Fernbank Pond 4 Stormwater Management Facility Design Brief

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Prepared for:
1384341 Ontario Ltd.

Prepared by:
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Sign-off Sheet

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1.0 INTRODUCTION AND BACKGROUND

1.1 OVERVIEW

Stantec Consulting Ltd. has been retained by 1384341 Ontario Ltd. to complete the design of the Fernbank Stormwater Management Pond 4 (Fernbank SWM Pond 4) in support of their Shea Road development draft plan approval application. The stormwater management facility (SWMF) will provide end-of-pipe treatment for the future development lands on the north-western quadrant of the intersection of Shea Road and Fernbank Road in the City of Ottawa as shown in **Figure 1**.

The future developments are owned by Tartan Homes on the western half and by Cavanagh Construction on the eastern half. The 59.2 ha tributary area is approximately 52% impervious and consists of a portion of Shea Road, a future park/open space area east of Shea Road, overland drainage from the existing recreational fields to the north and a mix of future residential areas, a school block, park areas and a SWM block designated for the proposed Fernbank SWM Pond 4.

The location of the Fernbank SWM Pond 4 is consistent with the information presented in the June 24, 2009 Fernbank Community Design Plan Environmental Management Plan (EMP) by Novatech Engineering Consultants Ltd. (Novatech) which shows the SWMF located immediately north of Fernbank Road and west of realigned Shea Road, partially within an existing Hydro corridor. The proposed Fernbank SWM Pond 4 will discharge into the Fernbank Road side ditch, which directs runoff south to the Faulkner Municipal Drain (MD) through an existing 700 mm diameter corrugated steel pipe (CSP) crossing Fernbank Road and ultimately discharges to the Jock River. Refer to **Drawing OSD-1** for details.

Figure 1: Approximate SWM Pond 4 Catchment Area

1.2 BACKGROUND

In 2008, the City of Ottawa completed the Fernbank Community Design Plan (FCDP). The FCDP covers approximately 675 ha of land between the established communities of Stittsville, Kanata West and Kanata South. The community extends from Hazeldean Road to the north, the Carp River and Terry Fox Drive to the east, Fernbank Road to the south and the existing Urban Area of Stittsville to the west.

In conjunction with preparation of the Community Design Plan, several Class Environmental Assessment Studies/Master Plans were also prepared. Two of those were the Master Servicing Study (MSS) for water and sanitary and an Environmental Management Plan (EMP) for the natural environment and stormwater management. Those reports identified planning level solutions for on-site storm drainage, wastewater collection and water supply and distribution to the community. The approved EMP and MSS recommended the construction of one stormwater management facility (referred to as Pond 4) and associated storm sewer systems to provide stormwater management for the Fernbank Community tributary to the Faulkner Drain Tributary. Based on the background documents, Pond 4 was to provide 'Enhanced' water quality and post to pre-development quantity control for approximately 60 ha of proposed development north-west of Fernbank Road and Shea Road, and south of Abbott Street East. Pond 4 was to outlet to the Faulkner Drain Tributary, which starts on the south side of Fernbank Road.

IBI Group prepared a Conceptual Servicing and SWM Report in 2013 to address servicing requirements for the subject lands owned by Tartan and Cavanagh (see **Drawing OSD-1**). IBI's report identified that a hydro corridor extends south on the east side of the subject site, crossing Fernbank Road at Shea Road, partially within the proposed Pond 4 location. The report outlined the stage-storage relationship representing Pond 4 in the EMP and MSS was used in their SWMHYMO hydrologic model. IBI's conceptual design provided a SWM pond footprint to meet MOECC quality control volumetric requirements and to restrict post development peak flows from the overall development to pre-development levels. Report excerpts have been provided in **Appendix E**.

During the pre-consultation meeting for the proposed Shea Road Lands development in 2016 (see attached correspondence in **Appendix F**), the City advised that the allowable release rate from the Fernbank SWM Pond 4 should be coordinated with the work being done to update the Faulkner Municipal Drain Engineer Report by Andy Robinson of Robinson Consultants. Subsequent correspondence with Robinson Consultants confirmed that the existing 700 mm diameter culvert under Fernbank Road has a maximum capacity of 0.9 m^3/s with a 0.5 m head and as such, the 100-year outflow from the proposed SWM Pond 4 should be restricted to 0.9 m^3/s, instead of the 100-year pre-development condition peak flow of 1.85 m^3/s previously identified in the background reports.

Stantec has circulated the conceptual SWM Pond 4 layout to HONI stakeholders and obtained approval on October 25, 2017 for the proposed footprint and measures provided to protect the existing Hydro structures and to provide adequate access for maintenance (correspondence included in **Appendix F**).

1.3 BACKGROUND RESOURCES

The following documents were referenced in the preparation of this report:

- *Fernbank Community Design Plan Existing Conditions Report – Storm Drainage and Hydrology,* Novatech Engineering Consultants Ltd., January 2007
- *Fernbank Community Design Plan Environmental Management Plan,* Novatech Engineering Consultants Ltd., June 24, 2009
- *Fernbank Community Design Plan Master Servicing Study,* Novatech Engineering Consultants Ltd., June 24, 2009

- *Geotechnical Investigation Proposed Residential Development Shea Road, Ottawa, Ontario,* Golder Associates, October 2011
- *Conceptual Site Servicing Plan, Stormwater Management Plan and Erosion and Sediment Control Plan Shea Road Lands Fernbank Community*, IBI Group, March 2013

Additional documents referenced in designing the SWM Plan for the Fernbank SWM Pond 4 include:

- *Stormwater Management Planning and Design Manual*, Ministry of the Environment (Ontario), March 2003
- *City of Ottawa Sewer Design Guidelines*, 2nd Ed., City of Ottawa, October 2012
- *Technical Bulletin PIEDTB-2016-01 Revisions to Ottawa Design Guidelines – Sewer,* City of Ottawa, September 2016

1.4 PURPOSE

This report has been prepared to demonstrate that the proposed design of the Fernbank SWM Pond 4 adheres to all of the established criteria presented in the background documents. The report includes hydrologic and hydraulic analyses for the tributary development lands and detailed design of the SWM Pond.

2.0 PROPOSED DEVELOPMENT STORMWATER MANAGEMENT PLAN

The following sections summarize the stormwater management plan for the development lands tributary to the proposed Fernbank SWM Pond 4.

2.1 PROPOSED DEVELOPMENT CONDITIONS

The proposed SWM facility will receive runoff from approximately 59.2 ha of land from the future developments and from the SWM pond footprint area. The proposed SWM facility will provide quantity and quality control (80% TSS removal) of runoff before discharging to the Faulkner Municipal Drain.

Detailed design of the SWM pond has been done using a lumped hydrologic/hydraulic model of the future development lands to determine the inflow rates to the pond. Hydrologic/hydraulic modelling used the "dual drainage" principle, whereby the minor (pipe) system is designed to convey the peak rate of runoff based on a 2-year return period storm capture rate for local streets and a 5-year return period storm capture rate for collector roads (Shea Road and Cope Drive) as per the City design criteria. Runoff from larger events will be conveyed via engineered channels (roadways, pathways and swales) to the proposed SWM Pond 4. Outlet links have been specified in the model to limit the inlet capture rates to the minor system and thus control the hydraulic grade line during major storms.

Drawing OSD-1 shows the overall major and minor flow paths as well as the proposed SWM Pond layout.

2.2 FACILITY DESIGN CRITERIA

2.2.1 Water Quality Control

The Fernbank SWM Pond 4 is designed to achieve 'enhanced' level of treatment of urban runoff according to Ministry of the Environment and Climate Change (MOECC) criteria – representing an 80% removal of total suspended solids (TSS). Treatment criteria were established based on the Jock River Reach 2 Subwatershed Study by the Rideau Valley Conservation Authority (RVCA).

The facility, as outlined in **Section 3.0**, has been designed with sufficient permanent pool and extended detention storage to provide this required quality control. The end-of-pipe facility has been designed according to the recommendations of the Ministry of the Environment Stormwater Management Planning and Design Manual, as provided in **Section 3.4**, and therefore no quality control infrastructure is required within the future development lands tributary to the SWM pond.

2.2.2 Water Quantity Control

The proposed Fernbank SWM Pond 4 will discharge upstream of the existing 700 mm dia. CSP crossing Fernbank Road that directs runoff south to the Faulkner Municipal Drain and ultimately to the Jock River. The Fernbank Community EMP outlined post to pre-development quantity control as a requirement for the Fernbank SWM pond 4 and identified the target existing condition peak flows as shown in **Table 1** below (report excerpts have been included in **Appendix E**).

Table 1: Existing Condition Peak Flows to the Faulkner Tributary at Fernbank Road

Distribution	Peak Flow (m^3/s)					
	2-year	5-year	10-year	25-year	50-year	100-year
12hr AES	0.46	0.74	0.94	1.19	1.37	1.55
12hr SCS	0.48	0.82	1.05	1.39	1.58	1.83
24hr SCS	**0.51**	**0.83**	**1.05**	**1.32**	**1.55**	**1.85**

The table above shows that the 24 hour SCS Type II is the critical storm distribution for the lands tributary to the Faulkner MD.

As mentioned in **Section 1.2**, recent correspondence with Robinson Consultants confirmed that the culvert under Fernbank Road has a maximum capacity of 0.9 m^3/s with a 0.5 m head and as such, post development outflows from the proposed SWM Pond 4 should be restricted to 0.9 m^3/s up to the 100-year storm (correspondence has been included in **Appendix F**).

2.3 MODEL SELECTION AND DEVELOPMENT

2.3.1 Model Selection

Hydrologic and hydraulic modeling of the SWM pond design was completed using PCSWMM modeling software which uses the EPA-SWMM 5.1.012 computational engine for analysis. The included models can also be opened and reviewed using the free EPA-SWMM GUI. PCSWMM model layout, input parameters, and example input file are provided in **Appendix C**. Electronic model files are provided on the enclosed CD.

2.3.2 Model Structure

The storm sewer network modeled in PCSWMM includes preliminary storm sewer layout along the proposed roads in the future development as shown on **Drawing OSD-1**, and the detailed components of the proposed SWM Pond. The storm sewer design sheet has been included in **Appendix A.** Major flows are routed overland via engineered channels such as roadways and pathways and modeled with the appropriate ROW transects.

2.3.3 Model Parameter Selection

Model parameters used in the hydrologic and hydraulic calculations within the PCSWMM model are based on City of Ottawa design criteria and were applied as outlined below. Detailed parameters for subcatchment areas, storage nodes etc. are summarized in **Appendix C.2**.

2.3.3.1 Hydraulic Parameter Selection

Exit losses at manholes were set for all pipe segments based on the flow angle through the structure. Exit losses were assigned as per City guidelines (Appendix 6b), see **Table 2** below.

Table 2: Exit Loss Coefficients for Bends at Manholes

Degrees	Coefficient
11	0.060
22	0.140
30	0.210
45	0.390
60	0.640
90	1.320
180	0.020

Other parameters applied within the model include the following:

- Manning's n for all smooth wall pipes = 0.013 for sewers *(Section 6.1.8.1)*
- Orifice Discharge Coefficient = 0.61 (circular)
- Weir Discharge Coefficient = 1.7

2.3.4 Subcatchment Storage

A unit storage rate of 40 m^3/ha as outlined in IBI's Servicing and SWM report for the Shea Road Lands was assumed for the lumped subcatchments except for the school block (area F108A), which has been assumed to provide sufficient on-site storage for the 100-year storm.

2.3.5 Inlet Rates

Inlet flow rates for each subcatchment were assigned based on the 2-year runoff rate for local streets (drainage areas defined with the prefix L), and the 5-year runoff rate for collector roads (drainage areas defined with the prefix C). The school block (area F108A) was assigned an inflow rate based on the 5-year runoff rate. Inlet capture rates are specified through outlet links which use a user-specified depth-discharge curve (inlet capture rates for each area are summarized in **Appendix C.2**).

2.4 RAINFALL DISTRIBUTIONS

Design storm events were selected to estimate the worst-case 100-year HGL across the future development and to assess the proposed pond performance. As an additional method of evaluating the performance of the proposed infrastructure, rainfall data from the July 1, 1979 historical rainfall event in the region was modeled, and a climate change scenario storm (20% increase of City IDF curves) was used to stress test the design.

2.4.1 Design Storms

The 3 hour Chicago distribution was selected to estimate the 2-year and 5-year capture rates for the proposed subcatchments, and to assess the 100-year HGL across the proposed development. The Chicago distribution was selected due to its tendency to generate high peak flows in urban catchments, similar to the future development. The SCS distribution was selected due to its tendency to produce a greater total volume of runoff. The following storm events were used to evaluate the minor and major systems performance and assess the worst-case HGL across the development:

- 2-year, 3 hour Chicago storm, 10-minute time step (2yr3hrChicago)
- 5-year, 3 hour Chicago storm, 10-minute time step (5yr3hrChicago)
- 100-year, 3 hour Chicago storm, 10-minute time step (100yr3hrChicago)
- 100-year, 24 hour SCS storm Type II, 12-minute time step from IBI (100yr24hrSCS)

2.4.2 Critical Storms

The 24 hour SCS Type II distribution was selected in the EMP as the critical storm and as such, this storm distribution has been used to compare the proposed SWM pond outflow to the allowable. The following events were run to assess pond operating levels for various storm events:

- 2-year, 24 hour SCS storm Type II, 10 min time step from IBI (2yr24hrSCS)
- 5-year, 24 hour SCS storm Type II, 10 min time step from IBI (5yr24hrSCS)
- 10-year, 24 hour SCS storm Type II, 10 min time step (10yr24hrSCS)
- 25-year, 24 hour SCS storm Type II, 10 min time step (25yr24hrSCS)
- 100-year, 24 hour SCS storm Type II, 12-minute time step from IBI (100yr24hrSCS)

2.4.3 Water Quality Event

The 25mm event with a 4-hour Chicago storm distribution was used to size the pond forebay and the bypass structure.

2.4.4 Climate Change Storms

As per City of Ottawa Sewer Design Guidelines 2012, drainage systems are to be 'stress tested' for climate change scenarios by using a 20% increase in the City's 100-year storm intensities. Therefore, the following climate change storm scenario was modeled:

- 100-year, 24 hour SCS storm Type II + 20%, 12-minute time step (100yr24hrSCS_20%)

All hydrologic and hydraulic modeling files are available on the enclosed compact disc located at the back of the report.

2.4.5 Boundary Conditions

- A free-flowing outfall was used as boundary condition for the 2, 5, 10, 25 and 100-year, 24 hour SCS Type II storms in order to compare the proposed SWM pond outflow hydrographs to the allowable release rates.

- A static backwater elevation of 106.53 m was used for the 100-year and 100-year increased by 20% for both the 3 hour Chicago and the 24 hour SCS Type II distributions in order to assess the worst-case HGL across the site and to set the emergency spillway elevation. The static backwater elevation of 106.53 m corresponds to the elevation of the existing 700 mm diameter CSP crossing Fernbank Road with a 0.5 m head (CSP inv=105.33 m)

- A free-flowing outfall was used for the 25 mm, 4 hour Chicago storm to size the forebay and design the bypass structure.

2.5 MODEL RESULTS

2.5.1 Pond Hydraulic Modeling Results

Each PCSWMM model scenario was analysed for the peak pond inflow and discharge rate as well as for peak pond HGL. **Table 3** below summarizes the peak pond outflow rates for the different storm events. Modelling of the proposed Fernbank SWM Pond 4 for the different storm events indicates that the proposed stage-storage and stage-discharge curves provide sufficient detention of runoff to meet the target release rates which were obtained from the Fernbank Community EMP and from recent correspondence with the City and Robinson Consultants. The Chicago storm scenarios were used to estimate the minor system capture rates and to assess the worst case 100-year HGL across the site. The climate change scenario was not intended to provide a level of service but was modeled to stress-test the design.

Table 3: Fernbank Pond 4 Peak Outflow Rates and Water Levels

Boundary Condition	Storm Event	Peak Pond Inflow (m^3/s)	Peak Pond Discharge (m^3/s)	Pond Water Level (m)	Target Peak outflow (m^3/s)
Free Outfall	25mm 4hr Chicago	3.68	0.077	106.20	N/A
Free Outfall	2yr3hrChicago	4.96	0.120	106.33	N/A
Free Outfall	5yr3hrChicago	6.02	0.223	106.55	N/A
Free Outfall	100yr3hrChicago	16.95	0.680	107.21	0.90
Fixed = 106.53 m	100yr3hrChicago	16.95	0.941	107.27	0.90
Free Outfall	2yr24hrSCS	4.04	0.166	106.43	0.51
Free Outfall	5yr24hrSCS	5.41	0.296	106.67	0.83
Free Outfall	10yr24hrSCS	5.93	0.321	106.71	0.90
Free Outfall	25yr24hrSCS	6.94	0.430	106.88	0.90
Free Outfall	100yr24hrSCS	13.76	0.785	107.34	0.90
Fixed = 106.53 m	100yr24hrSCS	13.76	0.941	107.64	0.90
Fixed = 106.53 m	100yr24hrSCS_20%	17.12	2.454	107.84	N/A

2.5.2 Proposed Development Hydraulic Grade Line Analysis

The worst case 100-year hydraulic grade line (HGL) elevation across the future development areas was estimated using the Fernbank Pond 4 PCSWMM model for the 100-year, 3 hour Chicago and the 100-year, 24 hour SCS Type II storms with a static backwater elevation of 106.53 m. **Table 4** below presents the clearance between the trunk sewer worst case HGL and the proposed road grade along the trunk sewer. The storm sewer design sheet is included in **Appendix A**. The climate change scenario was also run to stress-test the system.

Table 4: Fernbank Pond 4 HGL Results along Future Trunk Sewers

STM MH	Prop. Grade (m)	100-year Storms				100-year Increased by 20%	
		3 HR Chicago HGL (m)	24 HR SCS HGL (m)	Worst- Case HGL (m)	Prop. Grade-HGL Clearance (m)	24 HR SCS HGL (m)	Prop. Grade-HGL Clearance (m)
100B	108.15	107.27	107.64	107.64	0.51	107.84	0.31

STM MH	Prop. Grade (m)	100-year Storms				100-year Increased by 20%	
		3 HR Chicago HGL (m)	24 HR SCS HGL (m)	Worst- Case HGL (m)	Prop. Grade-HGL Clearance (m)	24 HR SCS HGL (m)	Prop. Grade-HGL Clearance (m)
101	108.48	107.27	107.64	107.64	0.84	107.85	0.63
102	108.81	107.27	107.64	107.64	1.17	107.87	0.94
103	110.43	107.70	107.83	107.83	2.60	108.09	2.34
104	110.37	107.86	107.95	107.95	2.42	108.22	2.15
105	110.14	107.87	107.96	107.96	2.18	108.23	1.91
106	110.16	107.98	108.05	108.05	2.11	108.35	1.81
107	111.95	108.17	108.21	108.21	3.74	108.56	3.39
108	111.11	108.05	108.10	108.10	3.01	108.41	2.70
109	111.00	108.37	108.37	108.37	2.63	108.42	2.58
110	111.15	108.21	108.24	108.24	2.91	108.53	2.62
111	111.24	108.87	108.87	108.87	2.37	108.89	2.35
112	110.81	108.17	108.27	108.27	2.54	108.54	2.27
113	110.95	108.43	108.53	108.53	2.42	108.80	2.15
114	111.02	108.27	108.36	108.36	2.66	108.64	2.38
115	112.02	108.37	108.46	108.46	3.56	108.75	3.27
116	111.48	108.56	108.63	108.63	2.85	108.98	2.50
117	112.00	108.64	108.69	108.69	3.31	109.07	2.93
118	110.82	108.70	108.74	108.74	2.08	109.78	1.04
119	112.54	108.77	108.84	108.84	3.70	109.10	3.44
120	113.00	108.85	108.92	108.92	4.08	109.16	3.84
121	112.59	109.21	109.21	109.21	3.38	109.31	3.28
200	113.32	108.69	108.76	108.76	4.56	109.12	4.20
201	115.71	108.82	108.88	108.88	6.83	109.30	6.41
202	115.86	108.86	108.91	108.91	6.95	109.34	6.52
203	116.79	109.01	109.05	109.05	7.74	109.50	7.29
204	113.43	108.73	108.78	108.78	4.65	109.20	4.22
205	116.54	108.85	108.88	108.88	7.66	109.36	7.18
206	116.50	109.04	109.06	109.06	7.44	109.54	6.96
207	112.93	108.42	108.50	108.50	4.43	108.81	4.12
208	113.70	108.47	108.55	108.55	5.15	108.86	4.84
209	114.17	108.61	108.69	108.69	5.48	109.06	5.11

STM MH	Prop. Grade (m)	100-year Storms				100-year Increased by 20%	
		3 HR Chicago HGL (m)	24 HR SCS HGL (m)	Worst- Case HGL (m)	Prop. Grade-HGL Clearance (m)	24 HR SCS HGL (m)	Prop. Grade-HGL Clearance (m)
210	114.12	108.64	108.71	108.71	5.41	109.09	5.03
211	114.11	108.73	108.79	108.79	5.32	109.16	4.95
212	113.31	108.97	109.03	109.03	4.28	109.26	4.05
213	113.94	109.10	109.15	109.15	4.79	109.36	4.58
214	113.75	109.13	109.17	109.17	4.58	109.38	4.37
215	113.69	109.20	109.23	109.23	4.46	109.42	4.27
216	113.16	109.29	109.31	109.31	3.85	109.48	3.68
217	114.15	109.34	109.36	109.36	4.79	109.51	4.64
218	114.20	109.59	109.59	109.59	4.61	109.68	4.52

The model results indicate that there is sufficient clearance between the worst case 100-year HGL and the proposed road grades. Detailed grading of the future developments should be based on the above results to ensure that a minimum clearance of 0.3 m is provided between all under side of footings (USFs) and the 100-year HGL, and that no basement flooding occurs in the climate change scenario.

