sumps; one located at the downstream end of Swale D and one at the storm sewer outlet that functions as an inlet to the storage basin. The purpose of these sumps is to remove larger sediment particles as pre-treatment prior to entering the main cell of the storage basin. They provide pre-treatment for the enhanced grassed swales located downstream of the sumps.

4.3.1 Enhanced Grassed Swales

Enhanced grassed swales are intended to achieve water quality benefits through infiltration and filtration of pollutants that are typically found in SWM runoff. Storage Basins #1 and #2 have channelized sections that meet enhanced grassed swale criteria as per the 2003 MOE Manual. These swales are sized to convey the 25mm quality event with a flow velocity equal to or less than 0.5 m/s to allow filtration and filtration benefits (see Appendix E).

The 2003 MOE Manual indicates that grassed swales are most effective for water quality control when the bottom width is maximized (≥ 0.75m), longitudinal slope is minimized (≤1 percent), and when the velocity is less than 0.5 m/s. Due to the shallow longitudinal slopes, flow check dams are not required.

A comparison of design parameters for the enhanced grassed swale to the guidelines in MOE, CVC, and TRCA documents is provided in Table 4-1. Table 4-1 shows that the proposed swale has been sized in accordance with these guidelines. For small catchment areas (< 2 ha), grassed swales can remove approximately 81% of TSS (United States Environmental Protection Agency, 1999)

The proposed treatment methods follow relevant agency guidance and are expected to achieve 80% or greater TSS removal (i.e. enhanced treatment). Therefore, quality treatment objectives are met.

Table 4-1: Comparison of Proposed Swale Dimensions to Guidance from Relevant Agencies

Parameter	Recommended	Swale B	Swale E	Check:
Drainage Area (ha)	< 2	1.42	1.06	✓
Flat Bottom Width (m)	≥ 0.75	0.75	0.75	✓
Longitudinal Slope (%)	≤ 1	0.3	0.5	✓
Velocity in 25mm event (m/s)	≤ 0.5	0.51	0.46	✓

4.4 Quantity Control

The quantity objective is to control post-development peak flows to the pre-development condition. Pre-development peak flows were calculated using the Rational Method and the pre-development input parameters were summarized in Table 3-3. Post-development peak flows were calculated based on the input parameters in Table 3-4.

4.4.1 Pre-Development vs. Uncontrolled Post-Development Peak Flows

JE prepared a comparison of existing peak flows to uncontrolled post-development peak flows using the Rational Method (see Tables 4-2 and 4-3). Pre-development peak flows represent flow rates that should not be exceeded with the proposed development. The uncontrolled post-development discharge rates are greater than pre-development flows due to an increase in impervious surface cover. **Therefore, quantity controls are required.**

Table 4-2: Pre-Development and Uncontrolled Post-Development Peak Flows at Outlet 1 (West)

Return Period	Q_{pre}	$Q_{post\ (uncontrolled)}$
	cms	
2	0.04	0.20
5	0.05	0.26
10	0.06	0.30
25	0.08	0.39
50	0.10	0.47
100	0.11	0.54

Table 4-3: Pre-Development and Uncontrolled Post-Development Peak Flows at Outlet 2 (East)

Return Period	Q_{pre}	$Q_{post\ (uncontrolled)}$
	cms	
2	0.03	0.09
5	0.04	0.12
10	0.05	0.14
25	0.07	0.18
50	0.08	0.21
100	0.09	0.25

4.4.2 Controlled Peak Flows

Quantity control is achieved with Storage Basin #1 (West) and Storage Basin #2 (East). These detention basins attenuate post-development flows to pre-development release rates. The Modified Rational Method (MRM) was used to determine storage requirements (see Appendix C) and outlet sizes. The MRM was selected for this site as it is relatively small (< 5 ha).

Two outlet pipes are recommended to control pond outflows at each basin. An orifice is used to control minor storm events and low flows. A second, larger pipe is used to control major flows.

The size of the basins is determined based on a stage-storage-discharge (SSD) relationship. The storage calculation for each facility was prepared using incremental CAD volumes. The orifice equation is applied to determine outflows at varying elevations and storage volumes. The SSD relationship is used to ensure the storage provided at the target release rate exceeds the storage requirement obtained from the MRM.

Tables 4-4 and 4-5 provide a summary of target release rates, storage required, and storage provided. The storage provided exceeds the storage required to meet the target release rates for each return period event. **Therefore, Storage Basin #1 and Storage Basin #2 are appropriately sized to meet quantity control objectives.**

Summary table for Storage Basin #1 (West):

Table 4-4: Summary of Controlled Outflows, Storage Required and Provided for Each Return Period Event at Outlet 1

Return Period	Q_{pre}	$Q_{east\ SWM\ facility}$	*Storage Required (m^3)	Storage Provided (m^3)
2	0.04	0.04	166	232
5	0.054	0.054	213	330
10	0.062	0.062	246	368
25	0.08	0.08	315	433
50	0.097	0.097	381	487
100	0.111	0.111	432	557

**Storage required calculated using 2071 MTO IDF Look-Up Data*

Summary tables for Storage Basin #2 (East):

Table 4-5: Summary of Controlled Outflows, Storage Required and Provided for Each Return Period Event at Outlet 2

Return Period	Q_{pre}	$Q_{103\ (uncontrolled)}$	$Q_{west\ SWM\ facility}$	Q_{Total}	*Storage Required (m^3)	Storage Provided (m^3)
2	0.033	0.004	0.029	0.033	42	89
5	0.044	0.005	0.039	0.044	55	98
10	0.051	0.006	0.045	0.051	63	104
25	0.066	0.007	0.059	0.066	81	110
50	0.080	0.009	0.071	0.080	98	116
100	0.092	0.010	0.082	0.092	111	122

**Storage required calculated using 2071 MTO IDF Look-Up Data*

A summary of storage basin elevations is provided in Section 7.

4.4.3 Interim SWM Facility

Storage Basin #1 (west) will not be implemented until full built out of the development lands. An interim basin will be provided with outlet controls until the west portion of the development (Catchment 101A in Appendix B) is constructed.

The interim basin is sized to control post-development peak flows from Catchment 101B to pre-development levels. The area identified as Catchment 101B generally drains north in existing conditions. Since this area does not drain to a recognized outlet, the controlled outflows from the interim basin are re-directed west and follow Swale B until discharging at the Millennium Trail.

While the interim basin attenuates post peak flows to pre-development levels, the change in drainage path will result in a temporary and slight increase in runoff towards Millennium Trail. This was selected as it is the only viable option for temporary SWM controls and does not present a drainage concern due to the small size of this interim drainage area (0.68 ha) and the relatively small controlled outflows. In full build-out conditions, Storage Basin #1 provides over-control to ensure no increase in overall runoff towards the Millennium Trail.

