FUNCTIONAL SERVICING REPORT

FOR

MATTAMY HOMES OTTAWA
VILLAGE OF RICHMOND

CITY OF OTTAWA

PROJECT NO.: 13-654

APRIL 2013 – REV 1

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APRIL 2013 – REV 1

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1.0 INTRODUCTION

Mattamy Homes Ottawa have retained David Schaeffer Engineering Ltd. (DSEL) to prepare a Functional Servicing report in support of their application for draft plan approval.

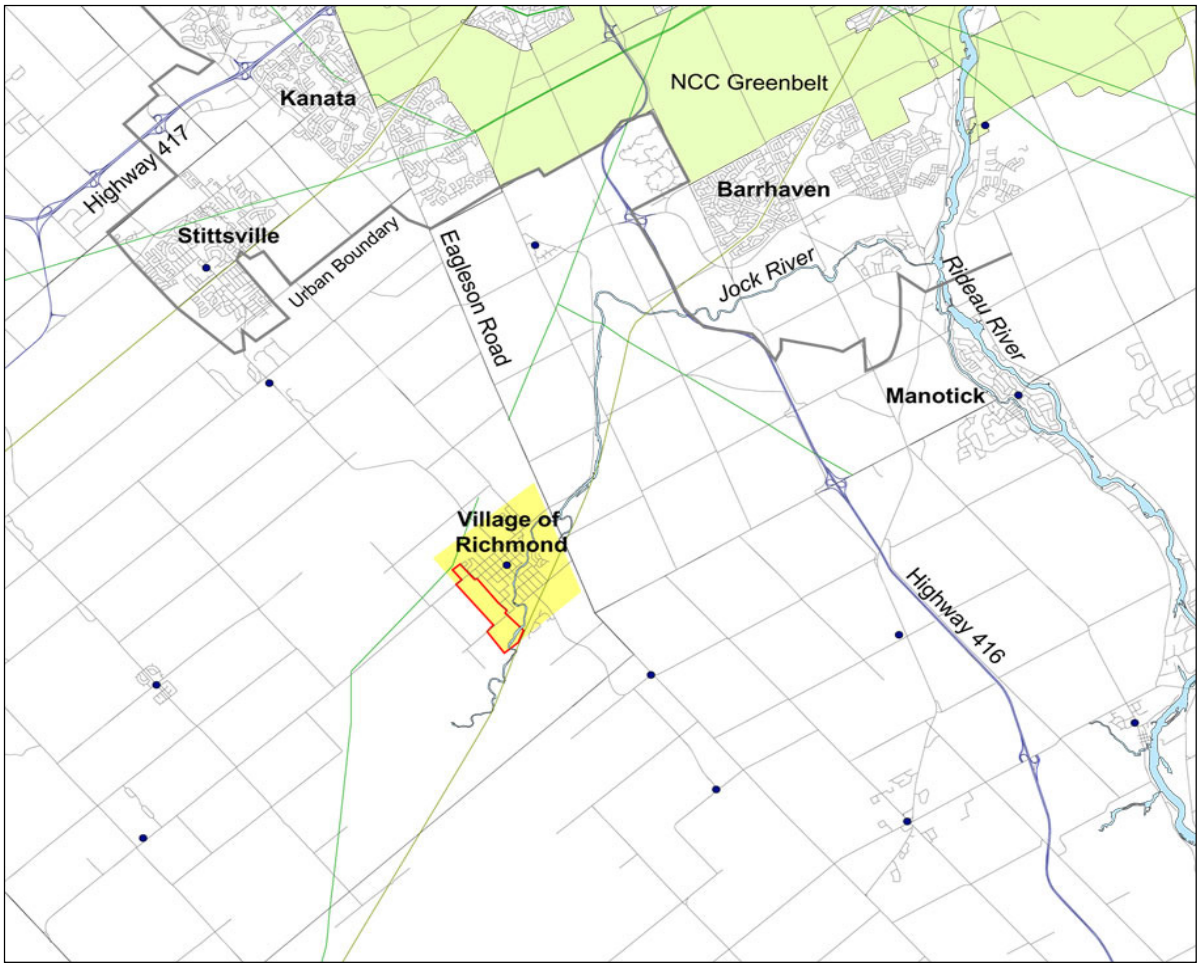


Figure 1: Location of the Village of Richmond

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Mattamy Homes Ottawa is proposing a residential development within the Village of Richmond Western Development Lands. The subject property measures approximately ***70ha*** and is located west of the existing Village of Richmond, South of Perth Street and extends to the Jock River. ***Figure 1*** illustrates the subject lands in the context of the City of Ottawa urban boundary. ***Figure 2*** provides site context within the Village of Richmond.

The draft plan contemplates approximately ***1100 units*** comprised of single detached dwellings and attached dwellings (townhomes and back-to-back units). The proposed subdivision layout is depicted on ***Figure 4*** included in ***Figures*** appended to this report.

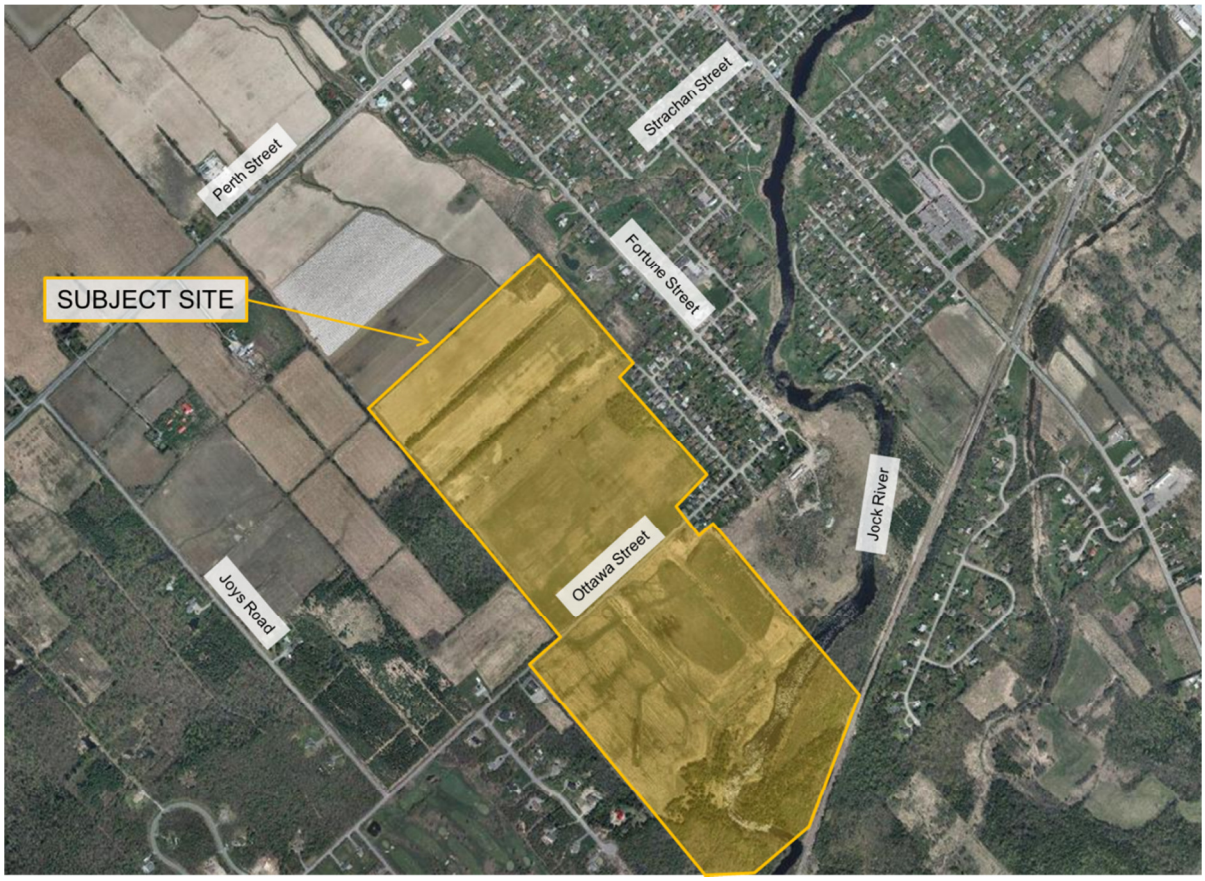


Figure 2: Site Context within Richmond

This functional servicing and stormwater management report is provided to demonstrate conformance with the design criteria of the City of Ottawa, the Background Studies, and general industry practice.

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1.1 Existing Conditions

The terrain is relatively flat and the majority has been cleared of trees, with the exception of a number of hedgerows around the periphery of the site. A forested area measuring approximately 1.0ha exists north of Ottawa Street along the eastern property boundary.

The lands to the west are located outside of the Village boundary and are predominantly occupied by agricultural uses. An estate lot subdivision, Jock River Estates, is situated west of the subject lands, south of Perth Street. The lands to the east are predominantly built out at varying residential densities. The lands immediately to the north are Secondary Plan / CDP approved for future residential development.

The proposed development is located within the jurisdiction of the Rideau Valley Conservation Authority (RVCA). The Richmond development is located within the Jock River sub-watershed and is connected to the Jock River via the Van Gaal Drain and Arbuckle Drains. The area south of Ottawa Street drains directly into the Jock River.

Existing ground elevations are between 94.00m to 97.80m. The soils in the area consist of dense sandy silt and glacial till. Bedrock is near the surface South of Ottawa Street. The ***Geotechnical Investigation*** indicates that the maximum grade raise for the site is between 2.0m and 4.0m.

The Rideau Valley Conservation Authority completed floodplain mapping for the Jock River in November 2004.

Figure 3 was extracted from the Jock River Flood Risk Map and illustrates a significant portion of the subject lands south of Ottawa Street within the Regulatory Flood Limit.