3.0 DETAILED FACILITY DESIGN COMPONENTS

The following sections describe the stormwater management design approach and hydraulic results for the proposed stormwater management facility. **Drawings POND-1**, **POND-2**, **POND-3** and **POND-4** show a plan view and cross sections of the proposed SWM pond.

3.1 DESIGN APPROACH

The proposed Fernbank SWM Pond 4 is designed to meet the quality control requirements outlined above and to achieve all physical design criteria established for wet pond facilities by the Ministry of the Environment and Climate Change. These physical design criteria are provided in the MOECC's Stormwater Management Design and Planning Manual (March 2003).

From the preceding sections, the general design approach for the SWMF is as follows:

1. Provide MOECC Enhanced water quality treatment, thereby establishing the permanent pool and extended detention volumes
2. Size inlet structure and forebay based on generated inflow and MOECC guidelines
3. Restrict post development peak flows to pre-development levels with a maximum release rate of 0.9 m^3/s
4. Consider environmental and operations and maintenance concerns in orientation and design of all pond components

See **Section 5.0** for details of the operations, maintenance, and monitoring component of the design. Detailed forebay calculations are provided in **Appendix B**.

3.2 POND GRADING AND STORAGE DESIGN

Side slopes for safety (max 3:1) have been provided throughout the facility and along the forebay berm. These slopes are varied throughout to promote a less-engineered, more aesthetically pleasing design, where sufficient room is available.

3.2.1 Water Quality Control

The maximum permanent water depth within the forebay and main cell of the facility is 1.5 m. As stated in **Section 2.2.1** above, the required level of treatment for the proposed SWM Pond is 'enhanced' or 80% as per the Jock River Reach 2 Subwatershed Study. **Table 5** illustrates how the proposed end-of-pipe SWMF design provides this level of treatment. Detailed pond design calculations have been provided in **Appendix B**.

Table 5: Fernbank Pond 4 MOECC Stormwater Quality Volumetric Requirements

Drainage Area (ha)	Actual % Imp.	Water Quality Unit Volume Requirements			Water Quality Volume Requirements		Water Quality Volumes Provided	
		Total Unit Volume (m^3/ha)	Permanent Pool (m^3/ha)	Extended Detention (m^3/ha)	Permanent Pool (m^3)	Extended Detention (m^3)	Permanent Pool (m^3)	Extended Detention (m^3)
59.2	55	190	150.0	40	8,880	2,368	9,569	5,442

The normal water level in the SWM pond has been set at 105.75 m as per the Fernbank Community EMP.

3.2.2 Water Quantity Control

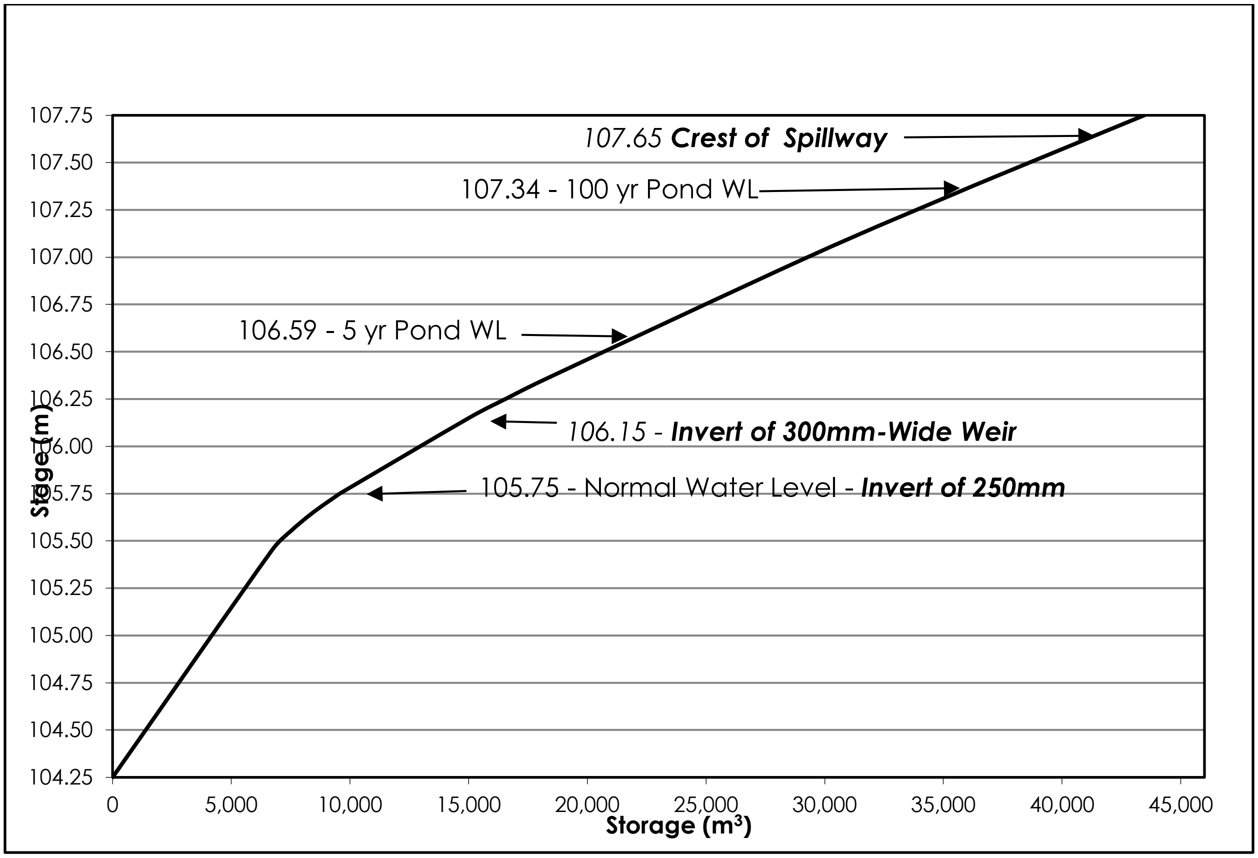
On-site water quantity control is provided for the future residential site at a unit rate of 40 m^3/ha with the exception of the school block that has been assumed to provide on-site storage for the 100-year storm. Overland flow from the future development lands will be directed to the SWM Pond through the proposed roads. Preliminary design of the storm sewers across the future development was based on available proposed road profiles as shown in the storm sewer design sheet included in **Appendix A**.

The SWM facility is required to restrict post development peak flows to pre-development levels with a maximum release rate of 0.9 m^3/s. The first 0.4 m of active storage is controlled by a 250 mm orifice (invert at 105.75 m). The secondary pond outlet occurs via a 300 mm-wide by 1,150 mm-high weir with a weir crest invert at 106.15 m. A 10.0 m-wide rip-rap lined spillway at invert 107.65 m is also provided as an emergency overflow path. The pond flow regulators are located within a common outlet chamber which subsequently discharges to the Fernbank Road side ditch via a 1050 mm diameter storm sewer. The spillway discharges directly to the Fernbank Road side ditch. Outlet details are provided on **Drawing DS-2** and **Drawing POND-2**

3.2.3 Stage-Storage Relationship

The stage-storage relationship for the entire facility was established using the average end area method as presented in **Appendix B**.

Figure 2: Fernbank Pond 4 Stage-Storage Relationship



3.2.4 Slope Stability and Erosion Control

Due to the high inlet flow rates to the pond, erosion control and flow dampening measures are proposed to maintain slope stability and prevent sediment re-suspension. For stability of the pond side slopes a maximum slope of 3:1 is proposed for the facility. Exposed slopes should be lined with biodegradable erosion control blankets and seeded with grass seed mulch once weather conditions are suitable for growth. The emergency overflow spillway is to be lined with 400 mm rip-rap underlain by woven geotextile and seeded with standard roadside mix grass seed. Refer to **Drawing POND-4, DrawingPOND-5** and **Drawing EC-1** for details.

3.3 FOREBAY DESIGN

The purpose of the forebay is to act as the primary settling zone in the pond for the initial influx of coarse sediment and associated pollutants flushing off the sewershed. The forebay is designed to provide sufficient cross-section and length to reduce velocities and promote settling, minimize resuspension of settled solids, minimize percentage of overall permanent pool, provide sufficient sediment storage for infrequent clean out (>5 years), and have adequate accessibility and bottom-treatment for maintenance operations.

The required forebay characteristics dictate a required forebay settling length of 27.8 m. Similarly, the required forebay dispersion length is equal to 58.8 m. The provided length is approximately 68.0 m. The resulting length to width ratio of the proposed configuration is approximately 2.8:1, also meeting MOECC design recommendations. The provision of 1.5 m depth within the forebay provides for 0.5 m sediment accumulation prior to recommended cleanout while maintaining 1.0 m permanent pool depth, thereby minimizing the risk of scour and re-suspension. The designed sediment storage volume provided in the bottom 0.5 m corresponds to an estimated sediment removal frequency of approximately 7 years for the forebay.

The permeable forebay berm to the main cell will be set 0.3 m below the permanent pool (elevation 105.75 m) and will be approximately a 3.0 m wide earth berm as shown on **Drawing POND-2**.

3.4 OUTLET DESIGN

The following subsections describe the pond outlet design. **Drawing DS-2** illustrates the outlet structure in plan and sectional view, while a profile view is shown on **Drawing POND-2**.

The outlet will be located opposite the inlet and will drain to the Fernbank Road side ditch and ultimately to the Faulkner Municipal Drain. A concrete outlet structure will house the required extended detention orifice, quantity control weir, and outlet pipes, including the associated maintenance infrastructure (i.e. sluice gates, etc.).

3.4.1 Extended Detention Control

The design of the required outlet structure incorporates a dual control configuration. Firstly, a 250 mm orifice provides an approximate 40-hour extended detention for quality control. The entire extended detention volume is stored between 105.75 m and 106.15 m, as calculated below.

<u>Required Storage:</u>
Tributary Area = 59.20 ha
Extended Detention Storage = 40 m^3/ha
Storage = 59.20 x 40 = 2,368 m^3

<u>Provided Storage</u>:
Pond area at NWL = 12,138 m^2
Pond area at 106.15 = 15,072 m^2
Provided Depth = 106.15 – 105.75 = 0.4 m
Provided Extended Detention Active Volume = 5,442 m^3

3.4.2 Flow Control Weir

Quantity control of the pond discharge above the extended detention elevation is provided by a flow control weir within the outlet structure. This weir has been incorporated into the outlet to meet the quantity control target peak flows which correspond to post to pre-development levels to a maximum of 0.9 m^3/s dictated by the capacity of the existing 700 mm diameter CSP crossing Fernbank Road. A 300 mm-wide weir with invert at 106.15 m is proposed to meet quantity control requirements.

3.4.3 Overland Spillway

The emergency spillway location is separate from the outlet control structure. The emergency spillway elevation is set to 107.65 m and acts as a broad-crested weir, approximately 10.0 m wide. Should the stormwater management facility outlet structure clog or be subject to rare rainfall events (beyond the 100-year event), the spillway is designed to safely convey runoff to the Fernbank Road side ditch.

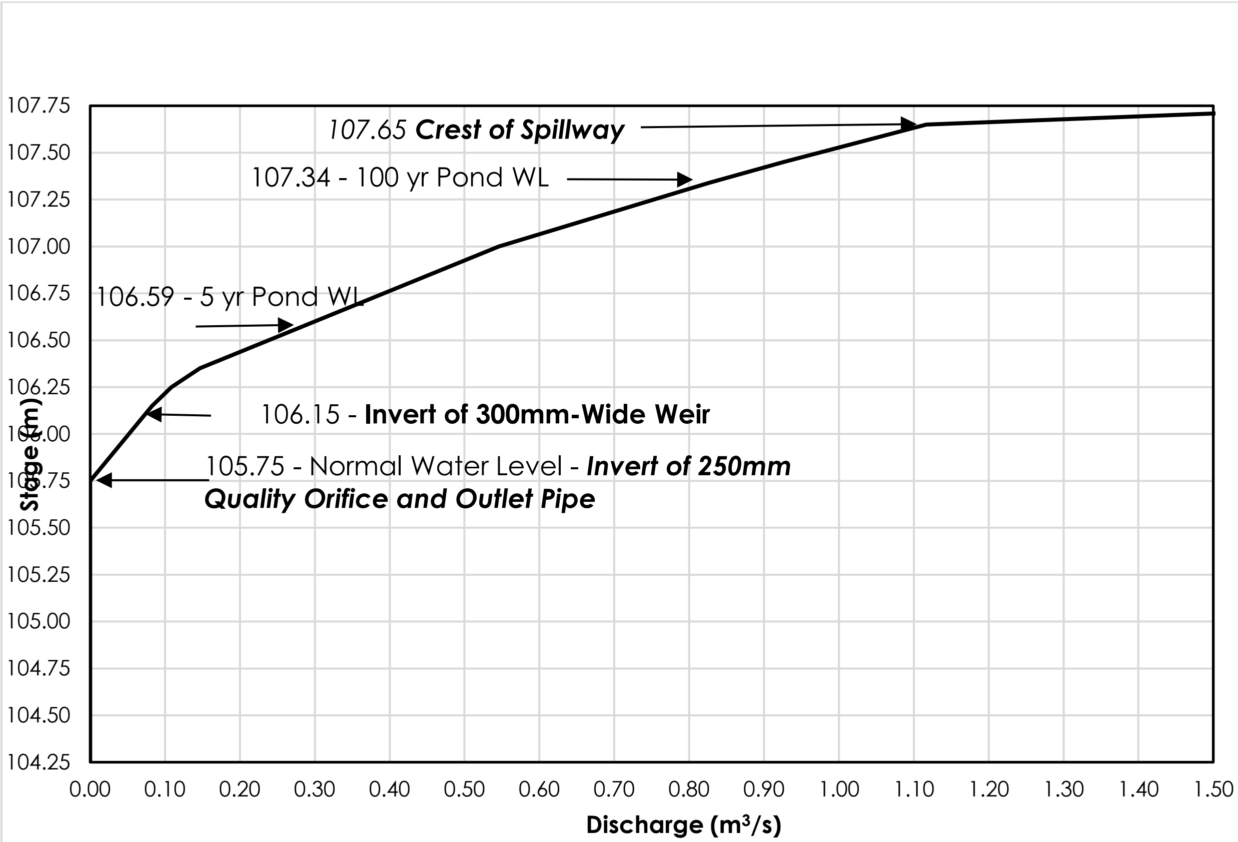
3.4.4 Outlet Channel

The proposed concrete outlet structure will discharge into a 1050 mm diameter storm sewer, which will outlet into a proposed channel sized to service the SWM pond requirements with a maximum conveyance capacity of 3.5 m^3/s including a 0.3 m freeboard (Inlet and outlet pipe calculations, and outlet channel calculations are provided in **Appendix D**).

3.4.5 Stage-Discharge Relationship

A stage-discharge relationship was estimated using standard orifice and weir equations as outlined in **Appendix B**. The resulting stage-discharge relationship is presented in **Figure 3** below.

Figure 3: Stage-Discharge Relationship for Fernbank SWM Pond 4



3.5 POND PERFORMANCE

As **Table 6** indicates, the water quality objectives of the SWM facility are met by providing extended detention of 24-48 hours and exceeding the MOECC recommended water quality volumes.

Table 6: Interim SWM Facility Operational Characteristics

SWM Basin Parameters	Basin Value
Total Contributing Area	59.20 ha
Imperviousness of Contributing Area [of Sewershed Area]	55.0 %
Unit Area Storage Volume Requirements as per SWMPD Manual	190 m^3/ha
Required Total Water Quality Volume	11,248 m^3
Wet Pond Bottom Elevation	104.25 m
Required Permanent Pool Volume	8,880 m^3
Permanent Pool Volume Provided (excluding sediment storage)	9,569 m^3

Permanent Pool Elevation	105.75 m
Permanent Pool Surface Area	12,138 m^2
Required Extended Detention Volume	2,368 m^3
Extended Detention Volume Provided	5,442 m^3
Peak Release Rate for Extended Detention	0.083 m^3/s
Extended Detention Drawdown Time	40 hours
Extended Detention Elevation (Weir 1Crest)	106.15 m
5 Year Storm Maximum Ponding Level (24hr SCS)	106.59 m
5 Year Storm Peak Pond Release (24hr SCS)	0.246 m^3/s
100 Year Storm Maximum Ponding Level (24hr SCS)	107.34 m
100 Year Storm Peak Pond Release (24hr SCS)	0.785 m^3/s
100 Year Storm Active Volume Required (24hr SCS)	25,952 m^3
Top of Berm (minimum grade of surrounding properties)	107.80 m
Forebay Parameters	
Forebay Bottom Elevation	104.25 m
Sediment Accumulation Depth	0.50 m
Forebay Depth from Permanent Pool	1.50 m
Required Forebay Length	58.8 m
Actual Forebay Length	68.0 m
Clean Out Frequency	~7 years
Outlet Parameters	
Quality Orifice Size (Orifice #1)	250 mm
Quality Orifice Invert (Orifice #1)	105.75 m
Quantity Weir Size (Weir #1)	300mm-W x 1150mm-H
Quantity Weir Cres Invert	106.15 m
Emergency Spillway Weir Crest Length	10.00 m
Emergency Spillway Weir Crest Elevation	107.65 m

3.6 OTHER CONSIDERATIONS

Additional key design notes include the following:

- A 4-m wide access road which consists of 3-m wide pavement and 0.5-m wide gravel shoulders has been provided for ease of inspection and maintenance of the inlet, forebay and main cell. The access road will have an engineered base consisting of granular ‘A’ and granular ‘B’ for durability and strength, while the surface will be asphaltic concrete for erosion protection. The route has been designed with a minimum slope to facilitate maintenance equipment maneuverability

4.0 CRITERIA AND CONSTRAINTS FOR FUTURE DEVELOPMENT

The following section discusses the criteria and constraints to be used during detailed design of the developments within the 59.20 ha tributary area to the proposed Fernbank SWM Pond 4.

4.1 STORMWATER MANAGEMENT DESIGN CRITERIA

The following design guidelines were established through review of the background documentation, supplemented with current design practices outlined by the City of Ottawa Sewer Design Guidelines (2012) and Ministry of the Environment Stormwater Management and Planning and Design Manual (2003) guidelines:

- Design using the dual drainage principle.
- Maximum 100-year water depth of 0.35 m in road sags, including overflow spill depth.
- Average sag storage of 40 m^3/ha to be provided in future residential areas.
- Future school block to provide on-site storage for the 100-year design storm.
- Rear-yard storage is not to be included in calculations.
- Parks and open spaces are to have no surface ponding storage.
- 100-year hydraulic grade line (HGL) to be a minimum 0.30 m below lowest building underside of footing elevation.
- Design inlets along local roadways to capture the 2-year peak flow.
- Design inlets within the school block and along collector roadways to capture the 5-year peak flow.
- Design storm sewers along local and collector roadways to convey the 2-year and 5-year peak flow respectively under free-flow conditions using 2004 City of Ottawa I-D-F parameters and an inlet time of 10 minutes.
- Provide adequate emergency overflow conveyance to SWM Pond 4 as shown on **Drawing OSD-1**.
- Design and submit a detailed Erosion Control Plan, as outlined in **Section 5.2**.

5.0 OPERATIONS AND MAINTENANCE

As with any SWM facility, maintenance will be required to ensure the operational efficiency and functionality of the facility. It is noted that until such a time as the ownership is transferred to the City of Ottawa, the developer will be responsible for any maintenance/operation/monitoring works. The preparation of an Operations, Maintenance and Monitoring Manual for the Fernbank SWM Pond 4 will be required at a later date and prepared under separate cover.

5.1 MAINTENANCE PROGRAM

The following summarizes the key components to be considered for the maintenance program:

- **Inventory of Stormwater System Components** (e.g. conveyance locations, elevations, outfalls, contributing drainage area, receiving watercourse, control structure components and specifications, material types, vegetative species and other pertinent information)
- **Periodic and Scheduled Inspections** (performed on a regular basis as determined in consultation with the city, and MOECC)
- **Maintenance Scheduling and Performance** (e.g. vegetation/landscaping maintenance, trash and debris removal, dewatering, sediment removal and disposal, pond and stream bank stabilization, inlet/outlet structure repairs, equipment testing/troubleshooting etc.)
- **Documentation and Reporting** (e.g. frequent inspection reports to the municipality and conservation authority during construction).