A summary of release rates and storage volumes for the interim facility is provided below.

Table 4-6: Summary of Controlled Outflows, Storage Required and Provided for Each Return Period Event for Interim West Facility

Return Period	Q_{pre}	$Q_{post\ (controlled)}$	*Storage Required (m^3)	Storage Provided (m^3)
2	0.014	0.014	50	67
5	0.018	0.018	65	90
10	0.021	0.021	75	104
25	0.028	0.028	94	121
50	0.033	0.033	115	133
100	0.038	0.038	131	145

Storage required calculated using 2071 MTO IDF Look-Up Data

The interim west SWM facility will provide similar water quality benefits as the permanent storage basin as it has dimensions that meet enhanced grassed swale requirements.

5 Conveyance

There is a total of five swales that are proposed to convey on-site runoff. These swales are shown in Figure 4-1 and their purpose is summarized in Table 5-1. Swale sizing calculations are provided in Appendix E.

Swales A, C, and D are provided for conveyance purposes. Swales B and E are part of the SWM Facilities and intended for quality treatment purposes.

Table 5-1: Summary of Swale Dimensions and Purpose

Swale	Dimensions	Purpose
A	V-shape, 3:1 side slopes	Receive drainage from Catchment 100 and drain towards Millennium Trail
B	Min. 0.75m bottom width, 3:1 side slopes	Enhanced grassed swale for quality treatment within Storage Basin #1
C	V-shape, 3:1 side slopes	Receive drainage from rear-yards for some lots within Catchment 102
D	V-shape, 3:1 side slopes	Receives drainage from Catchment 201 and from rear yards of some lots within Catchment 102
E	Min. 0.75m bottom width, 3:1 side slopes	Enhanced grassed swale for quality treatment within Storage Basin #2

A storm sewer network is provided for a portion of runoff contributing to the east storage basin. The storm sewer network is sized for the 5-yr return period. A storm sewer catchment drawing and storm sewer design sheet are provided in Appendix B.

6 Sediment and Erosion Control

Typical site development will remove much of the vegetated cover. While it is the intention to reduce vegetation removal, exposed soils from the work will be at risk of eroding into the receiving drainage system. Heavy duty silt fences and straw bale check dams are thus proposed for the site and shall be placed in all areas downgradient from the worksite to control sediment runoff. These measures will be required to be put in place to reduce erosion during construction and for a period of up to one year after construction is completed. Sediment and erosion controls should remain in place until the site has become stabilized after the construction period.

7 Maintenance Plan

The following sections provide basic instructions on good maintenance for the east and west SWM facilities.

7.1 Routine Maintenance

Once per month, the pond operators should perform a visual check including observations of:

- trash or debris collecting in the pond
- Water level between events and compare with expected levels
- Evidence of erosion

Pond operators should remove any trash that may be impeding the pond outlet structures. During and after a large rainfall event the operator should also perform a visual check to see that pond elevations are within expected levels.

7.2 Infrequent Maintenance

The storage basin facilities will collect sediment in proportion to the construction activity or winter road maintenance of the upstream catchment area. It is recommended the site owners remove accumulated sediment from the dry ponds as sediment begins to accumulate near the outlet structure, or if an average depth of sediment exceeds 0.2m. Sediment removal may be completed with an excavator or back hoe.

The facilities should be restored to their original configuration ensuring the basic elevations are maintained as given in the design drawings and summarized below.

West SWM Facility Pond Features:

- Bottom of pond: 92.50m
- 150mm orifice invert: 92.50m
- 300mm pipe invert: 93.20m
- Invert of Emergency Spillway: 93.70m
- Top of Freeboard: 94.00m
- Side slopes: 3:1

East SWM Facility Pond Features:

- Bottom of Pond: 90.25m
- 100mm orifice invert: 90.25m
- 300mm pipe invert: 91.15m
- Invert of Emergency Spillway: 91.45m
- Side slopes: 3:1

Interim West SWM Facility Pond Features:

- Bottom of Pond: 93.50m
- 100mm orifice invert: 93.50m
- 200mm orifice invert: 94.00m
- Invert of Emergency Spillway: 94.20m
- Side slopes: 3:1

7.3 Troubleshooting

Some basic issues that can develop with a pond and the remedies are described below.

7.3.1 Symptom – Pond is not emptying

The lower elevation outlets provide outflow control for frequent storm events and may become blocked with debris and should be monitored after every large runoff event. Observe that the pond is not overfilling and that it is also emptying out between events. Full storage for the 100-yr event should be should not be spilling over the emergency weir.

7.3.2 Symptom – Pond routinely overfills

If the stored water discharges through the emergency spillway the cause is blockage of the low flow. It requires cleanout.

8 Conclusions

Jewell has prepared this stormwater management (SWM) report for the proposed 2.6 ha Phase 3 development at the Wellings of Picton site. The proposed Phase 3 site layout is a residential development that includes townhouses and an access road. The objective of this report is to propose a SWM solution that meets the following SWM objectives.

- The **quality control** objective is to achieve Enhanced protection. Therefore, a minimum of 80% removal of TSS is recommended.
- The **quantity control** objective is to reduce post-development peak flows to the pre-development peak flows.
- **Sediment and erosion controls** should be provided during construction to minimize the potential for erosion of soils and construction materials. The release of sediment offsite should also be mitigated by sediment and erosion controls.

Sections 3 and 4 discussed the site drainage under existing and proposed conditions as well as quality and quantity control measures. For site drainage, pre-development and post-development catchment drawings are provided in Appendix A.

Quality treatment is achieved with pre-treatment sumps and enhanced grassed swales as described in Section 3. Quantity control is achieved with Storage Basin #1 (west) and Storage Basin #2 (east). JE applied the Modified Rational Method since the site is relatively small (< 5 ha). The stage-storage-discharge relationship was derived using incremental CAD volumes and the equations discussed in Section 3.2. The emergency spillways were sized to convey uncontrolled post-development peak flows in the event of blockage of the outlet pipes.

The proposed SWM solution satisfies the above SWM objectives.

Prepared by:

Elliott Fledderus, P. Eng.
Jewell Engineering Inc.