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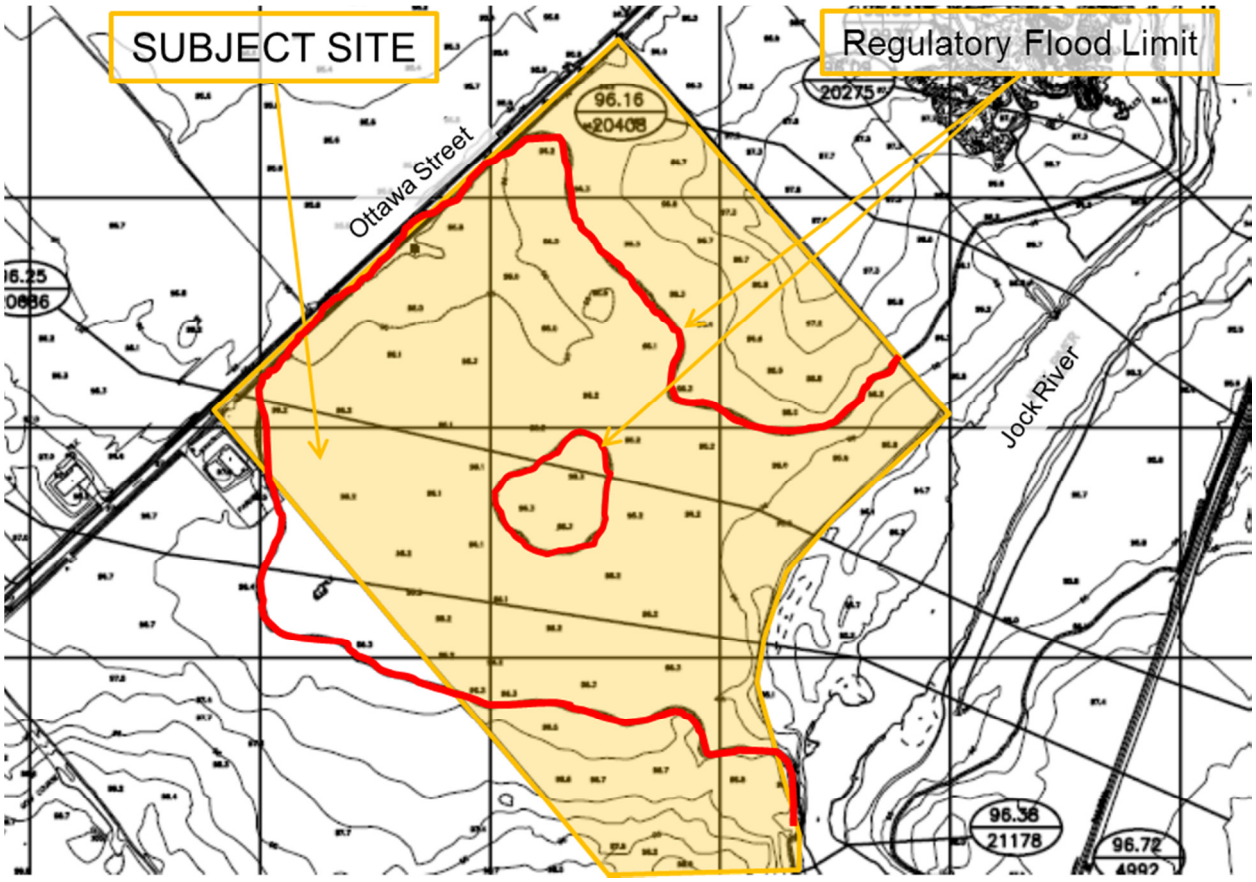


Figure 3: Regulatory Floodplain Mapping – Jock River

In December 2005, a letter of permission was issued by the RVCA to the original landowner for the construction of a berm to maintain flood risk mapping land levels as per (the 1980 Acres Floodplain) Mapping Study (96.0m) south of Ottawa Street. On March 3, 2009, the RVCA issued a letter of permission, included in ***Appendix A***, authorizing works to be conducted based on past approvals granted on the property. The authorized works involved the removal of the existing berm and relocation to the approved 2005 location. The existing flap gate and culvert from the drainage easement are to be removed. The berm will also extend parallel along both sides of the drainage easement north up to Ottawa Street. The permission letter also includes the placement of fill between the new berm and Ottawa Street to a maximum level of 96.5m.

It is acknowledged that the RVCA letter of permission, dated March 3, 2009, is over four years old and as such, the letter is considered expired.

DSEL will prepare and submit an alternate proposal under Ontario Regulation 174/06 to move forward with the draft plan application and the amendment to the floodplain mapping.

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The contemplated works are summarized as follows:

- Constructed stormwater infrastructure contemplated in the ***MDP*** along Ottawa Street from the western extent of the development limit to the Jock River outlet.
- Construct Pond #2 or Temporary sediment pond to capture and treat runoff prior to discharge to Jock River.
- Close Jock River Estates Drain and fill area behind berm with materials generated from Pond excavation.

1.2 Summary of Pre-consultation

The following provides a summary of pre-consultation meetings to date.

1.2.1 City of Ottawa, November 6, 2012.

A formal Pre-Application Consultation with Municipal Staff for the Village of Richmond Subdivision occurred on November 6, 2012. The intent of the meeting was to discuss the proposed development, review technical considerations and identify/confirm studies required to accompany the submission of a Plan of Subdivision application and Zoning By-Law Amendment. A copy of the Pre-Application Consultation meeting minutes in enclosed in ***Appendix A***.

1.3 Required Permits / Approvals

The Mattamy Richmond Development is subject to the following permits and approvals:

1.3.1 City of Ottawa

The City of Ottawa is required to approve the engineering design drawings and reports for the Richmond Subdivision. The City of Ottawa must review and sign off on the design and forward to the Ministry of the Environment (MOE) for their transfer of review program.

1.3.2 Ministry of the Environment

The MOE is required to review the engineering design and issue Environmental Compliance Approval (ECA) for Sanitary and Storm Sewers and Stormwater Management (including the stormwater management ponds). The Richmond Subdivision will not require an ECA for Watermains. The City will review the watermains on behalf of the MOE.

The MOE will also be required to issue an ECA for a proposed temporary sedimentation system comprised of on-site ditches and temporary sediment ponds.

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1.3.3 Rideau Valley Conservation Authority (RVCA)

The Rideau Valley Conservation Authority (RVCA) is required to review and approve the proposed stormwater management facilities. Furthermore, the RVCA will need to issue a permit under Ontario Regulation 174/06 for the construction of Pond #1 within the regulatory floodplain.

Lastly, RVCA approval is required for the amendment to the floodplain limit south of Ottawa Street. DSEL will prepare and submit an application under separate cover per Ont. Reg 174/06, as described in ***Section 1.1***.

1.3.4 Department of Fisheries and Oceans (DFO)

Based on a meeting at the Rideau Valley Conservation Authority May 19th, 2011, the proposed storm water solution for the site will not create a HADD (Harmful Alteration, Disruption or Destruction of Fish Habitat) and, thus, no DFO approvals will be required. This decision that a HADD will not be created will be monitored through the design process.

2.0 GUIDELINES, PREVIOUS STUDIES, AND REPORTS

2.1 Existing Studies, Guidelines, and Reports

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

- **Ottawa Sewer Design Guidelines,**
  City of Ottawa, November 2004.
  (Sewer Design Guidelines)

  - **Technical Bulletin ISD-2010-2**
    City of Ottawa, December 15, 2010.
    (*ISD-2010-2*)

  - **Technical Bulletin ISD-2012-1**
    City of Ottawa, January 31, 2012.
    (*ISD-2012-1*)

- **Ottawa Design Guidelines – Water Distribution**
  City of Ottawa, July 2010
  (Water Supply Guidelines)

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

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

- **Village of Richmond Water and Sanitary Master Servicing Study**
  Stantec Consulting Ltd., July 2011
  (MSS)

- **Preliminary Geotechnical Investigation Report, Proposed Residential Subdivision Perth and Ottawa Streets Richmond Area, Ottawa, ON.**
  Jacques Whitford Consultants, June 2007
  (Geotechnical Investigation)

- **Stormwater Management Report for Richmond Village (South) Limited**
  David Schaeffer Engineering Ltd., November 2012.
  (MDP)

2.2 Design Guideline Deviations

Section 7.2.1.6.8 of the ***City of Ottawa Sewer Design Guidelines*** outlines the Emergency Provision for Flood Protection for Pump Station Design. Where it is indicated that:

In anticipation of a potential catastrophic failure of a wastewater pumping facility and above contingency provisions, the feasibility of providing gravity based emergency conduit is to be evaluated as a last line of protection against basement flooding. The elevation and hydraulic capacity of emergency conduit connections are to be optimized to minimize the risk of basement flooding due to sanitary system backup. The elevation of this conduit must be maintained at least 1.0 m below the elevation of the lowest basement elevation within the service area. This emergency connection should permit the excess flow to bypass the pumping station. If this is not possible, then a conduit from the pumping station wet well will be permitted.

The existing Village of Richmond Pumping Station does not provide this level of service to the existing residents of Richmond.

Section 6.1.11 – Depth of Cover, indicates that there shall be a minimum separation of 0.50m from the storm sewer obvert to the top of building footing. Furthermore, the minimum cover from finished grade to top of sewer shall be 2.0m. The proposed storm sewer servicing solution violates both conditions. In order to reduce the quantity of fill imported to the site, it is proposed to service the foundations with sump pumps. Furthermore, the storm sewer collection system was designed to ensure that the 100-year HGL does not surcharge to the surface.

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3.0 WATER SUPPLY SERVICING

3.1 Existing Water Supply Services

The existing City of Ottawa water distribution network currently terminates in Kanata and Barrhaven, approximately 10km from the subject site.

The majority of existing residences and businesses in the Village of Richmond are supplied with potable water by both shallow and deep private wells. Parts of the Village of Richmond are supplied with potable water by a public communal well system (King's Park Water Treatment Facility).

3.2 Water Supply Servicing Design

Water Supply servicing for the subject site is contemplated in the Village of Richmond Water and Sanitary Master Servicing Study prepared by Stantec Consulting Ltd., July 2011 (***MSS***). The preferred design concept indicated by the ***MSS***, for development of the Western development Lands, consists of a new public communal well system connected to the deep aquifer. The communal well is contemplated to be located at the northeast corner of the development as depicted on ***Figure 4*** appended to this report in ***Figures***.

The ***MSS*** summarized the following short and long term water supply servicing components:

Short Term (0-12 years approximately)

- Two to four (2-4) groundwater wells.
- One at-grade water storage reservoir with 2-3 cells.
- High lift pumping station located adjacent to the reservoir with disinfection/treatment as required, including backup.
- Distribution system watermains.
- The City may elect to construct a watermain connection to the existing King's Park Communal Well System during this period.