5.1.1 Monitoring

Monitoring of the proposed SWM pond will be conducted to ensure proper hydraulic and water quality performance of the facility as designed. A detailed monitoring plan will be prepared following the receipt of MOECC Environmental Compliance Approval (ECA). Monitoring criteria outlined in the MOECC ECA, Rideau Valley Conservation Authority (RVCA) permits, and as required by the City of Ottawa, will be used to prepare a monitoring plan for the SWM facility.

5.1.2 Sediment Removal and Storage

An access road has been provided along the north and east sides of the proposed SWM pond. The access road will permit access to all proposed structures within the facility. The pond forebay area is located such that sediment removal activities can be conducted with access from the north end of the forebay. Stop log access hatches and guides are provided in the outlet and drawdown structures to facilitate sediment removal and maintenance activities.

Sediment removal is estimated to be required at 7-year intervals or at a sediment accumulation depth of 0.50 m. Sediment accumulation within the forebay is variable and dependent on many factors including the condition of the tributary lands and the frequency of rainfall events.

Any sediment removed from the site to be disposed of off-site must be analyzed for Ontario Regulation 347 criteria. Analytical results must meet inert fill requirements if the sediment is to be used for land application, and meet non-hazardous requirements as per the TCLP leachate test in O.Reg. 347 if it is to be disposed of in a municipal landfill. Monitoring of sediment depth should be conducted regularly and a hydrometric survey should be completed at regular intervals to confirm sediment accumulation rates. Sediment accumulation within the main cell will occur at lower rates and therefore require less frequent clean-outs than the forebay cell.

5.2 EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION

In order to control erosion and migration of sediment-laden runoff off site during construction, an erosion and sediment control plan will be required for the Fernbank SWM Pond 4, following the general principles outlined in **Drawing EC-1**. Therefore, an appropriate inspection and maintenance program is necessary that will be prepared by the contractor, and will consider phasing of construction and the following goals:

- Protection from migration of sediment-laden runoff entering the Faulkner Municipal Drain;
- Immediate stabilization of exposed soil and/or stockpiles;
- Frequent inspection of all controls during construction of the pond and after significant rainfall events (greater than 13 mm) for sediment accumulation and erosion;
- Immediate repair of all noticeable erosion, with investigation into the cause so implementation of mitigation measures to prevent recurrence will be more successful;
- Maintenance of the erosion control measures in good repair during pond construction;
- Preparation of weekly inspection reports during active pond construction outlining the condition of erosion control works, their overall performance, and any actions such as repairs, replacement or modification.

There is increased potential for high TSS inflow during subdivision construction therefore an increased clean-out frequency during build-out is likely. Individual developments will be responsible for their own sediment and erosion controls during construction, as to not impact the trunk infrastructure.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this report, the following conclusions can be drawn:

- Water quality control will be provided by the Fernbank SWM Pond 4 for an enhanced level of protection;
- Water quantity control will be provided by the SWM facility along with a combination of inlet control devices and sag storage within the development to restrict post development peak flows up to the 100-year storm to pre-development levels with a maximum allowable release rate of 0.9 m^3/s;

Based on the findings of this report, the following recommendations are advised:

- Future developments will ensure that a clearance of at least 0.30 m is achieved between building footings and the 100-year hydraulic grade line;
- 100-year ponding depths will be maintained at a maximum 0.35 m in road sags;
- Future developments shall follow those criteria provided in **Section 4.0** above;
- Future design is to be completed in accordance with this report and the City of Ottawa Design Guidelines;
- This report is to be used for submission to regulatory agencies in support of approvals applications.

Appendix A STORM SEWER DESIGN SHEET

Stantec

JOB NAME	
DATE:	2017-12-07
REVISION:	1
DESIGNED BY:	WAJ
CHECKED BY:	AMP

STORM SEWER DESIGN SHEET
(City of Ottawa)

FILE NUMBER: 160400900

DESIGN PARAMETERS

I = a / (t+b)^c (As per City of Ottawa Guidelines, 2012)

	1:2 yr	1:5 yr	1:10 yr	1:100 yr
a =	732.951	998.071	1174.184	1735.688
b =	6.199	6.053	6.014	6.014
c =	0.810	0.814	0.816	0.820

MANNING'S n = 0.013 BEDDING CLASS = B

MINIMUM COVER: 2.00 m

TIME OF ENTRY 10 min

LOCATION			DRAINAGE AREA																									PIPE SELECTION											
AREA ID NUMBER	FROM M.H.	TO M.H.	AREA (2-YEAR) (ha)	AREA (5-YEAR) (ha)	AREA (10-YEAR) (ha)	AREA (100-YEAR) (ha)	AREA (ROOF) (ha)	C (2-YEAR) (-)	C (5-YEAR) (-)	C (10-YEAR) (-)	C (100-YEAR) (-)	A x C (2-YEAR) (ha)	ACCUM. AxC (2YR) (ha)	A x C (5-YEAR) (ha)	ACCUM. AxC (5YR) (ha)	A x C (10-YEAR) (ha)	ACCUM. AxC (10YR) (ha)	A x C (100-YEAR) (ha)	ACCUM. AxC (100YR) (ha)	T of C (min)	I_{2-YEAR} (mm/h)	I_{5-YEAR} (mm/h)	$I_{10-YEAR}$ (mm/h)	$I_{100-YEAR}$ (mm/h)	$Q_{CONTROL}$ (L/s)	ACCUM. $Q_{CONTROL}$ (L/s)	Q_{ACT} (CIA/360) (L/s)	LENGTH (m)	PIPE WIDTH OR DIAMETER (mm)	PIPE HEIGHT (mm)	PIPE SHAPE (-)	MATERIAL (-)	CLASS (-)	SLOPE %	Q_{CAP} (FULL) (L/s)	% FULL (-)	VEL. (FULL) (m/s)	VEL. (ACT) (m/s)	TIME OF FLOW (min)
L113A	113	112	3.34	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	2.035	2.035	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	434.1	66.4	675	675	CIRCULAR	CONCRETE	-	0.35	518.8	83.67%	1.40	1.40	0.79
																				10.79																			
L121B, C121A	121	120	2.39	1.29	0.00	0.00	0.00	0.20	0.61	0.00	0.00	0.477	0.477	0.789	0.789	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	330.3	65.2	525	525	CIRCULAR	CONCRETE	-	0.80	401.3	82.30%	1.80	1.78	0.61
																				10.61																			
L218A	218	217	6.70	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	3.954	3.954	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	843.7	188.6	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	76.46%	1.23	1.20	2.61
	217	216	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	3.954	0.000	0.000	0.000	0.000	0.000	0.000	12.61	68.04	92.15	107.96	157.73	0.0	0.0	747.4	19.8	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	67.74%	1.23	1.16	0.29
	216	215	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	3.954	0.000	0.000	0.000	0.000	0.000	0.000	12.90	67.21	91.02	106.63	155.78	0.0	0.0	738.3	55.6	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	66.92%	1.23	1.16	0.80
	215	214	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	3.954	0.000	0.000	0.000	0.000	0.000	0.000	13.70	65.01	88.00	103.08	150.57	0.0	0.0	714.1	21.2	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	64.73%	1.23	1.14	0.31
	214	213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	3.954	0.000	0.000	0.000	0.000	0.000	0.000	14.01	64.21	86.90	101.78	148.66	0.0	0.0	705.3	25.1	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	63.92%	1.23	1.14	0.37
	213	212	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	3.954	0.000	0.000	0.000	0.000	0.000	0.000	14.38	63.28	85.62	100.28	146.46	0.0	0.0	695.0	72.8	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	62.99%	1.23	1.13	1.07
	212	120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	3.954	0.000	0.000	0.000	0.000	0.000	0.000	15.45	60.72	82.12	96.17	140.42	0.0	0.0	667.0	89.3	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	60.45%	1.23	1.12	1.33
																				16.78																			
	120	119	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.432	0.000	0.789	0.000	0.000	0.000	0.000	16.78	57.86	78.22	91.57	133.68	0.0	0.0	883.8	53.8	1050	1050	CIRCULAR	CONCRETE	-	0.30	1560.3	56.64%	1.75	1.55	0.58
C119A	119	115	0.00	2.52	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.000	4.432	1.540	2.329	0.000	0.000	0.000	0.000	17.36	56.71	76.64	89.72	130.96	0.0	0.0	1193.9	274.5	1200	1200	CIRCULAR	CONCRETE	-	0.15	1575.3	75.79%	1.35	1.31	3.50
																				20.86																			
C118A	118	117	0.00	1.04	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.000	0.000	0.635	0.635	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	183.6	85.1	600	600	CIRCULAR	PVC	-	0.15	248.1	74.02%	0.85	0.82	1.73
																				11.73																			
L206A	206	205	2.68	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	1.636	1.636	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	348.9	164.8	750	750	CIRCULAR	CONCRETE	-	0.15	449.8	77.57%	0.99	0.96	2.86
	205	204	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	1.636	0.000	0.000	0.000	0.000	0.000	0.000	12.86	67.33	91.18	106.81	156.05	0.0	0.0	305.9	82.2	750	750	CIRCULAR	CONCRETE	-	0.15	449.8	68.00%	0.99	0.92	1.48
	204	117	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	1.636	0.000	0.000	0.000	0.000	0.000	0.000	14.34	63.36	85.74	100.42	146.66	0.0	0.0	287.9	75.0	750	750	CIRCULAR	CONCRETE	-	0.15	449.8	64.00%	0.99	0.91	1.37
																				15.72																			
	117	116	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	1.636	0.000	0.635	0.000	0.000	0.000	0.000	15.72	60.13	81.31	95.21	139.02	0.0	0.0	416.5	85.9	825	825	CIRCULAR	CONCRETE	-	0.15	580.0	71.81%	1.05	1.00	1.43
																				17.14																			
L203A	203	202	6.66	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	4.061	4.061	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	866.4	148.5	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	78.53%	1.23	1.21	2.05
	202	201	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.061	0.000	0.000	0.000	0.000	0.000	0.000	12.05	69.75	94.50	110.73	161.79	0.0	0.0	786.8	20.3	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.4	71.31%	1.23	1.17	0.29
	201	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.061	0.000	0.000	0.000	0.000	0.000	0.000	12.34	68.87	93.29	109.30	159.70	0.0	0.0	776.9	158.6	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	70.41%	1.23	1.17	2.26
	200	116	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.061	0.000	0.000	0.000	0.000	0.000	0.000	14.59	62.75	84.90	99.43	145.21	0.0	0.0	707.8	77.8	1050	1050	CIRCULAR	CONCRETE	-	0.15	1103.3	64.16%	1.23	1.14	1.14
																				15.73																			
C116A	116	115	0.00	1.66	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.000	5.697	1.014	1.649	0.000	0.000	0.000	0.000	17.14	57.13	77.22	90.40	131.96	0.0	0.0	1257.8	227.9	1350	1350	CIRCULAR	CONCRETE	-	0.10	1760.8	71.43%	1.19	1.13	3.36
																				20.50																			
L211A	211	210	9.08	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	4.997	4.997	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	1066.0	83.0	1200	1200	CIRCULAR	CONCRETE	-	0.10	1286.2	82.88%	1.10	1.10	1.26
	210	209	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.997	0.000	0.000	0.000	0.000	0.000	0.000	11.26	72.28	97.97	114.82	167.80	0.0	0.0	1003.2	15.6	1200	1200	CIRCULAR	CONCRETE	-	0.10	1286.2	78.00%	1.10	1.08	0.24
	209	208	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.997	0.000	0.000	0.000	0.000	0.000	0.000	11.50	71.49	96.88	113.53	165.91	0.0	0.0	992.2	264.0	1200	1200	CIRCULAR	CONCRETE	-	0.10	1286.2	77.14%	1.10	1.07	4.10
	208	207	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.997	0.000	0.000	0.000	0.000	0.000	0.000	15.60	60.38	81.66	95.62	139.62	0.0	0.0	838.1	79.1	1200	1200	CIRCULAR	CONCRETE	-	0.10	1286.2	65.16%	1.10	1.02	1.29
	207	115	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.997	0.000	0.000	0.000	0.000	0.000	0.000	16.89	57.64	77.91	91.21	133.15	0.0	0.0	800.0	79.9	1200	1200	CIRCULAR	CONCRETE	-	0.10	1286.2	62.20%	1.10	1.01	1.32
																				18.21																			
	115	114	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	15.125	0.000	3.978	0.000	0.000	0.000	0.000	20.86	50.68	68.41	80.05	116.79	0.0	0.0	2885.4	87.3	1800	1800	CIRCULAR	CONCRETE	-	0.10	3792.1	76.09%	1.44	1.40	1.04
	114	112	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	15.125	0.000	3.978	0.000	0.000	0.000	0.000	21.90	49.16	66.33	77.61	113.20	0.0	0.0	2798.2	77.6	1800	1800	CIRCULAR	CONCRETE	-	0.10	3792.1	73.79%	1.44	1.39	0.93
																				22.83																			
L112A	112	103	1.73	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	1.054	18.213	0.000	3.978	0.000	0.000	0.000	0.000	22.83	47.88	64.59	75.56	110.20	0.0	0.0	3135.8	156.7	1800	1800	CIRCULAR	CONCRETE	-	0.10	3792.1	82.69%	1.44	1.44	1.82
																				24.65																			
L111A	111	110	3.52	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	1.937	1.937	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	413.2	203.9	675	675	CIRCULAR	CONCRETE	-	0.30	480.3	86.03%	1.30	1.31	2.60
	110	104	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	1.937	0.000	0.000	0.000	0.000	0.000	0.000	12.60	68.09	92.22	108.05	157.86	0.0	0.0	366.3	140.2	675	675	CIRCULAR	CONCRETE	-	0.30	480.3	76.26%	1.30	1.27	1.85
																				14.44																			
L109B, L109C, C109A	109	108	1.90	0.58	0.00	0.00	0.00	0.27	0.65	0.00	0.00	0.509	0.509	0.379	0.379	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	218.3	97.6	600	600	CIRCULAR	CONCRETE	-	0.15	248.1	87.97%	0.85	0.86	1.89
F108A	108	106	0.00	0.00	0.00	2.44	0.00	0.00	0.00	0.00	0.70	0.000	0.509	0.000	0.379	0.000	0.000	1.711	1.711	11.89	70.23	95.16	111.51	162.94	0.0	0.0	974.0	240.0	1200	1200	CIRCULAR	CONCRETE	-	0.10	1286.2	75.73%	1.10	1.07	3.75
																				15.64																			
L107A	107	106	4.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	2.437	2.437	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	520.0	135.6	900	900	CIRCULAR	CONCRETE	-	0.10	597.2	87.07%	0.91	0.92	2.46
																				12.46																			
C106A, C106B	106	105	0.00	1.97	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.000	2.946	0.848	1.227	0.000	0.000	0.000	1.711	15.64	60.29	81.54	95.47	139.41	0.0	0.0	1434.0	212.2	1350	1350	CIRCULAR	CONCRETE	-	0.10	1760.8	81.44%	1.19	1.18	3.00
	105	104	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	2.946	0.000	1.227	0.000	0.000	0.000	1.711	18.64	54.33	73.39	85.90	125.36	0.0	0.0	1290.7	11.1	1350	1350	CIRCULAR	CONCRETE	-	0.10	1760.8	73.30%	1.19	1.15	0.16
																				18.80																			
	104	103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	4.883	0.000	1.227	0.000	0.000	0.000	1.711	18.80	54.05	73.00	85.44	124.69	0.0	0.0	1574.6	47.5	1350	1350	CIRCULAR	CONCRETE	-	0.10	1760.9	89.42%	1.19	1.21	0.65
																				19.45																			
	102	101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	0.0	9.9	1500	1500	CIRCULAR	CONCRETE	-	0.26	3760.3	0.00%	2.06	0.00	0.00
	101	Forebay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10.00	76.81	104.19	122.14	178.56	0.0	0.0	0.0	21.8	1500	1500	CIRCULAR	CONCRETE	-	0.26	3760.3	0.00%	2.06	0.00	0.00
																				10.00									1500										
	103	102	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	23.096	0.000	5.205	0.000	0.000	0.000	1.711	24.65	45.58	61.46	71.88	104.81	0.0	0.0	4311.0	46.0	2100	2100	CIRCULAR	CONCRETE	-	0.12	6266.1	68.80%	1.75	1.65	0.46
L102A	102	100B	2.52	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	1.537	24.633	0.000	5.205	0.000	0.000	0.000	1.711	25.12	45.03	60.71	71.01	103.53	0.0	0.0	4451.3	72.8	2400	1200	RECTANGULAR	CONCRETE	-	0.30	6587.4	67.57%	2.29	2.14	0.57
	100B	Maincell	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	24.633	0.000	5.205	0.000	0.000	0.000	1.711	25.68	44.38	59.83	69.97	102.01	0.0	0.0	4386.9	22.0	2400	1200	RECTANGULAR	CONCRETE	-	0.40	7606.5	57.67%	2.64	2.36	0.16
																				25.84									2400	1200									

Appendix B FERNBANK POND 4 DESIGN CALCULATIONS

160400900 Shea Road Development Pond Design Brief - Fernbank Pond 4

Stormwater Quality Volumetric Requirements

Pond	Drainage Area (ha)	Actual % Imp.	MOE Control Level	Water Quality Unit Volume Requirments			Water Quality Volume Requirements			Water Quality Volumes Provided			
				Total Unit Volume (m^3/ha)	Permanent Pool (m^3/ha)	Extended Detention (m^3/ha)	Permanent Pool (m^3)	Extended Detention (m^3)	Total MOE Volume	Permanent Pool (m^3)	Extended Detention (m^3)	Total MOE Volume	Actual Provided Unit Volume (m^3/ha)
Fernbank Pond 4	59.20	55	Enhanced - 80% TSS Removal	190	150.0	40	8,880	2,368	11,248	9,569	5,442	15,011	254

*Enhanced Water Level protection as specified by Fernbank Community Master Servicing Study

For use in Interpolation of above formulae

	Wetpond					Wetland			
%	0	35	55	70	85	35	55	70	85
Enhanced - 80% TSS Removal	0	140	190	225	250	80	105	120	140
Normal - 70% TSS Removal	0	90	110	130	150	60	70	80	90
Basic - 60% TSS Removal	0	60	75	85	95	60	60	60	60

160400900 Shea Road Development Pond Design Brief - Fernbank Pond 4
Stage-Storage-Discharge Summary

Stage	Discharge	Storage		Depth	Forebay			Main Cell			
		Active	Total*		Area	Incremental Volume	Accumulated Volume	Area	Incremental Volume	Accumulated Volume	
(m)	(m^3/s)	(m^3)	(m^3)	(m)	(m^2)	(m^3)	(m^3)	(m^2)	(m^3)	(m^3)	
104.25		0	0	0.00	752	0	0	4,243	0	0	
105.45		0	6,711	1.20	1,348	1,260	1,260	5,571	5,889	5,889	
105.55		0	7,490	1.30	1,567	146	1,406	7,092	633	6,522	
105.65		0	8,443	1.40	1,785	168	1,574	8,614	785	7,307	
105.75		0	9,569	1.50	2,003	189	1,763	10,135	937	8,245	Permanent Pool
105.75		0	9,569	1.50	0	0	1,763	12,138	0	8,245	Permanent Pool
106.15		5,442	15,011	0.40	0	0	1,763	15,072	5,442	13,686	
106.25		6,979	16,548	0.50	0	0	1,763	15,665	1,537	15,223	
106.35		8,575	18,144	0.60	0	0	1,763	16,258	1,596	16,819	
107.00		19,712	29,281	1.25	0	0	1,763	18,009	11,137	27,956	
107.34		25,991	35,560	1.59	0	0	1,763	18,925	6,279	34,235	
107.45		28,088	37,657	1.70	0	0	1,763	19,204	2,097	36,332	
107.75		33,893	43,463	2.00	0	0	1,763	19,500	5,806	42,138	

* Total pond including forebay, excluding sediment storage (see forebay calculations)

160400900 Shea Road Development Pond Design Brief - Fernbank Por

Conceptual Outlet Structure Discharge Calculations

Elevation (m)	Overflow Outlet			Piped Outlet				Weir 1	Total Discharge
		Spillway	Total	Orifice 1	Orifice 2		Control		
104.25									0.000
105.55									0.000
105.65									0.000
105.75									0.000
105.75		0.000	0.000	0.000	0.000		0.000	0.000	0.000
106.15		0.000	0.000	0.083	0.000		0.000	0.000	**0.083**
106.25		0.000	0.000	0.092	0.000		0.000	0.016	**0.108**
106.35		0.000	0.000	0.101	0.000		0.000	0.046	**0.147**
107.00		0.000	0.000	0.146	0.000		0.000	0.400	**0.546**
107.34		0.000	0.000	0.165	0.000		0.000	0.662	**0.827**
107.45		0.000	0.000	0.170	0.000		0.000	0.756	**0.926**
107.65		0.000	0.000	0.180	0.000		0.000	0.937	**1.117**
107.75		0.550	0.550	0.184	0.000		0.000	1.032	**1.767**