9 References

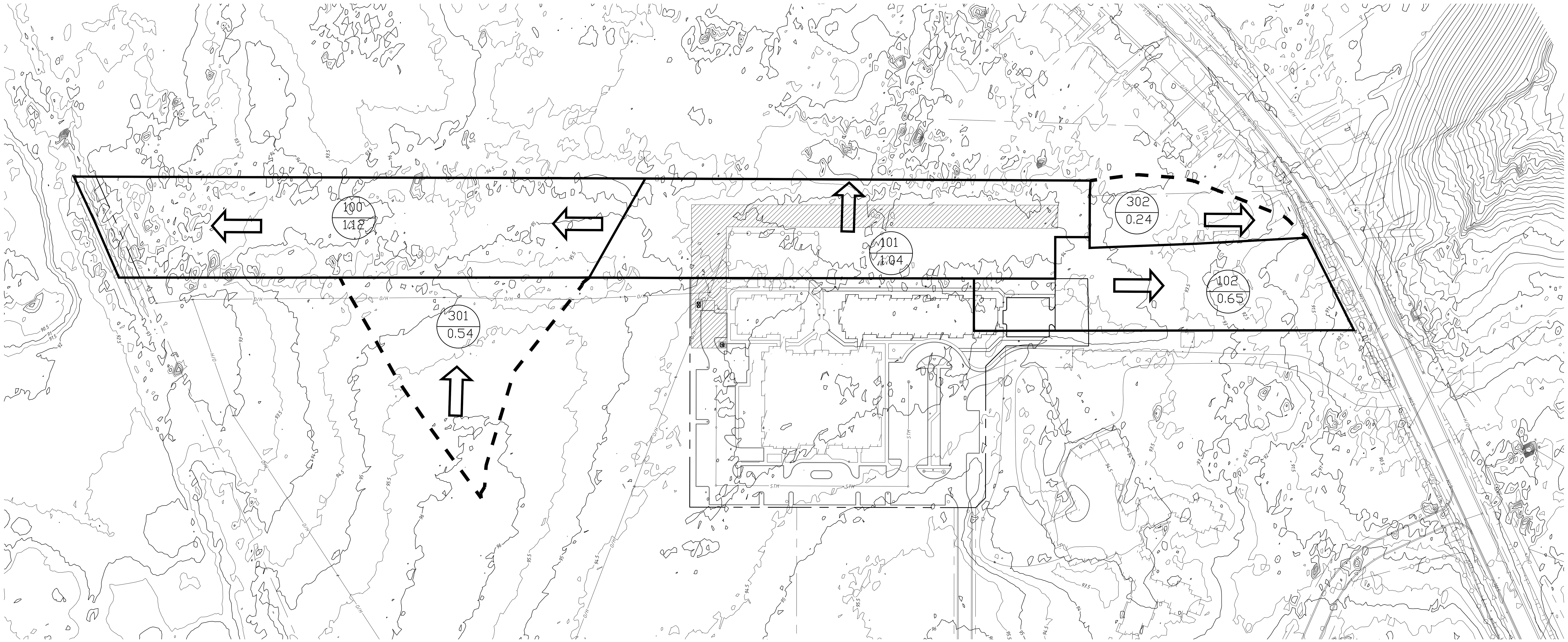
Ontario Ministry of the Environment. (2003). *Stormwater Management Planning and Design Manual.* Queen's Printer for Ontario.

Ontario Ministry of Transportation. (1997). *Drainage Management Manual.*

Appendix A

Catchment Area Drawings

03/24/2021



GENERAL NOTES:

ALL INFORMATION TO BE VERIFIED ON SITE PRIOR TO COMMENCING ANY WORK. ANY DISCREPANCIES ARE TO BE REPORTED TO THE CONSULTANT IMMEDIATELY.

ALL UTILITY LOCATIONS SHOWN ON THE DRAWINGS ARE APPROXIMATE. THE CONTRACTOR SHALL CONFIRM THE LOCATION ON SITE AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES.

EXCLUDING THE BENCHMARK AND DESCRIPTION PROVIDED FOR THIS PROJECT, NO OTHER ELEVATIONS ARE TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE.

METRIC NOTE:

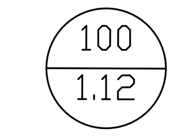
ALL DIMENSIONS SHOWN ARE IN METRES OR MILLMETRES, UNLESS OTHERWISE NOTED.

* * DRAWINGS ARE NOT TO BE SCALED * *

REVISIONS

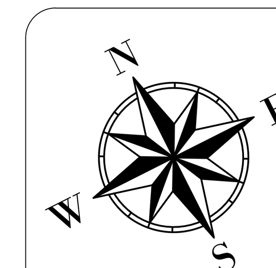
NO.	DATE	DESCRIPTION	BY
1	03/16/2019	ISSUED FOR SITE PLAN	
2	05/23/2019	REVISION PER CITY COMMENTS	CD
3	09/13/2020	CONCEPT REVISIONS	DFM
4	03/10/2021	CONCEPT REVISIONS	JH
5	03/24/2021	SITE PLAN SUBMISSION #1	JH

LEGEND



CATCHMENT ID

CATCHMENT AREA (ha)



JEWELL ENGINEERING

NAUTICAL LANDS GROUP
THE WELLINGS OF PICTON

PHASE 3

PRINCE EDWARD COUNTY

STORM CATCHMENT
PRE-DEVELOPMENT

DRAWN BY: JH	PROJECT NO: 180-4466	
DESIGNED BY:	DATE: March 2021	
CHECKED BY: BK	SCALE: HORIZONTAL - 1:1000 VERTICAL - N/A	
APPROVED BY:	CONTRACT NO:	DRAWING NO: ST-1