Medium to Long Term (> 15 years approximately)

- Two to three (2-3) additional groundwater wells
- Water storage reservoir expansion of one to two (1-2) additional cells
- High lift pumping station expansion/upgrade
- Distribution system watermains to service existing and all future development

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Potable water will be supplied to the subject lands through pressurized watermains. The watermain distribution network will be designed in accordance with the ***Water Supply Guidelines*** as summarized in ***Table 1***.

Table 1
Water Supply Design Criteria

Design Parameter	Value
Residential - Single Family	3.4 persons/unit
Residential - Townhome	2.7 persons/unit
Fire Flow	Calculated as per the Fire Underwriter's Survey 1999.
Minimum Watermain Size	150mm diameter
Service Lateral Size	19mm dia Soft Copper Type 'K'
Minimum Depth of Cover	2.4m from top of watermain to finished grade
Peak hourly demand operating pressure	275kPa and 690kPa
Fire flow operating pressure minimum	140kPa
Extracted from Section 4: Ottawa Design Guidelines, Water Distribution (July 2010)	

For communal systems, the "City of Ottawa Standard Flow Demand Design Parameters" considers blended unit demand rates as follows:

- Average Daily Demand = 360 L/p/day
- Maximum Daily Demand = 720 L/p/day
- Peak Hourly Demand = 1585 L/person/day

Fire flow requirements are to be determined in accordance with the Fire Underwriters Survey, City of Ottawa Guidelines and the Ontario Building Code. The City of Ottawa typically recommends a fire flow rate of 7500 L/min (125 L/s) for residential properties.

The water distribution network will be comprised primarily of 150, 200 and 300mm diameter watermains. The water supply will be looped in order to provide for system security. The proposed watermain layout is presented on ***Figure 5*** appended to this report in ***Figures***. ***MSS Figure 7.2***, enclosed in ***Appendix B*** illustrates the preliminary water distribution system for the ultimate build-out of the Village of Richmond.

A complete hydraulic analysis will be prepared for the proposed water distribution network at the time of detailed design to determine if water supply is available within the required pressure range under the anticipated demand during average day, peak hour and fire flow conditions.

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3.3 Water Supply Conclusion

Potable water will be delivered to the proposed development area via a communal well to be located at the northeast corner of the proposed development. The communal well will consist of groundwater wells, an at-grade water storage tank, and a high lift pumping station with disinfection and treatment as required.

The development will be serviced by a watermain network, which will be sized to meet maximum hour and maximum day plus fire flow demands. It is anticipated that the distribution network will consist of 150mm, 200mm and 300mm diameter mains to meet City pressure range objectives.

The water supply design will be designed to conform to all relevant City Standards and policies.

4.0 WASTEWATER SERVICING

4.1 Existing Wastewater Services

The existing Village of Richmond is serviced primarily by City of Ottawa sanitary sewers that convey wastewater to the Richmond Pumping Station located south of the Jock River, on the northwest corner of Cockburn and York Street. The Richmond Pump Station (RPS) discharges to the Glen Cairn Trunk Sewer just south of Hazeldean and Robertson Road in Kanata through a 13.85km long, 500mm diameter forcemain along Eagleson Road as depicted on ***MSS Figure 5.2***, enclosed in ***Appendix C*** for reference.

4.2 Off-site Wastewater Services Upgrades

Wastewater collection services for the subject site was contemplated in the Village of Richmond Water and Sanitary Master Servicing Study prepared by Stantec Consulting Ltd., July 2011 (***MSS***). The recommended solution is expanding the current wastewater collection system and to continue to pump wastewater to the City's central wastewater treatment facility. ***MSS Figure 9.1***, enclosed in ***Appendix C*** for reference.

The preferred design concept for the wastewater services includes:

- Upgrades to the existing gravity collection system (pipe size and length improvements for the gravity collection system along specific road segments)
- Expansion of the existing Richmond Pump Station
- Repairs to the existing 500mm diameter forcemain
- New 600mm forcemain from Richmond to the City's central collection system, and;

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The ***MSS*** provided a phasing plan for the preferred wastewater and water design option. Sanitary flows were projected assuming a growth rate of 150 units/year and initial and ultimate peak wet weather flow (WWF) of 160 L/s and 360 L/s. Based on these assumptions, the following phasing plan is anticipated:

Year 0:

- Construct +/- 3.0 km of new 600mm dia. Forcemain
- Repair Existing 50mm forecemain (+/-250m)
- Expand and Upgrade the Richmond Pump Station
- Upgrade Gravity Sanitary Sewers

Year 11 plus:

- Construct remaining =/- 10.5km of new 600mm Forcemain
- Upgrade Gravity Sanitary Sewers

4.3 Wastewater Design

The Mattamy development will be serviced by a network of new gravity sewers designed in accordance with City of Ottawa criteria. ***Table 2*** summarizes the ***City Standards*** employed in the design of the proposed wastewater sewer system. The subject lands are tributary to the future upgraded Martin Street sanitary sewer as contemplated in the ***MSS***. ***MSS Figure 8.6***, enclosed in ***Appendix C*** for reference illustrates the contemplated upgrades to the Martin Street sanitary sewer.

Table 2
Wastewater Design Criteria

Design Parameter	Value
Residential - Single Family	3.4 persons/unit
Residential - Townhome	2.7 persons/unit
Average Daily Demand	350 L/d/per
Residential Peaking Factor	Harmon's Peaking Factor. Max 4.0, Min 2.0
Infiltration and Inflow Allowance	0.28L/s/ha
Sanitary sewers are to be sized employing the Manning's Equation	$Q = \frac{1}{n} A R^{2/3} S^{1/2}$
Minimum Sewer Size	200mm diameter
Minimum Manning's 'n'	0.013
Minimum Depth of Cover	2.5m from crown of sewer to grade
Minimum Full Flowing Velocity	0.6m/s
Maximum Full Flowing Velocity	3.0m/s
Extracted from Sections 4 and 6 of the City of Ottawa Sewer Design Guidelines, November 2004.	

The estimated peak sanitary flow contributions from the proposed development were estimated to be ***70L/s*** at the outlet to the Martin Street sanitary trunk. The supporting

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preliminary sanitary sewer calculation sheets and sanitary drainage area plans are contained in ***Appendix C.***

4.4 Wastewater Servicing Conclusions

The proposed wastewater system will outlet to the Martin Street trunk sewer and will be supported by downstream sanitary infrastructure, requiring upgrades. The following upgrades are required immediately to support this development: upgrades to local gravity sewer on Martin Street and Cockburn Street, expansion of the existing pump station, repair of the existing 500mm diameter forcemain and construction of 3km of the new 600mm diameter forcemain. In the future (11 years plus) the remaining 10.5km of the new 600mm diameter forcemain will be required).

The wastewater system is designed in accordance with City of Ottawa guidelines.

5.0 STORMWATER CONVEYANCE

Stormwater conveyance for the subject site was contemplated in the Stormwater Management Report for Richmond Village (South) Limit prepared by David Schaeffer Engineering Ltd., November 2012 ***(MDP)***.

As presented in the ***MDP***, the recommended stormwater servicing solution consists of a major system, a minor system, and homes with basements will be equipped with sump pump to provide foundation drainage.

5.1 Grade Control Plan - Major System

The proposed master grading plan is depicted on ***Drawing 2***. ***Drawing 2*** illustrates centerline of road grades, which were established on three criteria:

- Minimum depth to pipe invert = 2.1m
- Minimum depth to pipe obvert = 1.5m
- Minimum slope of saw tooth road pattern = 0.15% from high point to high point.

Where major system flow is shown to cross Ottawa street, the minor system was designed to convey flow under these streets. Additional information regarding conveyance through the minor system is contained in ***Section 5.2***.

5.2 Minor System

Drawing 3 illustrates the proposed minor system. ***Table 3*** summarizes the minimum parameters utilized to size the stormwater conveyance system.

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Table 3
Storm Sewer Design Criteria

Design Parameter	Value
Intensity Duration Frequency Curve (IDF) 5-year storm event. A = 998.071 B = 6.053 C = 0.814	$i = \frac{A}{(t_c + B)^C}$
Minimum Time of Concentration	10 minutes
Rational Method	$Q = CiA$
Storm sewers are to be sized employing the Manning's Equation	$Q = \frac{1}{n} A R^{2/3} S^{1/2}$
Minimum Sewer Size	250mm diameter
Minimum Manning's 'n'	0.013
Service Lateral Size	100mm dia PVC SDR 28 with a minimum slope of 1.0%. Homes to be equipped with sump pump flow.
Minimum Depth of Cover	2.0m from crown of sewer to grade
Minimum Full Flowing Velocity	0.8m/s
Maximum Full Flowing Velocity	3.0m/s
Additional Considerations	Storm sewer maintenance holes serving sewers 900mm diameter and less shall be constructed with 300mm deep sumps. Maintenance holes for storm sewers greater than 900mm must be benched.
Extracted from Sections 5 and 6 of the City of Ottawa Sewer Design Guidelines, November 2004.	

A Rational Method design sheet is contained with ***Appendix D***. The pipe sizes were confirmed through hydraulic modeling as described in ***Section 5.4***.

The subject lands slope generally from west to east. There are significant areas west of the subject lands that drain through the development property. As illustrated on ***Drawing 2*** the external areas are summarized below:

- 94.2ha approximately midpoint between Perth and Ottawa Streets;
- 39.2ha Ottawa Street road side ditch north and;
- 34.5ha Ottawa Street road side ditch south.

Due to the anticipated urbanization of Ottawa Street the external area areas tributary to Ottawa Street will be collected and conveyed within proposed storm sewers. These areas will be directed through the Pond #2.

5.3 Sump Pump Service

Section 6.1.11 of the ***Sewer Design Guidelines*** specifies that a minimum separation of 0.50m from the storm sewer obvert to the top of building footing shall be provided. The

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proposed configuration establishes footings 0.15m above the storm invert. Situating the underside of footings above the sewer invert will promote the accumulation of groundwater to drain away from the house footings toward the sewer system.