Discharge (m^3/s)

1. Outlet structure consists of reverse-sloped lowflow pipe connected to orifice #1 (created by equivalent sluice gate orientation)
2. Secondary outlet is Weir#1 in weir wall inside structure

Parameters

	Orifice 1	
	Orifice Centre: 105.875 m	Perimeter: 0.785 m
	Orifice Invert: 105.75 m	Area: 0.0491 m^2
	Orifice Diameter: 250 mm	Orifice Coeff.: 0.61
Spillway Weir	Orientation: Vertical	Permanent Pool: 105.75 m
Crest Elevation: 107.65 m	**Orifice 2**	
Crest Width: 10 m*	Orifice Centre: 108.23 m	Perimeter: 1.445 m
	Orifice Invert: 108.00 m	Area: 0.1662 m^2
Weir Coeff. 1.740	Orifice Diameter: 460 mm	Orifice Coeff.: 0.61
	Orientation: Vertical	
	Weir 1	
	Top of Weir Structure: 107.30 m	Max Perimeter: 0.300 m
	Weir Crest Invert: 106.15 m	Max Open Area: 0.345 m^2
	Weir Dimensions (Height x Length): 1.15 m Height	0.30 m Len
	Side Walls: Vertical	Weir Coeff.: 1.700

0.3 m long weir at inv. = 106.15
250 mm lowflow outlet at inv. = 105.75 m
460 mm outlet at inv. = 108 m

Water Quality Extended Detention Summary

Required Extended Detention Time	24-48 hrs for water quality drawdown		
Actual Extended Detention Time	40 hrs	Q_{peak}	0.083 m^3/s
Extended Detention Elevation	106.15 m	Q_{avg}	0.041 m^3/s

Watershed Area (ha)	59.20
Percent Impervious	55.0%
Water Quality Criteria	Enhanced - 80% TSS Removal
Req'd Ext. Det. Volume (m^3/ha)	40
Req'd Ext. Det. Volume (m^3)	2,368
Provided Ext. Det. (m^3)	5,442
Req'd Perm. Pool Volume (m^3/ha)	150.0
Req'd Perm. Pool Volume (m^3)	8,880
Provided Perm. Pool Volume (m^3)	9,569

Storm	Discharge Rates from PCSWMM (m^3/s) Pond Inflow	Allowable	Pond Outflow	Storage (ha-m)	Water Level
25mm, 4hr Chi	3.677	N/A	0.077	6235	106.20
2-yr, 24hr SCS	4.037	0.480	0.149	9379	106.40
5-yr, 24hr SCS	5.408	0.760	0.246	12603	106.59
10-yr, 24hr SCS	5.928	0.900	0.319	14745	106.71
25-yr, 24hr SCS	6.943	0.900	0.429	17575	106.88
100-yr, 24hr SCS	13.762	0.900	0.785	25952	107.34
100-yr+20, 24hr SCS	17.124	N/A	2.454	35615	107.84
100-yr, 3hr Chi	16.946	N/A	0.680	23586	107.21
July 1, 1979	12.415	N/A	0.917	31263	107.61

$$Q = CA\sqrt{2g\left(h_2 - h_1 + \frac{D}{2000}\right)}$$

Where,
h2 = elevation at stage 2 (m)
h1 = elevation at stage 1 (m)
D = orifice diameter (mm)
C = orifice coefficient
A = orifice open area (m^2)

$$Q = CL(h_2 - h_1)^{1.5}$$

h2 = elevation at stage 2 (m)
h1 = elevation at stage 1 (m)
L = weir crest length (m)
C = weir coefficient

Weir flow calculation for orifice below centreline:

$$\theta = 2\cos^{-1}\left(1 - \frac{2h}{D}\right) = 2\,\mathrm{acos}\left(1 - \frac{2h}{D}\right)$$

$$P_w = \frac{D\theta}{2}$$

h = water level stage (m)
D = orifice diameter (m)
θ = angle based on water level (radians)
P_W = Wetted Perimeter = Crest Length (m)

160400900 Shea Road Development Pond Design Brief - Fernbank Pond 4

Sediment Forebay Sizing Calculations

Using MOE - Stormwater Management Planning and Design Manual (2003)

Forebay

Settling Length @ Perm. Pool

Dist = sqrt($r*Q_p/v_s$)

= **27.8** **m**

r : 1 = L to W ratio	r =	2.8	Average
Q_p = peak SWM outflow during quality storm	Q_p =	0.083	Note 1.
v_s = settling velocity for 0.15 mm particles (m/s)	v_s =	0.0003	

Dispersion Length @ Perm. Pool

Dist = 8Q/dv

= **58.8** **m**

y_d = total depth of sediment in forebay (m)	y_d =	0.5	
Q = 25mm max inlet flow (m^3/s)	Q =	3.677	Note 2.
d = depth of perm pool in forebay (m)	d =	1.0	
v_f = desired vel in forebay (m/s)	v_f =	0.5	

Provided = 68.0 m **Length Criteria Satisfied** **Provided L:W = 2.2**

Velocity @ Forebay Berm

v = Q/A

= **0.15** **m/s**

y = total depth of forebay from perm. pool (m)	y =	1.0	Assume max. sediment depth
b = bottom width of forebay (m)	b =	20	at forebay end
Q = 25mm inlet flow (m^3/s)	Q =	3.677	
A = cross-sectional area (m^2)	A =	23.78	Note 3.
Target velocity = 0.15	V_{targ} =	0.15	

Velocity Target Satisfied

Cleanout Frequency

Table 6.3 MOE SWMPD Manual

cleanout = Vol/(load*A_{sew}*effic)

= **7.1** **years**

Water Quality Level	Enhanced - 80% TSS Removal		
A_{sew} = Contributing Sewer Area (ha)	A_{sew} =	59.20	
Imp = Percent Impervious (%)	Imp =	55.0%	
load = Sediment Loading (m^3/ha)	load =	1.3	Assume same as overall
effic = Removal Efficiency (%) - Enhanced - 80% TSS Removal Level	effic =	80%	Note 4.
Targ = Cleanout Frequency Target (years)	Targ =	6	
Vol = Sediment volume (m^3)	Vol =	438	Note 5.

Surface Area Check

SA_f/SA_{pp} = **16.5%**

SA_f = Forebay Surface Area (m^2)	SA_f =	2,003
SA_{pp} = Total Permanent Pool Surface Area (m^2)	SA_{pp} =	12,138
Targ = Forebay size (as % of Permanent Pool Area)	Targ =	33%

Therefore, **The forebay size is OK!**

Notes

1. Peak pond outflow at extended detention elevation
2. Inlet flow is 25mm inflow from PCSWMM model
3. Cross-sectional area based on depth above maximum sedimentation depth (0.5 m)
4. Interpolated based on percent impervious
5. Volume of bottom 0.5 m depth, the maximum sediment accumulation depth

160400900 Shea Road Development Pond Design Brief - Fernbank Pond 4

Flow Augmentation Calculation

Falling Head Orifice Equation (used for approximating detention time).

(as per Equation 4.10 in MOE SWMPDM)

a)

$$t = \frac{2 * A_p}{CA_0(2g)^{0.5}} (h_1^{0.5} - h_2^{0.5})$$

where:

- t= drawdown time (seconds)
- A_p= pond surface area (sq.m),
- C= discharge coefficient
- A_0= area of orifice (sq.m)
- h_1= starting water elevation above orifice (m)
- h_2= ending water elevation above orifice (m)

Check for Detention Time

Ap	15071.8	m^2	Approximate pond area
C	0.6		
orifice dia.	0.25	m	
h1	0.40	m	
h2	0.00	m	
Ao =	0.04909	sq.m	
t =	146135.1707	s	
	1.7	days	
	40.6	**hours**	

Equation 4.11

b)

$$t = \frac{0.66C_2h^{1.5} + 2C_3h^{0.5}}{2.75A_0}$$

Where:

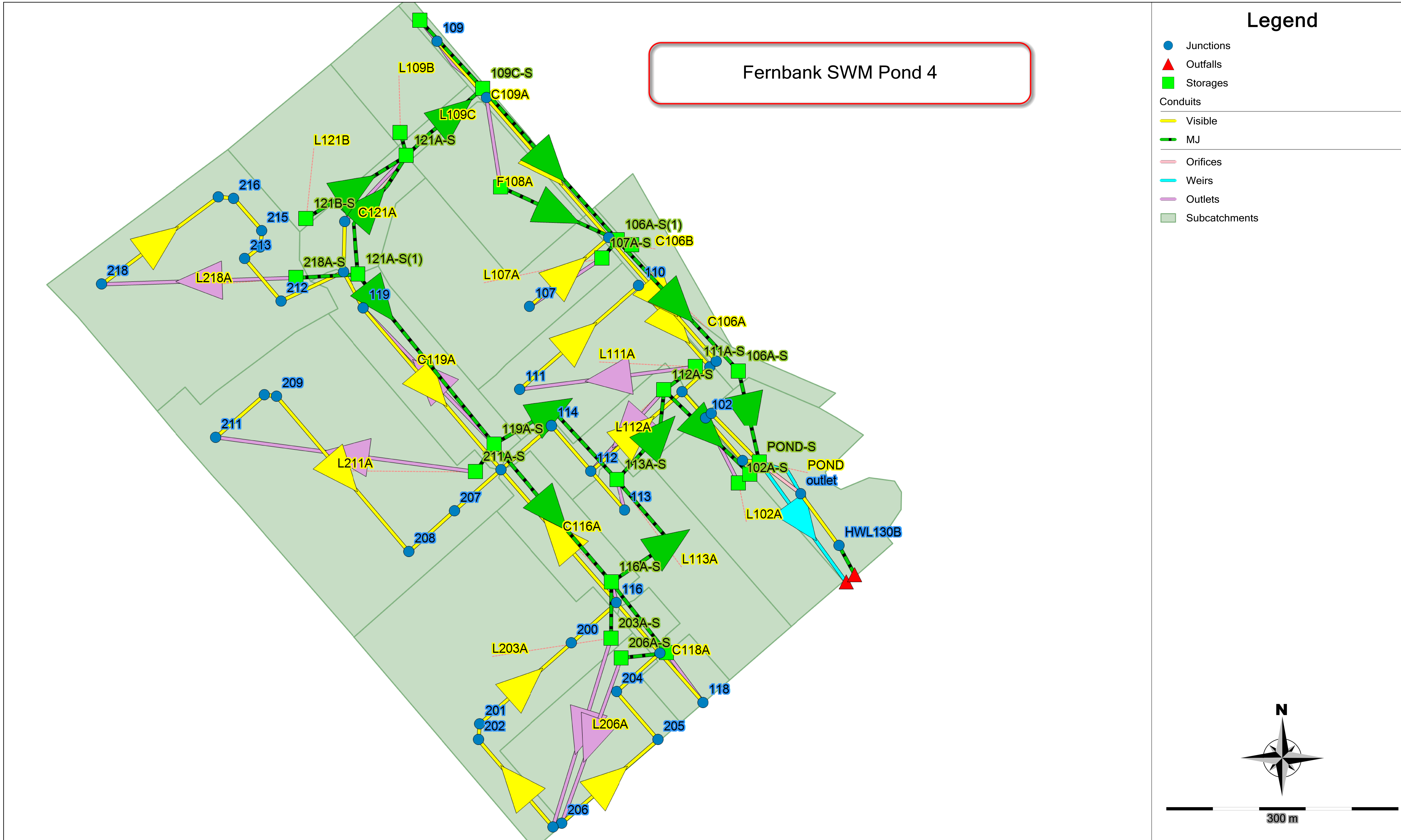
- t= drawdown time (seconds)
- A_0= cross sectional area of orifice (sq.m)
- h= maximum water elevation above the orifice (m)
- C_2= slope coefficient from the area-depth linear regression
- C_3= intercept form the area-depth linear regression

A_0	0.0491	sq.m
h	0.40	m
C_2	2966	
C_3	15071.8	
t=	144897	s
	1.7	days
	40.2	**hours**

Appendix C POST-DEVELOPMENT PCSWMM MODELLING

C.1 PCSWMM Layout
C.2 Input Parameters
C.3 Example Input File for 100-year, 3hr Chicago Storm Event

C.1 PCSWMM LAYOUT


Fernbank SWM Pond 4
Legend
Junctions
Outfalls
Storages
Conduits
Visible
MJ
Orifices
Weirs
Outlets
Subcatchments
N
300 m
109
109C-S
C109A
L109B
L109C
121A-S
L121B
121B-S
C121A
216
215
213
218
L218A
218A-S
212
121A-S(1)
119
F108A
106A-S(1)
107A-S
C106B
L107A
107
110
C106A
L111A
111A-S
106A-S
111
112A-S
102
C119A
209
211
L211A
119A-S
114
L112A
211A-S
112
113A-S
POND-S
102A-S
POND
outlet
113
207
208
C116A
L102A
HWL130B
L113A
116A-S
116
200
203A-S
L203A
206A-S
C118A
204
118
201
202
L206A
205
206

C.2 INPUT PARAMETERS

Summary of Subcatchment Parameters - Proposed Development Areas

40

Area ID	Area (ha)	Width (m)	Slope (%)	%IMP	Runoff Coefficient	Subarea Routing	% Routed		Minor System Capture (L/s)	STORAGE- (cu.m)
C106A	1.01	292.0	1.0	64.3%	0.65	OUTLET	100		207.0	0
C106B	0.96	241.0	1.0	0.0%	0.20	PERVIOUS	100		18.3	0
C109A	0.58	362.0	1.0	64.3%	0.65	OUTLET	100		128.0	0
C116A	1.66	567.0	1.0	58.6%	0.61	OUTLET	100		319.3	67
C118A	1.04	244.0	1.0	58.6%	0.61	OUTLET	100		193.3	0
C119A	2.52	656.0	1.0	58.6%	0.61	OUTLET	100		473.0	101
C121A	1.29	315.0	1.0	58.6%	0.61	OUTLET	100		241.2	52
F108A	2.44	200.0	2.0	71.4%	0.70	OUTLET	100	100 year storage	518.1	**208**
L102A	2.52	556.0	1.0	58.6%	0.61	OUTLET	100		315.1	101
L107A	4.00	1864.0	1.0	58.6%	0.61	OUTLET	100		504.0	160
L109B	1.61	116.0	2.0	0.0%	0.20	PERVIOUS	100		-	0
L109C	0.29	118.0	0.5	64.3%	0.65	OUTLET	100		39.6	12
L111A	3.52	536.0	1.0	50.0%	0.55	OUTLET	100		375.4	141
L112A	1.73	353.0	1.0	58.6%	0.61	OUTLET	100		216.2	69
L113A	3.34	816.0	1.0	58.6%	0.61	OUTLET	100		418.4	133
L121B	2.39	167.0	2.0	0.0%	0.20	PERVIOUS	100		-	0
L203A	6.66	1974.0	1.0	58.6%	0.61	OUTLET	100		836.5	266
L206A	2.68	939.0	1.0	58.6%	0.61	OUTLET	100		337.4	107
L211A	9.08	2655.0	1.0	50.0%	0.55	OUTLET	100		975.6	363
L218A	6.70	2358.0	1.0	55.7%	0.59	OUTLET	100		802.5	268
POND	3.13	280.0	2.0	40.0%	0.48	OUTLET	100		267.1	-

Storage Node Parameters

Storage Node	Invert Elevation (m)	Rim Elevation (m)	Total Depth (m)	Max Volume (m3)
106A-S(1)	108.56	110.71	2.15	0
106B-S	109.10	111.90	2.80	0
109A-S	110.20	112.35	2.15	0
116A-S	109.23	111.73	2.50	66
118A-S	110.06	112.21	2.15	0
119A-S	109.73	112.23	2.50	101
121A-S	109.72	112.22	2.50	52
108A-S	108.85	111.35	2.50	198
102A-S	108.12	110.77	2.65	100
107A-S	108.24	110.74	2.50	158
109B-S	112.00	112.60	0.60	0
109C-S	109.35	111.85	2.50	12
111A-S	108.44	110.94	2.50	140
112A-S	108.22	110.87	2.65	69
113A-S	108.53	111.03	2.50	132
121B-S	112.25	112.85	0.60	0
203A-S	109.25	111.75	2.50	265
206A-S	109.73	112.23	2.50	107
211A-S	109.75	112.25	2.50	363
218A-S	110.73	113.23	2.50	266
POND-S	104.25	107.75	3.50	34672

Outlet Results

Name	Inlet Node	Outlet Node	Inlet Elev. (m)	Max. |Flow| (L/s)
102A-IC	102A-S	108.12	315.18	315.18
106A-IC	106A-S(1)	108.56	207.00	207.00
106B-IC	106B-S	109.1	18.00	18.00
107A-IC	107A-S	108.24	504.51	504.51
108A-IC	108A-S	108.85	518.00	518.00
109A-IC	109A-S	110.2	128.00	128.00
109C-IC	109C-S	109.35	41.00	41.00
111A-IC	111A-S	108.44	375.00	375.00
112A-IC	112A-S	108.22	216.00	216.00
113A-IC	113A-S	108.53	418.00	418.00
116A-IC	116A-S	109.23	319.58	319.58
118A-IC	118A-S	110.06	193.00	193.00
119A-IC	119A-S	109.73	473.40	473.40
121A-IC	121A-S	109.72	241.40	241.40
203A-IC	203A-S	109.25	837.00	837.00
206A-IC	206A-S	109.73	337.00	337.00
211A-IC	211A-S	109.75	976.00	976.00
218A-IC	218A-S	110.73	802.00	802.00