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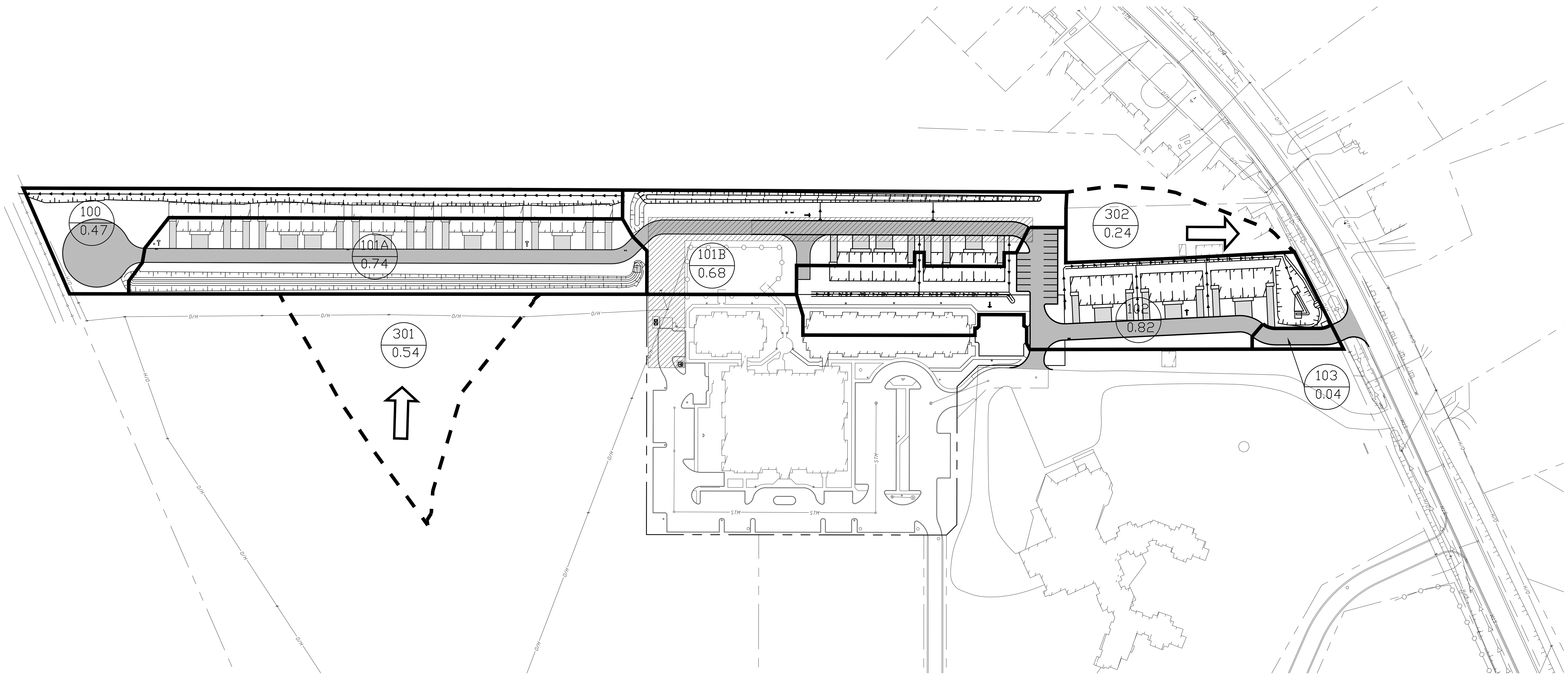
03/24/2021



GENERAL NOTES:

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METRIC NOTE:

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REVISIONS

NO.	DATE	DESCRIPTION	BY
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4	03/10/2021	CONCEPT REVISIONS	JH
5	03/24/2021	SITE PLAN SUBMISSION #1	JH

LEGEND

100 — CATCHMENT ID
0.47 — CATCHMENT AREA (ha)

N E S W

JEWELL ENGINEERING

NAUTICAL LANDS GROUP
THE WELLINGS OF PICTON

PHASE 3

PRINCE EDWARD COUNTY

STORM CATCHMENT
POST-DEVELOPMENT

DRAWN BY: JH
PROJECT NO: 180-4466
DESIGNED BY:
DATE: March 2021
CHECKED BY: BK
SCALE: HORIZONTAL - 1:1000; VERTICAL - N/A
APPROVED BY:
CONTRACT NO:
DRAWING NO: ST-2

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Appendix B

Storm Sewer Design Sheet & Catchments for Pipe Network to East SWM Facility

STORM SEWER DESIGN SHEET FOR NETWORK TO EAST SWM FACILITY - NAUTICAL LANDS Phase 3

Peak Runoff Estimate by Rational Method

$$Q = \frac{1}{360} C\, i\, A$$

Where:

Q = Peak Flow in cms
C = Runoff Coefficient
i = Rainfall Intensity in mm/hr
A = Area in hectares

Intensity for Belleville

$$i = A \cdot t^{B}$$

Where:

i = Rainfall Intensity in mm/hr
t = Time of Concentration in hours

5-Year Parameters

A = 28
B = -0.699

Manning's Coef

CSP 0.024
RCP/PVC 0.013

Pipe Capacity by Manning's Equation

$$Q = \frac{1}{n} A\, R^{2/3}\, S^{1/2}$$

Where:

A = area of pipe in m^2
R = Hydraulic radius = A / P
P = Wetted perimeter
S = Slope (m/m)
n = Manning's friction coef.