Golder and Associates prepared a long-term drainage model and a 100-year storm event model to assess the application of sump pump in accordance with the proposed design. Their analysis concluded that standard, commercially available sump pump, are suitable in this application. ***Appendix D*** contains a specification sheet of a style of sump pump contemplated for the subject site. This arrangement includes a sump pump with backup battery as well as audio and visual alarms. This particular sump pump is capable of discharging at ***90m^3/d*** (1000gph) the low end of the pump rate range. The anticipated daily inflow rate as determined through the groundwater model is ***1.07m^3/d*** during a 100-year event. The City of Ottawa's sewer design guidelines suggest a rate of ***0.45L/s/home*** in the absence of data (Section 5.4.7.), however the modeled rate for the maximum required pump rate was estimated to be ***0.012L/s/home***.

The sump pump will be equipped with a swan neck that is 0.30m above the modeled 100-year hydraulic grade line in the street storm sewer. The elevation of the swan neck provides protection to the homes during significant storm events in that the maximum modeled water level in the street sewers will remain below the outlet of the storm service to the house. The outlet of the sump pump will be a minimum of 0.30m above the 100-year hydraulic grade line. Note that the modeled hydraulic grade line within the street sewer system includes contributions from sump pumps. Therefore, the basements of the units are hydraulically separated from the street storm sewers by a minimum of 0.30m as in a typical servicing arrangement. ***Figure 6*** illustrates the proposed servicing arrangement.

The MOE SWM Planning and Design Manual suggest sump pumps should not be used where the seasonal high water table is within 1m of foundations, where it is proposed to pump to either an infiltration pit or the surface. In this event it is recommended to discharge to a storm sewer. The proposed servicing arrangement is designed to discharge to a storm sewer.

5.4 Hydraulic Grade Line

JFSA was retained to prepare hydrological and hydraulic models to assess the performance of the sewer system. Results of their analysis is included in ***Appendix D***. Their analysis concluded that the proposed drainage systems safely capture and convey all storms up to and including the 100-year event in accordance with City of Ottawa modeling practices.

The hydraulic analysis assumed that the external areas would be captured in the minor system. Furthermore, sump pump contribution during the simulated 100-year events assumed that 50% of the sump pumps would be on at any given time and that each lot would contribute 0.012L/s as indicated in Golder's analysis.

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Profiles of the proposed Trunk sewers are illustrated on ***Drawings 3 and 4***. The profiles illustrate the existing ground, minimum depth of cover to finished grade, and hydraulic grade line elevations.

6.0 STORMWATER MANAGEMENT FACILITIES

The Mattamy Homes Development is tributary to both ponds #1 and #2.

JFSA was retained to prepare hydrological and hydraulic models to assess the performance of the proposed stormwater management facilities. Their analysis is included as ***Appendix D***.

The following summarizes each stormwater management facility as well as the operational parameters of each.

6.1 Stormwater Management Facility #1

Pond 1 is located south of Perth Street and is situated between the regulatory flood limit (94.11m) and the maximum water level estimated on the Van Gaal drain (between 93.72m and 94.04m). The regulatory flood limit was established by way of a backwater effect on the Jock River during a 100-year 10-day snowmelt plus rainfall event that was based on AES Ottawa CDA snowmelt plus rainfall IDF curves. The maximum water level established on the Van Gaal Drain was established based on the same event with some improvements to the Fortune Street culvert. It is proposed to increase the size of the existing 4.2m wide culvert at Fortune Street with a 6.3m span.

The Van Gaal Drain peaks at 113.3 hour into the 10-day event, while the Jock River elevation peaks at 122.0 hour at the Van Gaal Drain. At the 122 hour mark flow contributions from the Van Gaal catchment are significantly lower. JFSA have accounted for the interactions between flow from the development and water levels on the Van Gaal drain. Additional modeling details are provided in ***Appendix D***.

Pond 1 is proposed as a wet pond with an erosion, quality, and quantity release components. Pond 1 outlets to the existing Van Gaal drain. Low flows are directed to a storm sewer and outlet approximately 40m downstream of the Fortune Street culvert. ***Figure 7*** illustrates the proposed pond layout and cross-section. The sewer profile of the outlet is depicted on ***Drawing 3.*** Runoff generated during events in excess of a 25-year storm would be released to the Van Gaal drain through the overflow weir in addition to the low flow outlet. The outlet structure will consist of two orifices to attenuate flow to the Quality and Erosion control targets. ***Table 4*** summarizes the outlet control design parameters.

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Table 4
Summary of SWMP 1 Outlet Structure Design

Quality Control	Erosion Control	Quantity Control
Vertical Orifice	Vertical Orifice	Rectangular Weir
300mm dia	300mm dia	45m Wide
INV = 92.35	INV = 92.45	INV = 93.68

Table 5 summarizes the pond's operational characteristics.

Table 5
Summary of SWMP 1 Storage Characteristics

Pond Component	Pre-development Outflow (m^3/s)	Pond Level (m)	Pond Outflow[(2)] (m^3/s)	Volume Used[(2)] (m^3)
Permanent Pool	N/A	92.35	N/A	28,659
Quality Control	N/A	92.45	0.025	3,083
2yr/24hr SCS	2.426	93.10	0.287	26,006
5yr/24hr SCS	3.773	93.43	0.365	39,869
10yr/24hr SCS	4.710	93.66	0.409	49,975
25hr/24hr SCS	5.906	93.74	1.615	51,691
50yr/24hr SCS	6.844	93.77	2.595	54,975
100yr/24hr SCS	7.864	93.80	3.557	56,212

6.2 Stormwater Management Facility #2

Pond 2 is located north of Ottawa Street and is a wet pond with quality and quantity release components. Pond 2 outlets to the Jock River via a 1200mm diameter sewer. In the event of a blockage the emergency overflow is directed to the north toward the Van Gaal Drain. ***Figure 8*** illustrates the proposed pond layout and cross-section. The sewer profile of the outlet is depicted on ***Drawing 4.***

The outlet structure will consist of a vertical orifice and rectangular weir to attenuate flow to the quality and quantity control targets. ***Table 6*** summarizes the outlet control design parameters.

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Table 6
Summary of SWMP 2 Outlet Structure Design

Quality Control	Quantity Control
Vertical Orifice	Rectangular Weir
350mm dia	1.30m Wide
INV = 93.20	INV = 93.35

Table 7 summarizes the pond's operational characteristics.

Table 7
Summary of SWMP 2 Storage Characteristics

Pond Component	Pre-development Outflow (m^3/s)	Pond Level (m)	Pond Outflow[(2)] (m^3/s)	Volume Used[(2)] (m^3)
Permanent Pool	N/A	93.20	N/A	17,136
Quality Control	N/A	93.35	0.047	1,983
2yr/24hr SCS	1.292	93.71	0.629	7,710
5yr/24hr SCS	1.983	93.88	1.009	10,646
10yr/24hr SCS	2.458	93.98	1.269	12,534
25hr/24hr SCS	3.058	94.11	1.600	14,875
50yr/24hr SCS	3.525	94.21	1.860	16,691
100yr/24hr SCS	4.029	94.31	2.142	18,669

6.3 Stormwater Management Conclusions

JFSA reviewed the impact of the proposed subdivision, the associated storm sewer collection system, and stormwater management facility designs in accordance with standard City of Ottawa modeling techniques.

Peak flow to the Van Gaal Drain generally decreases between the existing and proposed conditions. The volume attenuated in stormwater management facility 1 is primarily responsible for the decrease in flow.

7.0 EROSION AND SEDIMENT CONTROL

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

© DSEL

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

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

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

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

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

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

Establish material stockpiles away from watercourses, so that barriers and filters may be installed.

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

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

© DSEL

8.0 CONCLUSION AND RECOMMENDATIONS

Mattamy Homes Ottawa is proposing a residential development within the Village of Richmond Western Development Lands. The subject property measures approximately ***70ha*** and is located west of the existing Village of Richmond, South of Perth Street and extends to the Jock River. DSEL was retained to prepare a Functional Servicing Study in support of their draft plan application.

- The RVCA will be required to review and approve the proposed filling of lands south of Ottawa Street under Ont. Reg 174/06 to allow for development of the lands.
- Water supply to the subject lands was previously contemplated in the MSS. Water supply to the subject property will be through a new communal well and associated watermain designed in accordance with City Guidelines.
- Wastewater services will be provided through a network of gravity sewers that outlet to the future upgraded Martin Street sanitary sewer and Richmond Pumping Station. The off-site upgrades required to support the development were contemplated in the MSS.
- Stormwater services will be provided through gravity sewers that outlet to new stormwater management facilities. The foundation drainage will be provided through sump pumps.
- The proposed stormwater management facilities were designed to meet MOE Enhanced level of suspended solid removal and will attenuate stormwater to ensure no increase to water levels in the receiving water courses.

Reviewed by,
David Schaeffer Engineering Ltd.

Per: Stephen J. Pichette, P.Eng.

Prepared by,
David Schaeffer Engineering Ltd.

Per: Adam D. Fobert, P.Eng

© DSEL
z:\projects\13-654 mattamy - richmond\b_design\b3_reports\b3-2_servicing (dsel)\2013-03_draft_plan_sub_1\fsr-2013-04-04_mattamy_richmond.docx

APPENDIX A

Pre-Consultation

Meeting Minutes
November 6, 2012
Project: Mattamy Homes - Richmond Village, Western Development Lands
Purpose of Meeting: Pre consultation Meeting Minutes

Meeting Attendees:
Cheryl McWilliams (CM), City of Ottawa
Michel Kearney (MK), City of Ottawa
Jeff McEwen (JM), City of Ottawa
Kevin Hall (KH), City of Ottawa
Amira Shihata (AS), City of Ottawa
Don Morse (DM), City of Ottawa
Amy MacPherson (AX) (on behalf of Matt Hayley), City of Ottawa
Jocelyn Chandler (JC), Rideau Valley Conservation Authority
Mike Green (MG), Mattamy Homes
Gordon Frenke (GF), Mattamy Homes
Anthony (Tony) Francis (TF), Kilgour and Associates
Adam Fobert (AF), DSEL
Robert Vastag (RV), Stantec Consulting
Chris Gordon (CG), Stantec Consulting
Stephen Wilson (SW), Golder Associates
Sarah Millar Martin (SMM), FOTENN Consultants Inc.