C.3 EXAMPLE INPUT FILE FOR 100-YEAR, 3HR CHICAGO STORM EVENT

```
[TITLE]


[OPTIONS]
;;Options            Value
;;------------------ ------------
FLOW_UNITS           LPS
INFILTRATION         HORTON
FLOW_ROUTING         DYNWAVE
START_DATE           11/17/2017
START_TIME           00:00:00
REPORT_START_DATE    11/17/2017
REPORT_START_TIME    00:00:00
END_DATE             11/19/2017
END_TIME             00:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:01:00
WET_STEP             00:05:00
DRY_STEP             00:05:00
ROUTING_STEP         5
ALLOW_PONDING        NO
INERTIAL_DAMPING     PARTIAL
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
NORMAL_FLOW_LIMITED  BOTH
SKIP_STEADY_STATE    NO
FORCE_MAIN_EQUATION  H-W
LINK_OFFSETS         ELEVATION
MIN_SLOPE            0
MAX_TRIALS           8
HEAD_TOLERANCE       0.0015
SYS_FLOW_TOL         5
LAT_FLOW_TOL         5
MINIMUM_STEP         0.5
THREADS              4

[EVAPORATION]
;;Type          Parameters
;;------------- ----------
CONSTANT     0.0
DRY_ONLY     NO

[RAINGAGES]
;;               Rain      Time   Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
RG1              INTENSITY 0:10   1.0    TIMESERIES 100yr_3hr_Chicago_Ottawa

[SUBCATCHMENTS]
;;                                                 Total    Pcnt.             Pcnt.
  Curb     Snow
;;Name           Raingage         Outlet           Area     Imperv   Width    Slope
  Length   Pack
;;-------------- ---------------- ---------------- -------- -------- --------
-------- -------- --------
C106A            RG1              106A-S(1)        1.009065 64.286   292      1
  0
C106B            RG1              106B-S           0.960483 0        241      1
  0
C109A            RG1              109A-S           0.58286  64.286   362      1
```

```
  0
C116A           RG1             116A-S          1.663001 58.571   567      1
  0
C118A           RG1             118A-S          1.040192 58.571   244      1
  0
C119A           RG1             119A-S          2.523952 58.571   656      1
  0
C121A           RG1             121A-S          1.293885 58.571   315      1
  0
F108A           RG1             108A-S          2.444837 71.429   200      2
  0
L102A           RG1             102A-S          2.515228 58.571   556      1
  0
L107A           RG1             107A-S          3.995616 58.571   1864     1
  0
L109B           RG1             109B-S          1.609925 0        116      2
  0
L109C           RG1             109C-S          0.28776  64.286   118      0.5
  0
L111A           RG1             111A-S          3.521316 50       536      1
  0
L112A           RG1             112A-S          1.727354 58.571   353      1
  0
L113A           RG1             113A-S          3.335419 58.571   816      1
  0
L121B           RG1             121B-S          2.3862   0        167      2
  0
L203A           RG1             203A-S          6.657405 58.571   1974     1
  0
L206A           RG1             206A-S          2.681205 58.571   939      1
  0
L211A           RG1             211A-S          9.084765 50       2655     1
  0
L218A           RG1             218A-S          6.702376 55.714   2358     1
  0
POND            RG1             POND-S          3.128864 40       280      2
  0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo
PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ----------
----------
C106A           0.013      0.25       1.57       4.67       0          OUTLET
C106B           0.013      0.25       1.57       4.67       0          PERVIOUS
100
C109A           0.013      0.25       1.57       4.67       0          OUTLET
C116A           0.013      0.25       1.57       4.67       0          OUTLET
C118A           0.013      0.25       1.57       4.67       0          OUTLET
C119A           0.013      0.25       1.57       4.67       0          OUTLET
C121A           0.013      0.25       1.57       4.67       0          OUTLET
F108A           0.013      0.25       1.57       4.67       0          OUTLET
L102A           0.013      0.25       1.57       4.67       0          OUTLET
L107A           0.013      0.25       1.57       4.67       0          OUTLET
L109B           0.013      0.25       1.57       4.67       0          PERVIOUS
100
L109C           0.013      0.25       1.57       4.67       0          OUTLET
L111A           0.013      0.25       1.57       4.67       0          OUTLET
L112A           0.013      0.25       1.57       4.67       0          OUTLET
L113A           0.013      0.25       1.57       4.67       0          OUTLET
L121B           0.013      0.25       1.57       4.67       0          PERVIOUS
100
L203A           0.013      0.25       1.57       4.67       0          OUTLET
```

```
L206A            0.013      0.25       1.57       4.67       0          OUTLET
L211A            0.013      0.25       1.57       4.67       0          OUTLET
L218A            0.013      0.25       1.57       4.67       0          OUTLET
POND             0.013      0.25       1.57       4.67       0          OUTLET

[INFILTRATION]
;;Subcatchment   MaxRate    MinRate    Decay      DryTime    MaxInfil
;;-------------- ---------- ---------- ---------- ---------- ----------
C106A            76.2       13.2       4.14       7          0
C106B            76.2       13.2       4.14       7          0
C109A            76.2       13.2       4.14       7          0
C116A            76.2       13.2       4.14       7          0
C118A            76.2       13.2       4.14       7          0
C119A            76.2       13.2       4.14       7          0
C121A            76.2       13.2       4.14       7          0
F108A            76.2       13.2       4.14       7          0
L102A            76.2       13.2       4.14       7          0
L107A            76.2       13.2       4.14       7          0
L109B            76.2       13.2       4.14       7          0
L109C            76.2       13.2       4.14       7          0
L111A            76.2       13.2       4.14       7          0
L112A            76.2       13.2       4.14       7          0
L113A            76.2       13.2       4.14       7          0
L121B            76.2       13.2       4.14       7          0
L203A            76.2       13.2       4.14       7          0
L206A            76.2       13.2       4.14       7          0
L211A            76.2       13.2       4.14       7          0
L218A            76.2       13.2       4.14       7          0
POND             76.2       13.2       4.14       7          0

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
100B             105.5      2.65       0          0          0
101              105.477    3.003      0          0          0
102              105.519    3.291      0          0          0
;3000mm
103              105.634    4.792      0          0          0
;2400mm
104              106.282    4.089      0          0          0
;3000mm
105              106.296    3.848      0          0          0
;2400mm
106              106.568    3.592      0          0          0
;1800mm
107              107.154    4.796      0          0          0
;2400mm
108              106.958    4.152      0          0          0
;1200mm
109              107.704    3.296      0          0          0
;1800mm
110              107.377    3.775      0          0          0
;1500mm
111              108.049    3.192      0          0          0
;3000mm
112              105.941    4.867      0          0          0
;1500mm
113              107.298    3.65       0          0          0
114              106.079    4.943      0          0          0
;2400mm
115              106.226    5.79       0          0          0
;2400mm
```

```
116                 106.904    4.58       0          0          0
;1800mm
117                 107.558    4.44       0          0          0
;1200mm
118                 107.91     2.906      0          0          0
;2400mm
119                 107.238    5.3        0          0          0
;2400mm
120                 107.549    5.454      0          0          0
;1200mm
121                 108.596    3.994      0          0          0
;2400mm
200                 107.32     6.004      0          0          0
;2400mm
201                 107.563    8.143      0          0          0
;2400mm
202                 107.623    8.241      0          0          0
;2400mm
203                 107.876    8.91       0          0          0
;1800mm
204                 107.745    5.68       0          0          0
;1800mm
205                 107.928    8.611      0          0          0
;1500mm
206                 108.236    8.264      0          0          0
;2400mm
207                 106.906    6.02       0          0          0
;3000mm
208                 106.988    6.712      0          0          0
;2400mm
209                 107.312    6.855      0          0          0
;2400mm
210                 107.358    6.763      0          0          0
;2400mm
211                 107.471    6.643      0          0          0
;2400mm
212                 107.743    5.566      0          0          0
;3000mm
213                 107.912    6.028      0          0          0
;2400mm
214                 108.01     5.742      0          0          0
;2400mm
215                 108.072    5.622      0          0          0
;2400mm
216                 108.185    4.977      0          0          0
;2400mm
217                 108.245    5.905      0          0          0
;2400mm
218                 108.557    5.643      0          0          0
HWL130B             105.7      2.3        0          0          0
outlet              105.55     2.2        0          0          0

[OUTFALLS]
;;                  Invert     Outfall      Stage/Table      Tide
;;Name              Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
OF1                 107.65     FREE                          NO
OF3                 105.58     FREE                          NO

[STORAGE]
;;                  Invert   Max.     Init.     Storage    Curve
Ponded    Evap.
;;Name              Elev.    Depth    Depth     Curve      Params
```

```
Area     Frac.    Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- --------
-------- -------- -----------------------
102A-S          108.12   2.65     0        TABULAR    102A-S                     0
      0
102A-S(1)       107.5    0.7      0        FUNCTIONAL 0        0        0        0
      0
106A-S          108.27   0.5      0        FUNCTIONAL 0        0        0        0
      0
106A-S(1)       108.56   2.15     0        FUNCTIONAL 0        0        0        0
      0
106B-S          109.1    2.8      0        FUNCTIONAL 0        0        0        0
      0
107A-S          108.24   2.5      0        TABULAR    107A-S                     0
      0
108A-S          108.85   2.5      0        TABULAR    108A-S                     0
      0
109A-S          110.2    2.15     0        FUNCTIONAL 0        0        0        0
      0
109B-S          112      0.6      0        FUNCTIONAL 0        0        0        0
      0
109C-S          109.35   2.5      0        TABULAR    109C-S                     0
      0
111A-S          108.44   2.5      0        TABULAR    111A-S                     0
      0
112A-S          108.22   2.65     0        TABULAR    112A-S                     0
      0
113A-S          108.53   2.5      0        TABULAR    113A-S                     0
      0
116A-S          109.23   2.5      0        TABULAR    116A-S                     0
      0
118A-S          110.06   2.15     0        FUNCTIONAL 0        0        0        0
      0
119A-S          109.73   2.5      0        TABULAR    119A-S                     0
      0
121A-S          109.72   2.5      0        TABULAR    121A-S                     0
      0
121A-S(1)       112.87   0.35     0        FUNCTIONAL 0        0        0        0
      0
121B-S          112.25   0.6      0        FUNCTIONAL 0        0        0        0
      0
203A-S          109.25   2.5      0        TABULAR    203A-S                     0
      0
206A-S          109.73   2.5      0        TABULAR    206A-S                     0
      0
211A-S          109.75   2.5      0        TABULAR    211A-S                     0
      0
218A-S          110.73   2.5      0        TABULAR    218A-S                     0
      0
POND-S          104.25   3.5      1.5      TABULAR    POND                       0
      0

[CONDUITS]
;;              Inlet            Outlet                     Manning    Inlet
Outlet     Init.      Max.
;;Name          Node             Node             Length     N          Offset
Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ----------
---------- ---------- ----------
C1              121A-S(1)        121A-S           20         0.013      112.87
111.87     0          0
C10             119A-S           113A-S           20         0.013      111.88
110.68     0          0
```

C11	119A-S	116A-S	20	0.013	111.88	111.38	0	0
C12	118A-S	116A-S	86	0.013	111.86	111.38	0	0
C13	203A-S	116A-S	4	0.013	111.4	111.38	0	0
C14	206A-S	118A-S	4	0.013	111.88	111.86	0	0
C15	HWL130B	OF3	17.5	0.035	105.7	105.58	0	0
C16	116A-S	113A-S	20	0.013	111.38	110.68	0	0
C17	113A-S	112A-S	20	0.013	110.68	110.37	0	0
C18	111A-S	112A-S	48	0.013	110.59	110.37	0	0
C19	107A-S	106A-S(1)	6	0.013	110.39	110.36	0	0
C2	102	100B	72.87	0.013	106.5	106.28	0	0
C21	106A-S	POND-S	20	0.013	108	107.44	0	0
C23	102A-S	102A-S(1)	5	0.025	110.27	107.5	0	0
C24	100B	POND-S	22	0.013	105.85	105.75	0	0
C25	102A-S(1)	POND-S	10	0.025	107.5	107.35	0	0
C26	112A-S	102A-S(1)	153	0.025	110.37	107.5	0	0
C27	121B-S	121A-S	2	0.025	112.25	112	0	0
C28	109B-S	121A-S	2	0.025	112	111.87	0	0
C29	106B-S	106A-S(1)	2	0.025	110.9	110.36	0	0
C3	121A-S	109C-S	20	0.013	111.87	111.5	0	0
C30	109A-S	109C-S	50	0.013	112	111.5	0	0
C31	outlet	HWL130B	24.7	0.013	105.75	105.7	0	0
C4	109C-S	106A-S(1)	20	0.013	111.5	110.36	0	0
C5	106A-S(1)	106A-S	100	0.013	110.36	108	0	0
C6	108A-S	106A-S(1)	5	0.013	111	110.95	0	0
C7	218A-S	121A-S(1)	2	0.013	112.88	112.87	0	0
C8	121A-S(1)	119A-S	20	0.013	112.87	111.88	0	0
C9	211A-S	119A-S	4	0.013	111.9	111.88	0	0
Pipe_1	102	101	9.87	0.013	105.66	105.64	0	0
Pipe_22	112	103	156.728	0.013	106.241	106.084	0	0
Pipe_23	110	104	140.191	0.013	107.677	107.257	0	0
Pipe_24_(1)	111	110	203.904	0.013	108.349	107.737	0	0
Pipe_27	117	116	85.874	0.013	107.858			

107.729	0	0				
Pipe_28	118		117	85.068	0.013	108.21
108.083	0	0				
Pipe_29_(1)	116		115	227.891	0.013	107.204
106.976	0	0				
Pipe_3_(1)	106		105	212.193	0.013	106.868
106.656	0	0				
Pipe_30_(1)	119		115	274.488	0.013	107.538
107.126	0	0				
Pipe_31	120		119	53.76	0.013	107.849
107.688	0	0				
Pipe_32	121		120	65.24	0.013	108.896
108.374	0	0				
Pipe_35	107		106	135.621	0.013	107.454
107.318	0	0				
Pipe_43	103		102	45.979	0.013	105.77
105.71	0	0				
Pipe_44	113		112	66.392	0.013	107.598
107.366	0	0				
Pipe_47	204		117	75.004	0.013	108.045
107.933	0	0				
Pipe_48	205		204	82.176	0.013	108.228
108.105	0	0				
Pipe_49	206		205	164.822	0.013	108.536
108.288	0	0				
Pipe_5	108		106	240	0.013	107.258
107.018	0	0				
Pipe_50	200		116	77.768	0.013	107.62
107.504	0	0				
Pipe_50_(1)	201		200	158.607	0.013	107.863
107.625	0	0				
Pipe_51	202		201	20.319	0.013	107.923
107.893	0	0				
Pipe_52	203		202	148.464	0.013	108.176
107.953	0	0				
Pipe_53	207		115	79.926	0.013	107.206
107.126	0	0				
Pipe_53_(1)	208		207	79.1	0.013	107.288
107.209	0	0				
Pipe_54	209		208	264.023	0.013	107.612
107.348	0	0				
Pipe_55	210		209	15.557	0.013	107.658
107.642	0	0				
Pipe_56	211		210	83.021	0.013	107.771
107.688	0	0				
Pipe_58	218		217	188.555	0.013	108.857
108.575	0	0				
Pipe_59	217		216	19.773	0.013	108.545
108.515	0	0				
Pipe_6	109		108	97.573	0.013	108.004
107.858	0	0				
Pipe_61	212		120	89.327	0.013	108.043
107.909	0	0				
Pipe_62	213		212	72.822	0.013	108.212
108.103	0	0				
Pipe_63	214		213	25.111	0.013	108.31
108.272	0	0				
Pipe_63_(1)	215		214	21.157	0.013	108.372
108.34	0	0				
Pipe_63_(1)_(1)	216		215	55.562	0.013	108.485
108.402	0	0				
Pipe_64	114		112	77.623	0.013	106.379
106.301	0	0				

```
Pipe_65          115              114              87.275     0.013      106.526
106.439    0          0
Pipe_68          104              103              47.498     0.013      106.582
106.534    0          0
Pipe_69          105              104              11.063     0.013      106.596
106.585    0          0
Pipe_7           101              POND-S           21.827     0.013      105.61
105.55     0          0

[ORIFICES]
;;               Inlet            Outlet           Orifice      Crest      Disch.
 Flap Open/Close
;;Name           Node             Node             Type         Height     Coeff.
 Gate Time
;;-------------- ---------------- ---------------- ------------ ----------
---------- ---- ----------
C22              POND-S           outlet           SIDE         105.75     0.61
 NO   0

[WEIRS]
;;               Inlet            Outlet           Weir         Crest      Disch.
 Flap End      End
;;Name           Node             Node             Type         Height     Coeff.
 Gate Con.     Coeff.     Surcharge  RoadWidth  RoadSurf
;;-------------- ---------------- ---------------- ------------ ----------
---------- ---- -------- ---------- ---------- ---------- ----------
C20              POND-S           OF1              TRANSVERSE   107.65     1.74
 NO   0        0          YES
W1               POND-S           outlet           TRANSVERSE   106.15     1.7
 NO   0        0          YES

[OUTLETS]
;;               Inlet            Outlet           Outflow    Outlet
Qcoeff/                     Flap
;;Name           Node             Node             Height     Type
QTable           Qexpon     Gate
;;-------------- ---------------- ---------------- ---------- ----------------
---------------- ---------- ----
102A-IC          102A-S           102              108.12     TABULAR/HEAD
102A-IC                     NO
106A-IC          106A-S(1)        106              108.56     TABULAR/HEAD
106A-IC                     NO
106B-IC          106B-S           106              109.1      TABULAR/HEAD
106B-IC                     NO
107A-IC          107A-S           107              108.24     TABULAR/HEAD
107A-IC                     NO
108A-IC          108A-S           108              108.85     TABULAR/HEAD
108A-IC                     NO
109A-IC          109A-S           109              110.2      TABULAR/HEAD
109A-IC                     NO
109C-IC          109C-S           109              109.35     TABULAR/HEAD
109C-IC                     NO
111A-IC          111A-S           111              108.44     TABULAR/HEAD
111A-IC                     NO
112A-IC          112A-S           112              108.22     TABULAR/HEAD
112A-IC                     NO
113A-IC          113A-S           113              108.53     TABULAR/HEAD
113A-IC                     NO
116A-IC          116A-S           116              109.23     TABULAR/HEAD
116A-IC                     NO
118A-IC          118A-S           118              110.06     TABULAR/HEAD
118A-IC                     NO
119A-IC          119A-S           119              109.73     TABULAR/HEAD
```

```
119A-IC                     NO
121A-IC          121A-S          121              109.72     TABULAR/HEAD
121A-IC                     NO
203A-IC          203A-S          203              109.25     TABULAR/HEAD
203A-IC                     NO
206A-IC          206A-S          206              109.73     TABULAR/HEAD
206A-IC                     NO
211A-IC          211A-S          211              109.75     TABULAR/HEAD
211A-IC                     NO
218A-IC          218A-S          218              110.73     TABULAR/HEAD
218A-IC                     NO

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4
Barrels
;;-------------- ------------ ---------------- ---------- ---------- ----------
----------
C1               IRREGULAR    24mROW           0          0          0          1

C10              IRREGULAR    18mROW           0          0          0          1

C11              IRREGULAR    24mROW           0          0          0          1

C12              IRREGULAR    24mROW           0          0          0          1

C13              IRREGULAR    18mROW           0          0          0          1

C14              IRREGULAR    18mROW           0          0          0          1

C15              TRAPEZOIDAL  0.65             1          3          3          1

C16              IRREGULAR    18mROW           0          0          0          1

C17              IRREGULAR    18mROW           0          0          0          1

C18              IRREGULAR    18mROW           0          0          0          1

C19              IRREGULAR    18mROW           0          0          0          1

C2               RECT_CLOSED  1.35             2.1        0          0          1

C21              TRAPEZOIDAL  0.5              2          10         10         1

C23              TRAPEZOIDAL  0.5              1          3          3          1

C24              RECT_CLOSED  1.35             2.1        0          0          1

C25              TRAPEZOIDAL  0.5              4          3          3          1

C26              TRAPEZOIDAL  0.5              4          3          3          1

C27              TRIANGULAR   0.6              3.6        0          0          1

C28              TRIANGULAR   0.6              3.6        0          0          1

C29              TRIANGULAR   1                6          0          0          1

C3               IRREGULAR    24mROW           0          0          0          1

C30              IRREGULAR    24mROW           0          0          0          1

C31              CIRCULAR     1.05             0          0          0          1
```