Check

$q \leq Q$
$V \leq 6\ m/s$

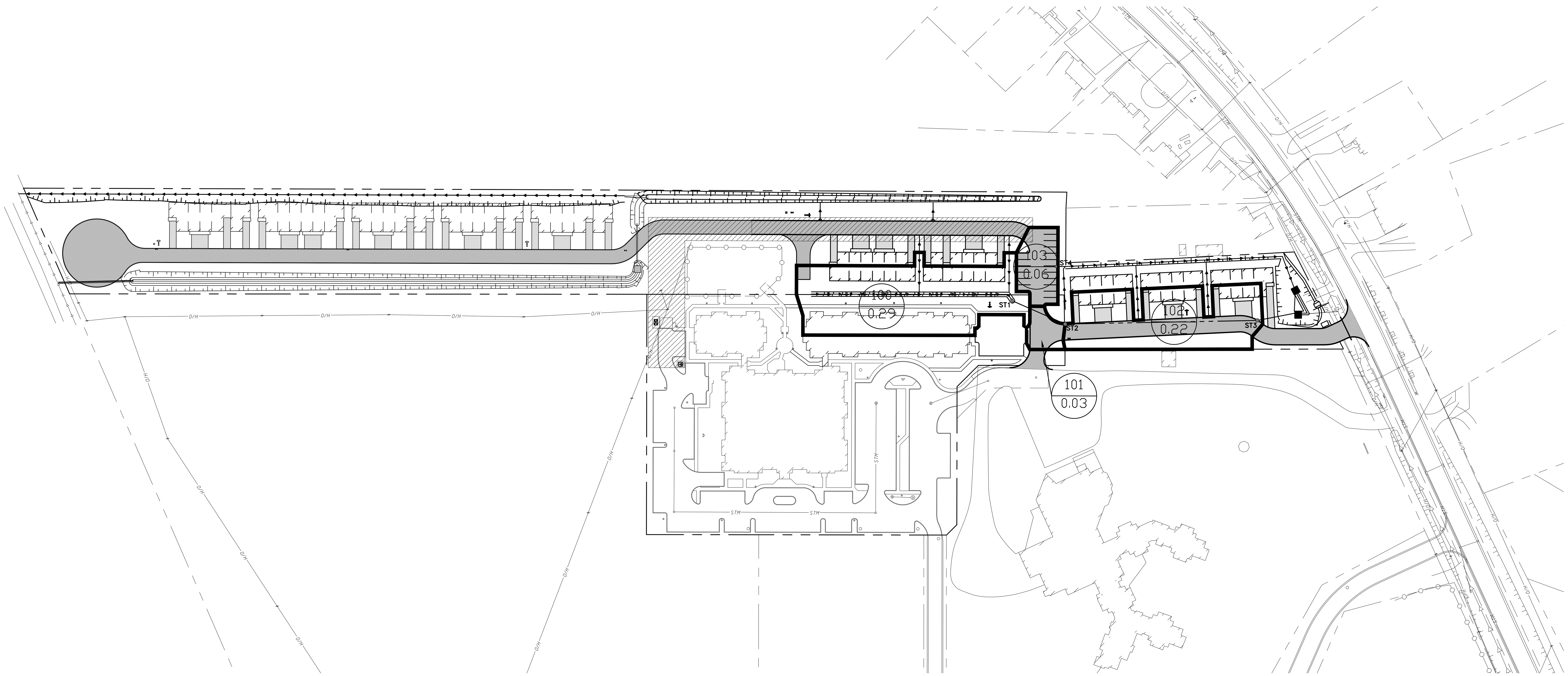
LOCATION			PEAK FLOW CALCULATION									PROPOSED SEWER									
CATCHMENT	FROM	TO	CATCHMENT AREAS RUNOFF COEFFICIENT 0.35	0.45	0.6	0.9	R.C. x A (ha)	CUM. R.C x A (ha)	TIME OF CONCENTRATION (min)	INTENSITY (mm/hr)	PEAK FLOW (m^3/s)	Pipe Size (mm)	Length (m)	Type of Pipe	Grade *(use m/m)* (%)	Capacity, n = 0.013 (m^3/s)	Full Flow Velocity (m/s)	Time of Flow (min)	Actual Velocity at Q_d (m/s)	Check Capacity
100	ST1	ST2			0.29		0.17	0.2	10.0	98.0	0.05	300	24.2	PVC	2.00%	0.14	1.93	0.21	1.75	OK
101	ST2	ST3				0.03	0.03	0.0	10.2	96.6	0.01	300	83.9	PVC	2.50%	0.15	2.16	0.65	1.09	OK
102	ST3	East Pond Inlet				0.22	0.20	0.2	10.9	92.5	0.05	300	16.5	PVC	2.28%	0.15	2.07	0.13	1.87	OK
103	ST4	Swale				0.06	0.05	0.1	10.0	98.0	0.01	300	4.2	PVC	0.50%	0.07	0.97	0.07	0.77	OK

Jewell Engineering Inc Ph. 613-969-1111
1-71 Millennium Parkway Fx. 613-969-8988
Belleville, ON, K8N 4Z5 www.jewelleng.ca

Designed: Julie Humphries, C.E.T.
Checked: Elliott Fledderus, P.Eng.
Date: Wednesday, March 24, 2021

Project:
Nautical Lands - Wellings of Picton - Phase 3
Prince Edward County

03/24/2021



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REVISIONS

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3	09/13/2020	CONCEPT REVISIONS	DFM
4	03/10/2021	CONCEPT REVISIONS	JH
5	03/24/2021	SITE PLAN SUBMISSION #1	JH

LEGEND

100 — CATCHMENT ID

0.29 — CATCHMENT AREA (ha)

N E S W

JEWELL ENGINEERING

NAUTICAL LANDS GROUP
THE WELLINGS OF PICTON

PHASE 3

PRINCE EDWARD COUNTY

STORM CATCHMENT
STORM NETWORK

DRAWN BY: JH
PROJECT NO: 180-4466
DESIGNED BY:
DATE: March 2021
CHECKED BY: BK
SCALE: HORIZONTAL - 1:1000, VERTICAL - N/A
APPROVED BY:
CONTRACT NO:
DRAWING NO: ST-3

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Appendix C

Modified Rational Method Spreadsheet and Calculations

Intensity (MM/HR) - from 2071 MTO IDF Look-Up Tool Rainfall Data							
DURATION		2	5	10	25	50	100
5 MIN	5	125.6	164.8	190.4	222.8	247.2	270.5
10 MIN	10	77.9	102.1	117.8	137.8	152.8	167.2
15 MIN	15	59	77.2	89	104	115.4	126.2
30 MIN	30	36.7	47.9	55.2	64.4	71.4	78
1 H	60	22.8	29.7	34.2	39.9	44.2	48.3
2 H	120	14.2	18.4	21.2	24.7	27.4	29.9
6 H	360	6.7	8.7	10	11.6	12.8	14
12 H	720	4.2	5.4	6.2	7.2	8	8.7
24 H	1440	2.6	3.4	3.9	4.5	5	5.4

West Facility:

2-Yr:

Area = 2.43 ha Required Release Rate = 0.04 cms
C = 0.53
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	125.6	0.452	0.040	0.412	124
10	77.9	0.280	0.040	0.240	144
15	59	0.212	0.040	0.172	155
30	36.7	0.132	0.040	0.092	166
60	22.8	0.082	0.040	0.042	151
240	14.2	0.051	0.040	0.011	160

5-Yr:

Area = 2.43 ha Required Release Rate = 0.05 cms
C = 0.533333
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	164.8	0.593	0.054	0.539	162
10	102.1	0.368	0.054	0.314	188
15	77.2	0.278	0.054	0.224	202
30	47.9	0.172	0.054	0.118	213
60	29.7	0.107	0.054	0.053	191

10-Yr:

Area = 2.43 ha Required Release Rate = 0.06 cms
C = 0.533333
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	190.4	0.685	0.062	0.623	187
10	117.8	0.424	0.062	0.362	217
15	89	0.320	0.062	0.258	233
30	55.2	0.199	0.062	0.137	246
60	34.2	0.123	0.062	0.061	220

25-Yr:

Area = 2.43 ha Required Release Rate = 0.08 cms
C = 0.586667
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	222.8	0.882	0.080	0.802	241
10	137.8	0.546	0.080	0.466	279
15	104	0.412	0.080	0.332	299
30	64.4	0.255	0.080	0.175	315
60	39.9	0.158	0.080	0.078	281

50-Yr:

Area = 2.43 ha Required Release Rate = 0.10 cms
C = 0.64
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	247.2	1.068	0.097	0.971	291
10	152.8	0.660	0.097	0.563	338
15	115.4	0.499	0.097	0.402	361
30	71.4	0.308	0.097	0.211	381
60	44.2	0.191	0.097	0.094	338