REF	CONTENT	ACTION
1.0	**Project Overview**	
1.1.	SMM provided project overview, highlighted features of the design. A clear outline of the submission requirements for subdivision and zoning was requested as an outcome of the meeting.	
1.2.	SMM requested comment from the RVCA on the interim floodplain south of Ottawa Street.	
1.3.	SMM requested an update on the status of: - The update to the terms of reference for the Source Water Protection Plan; - The Financial Implementation Plan.	
1.4.	Project Features: - approximately 1,000 lots; - Phased development in line with the CDP; - Areas of varying unit density with higher density lots targeted north of Ottawa Street and the N-S collector, but overall the plan will maintain consistency with the CDP and provide continuity of village character.	
2.0	**City Staff Comments**	
1.1.	DM requested the provision of a sidewalk connectivity	

	plan with the application in order to understand the linkages throughout the site and into the development to the north and existing village to the east. DM supplied MG with a concept connectivity plan from the City for consideration. **MG to review and provide to consultant team for application.**	
1.2.	DM commented that he would like to see a small number of Village-Style lots provided on the plan. **MG to review for application submission.**	
1.3.	LC enquired about the status of the woodlot that sits just north of Ottawa Street – as it is shown to be hatched on the plan with lotting underneath. MG confirmed that the woodlot sits outside of the Mattamy property boundary. The road pattern shown in the area was only to provide some context. LC and AX requested the Tree Conservation Report for the subdivision include the woodlot regardless, given the liklihood of the Mattamy application proceeding well in advance of the neighbouring lot. **MG agreed, TF to incorporate into study.**	**TF**
1.4.	LC requested confirmation of the parkland dedication on the plan. SMM confirmed that the Community Park was 3.25 Ha. in line with the CDP; and the Neighbourhood Park was 0.8 Ha in line with the CDP. LC commented that the green open space areas provided adjacent to the Jock River corridor would not be considered parkland for dedication purposes. LC also noted that if the woodlot were to be retained, it would not be considered parkland dedication. **MG acknowledged and concurred**.	
1.5.	AS confirmed that a Transportation Brief (TB) would be appropriate for submission with the Draft Plan of Subdivision application, but that a Transportation Impact Study (TIS) would be made a condition of draft approval	**CG/RV**

	for every phase registration. Brief to outline any required road modifications. AS needs to understand the timeframes if they differ from the CDP approved timeframes. **CG/RV to submit terms of reference to AS prior to completion of study for approval.**	
1.6.	CM confirmed that a Phase 1 Environmental Site Assessment would be required.	
1.7.	AX outlined that both a Tree Conservation Report (TCR) and an Environmental Impact Statement (EIS) would be required. AX outlined that the triggers for both studies were that the property sat within 120m of a significant woodlot (Marlborough Forest); and 120m of a rural natural feature. **TF to address species at risk in the EIS – including: Butternut trees; Eastern Meadowlark and the Bobolink.**	**TF**
1.8.	SMM requested confirmation from CM and AX that the application would still be Deemed Complete should the submission of the EIS occur prior to breeding season for the Bobolink and the Meadowlark. **CM to confirm**.	**CM**
1.9.	AX outlined that with each phase registration, the EIS would need to be reviewed to confirm if it required updating.	
1.10.	**CM to confirm that the woodlot adjacent to the Mattamy has no status with the City. i.e. not a Rural Natural Feature.**	**CM**
3.0	**Servicing, Stormwater and Drainage**	
1.1.	DC noted that the Master Drainage Plan update and approval had not been granted. DC understands that this is being led through the Caivan Application.	
1.2.	AF confirmed that the Stormwater Management and Drainage Report supports both the Caivan and the Mattamy applications.	
1.3.	DC requested that a meeting be arranged asap with City	**CM/SMM**

	staff (including DC; MK; CM) and DSEL prior to the resubmission of the Stormwater and Drainage Plan in order to run through the matters that need to be addressed in the final report. **CM to coordinate a time internally and request attendance of the project team through SMM.** **SMM to coordinate project team.**	
1.4.	DC noted that the City do not have a clear direction on the Environmental Assessment process being undertaken for storm water in the Western Development Lands. MG confirmed that the EA process for Water and Sanitary was completed as part of the overall Master Servicing Study for the western development lands as part of CDP. MG noted that a ministerial decision was still outstanding 11 months after submission. AF confirmed that as requested, Kelly Roberts was preparing a memo to outline the Environmental Assessment process being undertaken for Stormwater.	
4.0	**Servicing, Water**	
4.1.	CM outlined that the Terms of Reference to the Source Water Protection Plan were still outstanding. MK noted that Brian Stratton (Mississippi Rideau) is the co-chair of the source protection committee. CM outlined that the implementation of this update requires Council endorsement first and then Ministry approval.	
4.2.	CM outlined that the Financial Implementation Plan for the Village of Richmond was still outstanding. **CM to follow up internally to get update on status and determine who would push this forward.**	**CM**
4.3.	MK would like to address land set aside for the Communal Well on the draft plan. Is the Block shown the appropriate size? MK highlighted that the plan must follow the Drinking Water Services Standards and the Communal Municipal Well Standards.	**MK**

	MK to confirm to CM and Mattamy if additional modeling is needed to determine this.	
4.4.	MK would like to talk to Drinking Water Services about assessment of capture zone influences – particularly the Kings Park and Munster municipal wells**.** Ultimately who is responsible for this assessment? **MK to advise.**	**MK**
4.5.	MK confirmed receipt of Golder Wellhead Protection Study, and peer review by Dillon Consulting. SW noted no comments had been received to date. CM noted she was still waiting on comments from City Water services and Drinking Water.	**MK**
5.0	**RVCA Matters**	
5.1.	JC identified that the existing test well existed on the Mattamy land. SW confirmed that the Artisinal Well had been capped and the monitoring data for this well was included as part of the 72 hour pump test.	
5.2.	JC outlined that required setbacks to the Moore Drain as per the CDP: - 30.0m setback on drain Sections 3&4 Mattamy Land - North) - 15.0m setback on drain Sections 5-8 (Mattamy land - West)	
5.3.	JC highlighted existing watercourses on site (agricultural drains) will need permits from the RVCA to close. **MG noted. AF/SP to coordinate.**	**AF/SP**
5.4.	JC noted that there were other drains on the property south of Ottawa Street that have City easements that will need to be lifted. **Project Team noted.**	
5.5.	JC inquired about the outlet for the Stormwater pond under Ottawa Street. **DSEL to review the existing outfall off of Queen Charlotte in the servicing brief.**	**AF/SP**
5.6.	JC requested that contributing flows to the Moore Drain be nominated in the DSEL report.	**AF/SP**

	AF confirmed that all the Mattamy land south of Ottawa Street would be draining to Pond #2 North of Ottawa Street. **AF/SP to include analysis in application submission.**	
5.7.	JC raised the matter of the Berm Construction along the Jock River and permit issue. JC noted the existing permit had expired, and a new permit application would need to be submitted – along with the existing and proposed grades pre-and post berm. JC noted that it not her preference to have to issue conditions for draft plan approval prior to a permit for the berm being resolved. **AF/SP to coordinate with the RVCA on this matter.**	**AF/SP/JC**
5.8.	JC aware of interim floodplain over section of Mattamy Land. **JC to review and advise how best to resolve amendment to interim floodplain in line with applications from RVCA perspective.**	**JC**
6.0	**Zoning**	
6.1.	CM requested the following plans be included to support the Zoning Application: - Conceptual Streetscape plan which includes sidewalks; - Street Cross Section showing sidewalk and street tree layout; - Conceptual elevations (examples of product types). **MG/GF to review for application and coordinate with SMM.**	**MG/GF/SMM**
7.0	**Next Steps**	
7.1.	CM to provide list of required studies to SMM for application submission.	
7.2.	CM outlined that she would like to provide two separate lists: 1) Draft Plan of Subdivision; 2) Zoning Amendment; and also highlight those reports which sit at a Western Development Lands level rather than specific to the	**CM**

	Mattamy application. **CM to forward to SMM on completion**.	

Meeting concluded at 3:00 pm.

NOTE: Any omissions or errors in these minutes should be forwarded to the author immediately.

RIDEAU VALLEY
CONSERVATION AUTHORITY

3889 Rideau Valley Drive, P.O. Box 599, Manotick, ON K4M 1A5
tel 613-692-3571 | 1-800-267-3504 | fax 613-692-0831 | www.rvca.ca

A member of Conservation Ontario

RVCA LETTER OF PERMISSION – ONT. REG. 174/06, S. 28 CONSERVATION AUTHORITIES ACT 1990, AS AMENDED.

Revised Date: March 3, 2009
Orig Date: February 17, 2009
File: RV5 0309

Mattamy Ltd. (Jock River)
123 Huntmar Drive
Ottawa, ON
K2S 1B9

Attention: Sean MacFarlane,

Subject: **Application for Development being the establishment of an earth berm on a property at part of Unit 19, Index Plan 4D-23 and part of Lot 2, Concession 2, former Township of Goulbourn, now in the City of Ottawa, bounded by Ottawa Street to the North and the Jock River to the south within the Village of Richmond.**

Dear Mr. MacFarlane,

The Rideau Valley Conservation Authority has reviewed the application submitted on behalf of Mattamy Ltd. and understands the proposal to be for:

1. The removal of fill associated with construction of a berm already on the property.
2. The establishment of a new berm closer to the municipal road and farther from the river.
3. The reinstatement of the land area at the existing/"*original*" berm site.
4. The placement of fill between the new berm and Ottawa Street to match existing surrounding grades.

This proposal was reviewed under Ontario Regulation 174/06, the "*Development, Interference with Wetlands, and Alteration to Watercourse and Shorelines*" regulation, which the Conservation Authority administers as well as the approved "Policies Regarding the Construction of Buildings and Structures, Placing of Fill and Alterations to Waterways" (Adopted by the Executive Committee, October 21, 1993 and last revised and approved by the Board of Directors, April 2006).

History

This proposal relates to two previous regulation application filings on the property, RV5-16/05 submitted and approved by the RVCA on December 9, 2005 under Ont. Regulation 166/90 and RV5-01/08 submitted by Mattamy relating to work undertaken in December 2007.