C4	IRREGULAR	24mROW	0	0	0	1
C5	IRREGULAR	24mROW	0	0	0	1
C6	IRREGULAR	16.5mROW	0	0	0	1
C7	IRREGULAR	18mROW	0	0	0	1
C8	IRREGULAR	24mROW	0	0	0	1
C9	IRREGULAR	18mROW	0	0	0	1
Pipe_1	CIRCULAR	1.5	0	0	0	1
Pipe_22	CIRCULAR	1.8	0	0	0	1
Pipe_23	CIRCULAR	0.675	0	0	0	1
Pipe_24_(1)	CIRCULAR	0.675	0	0	0	1
Pipe_27	CIRCULAR	0.825	0	0	0	1
Pipe_28	CIRCULAR	0.6	0	0	0	1
Pipe_29_(1)	CIRCULAR	1.35	0	0	0	1
Pipe_3_(1)	CIRCULAR	1.35	0	0	0	1
Pipe_30_(1)	CIRCULAR	1.2	0	0	0	1
Pipe_31	CIRCULAR	1.05	0	0	0	1
Pipe_32	CIRCULAR	0.525	0	0	0	1
Pipe_35	CIRCULAR	0.9	0	0	0	1
Pipe_43	CIRCULAR	2.1	0	0	0	1
Pipe_44	CIRCULAR	0.675	0	0	0	1
Pipe_47	CIRCULAR	0.75	0	0	0	1
Pipe_48	CIRCULAR	0.75	0	0	0	1
Pipe_49	CIRCULAR	0.75	0	0	0	1
Pipe_5	CIRCULAR	1.2	0	0	0	1
Pipe_50	CIRCULAR	1.05	0	0	0	1
Pipe_50_(1)	CIRCULAR	1.05	0	0	0	1
Pipe_51	CIRCULAR	1.05	0	0	0	1
Pipe_52	CIRCULAR	1.05	0	0	0	1
Pipe_53	CIRCULAR	1.2	0	0	0	1
Pipe_53_(1)	CIRCULAR	1.2	0	0	0	1
Pipe_54	CIRCULAR	1.2	0	0	0	1
Pipe_55	CIRCULAR	1.2	0	0	0	1

```
Pipe_56          CIRCULAR     1.2              0          0          0          1

Pipe_58          CIRCULAR     1.05             0          0          0          1

Pipe_59          CIRCULAR     1.05             0          0          0          1

Pipe_6           CIRCULAR     0.6              0          0          0          1

Pipe_61          CIRCULAR     1.05             0          0          0          1

Pipe_62          CIRCULAR     1.05             0          0          0          1

Pipe_63          CIRCULAR     1.05             0          0          0          1

Pipe_63_(1)      CIRCULAR     1.05             0          0          0          1

Pipe_63_(1)_(1)  CIRCULAR     1.05             0          0          0          1

Pipe_64          CIRCULAR     1.8              0          0          0          1

Pipe_65          CIRCULAR     1.8              0          0          0          1

Pipe_68          CIRCULAR     1.35             0          0          0          1

Pipe_69          CIRCULAR     1.35             0          0          0          1

Pipe_7           CIRCULAR     1.5              0          0          0          1

C22              CIRCULAR     0.25             0          0          0
C20              RECT_OPEN    1                10         3          3
W1               RECT_OPEN    1.15             0.3        0          0

[TRANSECTS]

;Full street, width = 8.5m, curb = 0.15m , cross-slope = 0.02m/m, bank-slope =
0.02m/m, bank-height = 0.23m.
NC 0.02     0.02     0.013
X1 16.5mROW          7        4        12.5     0.0       0.0       0.0      0.0
0.0
GR 0.23     0        0.15     4        0        4         0.13      8.25     0
12.5
GR 0.15     12.5     0.23     16.5

;Full street, width = 8.5m, curb = 0.15m , cross-slope = 0.03m/m, bank-slope =
0.02m/m, bank-height = 0.245m.
NC 0.025    0.025    0.013
X1 18mROW            7        10       18.5     0.0       0.0       0.0      0.0
0.0
GR 0.35     0        0.15     10       0        10        0.13      14.25    0
18.5
GR 0.15     18.5     0.35     28

;Full street, width = 8.5m, curb = 0.15m , cross-slope = 0.03m/m, bank-slope =
0.02m/m, bank-height = 0.27m.
NC 0.02     0.02     0.013
X1 20mROW            7        10       18.5     0.0       0.0       0.0      0.0
0.0
GR 0.35     0        0.15     10       0        10        0.13      14.25    0
18.5
GR 0.15     18.5     0.35     28.5

;Full street, width = 24m, curb = 0.15m , cross-slope = 0.016m/m, bank-slope =
```

```
0.02m/m, bank-height = 0.23m.
NC 0.025    0.025    0.014
X1 24mROW           7         10        21        0.0        0.0        0.0       0.0
0.0
GR 0.35     0        0.15     10        0         10        0.13      15.5      0
21
GR 0.15     21       0.35     31

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate  SeepageRate
;;-------------- ---------- ---------- ---------- ---------- ----------
C2               0          0.39       0          NO         0
C24              0          0.06       0          NO         0
Pipe_1           0          0.39       0          NO         0
Pipe_22          0          1.32       0          NO         0
Pipe_23          0          1.32       0          NO         0
Pipe_24_(1)      0          1.32       0          NO         0
Pipe_27          0          0.06       0          NO         0
Pipe_28          0          0.06       0          NO         0
Pipe_29_(1)      0          0.02       0          NO         0
Pipe_3_(1)       0          0.02       0          NO         0
Pipe_30_(1)      0          0.02       0          NO         0
Pipe_31          0          0.14       0          NO         0
Pipe_32          0          0.21       0          NO         0
Pipe_35          0          1.32       0          NO         0
Pipe_43          0          1.32       0          NO         0
Pipe_44          0          1.32       0          NO         0
Pipe_47          0          1.32       0          NO         0
Pipe_48          0          1.32       0          NO         0
Pipe_49          0          0.02       0          NO         0
Pipe_5           0          0.06       0          NO         0
Pipe_50          0          1.32       0          NO         0
Pipe_50_(1)      0          0.06       0          NO         0
Pipe_51          0          0.39       0          NO         0
Pipe_52          0          0.39       0          NO         0
Pipe_53          0          0.06       0          NO         0
Pipe_53_(1)      0          0.06       0          NO         0
Pipe_54          0          0.02       0          NO         0
Pipe_55          0          0.39       0          NO         0
Pipe_56          0          0.64       0          NO         0
Pipe_58          0          0.39       0          NO         0
Pipe_59          0          0.39       0          NO         0
Pipe_6           0          0.06       0          NO         0
Pipe_61          0          1.32       0          NO         0
Pipe_62          0          1.32       0          NO         0
Pipe_63          0          0.02       0          NO         0
Pipe_63_(1)      0          0.64       0          NO         0
Pipe_63_(1)_(1)  0          0.64       0          NO         0
Pipe_64          0          0.02       0          NO         0
Pipe_65          0          0.02       0          NO         0
Pipe_68          0          1.32       0          NO         0
Pipe_69          0          0.06       0          NO         0
Pipe_7           0          0.64       0          NO         0

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
102A-IC          Rating     0          0
102A-IC                     1.8        315
102A-IC                     2.15       315
102A-IC                     2.65       316

106A-IC          Rating     0          0
```

```
106A-IC                     1.8         207
106A-IC                     2.15        207

106B-IC          Rating     0           0
106B-IC                     1.8         18
106B-IC                     2.8         18

107A-IC          Rating     0           0
107A-IC                     1.8         504
107A-IC                     2.15        504
107A-IC                     2.5         505

108A-IC          Rating     0           0
108A-IC                     1.8         518
108A-IC                     2.15        518
108A-IC                     2.5         519

109A-IC          Rating     0           0
109A-IC                     1.8         128
109A-IC                     2.15        128

109B-IC          Rating     0           0
109B-IC                     1.8         1
109B-IC                     2.15        1

109C-IC          Rating     0           0
109C-IC                     1.8         40
109C-IC                     2.15        41
109C-IC                     2.5         41

111A-IC          Rating     0           0
111A-IC                     1.8         375
111A-IC                     2.15        375
111A-IC                     2.5         375

112A-IC          Rating     0           0
112A-IC                     1.8         216
112A-IC                     2.15        216
112A-IC                     2.65        216

113A-IC          Rating     0           0
113A-IC                     1.8         418
113A-IC                     2.15        418
113A-IC                     2.5         418

116A-IC          Rating     0           0
116A-IC                     1.8         319
116A-IC                     2.15        319
116A-IC                     2.5         320

118A-IC          Rating     0           0
118A-IC                     1.8         193
118A-IC                     2.15        193

119A-IC          Rating     0           0
119A-IC                     1.8         473
119A-IC                     2.15        473
119A-IC                     2.5         474

119A-IC(1)       Rating     0           0
119A-IC(1)                  1.8         473
119A-IC(1)                  2.15        473
```

121A-IC	Rating	0	0
121A-IC		1.8	241
121A-IC		2.15	241
121A-IC		2.5	242
121B-IC	Rating	0	0
121B-IC		1.8	1
121B-IC		2.15	1
203A-IC	Rating	0	0
203A-IC		1.8	837
203A-IC		2.15	837
203A-IC		2.5	837
206A-IC	Rating	0	0
206A-IC		1.8	337
206A-IC		2.15	337
206A-IC		2.5	337
211A-IC	Rating	0	0
211A-IC		1.8	976
211A-IC		2.15	976
211A-IC		2.5	976
218A-IC	Rating	0	0
218A-IC		1.8	802
218A-IC		2.15	802
218A-IC		2.5	802
102A-S	Storage	0	0
102A-S		1.8	0
102A-S		2.15	380
102A-S		2.65	380
106A-S	Storage	0	0
106A-S		1.8	0
106A-S		2.15	100
107A-S	Storage	0	0
107A-S		1.8	0
107A-S		2.15	450
107A-S		2.5	450
108A-S	Storage	0	0
108A-S		1.8	0
108A-S		2.15	1870
108A-S		2.5	1870
109A-S	Storage	0	0
109A-S		1.8	0
109A-S		2.15	100
109C-S	Storage	0	0
109C-S		1.8	0
109C-S		2.15	41
109C-S		2.5	41
111A-S	Storage	0	0
111A-S		1.8	0
111A-S		2.15	305
111A-S		2.5	305
112A-S	Storage	0	0

```
112A-S                       1.8         0
112A-S                       2.15        103
112A-S                       2.65        103

113A-S           Storage     0           0
113A-S                       1.8         0
113A-S                       2.15        265
113A-S                       2.5         265

116A-S           Storage     0           0
116A-S                       1.8         0
116A-S                       2.15        175
116A-S                       2.5         175

118A-S           Storage     0           0
118A-S                       1.8         0
118A-S                       2.15        50

119A-S           Storage     0           0
119A-S                       1.8         0
119A-S                       2.15        322
119A-S                       2.5         322

121A-S           Storage     0           0
121A-S                       1.8         0
121A-S                       2.15        166
121A-S                       2.5         166

203A-S           Storage     0           0
203A-S                       1.8         0
203A-S                       2.15        695
203A-S                       2.5         695

206A-S           Storage     0           0
206A-S                       1.8         0
206A-S                       2.15        328
206A-S                       2.5         328

211A-S           Storage     0           0
211A-S                       1.8         0
211A-S                       2.15        906
211A-S                       2.5         906

218A-S           Storage     0           0
218A-S                       1.8         0
218A-S                       2.15        695
218A-S                       2.5         695

POND             Storage     0.00        4995
POND                         1.20        6920
POND                         1.30        8659
POND                         1.40        10399
POND                         1.50        12138
POND                         1.90        15072
POND                         2.00        15665
POND                         2.10        16258
POND                         2.75        18009
POND                         3.09        18925
POND                         3.20        19204
POND                         3.50        19500


[REPORT]
```

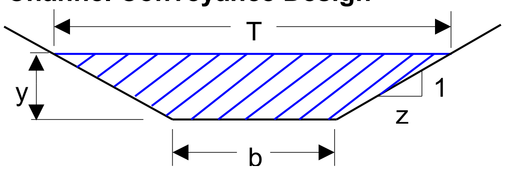
```
INPUT       YES
CONTROLS    NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]
Link        C1               MJ
Link        C10              MJ
Link        C11              MJ
Link        C12              MJ
Link        C13              MJ
Link        C14              MJ
Link        C15              mj
Link        C16              MJ
Link        C17              MJ
Link        C18              MJ
Link        C19              MJ
Link        C21              MJ
Link        C23              MJ
Link        C25              MJ
Link        C26              MJ
Link        C27              MJ
Link        C28              MJ
Link        C29              MJ
Link        C3               MJ
Link        C30              MJ
Link        C4               MJ
Link        C5               MJ
Link        C6               MJ
Link        C7               MJ
Link        C8               MJ
Link        C9               MJ
Link        C20              MJ
```

Appendix D FERNBANK POND 4 INLET AND OUTLET SEWER SIZING AND CHANNEL CALCULATIONS

Job # 160400900 - Fernbank Pond 4

Date: 30-Nov-17

Channel Conveyance Design



$$\boxed{A = (b + z \cdot y)y}$$

$$\boxed{P = b + 2 \cdot y \cdot \sqrt{1 + z^2}}$$

$$\boxed{R = \frac{A}{P}} \quad \boxed{T = b + 2zy}$$

$$\boxed{Q = \frac{A}{n} R^{2/3} \sqrt{S}} \quad \boxed{V = \frac{Q}{A}}$$

$$\boxed{Fr = \sqrt{\frac{Q^2 T}{g A^3}}}$$

	Expected Flow Depth	w Freeboard
n=	0.025	0.025
z=	3	3
b=	1	1
y=	0.35	0.65
A=	0.7175	1.9175
P=	3.213594	5.110961
R=	0.22327	0.375174
S=	0.0075	0.0075
T=	3.1	4.9
Q=	**0.915** m^3/s	3.455 m^3/s
V=	1.27 m/s	1.80 m/s
Fr # =	0.846084	0.91969

100 Year Flow Generated = 1.000 m^3/s

Full Flow Channel Capacity = 3.455 m^3/s

Channel OK

Fernbank SWM Pond 4 - Shea Road Development
Mannings Flowrate Determination for Circular Pipe
Flowing full, Capacity

	Trial 1	**Input**	
Slope,	S	0.26	%
Roughness,	n	0.013	
Diameter	d	1500	mm
		Calculated	
Area,	A	1.767	m^2
Wetted Perimeter,	P	4.71	m
Hydraulic Radius,	R	0.375	m
Velocity,	v	2.04	m/s
	Q	**3.60**	**m^3/s**
	Q_{match}	3.567	m^3/s
	difference	*0.04*	*m^3/s*

Fernbank SWM Pond 4 - Shea Road Development
Mannings Flowrate Determination for Circular Pipe
Flowing full, Capacity

	Trial 1	**Input**	
Slope,	S	0.2	%
Roughness,	n	0.013	
Diameter	d	1050	mm
		Calculated	
Area,	A	0.866	m^2
Wetted Perimeter,	P	3.30	m
Hydraulic Radius,	R	0.263	m
Velocity,	v	1.41	m/s
	Q	**1.22**	**m^3/s**
	Q_{match}	0.9	m^3/s
	difference	*0.32*	*m^3/s*

Appendix E BACKGROUND REPORT EXCERPTS

FERNBANK
COMMUNITY DESIGN PLAN

ENVIRONMENTAL MANAGEMENT PLAN
Volume 1 of 2

As Approved by Council
JUNE 24, 2009

Monahan Drain Modeling Results - Summer Event

For the summer event (24-hr SCS distribution), the Fernbank CDP model provides a very close correlation to the RVCA model. The greatest difference in peak flow occurs for the 100-year event: The 100-year peak flow is 41.8 m^3/s for the Fernbank CDP model vs. 40.0 m^3/s for the RVCA model, a difference of approximately 4.5%.

Modeled peak flows from both the RVCA (2004) and Novatech (2007) simulations are both slightly higher than the peak flows modeled by J.L. Richards in 1993. The primary reason for the increase in flows is that J.L. Richards used IDF data from the former City of Kanata in their analysis, which generate slightly smaller runoff volumes than the current City of Ottawa IDF parameters.

Monahan Drain Modeling Results - Spring Event

The model results for the J.L. Richards spring event have been included in **Table 4-1** for comparison purposes, but it should be noted that the 1993 analysis only considered a 24-hour rain-on-snow event and not a 10-day event.

There is a good correlation between the RVCA and Novatech 100-year peak flows for the spring event (10-day Rain+Snow). The 100-year peak flow is 20.1 m3/s for the Fernbank CDP model vs. 21.0 m^3/s for the RVCA model, a difference of approximately 4.5%. The spring peak flows do not correlate as closely for the more frequent return periods. The primary reason for the difference in peak flows is likely due to the influence of the Monahan Drain Constructed Wetlands: The wetlands are modeled as a discrete element in the Fernbank CDP model, while the RVCA model does not specifically account for storage and routing through the wetlands. The wetlands do significantly attenuate peak flows for smaller storm events, but the attenuation effect is reduced for larger storm events.

It should be noted that the Jock River Flood Risk Mapping - Hydrology Report states "…the calibration/validation effort concentrated on the simulation of high flows for the purpose of flood risk mapping, and that the estimates of more frequent Return Period Flows, such as the 2 year and 5 year, should be used with caution."

The Fernbank CDP SWMHYMO model provides a good correlation of peak flows to the RVCA model for the full range of summer events (24-hr SCS distribution), and good correlation to the RVCA model for the 100-year spring event. Therefore, the Fernbank CDP model of the Monahan Drain will provide a good benchmark for the analysis of impacts resulting from development of the Fernbank CDP on the downstream Monahan and Flewellyn Drains.

Faulkner Drain

The Fernbank CDP lands situated northwest of Shea Road are tributary to the Faulkner Drain, which is in turn tributary to Flowing Creek. The lands within the Fernbank Community represent only 48.5 hectares of the 4945 hectare area comprising the Flowing Creek Watershed (approximately 1%), and any meaningful comparison to the Flowing Creek Subwatershed model used in the Jock River Hydrology Study is not possible for this area.

Existing conditions for the Fernbank CDP lands tributary to the Faulkner Drain have instead been modeled based on the physical characteristics of the watershed. Modeling parameters were derived as follows:

- The soil types (and corresponding CN values) have been verified through test pit data;
- The drainage area has been verified based on detailed topographic mapping;
- The time to peak (t_p) has been calculated based on the average slope, length and land use within the catchment.

Table 4-2: Existing Conditions Peak Flows

	Peak Flow (m^3/s)						
	Distribution	**2yr**	**5yr**	**10yr**	**25yr**	**50yr**	**100yr**
Carp Subwatershed							
Carp Headwaters +	12hr AES	2.53	3.92	4.86	6.08	6.93	7.79
Carp River West Tributary	12hr SCS	2.76	**4.46**	**5.62**	**7.27**	**8.20**	**9.39**
HEC-RAS Station 44751	24hr SCS	**2.91**	4.45	5.52	6.84	7.92	9.38
Fernbank Lands north of West	12hr AES	0.65	1.05	1.33	1.74	2.04	2.36
Tributary + Westcreek Meadows	12hr SCS	0.84	**1.46**	**1.90**	**2.53**	**2.90**	**3.37**
HEC-RAS Station 44548	24hr SCS	**0.89**	1.46	1.86	2.37	2.76	3.34
Hazeldean Creek @	12hr AES	0.91	1.38	1.72	2.19	2.53	2.94
Carp River	12hr SCS	**1.82**	**2.65**	**3.28**	**4.42**	**4.74**	**5.45**
HEC-RAS Station 43966	24hr SCS	1.49	2.16	2.68	3.40	3.98	4.83
Jock Subwatershed							
Monahan Drain @	12hr AES	**1.21**	**1.99**	**2.54**	**3.24**	**3.74**	4.24
Terry Fox Drive	12hr SCS	1.13	1.87	2.39	3.13	3.55	4.10
	24hr SCS	1.21	1.92	2.42	3.05	3.57	**4.28**
Flewellyn Drain @	12hr AES	1.12	**1.83**	**2.33**	**2.97**	**3.42**	3.88
Fernbank Road	12hr SCS	1.05	1.76	2.25	2.97	3.37	3.90
	24hr SCS	**1.13**	1.81	2.28	2.88	3.37	**4.05**
Faulkner Tributary @	12hr AES	0.46	0.74	0.94	1.19	1.37	1.55
Fernbank Road	12hr SCS	0.48	0.82	1.05	1.39	1.58	1.83
	24hr SCS	**0.51**	**0.83**	**1.05**	**1.32**	**1.55**	**1.85**

Critical Storm Distributions

The 12-hour SCS distribution appears to be the critical storm distribution for lands in the Carp River subwatershed. This is consistent with the 12-hour SCS distribution used in the Carp River XP-SWMM hydrologic modeling (CH2MHill, MVC).

The 12 hour AES distribution generates higher peak flows for the more frequent return periods on both the Monahan Drain and the Flewellyn Drain. However, the 24hr SCS distribution generates the highest 100-year peak flows for all three catchment areas in the Jock River subwatershed. The 24-hour distribution was used in the Jock River Flood Risk Mapping analysis (PSR Group, RVCA).

6.4 SWM Criteria - Jock River Subwatershed

Stormwater management criteria for the Fernbank Community lands tributary to the Jock River subwatershed have been developed based on the recommendations of the Jock River Reach 2 River Subwatershed Study and input from RVCA:

- The proposed stormwater management strategy will need to adhere to all applicable policies and guidelines of the Rideau Valley Conservation Authority; the City of Ottawa, MOE, and other approvals agencies.

Quality Control / Fish Habitat

- Level 1 - Enhanced protection for lands tributary to the Jock River (80% long term TSS removal);
- End-of-pipe facilities will be designed to provide extended detention storage for both baseflow enhancement and water quality control.
- The proposed development must have no adverse impacts on downstream fish habitat.
- The Monahan Drain, Flewellyn and Faulkner Drains have been classified as intermittent watercourses that provide indirect habitat supporting tolerant warm/cool water fish communities. Temperature mitigation measures are to be incorporated into all proposed SWM facilities tributary to the Jock River, with the goal of ensuring that the temperature of discharged stormwater does not exceed the following target values:
    - Maximum Discharge Temperature = 25ºC
    - Preferred Discharge Temperature = 22ºC

Quantity Control

- Ensure the proposed SWM infrastructure will not result in any adverse impacts on flood elevations or increase the extent of flooding in downstream watercourses.
- Ensure the Monahan Drain ponds are designed to have no adverse impacts the function of the Monahan Drain Constructed Wetlands SWM Facility. No additional analysis of the Constructed Wetlands will be required provided that the proposed development conforms to the following:
    - The main branch of the Monahan Drain is retained upstream of Terry Fox Drive;
    - Fernbank lands tributary to the Monahan Drain to be serviced by 3 SWM facilities:
        - One SWM facility at the headwaters of the Monahan Drain;
        - Two SWM facilities on each side of the Monahan Drain upstream of Terry Fox Drive.
    - The design of the Constructed Wetlands assumed a total drainage area tributary to the Monahan Drain upstream of Terry Fox Drive of approximately 296 hectares with an average imperviousness of 46%.
- Post-development peak flows are not to exceed pre-development levels for all storms up to the 100-year event.
    - **Pre-Development Peak Flow targets are listed in Table 4-2.**

Erosion control / Fluvial Geomorphology

- Continuous hydrologic modeling should be used to demonstrate that the proposed development will not result in an adverse change to the geomorphology of the outlet watercourses. The number of exceedences of the erosion thresholds established by the fluvial geomorphic analysis should not increase under post-development conditions.
    - **Critical flow (Erosion) targets for watercourses are listed in Table 3-7.**

Section 8.0 Post Development Storm Drainage Conditions

8.1 Hydrology

The post-development hydrologic analysis of the Fernbank community has been completed using the SWMHYMO hydrologic model, and includes both event-based modeling (2-100yr), and continuous modeling using long-term rainfall data for the City of Ottawa. The results of the pre-development analysis were used as a benchmark for the evaluation of post-development conditions.

8.1.1 Storm Drainage Areas

The post-development storm drainage areas used in the hydrologic model are based on the storm drainage area plans developed as part of the master servicing study. Minor system capture rates have been approximated at 100 L/s/ha. Major system storage has been approximated at 50 m^3/ha.

Post-development drainage areas have been established based on the proposed macro grading plan for the road network through the Fernbank Community. The grading plan can be found in the Master Servicing Study. The proposed grading plan results in changes to the drainage areas between the Flewellyn, Faulkner, and Monahan Drains. RVCA has confirmed that the proposed post-development drainage areas are acceptable. Correspondence is provided in **Appendix B**.

8.1.2 Modeling Parameters

The impervious values used in the post-development conditions analysis are based on the proposed land use plan from the Fernbank CDP and correspond to the runoff coefficients used in the storm sewer design sheets from the Master Servicing Study.