100-Yr:

Area = 2.43 ha Required Release Rate = 0.11 cms
C = 0.67
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	270.5	1.217	0.111	1.106	332
10	167.2	0.752	0.111	0.641	385
15	126.2	0.568	0.111	0.457	411
30	78	0.351	0.111	0.240	432
60	48.3	0.217	0.111	0.106	383

East SWM Facility:

2-Yr:

Area = 0.86 ha
Required Release Rate = 0.029 cms
C = 0.53
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	125.6	0.16	0.03	0.13	39
10	77.9	0.10	0.03	0.07	42
15	59	0.08	0.03	0.05	42
30	36.7	0.05	0.03	0.02	32

5-Yr:

Area = 0.86 ha
Required Release Rate = 0.039 cms
C = 0.534545
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	164.8	0.210	0.039	0.171	51
10	102.1	0.130	0.039	0.091	55
15	77.2	0.099	0.039	0.060	54
30	47.9	0.061	0.039	0.022	40

10-Yr:

Area = 0.86 ha
Required Release Rate = 0.045 cms
C = 0.534545
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	190.4	0.243	0.045	0.198	59
10	117.8	0.150	0.045	0.105	63
15	89	0.114	0.045	0.069	62
30	55.2	0.070	0.045	0.025	46

25-Yr:

Area = 0.86 ha
C = 0.588
Q = 1/360 x CiA

Required Release Rate = 0.059 cms

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	222.8	0.313	0.059	0.254	76
10	137.8	0.194	0.059	0.135	81
15	104	0.146	0.059	0.087	78
30	64.4	0.090	0.059	0.031	57

50-Yr:

Area = 0.86 ha
C = 0.641455
Q = 1/360 x CiA

Required Release Rate = 0.071 cms

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	247.2	0.379	0.071	0.308	92
10	152.8	0.234	0.071	0.163	98
15	115.4	0.177	0.071	0.106	95
30	71.4	0.109	0.071	0.038	69

100-Yr:

Area = 0.86 ha
C = 0.67
Q = 1/360 x CiA

Required Release Rate = 0.082 cms

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	270.5	0.432	0.082	0.350	105
10	167.2	0.267	0.082	0.185	111
15	126.2	0.201	0.082	0.119	107
30	78	0.125	0.082	0.043	77

Interim West SWM Facility:

2-Yr:

Area = 0.68 ha
C = 0.60
Q = 1/360 x CiA

Required Release Rate = 0.01 cms

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	125.6	0.142	0.014	0.128	39
10	77.9	0.088	0.014	0.074	45
15	59	0.067	0.014	0.053	48
30	36.7	0.042	0.014	0.028	50
60	22.8	0.026	0.014	0.012	43

5-Yr:

Area = 0.68 ha
C = 0.6
Q = 1/360 x CiA

Required Release Rate = 0.02 cms

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	164.8	0.187	0.018	0.169	51
10	102.1	0.116	0.018	0.098	59
15	77.2	0.087	0.018	0.069	63
30	47.9	0.054	0.018	0.036	65
60	29.7	0.034	0.018	0.016	56

10-Yr:

Area = 0.68 ha Required Release Rate = 0.02 cms
C = 0.6
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	190.4	0.216	0.021	0.195	58
10	117.8	0.134	0.021	0.113	68
15	89	0.101	0.021	0.080	72
30	55.2	0.063	0.021	0.042	75
60	34.2	0.039	0.021	0.018	64

25-Yr:

Area = 0.68 ha Required Release Rate = 0.03 cms
C = 0.66
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	222.8	0.278	0.028	0.250	75
10	137.8	0.172	0.028	0.144	86
15	104	0.130	0.028	0.102	91
30	64.4	0.080	0.028	0.052	94
60	39.9	0.050	0.028	0.022	78

50-Yr:

Area = 0.68 ha Required Release Rate = 0.03 cms
C = 0.72
Q = 1/360 x CiA

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	247.2	0.336	0.033	0.303	91
10	152.8	0.208	0.033	0.175	105
15	115.4	0.157	0.033	0.124	112
30	71.4	0.097	0.033	0.064	115
60	44.2	0.060	0.033	0.027	98

100-Yr:

Area = 0.68 ha

C = 0.75

Q = 1/360 x CiA

Controlled Release Rate = 0.04 cms

Time (min)	i	Qi	Qallow	Qdiff	Storage
	mm/hr	cms	cms	cms	m^3
5	270.5	0.383	0.038	0.345	104
10	167.2	0.237	0.038	0.199	119
15	126.2	0.179	0.038	0.141	127
30	78	0.111	0.038	0.073	131
60	48.3	0.068	0.038	0.030	110

Appendix D

Stage-Discharge-Storage Calculations

West SWM Facility:

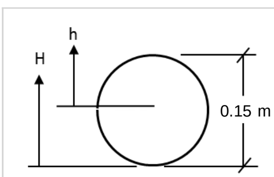
Determine Stage - Storage - Discharge Relationship

Active Storage Calculations

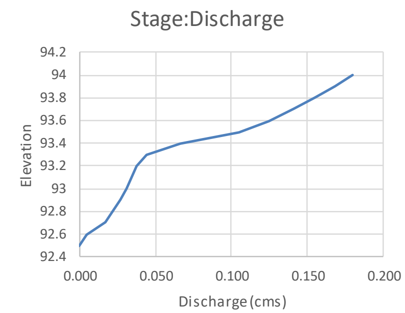
Full Storage Elevation (m)	**93.7**	
Depth of Active Storage (m)	**1.2**	
Bottom of Active Storage (m)	**92.5**	
Active Volume (cu.m)	**813**	*(approx)*

Select Stage Increment (m) **0.1** *(not less than 0.01 m)*

Select Storage Value Method **User Defined**



	Outlet 1		Outlet 2		Outlet 3	
Use Outlet?	**Yes**		**Yes**		**No**	
Type	**Orifice**		**Orifice**		**Broad Crested Weir**	
Formula	$Q = CA_o(2gh)^{0.5}$		Q = CAo(2gh)^(0.5)		Q = 1.67LH13/2	
Invert =	**92.50**	m	**93.20**	m	**93.70**	m
Coeff =	**0.60**		**0.60**			
Length					**2.5**	m
Orifice Dia =	**0.15**	m	**0.30**	m		
Circular?	**Yes**	*(Select Yes or No)*			*(No End Contractions)*	
Area =	0.018	m^2	0.058			
Obvert =	92.65	m	93.50			