In 2005, a letter of permission was issued by the RVCA for the construction of a berm "to maintain flood risk mapping land levels as per (the 1980 Acres Floodplain) Mapping Study (96.0 metres)". The application indicated that the berm would be 15 cm to 30 cm in height and on site material would be used to construct the berm at a height of land determined in the field as the natural or high point of land, approximately the 96.0 metre contour. The berm as it exists today is 1-2 metres in height, 10-20 metres in width at the base, 2-100 metres from the Jock River and established more or less at the 95.5 metres contour.

On May 6, 2006, Ontario Regulation 166/90 (Fill, Construction and Alteration to Waterways Regulation) was rescinded and Ontario Regulation 174/06 was enacted. Both regulations were made pursuant to the provisions of Section 28 of the Conservation Authorities Act, and both gave responsibility for administration to the Rideau Valley Conservation Authority. The change in the regulatory legislation in May 2006 resulted in, amongst other things, incorporation of revised and extended hazard delineation along the Jock River (Jock River Floodplain Mapping Study completed in July 2005 by PSR). The new Mapping Study extended the hazard mapping upstream of the previous limit of study and provided for additional lands being subject to RVCA's regulatory jurisdiction; the 1:100 year flood level was considered to be 96.35 metres. A provincially mandated public process was followed in order for this new mapping to take effect.

The purpose of the 2005 application (previous property owner) was to establish a berm at the flood level, (96.0 metres – defined by the pre 2006 Flood Plain Mapping Study) thereby, preventing the remainder of the property from being subject to the floodplain regulations after incorporation of the New Mapping Study into the regulation in May 2006.

Project Scope

This application proposes removing the existing berm [established in Winter/Spring 2006, with further filling and reinforcement in December 2007] and locating it at the 2005 approved location. It is also proposed to remove the flapgate and culvert from the drainage easement until the issues relating to drainage for the property and greater surrounding area can be addressed. The berm will also be extended parallel along both sides of the drainage easement north up to Ottawa Street. The overall function of the drainage ditch/easement will be reviewed as part of a Storm Water Management and Drainage Plan to be completed by Mattamy respecting any future development applications.

The placing of fill for the berm and the associated filling behind the berm up to Ottawa Street is not expected to have a negative impact on the control of flooding. The filling operation and location of the "berm" should not impact the roadside conveyance of water and should not impact the conveyance of water through the Drainage Easement running through the centre of the subject property providing the work in undertaken as proposed.

This permission results in the re-location of the 2005 berm in the originally approved location. The filling between the relocated berm (maximum height 96.4 metres geodetic) and Ottawa Street will be to a maximum level of 96.5 and only to a level to taper to match existing grades.

Permission and Conditions

By this letter the Rideau Valley Conservation Authority hereby grants you permission to undertake the works on this property as outlined in the application, covering letter dated January 23, 2009 from David Schaeffer Engineering Ltd. and Drawings completed by same, Project 303, Figures 1-4, dated January 21, 2009 prepared for Mattamy Ltd. and all subject to the following conditions:

1. The existing berm will be removed from its current site. The material may be used for the construction of the new berm **if** deemed appropriate by a qualified Professional Engineer. Any excess material not required for the construction of the new berm may be used as fill in areas to the north of the relocated berm to a maximum elevation of 96.5 metres, noting the maximum berm height will be 96.4 metres. Any excess material will be disposed of in a suitable location outside all 1:100 year floodplains and regulated areas and not within a wetland.

2. The proposed berm shall be established as noted on the attached plan, (DSEL, Project 303, Figure 1-4 dated January 21, 2009) with the southern most boundary of the berm located no further south than the line denoted on the plan and established at an original grade no lower than 96. 1 metres

as depicted on the plan with the top of the berm at a maximum elevation of 96.4 metres or not greater than 0.3 metres in height. Grades along Ottawa Street will also be no higher than 96.4 metres.

3. The berm is to be located no closer than 3 metres to the drainage watercourse on both sides and/or **not** within the City of Ottawa's Drainage Easement, whichever is greater.

4. The culvert located in the drainage easement will be removed as the earthworks are completed and no fill or other obstruction will be placed in the drainage easement without approval from the City of Ottawa. The flap gate will be removed immediately from the culvert to ensure free flow of water.

5. The area of the original berm will be rehabilitated to original grade with plant material re-established as discussed in DSEL letter dated January 23, 2009.

6. A finished grading plan will be submitted as soon as the work is complete to confirm the height and location of the new berm and the grade height and location of the existing berm reinstated to original grade. A refundable deposit of $3000.00 is required to be submitted prior to commencement of the work.

7. No earthworks shall commence before May 1, 2009 and only if flows in the Jock River are considered at or lower than summer levels. Sediment control will be established as defined on Figure 3 prepared by David Schaeffer Engineering Ltd. (DSEL), dated January 21, 2009 and additional measures will be installed as deemed necessary.

8. Sediment and Erosion control Inspections will take place daily by DSEL or other appropriate and designated engineering staff while work is ongoing, and thereafter prior to and immediately following any forecasted rainfall event until such time as the site is revegetated, to ensure sediment control is operational and functional. This is ultimately the responsibility of the property owner and all persons associated with the construction/earthworks/grading on the property. Failure to comply may result in this permission being revoked and charges under other applicable law.

9. Any material excavated from the property and not required must be removed immediately and disposed of at a suitable disposal site outside the 100 year floodplain and regulated area.

10. The RVCA is to receive 48 hours notice of the proposed commencement of the proposed works to ensure compliance with all conditions.

11. There is to be **no** work at the bank or in the Jock River as part of this approval. The contractor will take all necessary measures to ensure no sediment migration into the river occurs and that no machinery, no grubbing and no further vegetation clearing takes place on the property as part of the proposed rehabilitation work. Failure to comply may result in this permission being revoked and charges under other applicable law.

12. It is acknowledged by all parties that the area of the fill operation between the new berm and Ottawa Street, when completed and confirmed, will be considered outside the 1:100 year flood plain of the Jock River. The Regulated Area of Ontario Regulation 174/06 nevertheless extends 15 metres from the 1:100 flood elevation which will be confirmed as the outer limit of the relocated berm. The portion of the property within the Regulated Area of Ontario Regulation 174/06 remains subject to the RVCA's regulatory jurisdiction regarding the *Development, Interference with Wetlands and Alteration to Watercourses"* regulation and associated implementation policies, as amended from time to time by the RVCA Board of Directors.

The regulatory mapping for Ontario Regulation 174/06 is reviewed once a year and amendments introduced as required. Once the works are completed, the Rideau Valley Conservation Authority agrees to pursue an amendment to the regulatory mapping to reflect the changes to the 1:100 floodplain contemplated in this approval.

Failure to comply with any or all conditions will result in the letter of permission being revoked with associated legal action to remedy the situation to the Conservation Authority's satisfaction.

By this letter, the Rideau Valley Conservation Authority assumes no responsibility or liability for any flood or erosion damage which may occur either to your property or the structures on it, or if any activity undertaken by you adversely affects the property or interests of adjacent landowners. This letter does not relieve you of the necessity or responsibility for obtaining any other federal or provincial permits including, but not limited to, approvals under the Public Lands Act, Ontario Water Resources Act, Building Code Act, Planning Act, Endangered Species Act etc.

Nothing in this letter of permission is intended to imply or confer any right of occupation or use of public land. This permission may not be transferred to any other party.

Should you have any questions, please contact Shelley Macpherson at our office.

Yours truly,

Donald A. Maciver, MCIP, RPP
Director of Planning

SM/DAM/sm

cc: Susan Murphy, Mattamy Ltd.
City of Ottawa, Guy Bourgon
City of Ottawa, Mike Wildman
City of Ottawa, Don Morse MCIP RPP
Helmut Brodmann LL.B. Bell, Baker
DSEL

NOTE: This letter of permission does not come into full force and effect until the attached copy of this letter is signed by the responsible corporate official, dated, and returned to the Authority offices in Manotick.

This letter's **return shall be taken as an acknowledgment and an acceptance of the conditions contained herein, as per the Authority's approval based on the application submitted.**

Pursuant to the provisions of S. 28 (12) of the Conservation Authorities Act (R.S.O. 1990, as amended) any or all of the conditions set out above may be appealed to the Executive Committee of the Conservation Authority in the event that they may be unsatisfactory or can not be met.