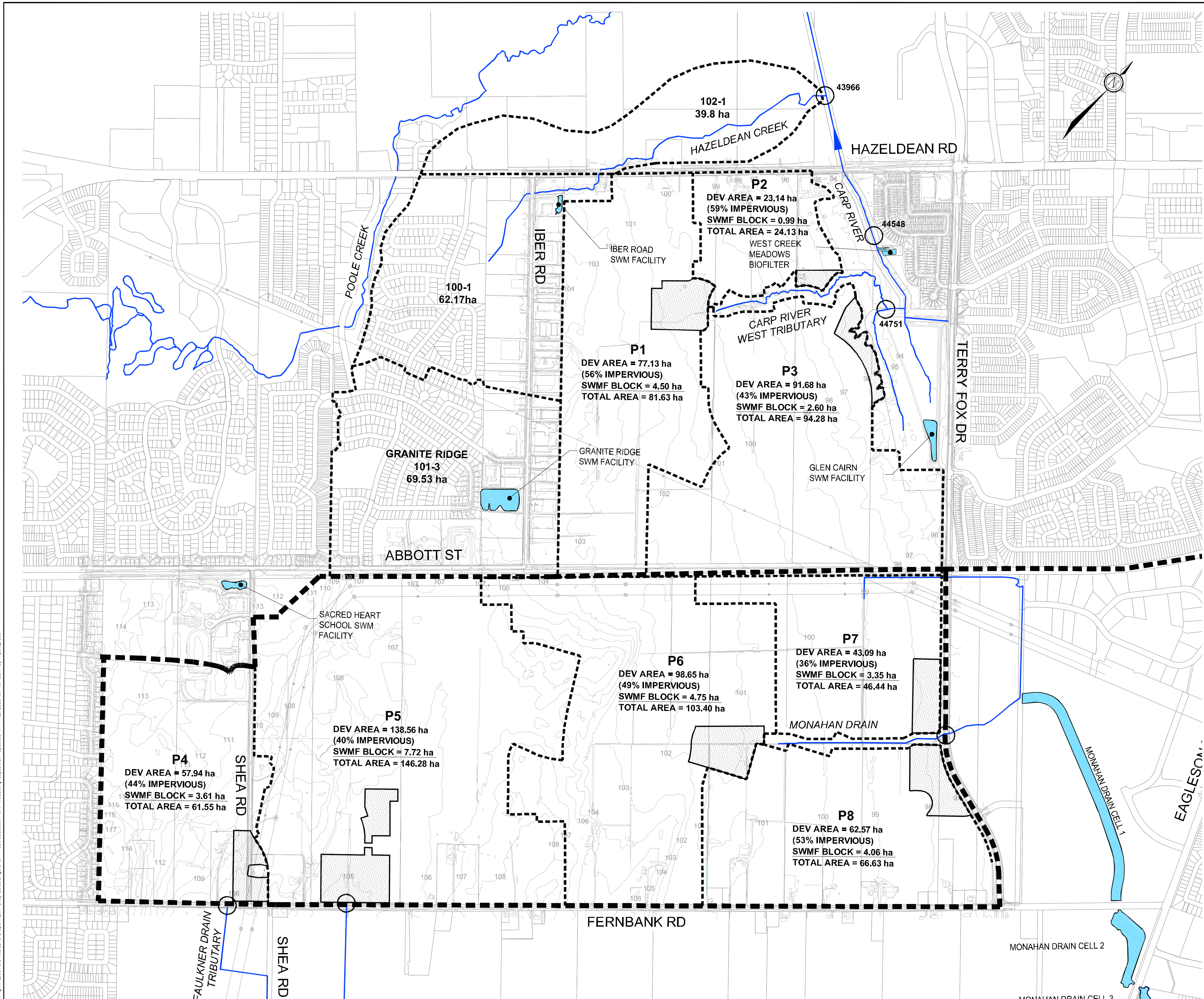
- The minor system capture rate was established at 100 L/s/ha.
- Major system storage in roadways was estimated at 50 m^3/ha.

Post-development drainage areas are shown on **Figure 8.1**. Modeling parameters are listed in **Table 8-1**.

Table 8-1: Post-Development Storm Drainage Areas to SWM Facilities

SWM Pond ID	Drainage Area[1] (ha)	Imperviousness		Soil CN	Major System Storage (m^3)	Minor System Capture Rate (m^3/s)
		Directly Connected	Total			
Carp River						
P1	77.13	0.45	0.56	80.5	3,857	7.71
P2	23.14	0.47	0.59	80.5	1,157	2.31
P3	91.68	0.34	0.43	80.5	4,584	9.17
Faulkner Drain						
P4	57.94	0.35	0.44	80.5	2,897	5.79
Flewellyn Drain						
P5	138.56	0.32	0.40	80.5	6,928	13.86
Monahan Drain						
P6	98.65	0.39	0.49	80.5	4,933	9.87
P7	43.09	0.29	0.36	80.5	2,155	4.31
P8	62.57	0.42	0.53	80.5	3,129	6.26

1. Drainage area does not include SWMF Block (refer to Figure 8.1)



FERNBANK COMMUNITY DESIGN PLAN

City of Ottawa

ENVIRONMENTAL MANAGEMENT PLAN

FIGURE 8.1

Post-Development Conditions

Storm Drainage Subcatchments

HYDROGRAPH LOCATIONS

44751 HEC-RAS INFLOW NODE ID (CARP RIVER ONLY)

0 50 100 200 400 600 metres

SCALE : 1:6000 -B1 Sheet

SCALE : Not to Scale -Report

MAY 2009

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9.2 Faulkner Drain SWM Facility

The recommended SWM strategy for the Fernbank Community lands west of Shea Road includes the construction of a SWM facility at the northwest corner of Shea Road and Fernbank Road to provide water quality, erosion, and peak flow control. This facility will outlet to a tributary of the Faulkner Drain that flows southwards from Fernbank Road.

The location of the Faulkner Drain SWM facility is flexible, and two optional locations for this facility were shown in **Figure 7.3** to accommodate current land ownership in this area. This concept shows the facility located partially in the hydro corridor. The placement of the Faulkner Drain can be re-visited as development plans are brought forward in this area.

Conceptual design details for the proposed Faulkner Drain SWM facility (P4) are provided in **Table 9-4**. A conceptual design drawing for this facility is provided as **Figure 9.4**.

Table 9-4: Faulkner Drain SWM Facility (P4)

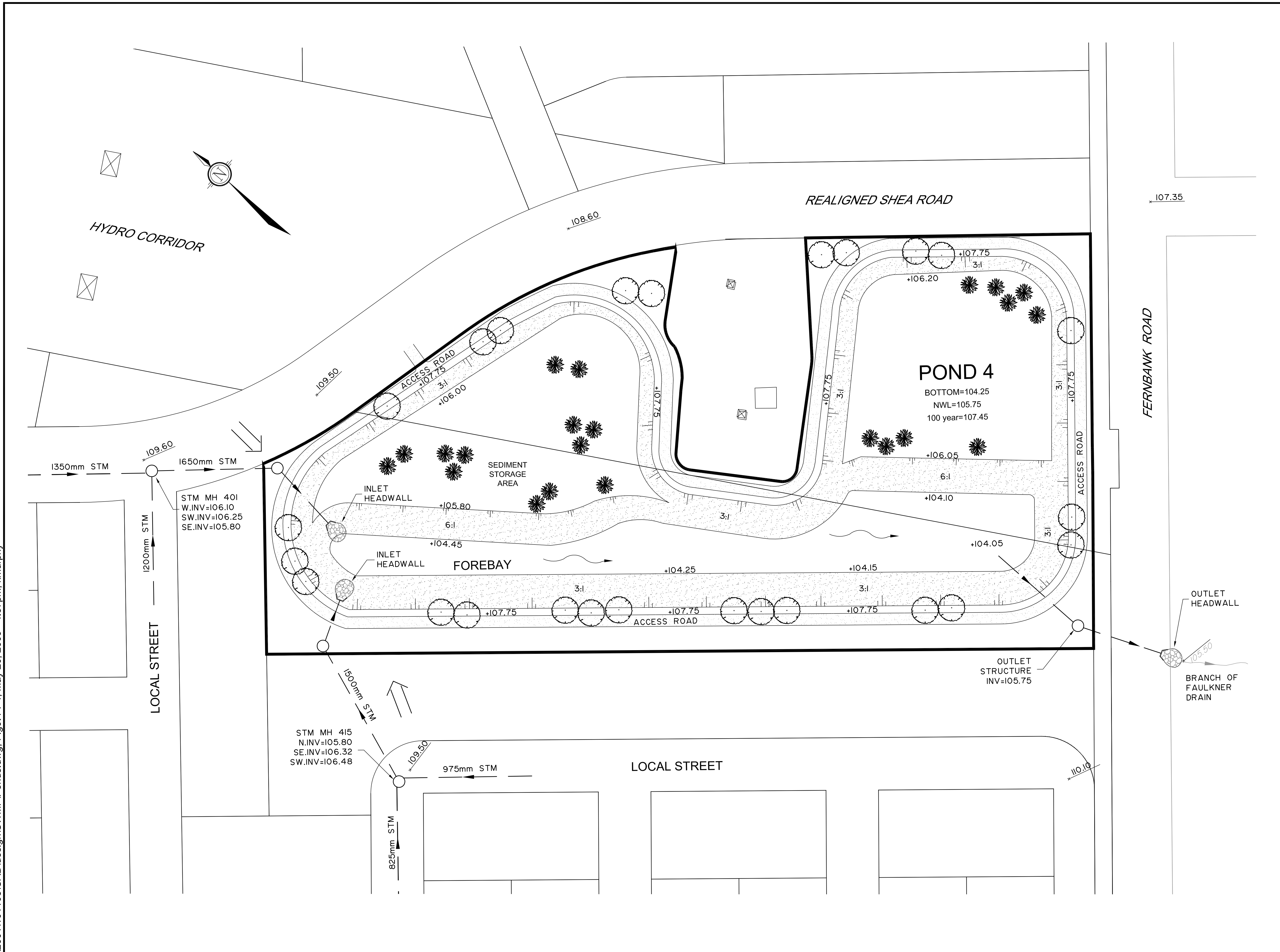
Area of SWM Block	3.61 ha		
Drainage Area to SWMF	57.94 ha	(44% Impervious)	
Quality Control	Enhanced 7,200 m^3 2,400 m^3	(80% TSS Removal) Req. Permanent Pool Volume Req. Extended Detention Volume	
Quantity Control	100yr 1.75 m^3/s	(post-to-pre) Target 100yr Release Rate	
Stage	**Elevation (m)**	**Volume (m3)**	**Release Rate (m^3/s)**
Bottom	104.25	0	0.00
Normal Water Level	105.75	8,700*	0.00
Extended Detention Storage	106.00	2,400	0.04
1:2yr	106.65	13,400	0.29
1:5yr	109.85	18,300	0.45
1:10yr	107.05	21,300	0.67
1:25yr	107.10	24,200	1.05
1:50yr	107.25	26,450	1.35
1:100yr	107.45	29,600	1.75

* Permanent Pool Volume

9.3 Flewellyn Drain SWM Facility

The recommended SWM strategy for the Fernbank Community lands tributary to the Flewellyn Drain includes the construction of a SWM facility to provide water quality, erosion, and peak flow control for the proposed development prior to outletting to the Flewellyn Drain.

Portions of the Flewellyn Drain downstream of the site do not have the capacity to convey the 1:100 year pre-development peak flow, and the increase in runoff associated with development has the potential to increase the extent of flooding in those areas. The facility has been designed to provide reduce post-development peak flows to less than pre-development conditions for larger storm events (>1:10yr event) to reduce the potential for downstream flooding. Storage requirements have been based on providing sufficient storage to control post-development flooding volumes (volume of flow above channel capacity) to pre-development levels.



FERNBANK COMMUNITY DESIGN PLAN

City of Ottawa

ENVIRONMENTAL MANAGEMENT PLAN

FIGURE 9.4

SWMF POND 4

LEGEND

- ACCESS ROAD
- DIRECTION OF POND FLOW
- STORM SEWER AND DIRECTION OF FLOW
- 101.25 / 100.25 — PROPOSED GRADE / EXISTING GRADE
- +96.65 — PROPOSED GRADE
- HEADWALL C/W RIPRAP
- MAJOR OVERLAND FLOW DIRECTION
- NWL — NORMAL WATER LEVEL
- STORM MANHOLE
- 3:1 — TERRACING (MAX SLOPE)
- TREE
- WATER TOLERANT TREE
- EXISTING BRUSH LINE
- EX. NATURAL CHANNEL & DIRECTION OF FLOW

SCALE : 1:1250

JUNE 2009

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M:\2001\101108\CAD\design\SWMF\Ponds.dwg, Fig9.4-P4, May 26, 2009 - 4:57pm, kmurphy

TARTAN/CAVANAGH

CONCEPTUAL SITE SERVICING PLAN
STORMWATER MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN
SHEA ROAD LANDS
FERNBANK COMMUNITY

Project: 11218-5.2.2

MARCH 2013

IBI GROUP

4. STORMWATER MANAGEMENT

4.1 Background

The stormwater management strategy for the Fernbank Community has been outlined in the Fernbank EMP and MSS. The approved EMP and MSS recommend the construction of one stormwater management facility (referred to as Pond 4) and associated storm sewer systems to provide stormwater management for the Fernbank Community tributary to the Faulkner Drain Tributary. Pond 4 is to provide water quality and quantity control for approximately 60 ha of proposed development northeast of Fernbank Road and Shea Road, and south of Abbott Street East. The proposed SWM facility will outlet to the Faulkner Drain Tributary, which starts on the south side of Fernbank Road. According to the EMP and MSS, the Faulkner Drain Tributary is classified as an intermittent watercourse providing indirect fish habitat.

Under existing conditions, the subject site is comprised of uncultivated grass lands and wooded areas. The site topography is generally between elevations 114 m and 107 m with most of the site draining towards the Faulkner Drain Tributary, itself tributary to the Jock River. The EMP and MSS identify that a northwest portion of the site drains east and south to the Flewellyn Drain, also tributary to the Jock River. The existing topography and general drainage patterns are presented on Figure 7.

In 2012, the City updated its stormwater management criteria from that previously established for the EMP and MSS. The proposed conceptual design is based on the latest stormwater management criteria.

4.2 Objective

The stormwater management objective is to complete the conceptual storm servicing of the lands tributary to Pond 4, as well as to confirm the pond size that was presented in the EMP and MSS.

4.3 Design Constraints and Regulatory Requirements

4.3.1 WATER QUALITY CONTROL

Water quality control targets were established in the "Jock River Reach One Subwatershed Study," (Stantec 2007), and maintained in the EMP and MSS. With respect to suspended solids, it was concluded in the Subwatershed Study that all stormwater facilities discharging to the Jock River must be designed to provide an Enhanced Level of Protection, which corresponds to 80% TSS removal as per the Ontario Ministry of the Environment (MOE) Stormwater Management Planning and Design Manual (March 2003).

According to the EMP and MSS, temperature mitigation measures are to be incorporated into SWM facilities tributary to the Jock River. Specifically, the goal is for the discharged stormwater to not exceed a temperature of 25°C and the preferred temperature identified is 22°C.

4.3.2 WATER QUANTITY CONTROL

Water quantity control criteria for the Faulkner Drain Tributary were outlined in the EMP and MSS. Post-development peak flows are not to exceed pre-development levels for all storm events up to the 100 year event.

potential network for the subject site. Storm sewer sizes are included only for the larger sewers which are also identified in the MSS report. All minor storm sewer sizes will be reviewed and confirmed at the time of detailed design. Major flow will cascade overland from the northern portion of the site downstream to the southern limits of the site, where it will overflow to Pond 4. Conceptual major flow routing is presented on Figure 6.

4.4.2 END-OF-PIPE SWM FACILITY

The conceptual design of Pond 4 was presented in the EMP and MSS. The facility is proposed to be located north of Fernbank Road at the hydro corridor and is designed to provide water quality and water quantity control of stormwater runoff from the subject site. It is designed as a wet pond with two minor system inlets and an outlet to the Faulkner Drain Tributary. In accordance with the EMP and MSS, there are no proposed changes to the Faulkner Drain Tributary. The location of Pond 4 is indicated on Figure 6.

The stage-storage relationship representing Pond 4 in the EMP and MSS has been maintained in the current SWMHYMO evaluation. It is presented in Table 4.1.

Table 4.1 Pond 4 conceptual design data from EMP and MSS

Elevation (m)	Extended Storage (ha-m)
104.25	0
106.00	0.240
106.65	1.340
106.85	1.830
107.05	2.130
107.10	2.420
107.25	2.645
107.45	2.960

As discussed above, the stormwater management facility is designed to provide an Enhanced Level of Protection. According to the MOE Stormwater Management Planning and Design Manual (March 2003), treatment volume is a function of drainage area, the type of pond, the urban imperviousness ratio, and the Level of Protection. The Enhanced Level of Protection corresponds to end-of-pipe storage volumes required for the long-term average removal of 80% of total suspended solids. The storage requirements suggested by the MOE Manual and those provided based on the above conceptual design are summarized in the following table. Supporting calculations are provided in Appendix E.

Table 4.2 Water quality volumes

Enhanced Protection Level 80% Removal of TSS							
Tributary Urban Area (ha)	Imp.% Pond Type Unit Storage	Storage Volume (cu-m)					
		Permanent		Extended Detention		Total	
		Required	Design	Required	Design	Required	Design
56.57	57% Wet Pond 195 cu-m/ha	8749	8700	2263	2400	11012	11100

According to MOE guidelines, the required total storage for the facility is 11012 cu-m. The total water quality storage provided by the proposed facility is 11100 cu-m, which consists of permanent storage of 8700 cu-m and 2400 cu-m of extended detention storage. Due to the increase in imperviousness within the tributary drainage area, the required permanent volume slightly exceeds the permanent volume provided by the conceptual design (by 49 cu-m). This additional volume requirement will be accommodated at the detailed design stage. In practical terms, the bottom of the pond could be lowered by 20 mm to gain the additional volume. The potential to further oversize the permanent volume will be considered at the detailed design stage, as will the use of a bottom-draw outlet, to mitigate temperature increases of the stormwater discharge.

The 25 mm 4 hour Chicago storm simulation indicates that the extended detention drawdown time will be greater than 48 hours. The outflow hydrograph from the facility is presented in Appendix E.

4.5 Hydrological Evaluation

4.5.1 EXISTING CONDITIONS

Existing conditions hydrological analysis was completed in the EMP and MSS. The study area was evaluated using the SWMHYMO computer model. This technique offers single storm event flow generation and routing. The existing conditions model was executed using the 24 hour SCS Type II design storm with 2 through 100 year return periods with a 60 minute time step. Relevant excerpts from the EMP and MSS are enclosed as reference in Appendix D, including a copy of the 100 year existing conditions SWMHYMO input and summary output, as well as Figure 4.1 "Existing Conditions Storm Drainage Subcatchments." A summary of peak flows in the Faulkner Drain Tributary at Fernbank Road are presented in the below table.