					Low Flow Outlet (Orifice)			Orifice			Emergency Spillway		Total		User Defined Storage		
Elevation	**Length**	**Width**	**Incr Vol**	**Cum vol**	**Weir (H)**	**Head (h)**	**Flow (Q)**	**Head (H)**	**Head (h)**	**Flow (Q)**	**Head (H)**	**Flow (Q)**	**Discharge**	**Area**	Storage (m^3)		
m	**m**	**m**	**m3**	**m3**	**m**	**m**	**cms**	**m**	**m**	**cms**	**m**	**cms**	**cms**	**m^2**	**Stage**	**Incr.**	**Cum.**
92.5				0	0.000	-0.075	0.000	0.000	-0.150	0.000	0.000	0.000	0.000		92.5		0
92.6				2	0.100	0.025	0.005	0.000	-0.150	0.000	0.000	0.000	0.005		92.6		2
92.7				7	0.200	0.125	0.017	0.000	-0.150	0.000	0.000	0.000	0.017		92.7		7
92.8				19	0.300	0.225	0.022	0.000	-0.150	0.000	0.000	0.000	0.022		92.8		19
92.9				41	0.400	0.325	0.027	0.000	-0.150	0.000	0.000	0.000	0.027		92.9		41
93				77	0.500	0.425	0.031	0.000	-0.150	0.000	0.000	0.000	0.031		93		77
93.1				129	0.600	0.525	0.034	0.000	-0.150	0.000	0.000	0.000	0.034		93.1		129
93.2				198	0.700	0.625	0.037	0.000	-0.150	0.000	0.000	0.000	0.037		93.2		198
93.3				285	0.800	0.725	0.040	0.100	-0.050	0.004	0.000	0.000	0.044		93.3		285
93.4				390	0.900	0.825	0.043	0.200	0.050	0.024	0.000	0.000	0.066		93.4		390
93.5				512	1.000	0.925	0.045	0.300	0.150	0.060	0.000	0.000	0.105		93.5		512
93.6				653	1.100	1.025	0.048	0.400	0.250	0.077	0.000	0.000	0.124		93.6		653
93.7				813	1.200	1.125	0.050	0.500	0.350	0.091	0.000	0.000	0.141		93.7		813

East SWM Facility:

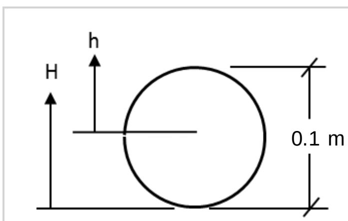
Determine Stage - Storage - Discharge Relationship

Active Storage Calculations

Full Storage Elevation (m)	**91.45**	
Depth of Active Storage (m)	**1.2**	
Bottom of Active Storage (m)	**90.25**	
Active Volume (cu.m)	**123**	*(approx)*

Select Storage Value Method User Defined

Select Stage Increment (m) 0.1
(not less than 0.01 m)



Outlet 1		Outlet 2		Outlet 3	
Use Outlet 1 ?	**Yes**	**Use Outlet 2 ?**	**Yes**	**Use Outlet 3 ?**	**Yes**
Orifice		Orifice		Broad Crested Weir	
Formula	$Q = CA_o(2gh)^{0.5}$	Formula	Q = CAo(2gh)^(0.5)	Formula	Q = 1.67LH13/2
Invert =	90.25 m	**Invert =**	91.15 m	**Invert =**	91.45 m
Coeff =	0.60	**Coeff =**	0.60	**Length**	2.5 m
Orifice Dia =	0.1 m	**Orifice Dia =**	0.30 m		
Circular?	**Yes** *(Select Yes or No)*				*(No End Contractions)*
Area =	0.008 m^2	Area =	0.058		
Obvert =	90.35 m	Obvert =	91.45		

Elevation	Length	Width	Incr Vol	Cum vol	Low Flow Outlet (Orifice) Weir (H)	Low Flow Outlet (Orifice) Head (h)	Low Flow Outlet (Orifice) Flow (Q)	Orifice Head (H)	Orifice Head (h)	Orifice Flow (Q)	Emergency Spillway Head (H)	Emergency Spillway Flow (Q)	Total Discharge
m	m	m	m3	m3	m	m	cms	m	m	cms	m	cms	cms
90.25				0	0.000	-0.050	0.000	0.000	-0.150	0.000	0.000	0.000	0.000
90.35				2	0.100	0.050	0.005	0.000	-0.150	0.000	0.000	0.000	0.005
90.45				5	0.200	0.150	0.008	0.000	-0.150	0.000	0.000	0.000	0.008
90.55				10	0.300	0.250	0.010	0.000	-0.150	0.000	0.000	0.000	0.010
90.65				17	0.400	0.350	0.012	0.000	-0.150	0.000	0.000	0.000	0.012
90.75				25	0.500	0.450	0.014	0.000	-0.150	0.000	0.000	0.000	0.014
90.85				34	0.600	0.550	0.015	0.000	-0.150	0.000	0.000	0.000	0.015
90.95				45	0.700	0.650	0.017	0.000	-0.150	0.000	0.000	0.000	0.017
91.05				57	0.800	0.750	0.018	0.000	-0.150	0.000	0.000	0.000	0.018
91.15				71	0.900	0.850	0.019	0.000	-0.150	0.000	0.000	0.000	0.019
91.25				87	1.000	0.950	0.020	0.100	-0.050	0.004	0.000	0.000	0.025
91.35				104	1.100	1.050	0.021	0.200	0.050	0.024	0.000	0.000	0.045
91.45				123	1.200	1.150	0.022	0.300	0.150	0.060	0.000	0.000	0.082

Interim West SWM Facility:

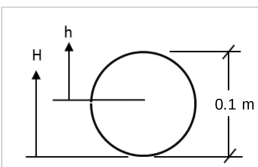
Determine Stage - Storage - Discharge Relationship

Active Storage Calculations

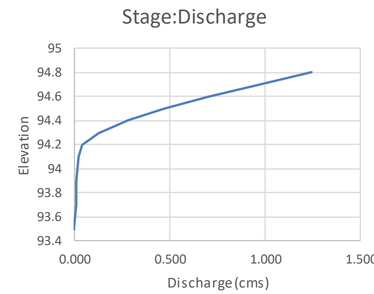
Full Storage Elevation (m)	**94.5**	
Depth of Active Storage (m)	**1**	
Bottom of Active Storage (m)	**93.5**	
Active Volume (cu.m)	**337**	*(approx)*