Name (printed) _____ **Date**: _____

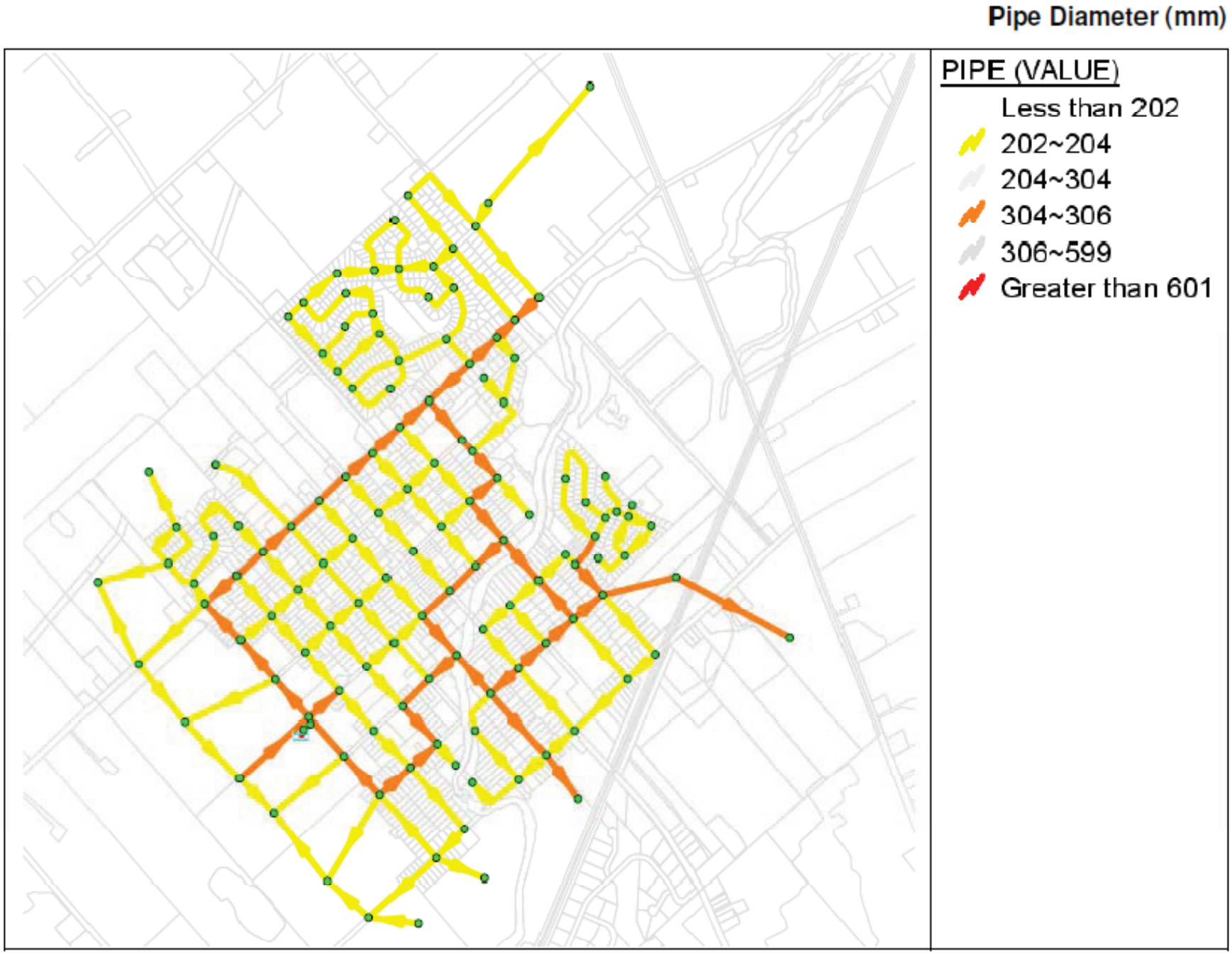
Corporate position / title: _____

Signed: _____

APPENDIX B

Water Supply

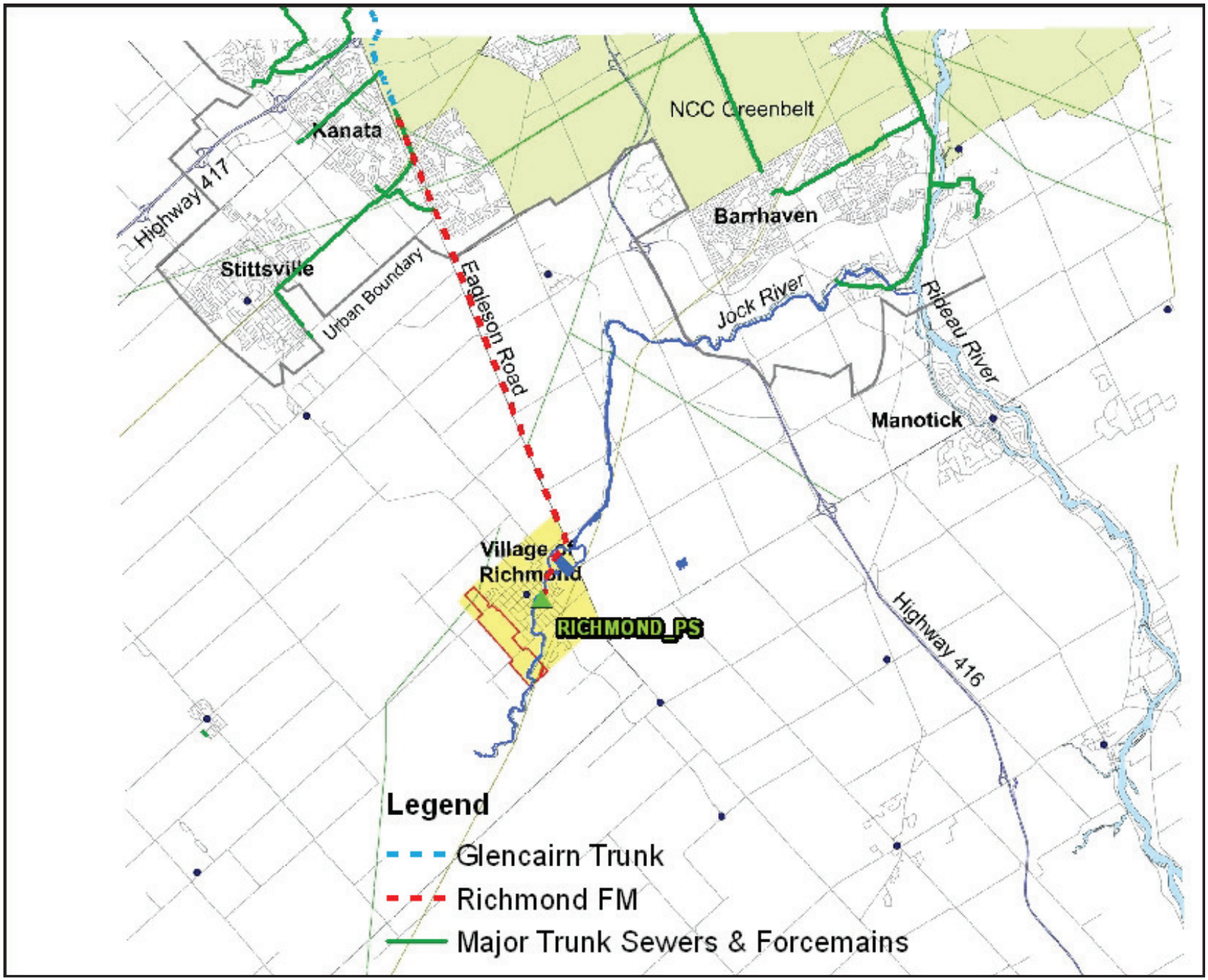
Figure 7-2: Preliminary Water Distribution System Piping

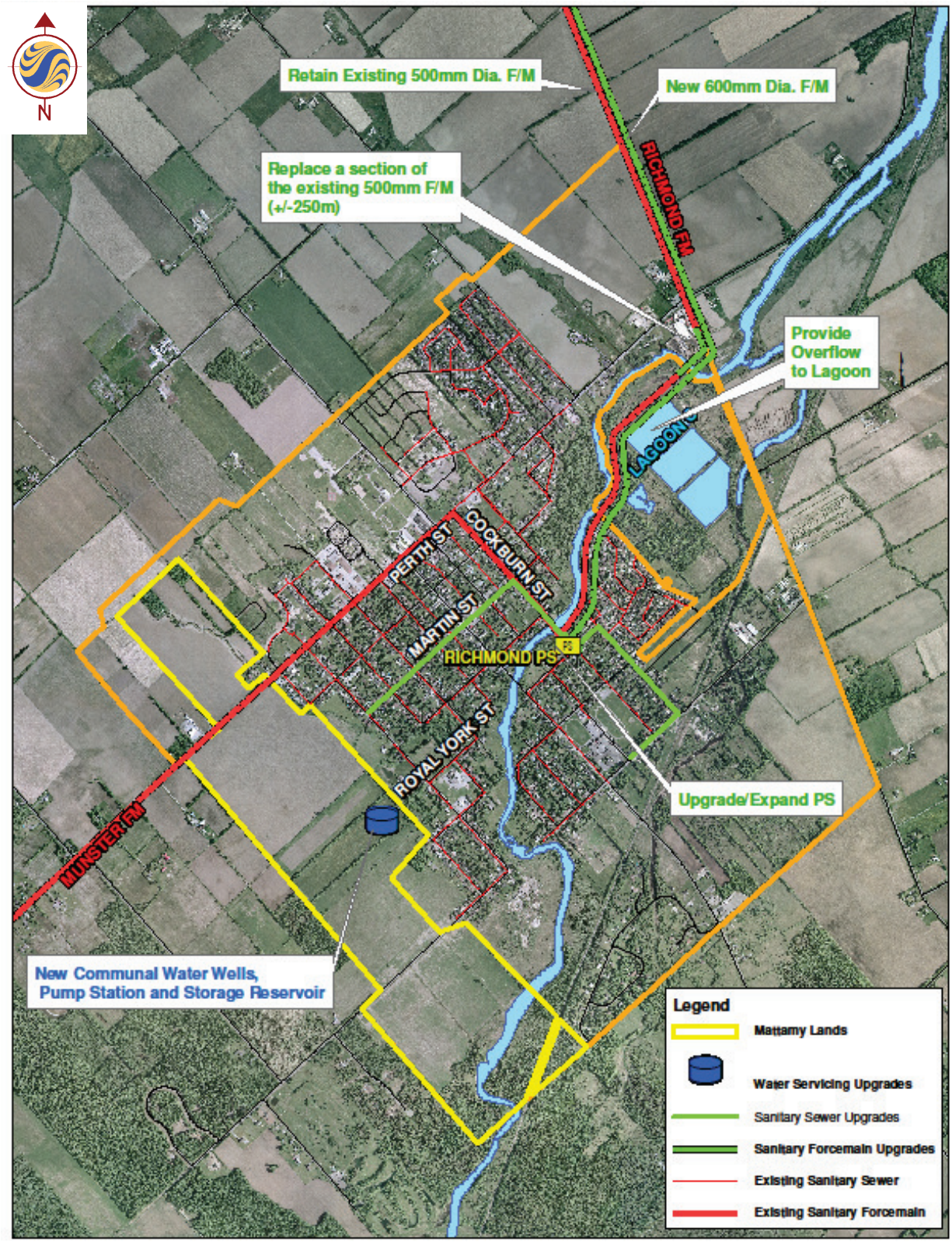


APPENDIX C

Wastewater Collection

Figure 5-2: Richmond Connection to Central Wastewater Collection System





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Client/Project

CITY OF OTTAWA
VILLAGE OF RICHMOND
MASTER SERVICING STUDY

Figure No.