Table 4.3 Summary of pre-development flow rates

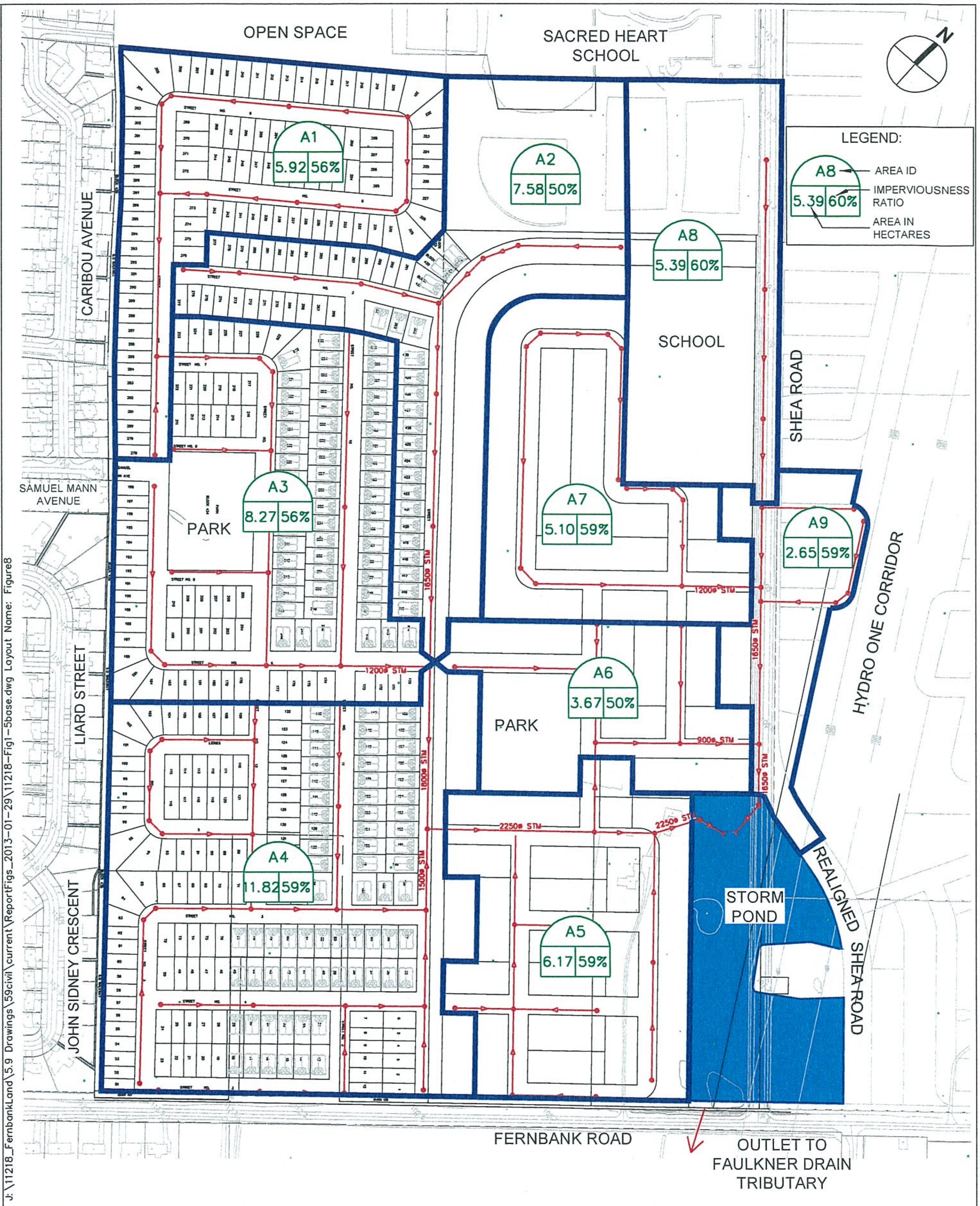
Peak Flow (cms)	24 hour SCS Type II Design Storm		
	2 Year	5 Year	100 Year
Faulkner Drain Tributary at Fernbank Road	0.48	0.76	1.75

4.5.2 POST-DEVELOPMENT CONDITIONS

As mentioned in Section 4.4.1, hydrological analysis of the proposed dual drainage system was conducted using SWMHYMO. This technique offers a single storm event flow generation and routing. The overall post-development SWMHYMO model of the Faulkner Drain Tributary used in the EMP and MSS has been updated to reflect the proposed changes to the tributary drainage area. The model has been revised to isolate the study area tributary to Pond 4. Land use, selected modeling routines, and input parameters are discussed in the following sections. A post-development model schematic and model files are included in Appendix E. As previously noted, the design is currently at a conceptual level and will be further refined at the detailed design stage.

Land Use

The site will be developed as a mixture of low and medium density residential areas with two park areas and a school. The existing recreational area located at the northern end of the site that abuts Shea Road to the west also contributes stormwater runoff to the proposed system. The tributary drainage area was divided into semi-lumped drainage areas reflective of the conceptual design of the minor system. The post-development drainage scheme is indicated in Figure 8.



Plot Style: AIA STANDARD COLOR-HALF.CTB Plot Scale: 1:1 Plotted At: Feb. 13, 13 2:28 PM Printed By: DON SIURNA Last Saved By: DSIURNA Last Saved At: Feb. 13, 13

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CONCEPTUAL SITE SERVICING STUDY
SHEA ROAD LANDS
FERNBANK COMMUNITY

STORM DRAINAGE
AREA PLAN

FIGURE 8

Storms and Drainage Area Parameters

The main hydrology parameters are summarized below and in Table 4.4. Supporting calculations are presented in Appendix E.

- **Design storms:** The site was evaluated using the following storms:
  - 25 mm 4 hour Chicago 12 minute time step (for water quality simulation);
  - 2, 5 and 100 year 24 hour SCS Type II design storm events, 12 minute time step (the EMP and MSS identified the 24 hour SCS Type II as the design storm);
  - 100 year 24 hour SCS Type II design storm events + 20% increase in intensity, 12 minute time step (stress test per City of Ottawa guidelines);
  - 100 year 3 hour Chicago storm event with a 10 minute time step (for dual drainage evaluation, specifically major flow conveyance); and,
  - July 1, 1979, August 4, 1988, and August 8, 1996 storms (historical storms per City of Ottawa guidelines).

- **Area**: Semi-lumped drainage areas are based on the proposed minor system network of storm sewers. The total drainage area contributing minor and major flow to Pond 4 measures 56.57 ha. This is consistent with the drainage area presented in the EMP and MSS of 57.94 ha. The pond block area of 3.61 ha has been maintained as in the EMP and MSS.

- **Imperviousness:** Typical total and directly connected impervious ratios for single family and townhouse units based on typical runoff coefficients have been applied across the site. The calculations to support the runoff coefficients are included in Appendix E. The overall weighted average for the Pond 4 drainage area is 57%, which is higher than the EMP and MSS value of 44%.

- **Minor system capture:** Based on 2012 City guidelines, the minor system capture is based on 5 year rational method flow with a fixed time of concentration of 10 minutes. This results in an overall average unit rate of 170 l/s/ha across the site, which is higher than the EMP and MSS unit flow rate of 100 l/s/ha applied to the Pond 4 drainage area. Supporting calculations are enclosed in Appendix E.

- **Surface storage:** Available surface storage has been approximated based on the macro grading plan. An average unit value of 40 cu-m/ha was applied to the semi-lumped drainage areas in the SWMHYMO model. This value is slightly lower than EMP and MSS value of 50 cu-m/ha.

- **Infiltration:** Infiltration losses were selected to be consistent with the City of Ottawa Sewer Design Guidelines. The Horton values are as follows: f_o = 76.2 mm/h, f_c = 13.2 mm/h, k = 0.00115 s^{-1}.

- **Length:** The impervious length is based on an average of the measured length of the trunk through the catchment and the calculated length based on the SWMHYMO user's manual. The pervious length is based on an average lot depth. This approach is consistent with City of Ottawa Sewer Design Guidelines. Relevant calculations are enclosed in Appendix E.

- **Initial Abstraction (Depression Storage):** Depression storage depths of 1.57 mm and 4.67 mm were used for impervious and pervious areas, respectively. These values are consistent with those in the City of Ottawa Sewer Design Guidelines.

Performance of the Pond

The performance of Pond 4 is summarized in the below table.

Table 4.8 Summary of Pond 4 stage, storage and discharge during various storm events
Post-development conditions SWMHYMO model file: D008.dat

	Storage (ha-m)	Discharge (cms)	Elevation (m)
Permanent Storage	0.87	N/A	105.75
25 mm 4 hour Chicago	0.66*	0.136	106.05
2 year 24 hour SCS Type II	1.19*	0.256	106.31
5 year 24 hour SCS Type II	1.67*	0.397	106.78
100 year 24 hour SCS Type II (Design Storm)	**2.83***	**1.579**	**107.37**
100 year 24 hour SCS Type II + 20%	3.40*	2.314	107.73**
100 year 3 hour Chicago	2.56*	1.230	107.19
July 1 1979	3.39*	2.285	107.72**
August 1988	2.82*	1.574	107.36
August 1996	2.64*	1.341	107.25

** Extended storage only*
*** Extrapolated values*

The maximum water level during the 100 year design storm is 107.37 m, which closely corresponds to the Pond 4 100 year water level published in the EMP and MSS of 107.45 m. It is suggested that at the detailed design stage consideration be given to providing an emergency overflow in the pond at elevation 107.37 m. This provision would allow overflow from the pond during the 100 year 24 hour SCS Type II storm with 20% increase in intensity as well as the July 1, 1979 storm.

4.6 Hydraulic Grade Line Analysis

No submerged inlets

The maximum water level in the pond is proposed to be 107.37 m during the design storm (100 year 24 hour SCS Type II storm). This is below the obvert elevation of the two inlet pipes to the pond (107.55 m). There is therefore no anticipated hydraulic grade line in the upstream storm system. The required 0.3 m minimum clearance between the underside of footing and storm obvert or hydraulic grade line would therefore be governed by the storm obvert.

The emergency overflow at elevation 107.37 m recommended in Section 4.5.3 would allow for overflow during emergency conditions, preventing the water level in the pond from exceeding the maximum 100 year design water level of 107.37 m.

The hydraulic grade line will be confirmed at the detailed design stage.

Appendix F CORRESPONDENCE

From:	Paerez, Ana
To:	Kilborn, Kris
Subject:	RE: Shea Road Lands Cavanagh
Date:	Thursday, October 06, 2016 3:51:00 PM
Attachments:	image003.png

Hi Kris,

Based on the email below, we will have to restrict post development peak flows from the Tartan/Cavanagh development to approximately 10 year pre-development levels (~0.9 cms). That being said, the SWM pond block will be significantly bigger than what was originally shown in the EMP.

I will be flying to Ottawa on Tuesday and will be at the office on Wednesday so we can touch base then.

Happy Thanksgiving!!

Ana

Ana M. Paerez, P. Eng.
Municipal Engineer
Stantec
Phone: 506-863-0127
Fax: 506-858-8698
ana.paerez@stantec.com

From: Kilborn, Kris
Sent: Thursday, October 06, 2016 2:30 PM
To: Paerez, Ana <Ana.Paerez@stantec.com>
Subject: FW: Shea Road Lands Cavanagh

Ana

Please see email below from Andy Robinson on the flow from pond 4.

I am out of the office on Friday, but maybe we can touch base next Tuesday or wed when you are in Ottawa

Sincerely

Kris Kilborn
Associate, Community Development
Business Center Sector Leader (BCSL)
Stantec
400 - 1331 Clyde Avenue Ottawa ON K2C 3G4
Phone: (613) 724-4337
Cell: (613) 297-0571
Fax: (613) 722-2799
kris.kilborn@stantec.com

From: Andy Robinson [mailto:ajrobinson@rcii.com]
Sent: Thursday, October 06, 2016 11:59 AM
To: 'Surprenant, Eric'; Kilborn, Kris

Cc: Ryan, David W; Gagne, Marc (TUPW)
Subject: RE: Shea Road Lands Cavanagh

Eric & Kris,

In our initial review of the Hydrotechnical Report prepared by Novatech in support of development in Area 6, we pointed out that the culvert under Fernbank Road had a capacity of 0.75 to 0.9 cms. (the 0.9 is with a 0.5 m head). The community development plan used a release rate of 1.75 cms. from Pond 4. Therefore, our position (from the perspective of the flow reaching the Faulkner Municipal Drain) is that the flow from north of Fernbank Road should be limited to a maximum of 0.9 cms.

The update of the Faulkner Municipal Drain is ongoing, but cannot be advance very far until we have the final agreed upon hydrology (pre and post development) and the final plan of the proposed developments (Cavanagh and Tartan) north of Fernbank Road. This includes any modifications to the watershed boundary.

In order to reduce the duplication of effort we generally rely upon the hydrology report completed by the engineer working for the developer, which in turn will have been reviewed and approved by the City. We do review the reports to make sure that we are in agreement. Where there could be a difference for instant is the release rate from Pond 4. From the perspective of the Municipal Drain we will require that the maximum flow rate at Fernbank Road not exceed the present capacity of the controlling culvert under Fernbank Road, whereas the development approvals may be governed by the higher release rate from Pond 4 in the documents supporting the Community Development plan.

Andy

Andy Robinson, P.Eng.
Robinson Consultants Inc.
Ph: (613) 592-6060 ext. 104

From: Surprenant, Eric [mailto:Eric.Surprenant@ottawa.ca]
Sent: October-03-16 12:05 PM
To: 'Kilborn, Kris'
Cc: Ryan, David W; Gagne, Marc (TUPW); Andy Robinson
Subject: RE: Shea Road Lands Cavanagh

Kris,

Sorry for the delay, I started getting back to you but got side tracked. See below my responses in red. Please don’t hesitate to contact me if you would like to discuss further.

Thanks

Eric Surprenant, C.E.T. / 613 580-2424 ext.:27794
Project Manager, Infrastructure Approvals

Development Review Suburban Services Branch
Planning, Infrastructure and Economic Development Dept.

Gestionaire de projets, Approbation de l'infrastructure
Examen des demandes d'aménagement (Services Suburbains Ouest)
Services de la planification, de l'infrastructure et du développement économique

PLANNING AND GROWTH MANAGEMENT
URBANISME ET GESTION DE LA CROISSANCE

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ottawa.ca/planning / ottawa.ca/urbanisme

From: Kilborn, Kris [mailto:kris.kilborn@stantec.com]
Sent: October 03, 2016 9:53 AM
To: Surprenant, Eric
Subject: RE: Shea Road Lands Cavanagh

Good Monday morning Eric

Just thought I would circle back around on my request for information of sept 21.
Please get back to me at your earliest convenience
Regards

Kris Kilborn
Associate, Community Development
Business Center Sector Leader (BCSL)
Stantec
400 - 1331 Clyde Avenue Ottawa ON K2C 3G4
Phone: (613) 724-4337
Cell: (613) 297-0571
Fax: (613) 722-2799
kris.kilborn@stantec.com

From: Kilborn, Kris
Sent: Wednesday, September 21, 2016 3:19 PM
To: 'Eric.Surprenant@ottawa.ca' (Eric.Surprenant@ottawa.ca) (Eric.Surprenant@ottawa.ca)
Subject: Shea Road Lands Cavanagh

Good afternoon Eric hope all is well.
Further to our preconsultation meeting for the Cavanagh Shea Road Development on July 13 2016 and to the comments received on
July 25, we have reviewed all of the background information for the site, including the previous submission by IBI on Behalf of Tartan and Cavanagh and have a few outstanding items that we would like clarification on from the City.

1. Based on meeting notes from the pre-consultation meeting, the design of Pond 4 needs to include an additional 1,200 m^3. Need confirmation on the design requirements for the pond (i.e. volume requirements, target release rates, imperviousness).

The release rate and Pond 4 design question is somewhat multi-facet. At present the release rate should be coordinated with the work being done by Andy Robinson of Robinson Consultants since Andy is the Drainage Engineer having been appointed through By-Law to look at the Faulkner MD. Pond 4 and this development fall within the drainage area for the Faulkner MD. As discussed at our pre-consult meeting the Fernbank EMP identified a release rate which may be greater than what the Fernbank road crossing culvert may be able to handle at this time, however as stated it will be important to coordinate with the drainage engineer on your design release rate and any additional storage. The Fernbank EMP can be used for the initial pond design, imperviousness etc…however, the revised Sewer Design Guidelines should be applied where your conceptual design is concerned. (Give me a call if you require further clarifications)

2. Based on the pre-consultation meeting notes, there is an on-going review/update of the Faulkner Drain. Need to review the finalized report. Is this report available?

The update to the Drainage Report is currently ongoing. Please see #1. I have copied our Drainage Superintendent(s) and Andy Robinson on this as they may be able to update you further.

3. Please confirm that this development will be utilizing the latest City bulletin with revisions to the SWM guidelines and will l be implemented for this site.

Please see #1.

4. The pre-consultation meeting notes state “reconcile and review the release rate across Fernbank Road”. Need clarification. Is there a document where this information can be obtained?

Please see #1.

5. IBi’s servicing report for Tartan and Cavanagh’s lands state that the urban boundary was extended southerly resulting in extended alignment of the sanitary trunk sewer and an increase in peak flows to be routed through our site. Need additional information on the additional drainage area, land use and location. Is there a master servicing report or Drainage Drawings available for the lands south of Fernbank Road.

Area 6 lands will be draining through the Fernbank Lands. Presently a section of the oversized sanitary sewer is being designed through the CRT lands (in Goldhawk Drive). Coordination of the oversized sanitary sewer to accommodate Area 6 flows should be coordinated with CRT’s consultants (IBI) and Novatech who are designing the new Area 6 Pump Station and it’s forcemains.

Please get back to me at your earliest convenience

Sincerely

Kris Kilborn
Associate, Community Development
Business Center Sector Leader (BCSL)
Stantec
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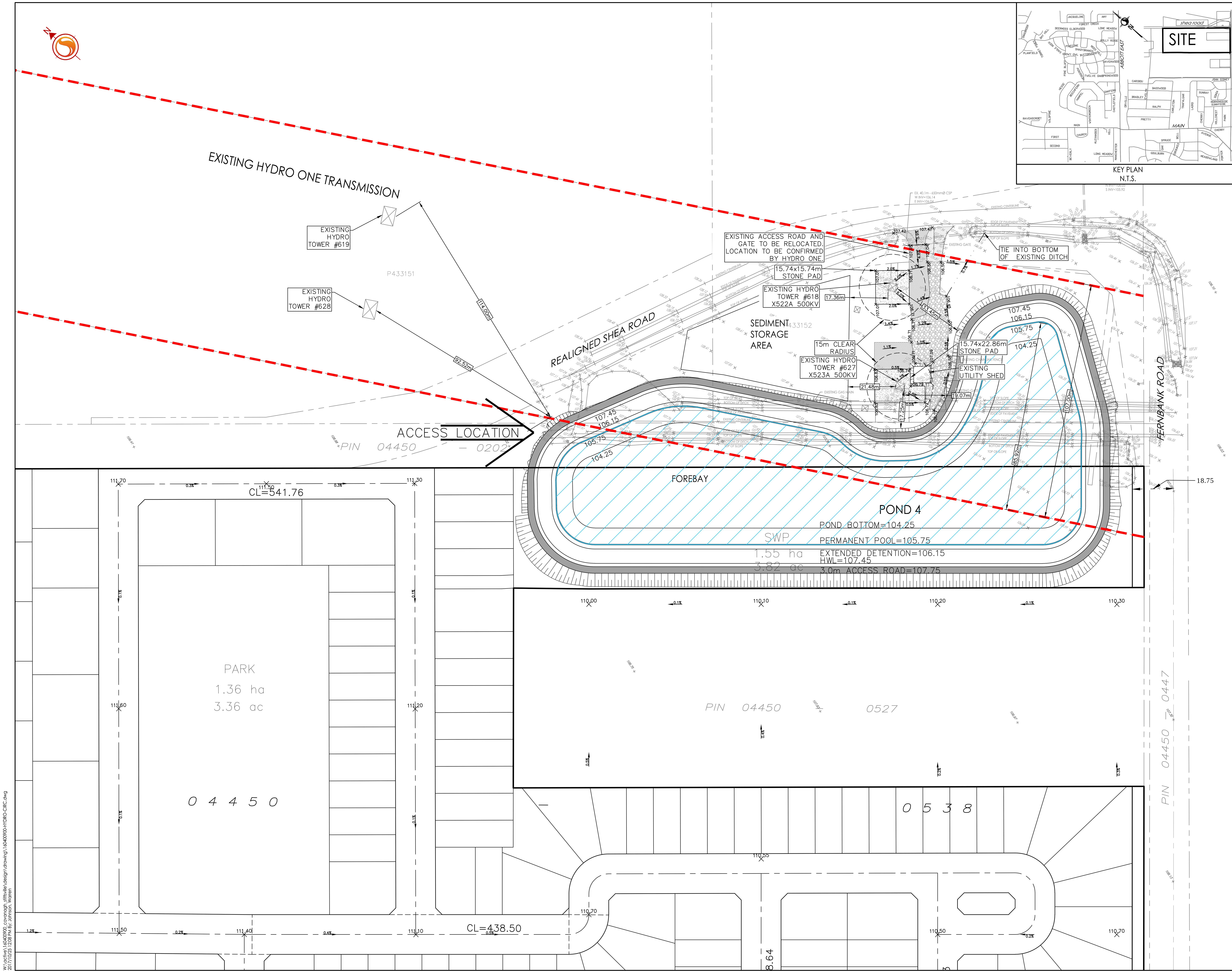

Stantec

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Ottawa ON
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Legend

106.15 PROPOSED ELEVATION
106.88 EXISTING ELEVATION
8.07m DIMENSION FROM HYDRO ONE FACILITIES TO PROPOSED GRADE CHANGE
ACCESS LOCATION POND ACCESS
EXISTING GRAVEL ACCESS TO BE REINSTATED
EXISTING GRAVEL ACCESS TO BE REMOVED
PROPOSED GRAVEL ACCESS

PERMANENT POOL (105.75):
$A=13860m^2$
$V=17250m^3$

EXTENDED DETENTION (106.15):
$A=15140m^2$
$V=5800m^3$

Notes

3	REVISED ACCESS	WAJ	KJK	17.10.19
2	REVISED ACCESS AND PAD LOCATIONS	WAJ	KJK	17.08.31
1	REVISED AS PER HYDRO ONE COMMENTS	WAJ	KJK	17.07.13
Revision		By	Appd.	YY.MM.DD

File Name: 160400900-DB	WAJ	KJK	WAJ	16.11.29
	Dwn.	Chkd.	Dsgn.	YY.MM.DD

Permit-Seal

Client/Project

1384341 ONTARIO LTD.

SHEA ROAD LANDS

OTTAWA, ON

Title

PRELIMINARY
SITE AND GRADING PLAN
HYDRO ONE CORRIDOR

Project No. 160400900

Scale 1:750 (0 7.5 22.5 37.5m)

Drawing No. GP-1

Sheet 1of 4

Revision 3

Appendix G DRAWINGS