Select Storage Value Method User Defined

Select Stage Increment (m) 0.1 *(not less than 0.01 m)*



Outlet 1	Outlet 2	Outlet 3
Use Outlet 1 ? **Yes**	Use Outlet 2 ? **Yes**	Use Outlet 3 ? **Yes**
Orifice	Orifice	Broad Crested Weir
Formula: $Q = CA_o(2gh)^{0.5}$	Formula: Q = CAo(2gh)^(0.5)	Formula: Q = 1.67LH13/2
Invert = 93.50 m	**Invert =** 94.00 m	**Invert =** 94.20 m
Coeff = 0.60	**Coeff =** 0.60	**Length** 1.5 m
Orifice Dia = 0.1 m	**Orifice Dia =** 0.20 m	
Circular? Yes *(Select Yes or No)*		*(No End Contractions)*
Area = 0.008 m^2	Area = 0.026	
Obvert = 93.60 m	Obvert = 94.20	



					Low Flow Outlet (Orifice)			Orifice			Emergency Spillway		Total		User Defined Storage			
Elevation	Length	Width	Incr Vol	Cum vol	Weir (H)	Head (h)	Flow (Q)	Head (H)	Head (h)	Flow (Q)	Head (H)	Flow (Q)	Discharge	Area		Storage (m^3)		Area
m	m	m	m3	m3	m	m	cms	m	m	cms	m	cms	cms	m^2	Stage	Incr.	Cum.	m^2
93.5				0	0.000	-0.050	0.000	0.000	-0.100	0.000	0.000	0.000	0.000		93.5		0	**0.0**
93.6				0	0.100	0.050	0.005	0.000	-0.100	0.000	0.000	0.000	0.005		93.6		0	**137.0**
93.7				8	0.200	0.150	0.008	0.000	-0.100	0.000	0.000	0.000	0.008		93.7		8	**524.0**
93.8				21	0.300	0.250	0.010	0.000	-0.100	0.000	0.000	0.000	0.010		93.8		21	**1170.0**
93.9				40	0.400	0.350	0.012	0.000	-0.100	0.000	0.000	0.000	0.012		93.9		40	
94				67	0.500	0.450	0.014	0.000	-0.100	0.000	0.000	0.000	0.014		94		67	
94.1				102	0.600	0.550	0.015	0.100	0.000	0.004	0.000	0.000	0.020		94.1		102	
94.2				145	0.700	0.650	0.017	0.200	0.100	0.022	0.000	0.000	0.038		94.2		145	

Appendix E

Swale Sizing Calculations

Swale A Sizing Calculation (100-Yr):

Mannings - Open channel flow

$Q = 1/n\ AR^{2/3}S^{1/2}$

Desired Flow Capacity = **0.091** **<=== Q100-yr from Rational Method for Catchment 100 contributing to Swale A**

Channel Configuration

Bottom Width	0	m
Side Slopes	3	:1
Slope	0.005	m/m
Roughness	0.035	
Channel Depth	0.3	m

R = Hydraulic Radius = Area / Wetted Perimeter (m)
P = Wetted Perimeter (m)
A= Area (m^2)

<u>Assume Full Flow</u>

A =	0.27	
P =	1.897367	
R =	0.142302	
V = Channel Velocity (m/s) =	0.55	
Q = Channel Flow Capacity =	**0.15**	**cms**

Check: **Capacity > Desired** **OK**

Swale B Sizing Calculation (25mm Quality Event):

Mannings - Open channel flow

$Q = 1/n\ AR^{2/3}S^{1/2}$

Desired Flow Capacity = **0.104** **<=== 25mm Quality Event from Rational Method for Catchments 101 and 200 Contributing to Swale B**

Channel Configuration

Bottom Width	0.75	m
Side Slopes	3	:1
Slope	0.003	m/m
Roughness	0.035	
Channel Depth	0.25	m

R = Hydraulic Radius = Area / Wetted Perimeter (m)
P = Wetted Perimeter (m)
A= Area (m^2)

<u>Assume Full Flow</u>

A =	0.375	
P =	2.331139	
R =	0.160866	
V = Channel Velocity (m/s) =	0.46	
Q = Channel Flow Capacity =	**0.17**	**cms**

Check: **Capacity > Desired** **OK**

Swale C Sizing Calculation (100-Yr):

Mannings - Open channel flow

$Q = 1/n\ AR^{2/3}S^{1/2}$

Desired Flow Capacity = **0.17** **<=== Q100-yr from Rational Method for Catchment 102 contributing to Swale C**

Channel Configuration

Bottom Width	0	m
Side Slopes	3	:1
Slope	0.01	m/m
Roughness	0.035	
Channel Depth	0.3	m

R = Hydraulic Radius = Area / Wetted Perimeter (m)
P = Wetted Perimeter (m)
A= Area (m^2)

<u>Assume Full Flow</u>

A =	0.27	
P =	1.897367	
R =	0.142302	
V = Channel Velocity (m/s) =	0.78	
Q = Channel Flow Capacity =	**0.21**	**cms**

Check: **Capacity > Desired** **OK**

Swale D Sizing Calculation (100-Yr):

Mannings - Open channel flow

$Q = 1/n\ AR^{2/3}S^{1/2}$

Desired Flow Capacity = **0.19** **<=== Q100-yr Rational Method for Catchments 102 and 201 contributing to Swale D**

Channel Configuration

Bottom Width	0	m
Side Slopes	3	:1
Slope	0.015	m/m
Roughness	0.035	(grass = 0.025, stone = 0.03)
Channel Depth	0.3	m

R = Hydraulic Radius = Area / Wetted Perimeter (m)
P = Wetted Perimeter (m)
A= Area (m^2)

<u>Assume Full Flow</u>

A =	0.27	
P =	1.897367	
R =	0.142302	
V = Channel Velocity (m/s) =	0.95	
Q = Channel Flow Capacity =	**0.26**	**cms**

Check: **Capacity > Desired** **OK**

Swale E Sizing Calculation (25mm Quality Event):

Mannings - Open channel flow

$Q = 1/n\ AR^{2/3}S^{1/2}$

Desired Flow Capacity = **0.045** **<=== 25mm Quality Event from Rational Method for Catchments 102 and 201 Contributing to Swale E**

Channel Configuration

Bottom Width	0.75	m
Side Slopes	3	:1
Slope	0.003	m/m
Roughness	0.035	
Channel Depth	0.25	m

R = Hydraulic Radius = Area / Wetted Perimeter (m)
P = Wetted Perimeter (m)
A= Area (m^2)

<u>Assume Full Flow</u>

A =	0.375	
P =	2.331139	
R =	0.160866	
V = Channel Velocity (m/s) =	0.46	
Q = Channel Flow Capacity =	**0.17**	**cms**

Check: **Capacity > Desired** | **OK**