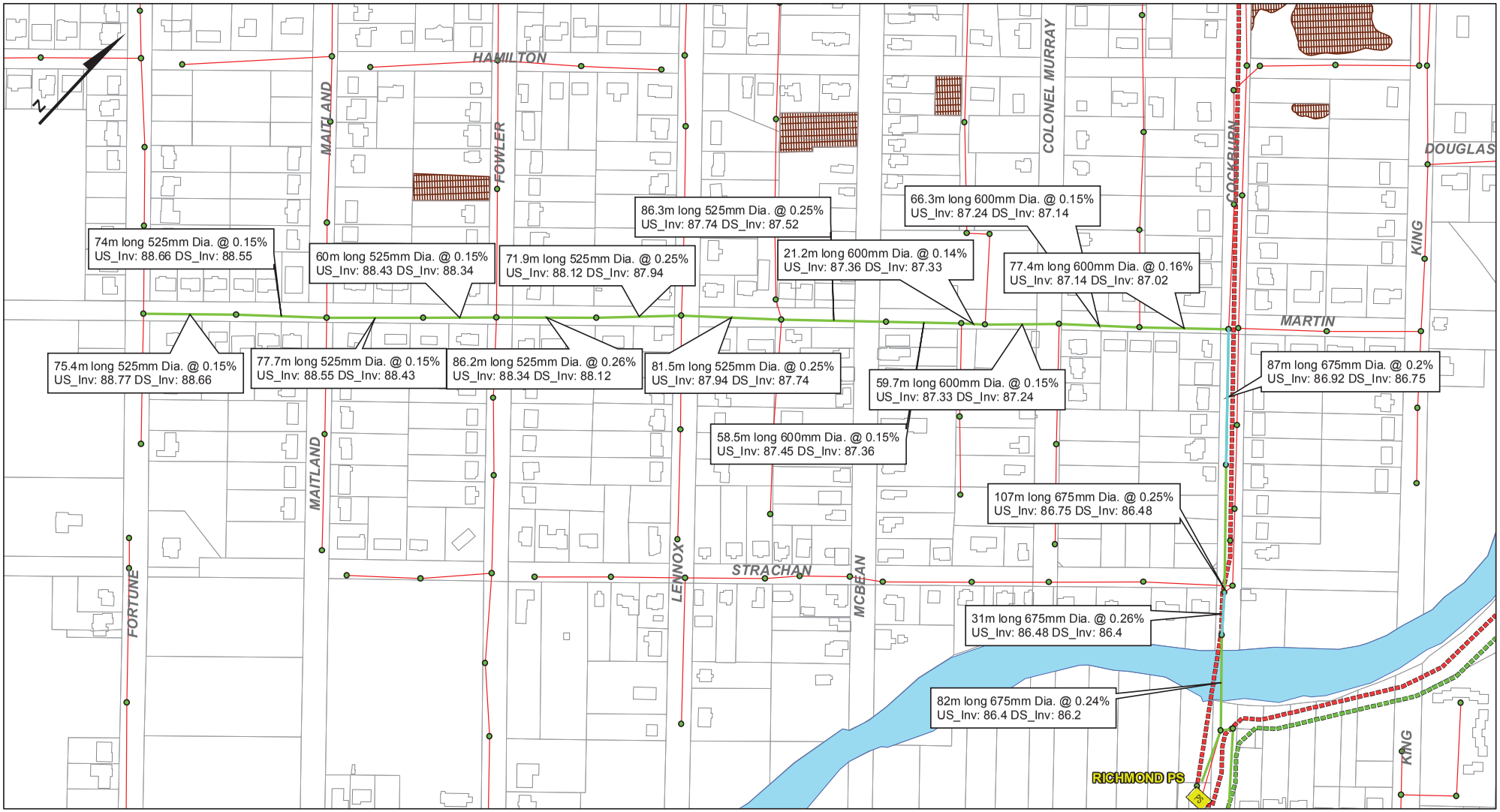
9.1

Title

Prefered Water and Wastewater Servicing Solutions

June 2011

Stantec



W:\active\1634_00808_Richmond_Water_Sanitary\planning\drawing\GIS Data\Open House April 8, 2010\Wastewater Options_A_B_C_mt20100503.mxd

May 2010
1634-00808

Stantec

Legend

- Sanitary Sewer Options A, B, C
- Sanitary Forcemain Upgrades
- Existing Sanitary Sewer
- Existing Sanitary Forcemain
- Future Infill
- Future Development
- Sanitary Manhole

0 25 50 100 150 200 Meters

1:3,000

Client/Project
CITY OF OTTAWA
VILLAGE OF RICHMOND
MASTER SERVICING STUDY

Figure No.
8.6

Title
Functional Sanitary Sewer Design
North of the Jock River

SANITARY SEWER CALCULATION SHEET

Manning's n=0.013

LOCATION				RESIDENTIAL AREA AND POPULATION									COMM		INDUST		INSTIT		C+I+I	INFILTRATION				PIPE					
STREET		FROM M.H.	TO M.H.	AREA	UNITS	UNITS	UNITS*	POP.	CUMULATIVE AREA	CUMULATIVE POP.	PEAK FACT.	PEAK FLOW	AREA	ACCU. AREA	AREA	ACCU. AREA	AREA	ACCU. AREA	PEAK FLOW	TOTAL AREA	ACCU. AREA	INFILT. FLOW	TOTAL FLOW	DIST	DIA	SLOPE	CAP. (FULL)	VEL. (FULL)	VEL. (ACT.)
				(ha)		Towns	(KWR)		(ha)			(l/s)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(l/s)	(ha)	(ha)	(l/s)	(l/s)	(m)	(mm)	(%)	(l/s)	(m/s)	(m/s)
TRUNK 2																													
		201A	202A	0.90				54	0.90	54	4.00	0.88							0.00	0.90	0.90	0.252	1.13	53.5	200	0.65	26.44	0.84	0.42
		202A	203A					0	0.90	54	4.00	0.88							0.00	0.00	0.90	0.252	1.13	14.5	200	0.40	20.74	0.66	0.35
		203A	204A	0.80				48	1.70	102	4.00	1.65							0.00	0.80	1.70	0.476	2.13	55.0	200	0.40	20.74	0.66	0.42
		204A	205A					0	1.70	102	4.00	1.65							0.00	0.00	1.70	0.476	2.13	75.0	200	0.40	20.74	0.66	0.42
		205A	206A	0.50				30	2.20	132	4.00	2.14							0.00	0.50	2.20	0.616	2.76	14.0	200	0.40	20.74	0.66	0.46
		206A	207A					0	2.20	132	4.00	2.14							0.00	0.00	2.20	0.616	2.76	52.0	250	0.24	29.13	0.59	0.37
		207A	208A					0	2.20	132	4.00	2.14							0.00	0.00	2.20	0.616	2.76	11.5	250	0.24	29.13	0.59	0.37
		208A	209A					0	2.20	132	4.00	2.14							0.00	0.00	2.20	0.616	2.76	33.0	250	0.24	29.13	0.59	0.37
		209A	210A	0.60				36	2.80	168	4.00	2.72							0.00	0.60	2.80	0.784	3.50	12.0	250	0.24	29.13	0.59	0.39
		210A	211A					0	2.80	168	4.00	2.72							0.00	0.00	2.80	0.784	3.50	23.0	250	0.24	29.13	0.59	0.39
		211A	212A					0	2.80	168	4.00	2.72							0.00	0.00	2.80	0.784	3.50	12.0	250	0.24	29.13	0.59	0.39
		212A	213A					0	2.80	168	4.00	2.72							0.00	0.00	2.80	0.784	3.50	62.0	250	0.19	25.92	0.53	0.37
		213A	214A	1.80				108	4.60	276	4.00	4.47							0.00	1.80	4.60	1.288	5.76	71.5	250	0.24	29.13	0.59	0.46
		214A	215A	1.00				60	5.60	336	4.00	5.44							0.00	1.00	5.60	1.568	7.01	71.5	250	0.24	29.13	0.59	0.48
		215A	216A	1.50				90	7.10	426	4.00	6.90							0.00	1.50	7.10	1.988	8.89	71.5	250	0.24	29.13	0.59	0.52
		216A	217A	2.80				168	9.90	594	3.94	9.48							0.00	2.80	9.90	2.772	12.25	74.5	250	0.24	29.13	0.59	0.56
Park																	0.80	0.80	0.09	0.80	10.70								
		217A	218A	0.40				24	10.30	618	3.93	9.84						0.80	0.09	0.40	11.10	3.108	13.04	93.0	250	0.24	29.13	0.59	0.57
		218A	219A	8.30				498	18.60	1116	3.77	17.04						0.80	0.09	8.30	19.40	5.432	22.56	54.5	300	0.19	42.15	0.60	0.61
		219A	220A	3.50				210	22.10	1326	3.72	19.98						0.80	0.09	3.50	22.90	6.412	26.48	91.5	300	0.19	42.15	0.60	0.63
		220A	221A	2.30				138	24.40	1464	3.69	21.88						0.80	0.09	2.30	25.20	7.056	29.03	71.5	300	0.19	42.15	0.60	0.65
		221A	222A	1.40				84	25.80	1548	3.67	23.01						0.80	0.09	1.40	26.60	7.448	30.55	58.5	300	0.19	42.15	0.60	0.65
		222A	223A	6.50				390	32.30	1938	3.60	28.26						0.80	0.09	6.50	33.10	9.268	37.62	92.0	375	0.14	65.60	0.59	0.61
		223A	224A	3.10				186	35.40	2124	3.57	30.72						0.80	0.09	3.10	36.20	10.136	40.95	40.0	375	0.14	65.60	0.59	0.62
Park																	3.30	4.10	0.44	3.30	39.50								
		224A	225A	0.70				42	36.10	2166	3.56	31.24						4.10	0.44	0.70	40.20	11.256	42.94	71.5	375	0.14	65.60	0.59	0.63
		225A	226A	1.90				114	38.00	2280	3.54	32.70						4.10	0.44	1.90	42.10	11.788	44.93	34.0	375	0.14	65.60	0.59	0.63
		226A	227A					0	38.00	2280	3.54	32.70					2.40	6.50	2.52	2.40	44.50	12.460	47.68	71.5	375	0.14	65.60	0.59	0.64
		227A	228A	1.30				78	39.30	2358	3.53	33.72						6.50	2.52	1.30	45.80	12.824	49.06	71.5	375	0.14	65.60	0.59	0.65
		228A	229A	6.40				384	45.70	2742	3.48	38.65						6.50	2.52	6.40	52.20	14.616	55.79	73.5	450	0.12	98.76	0.62	0.64
		229A	230A	0.50				85	46.20	2827	3.46	39.62						6.50	2.52	0.50	52.70	14.756	56.90	77.5	450	0.12	98.76	0.62	0.64
		230A	231A	3.10				527	49.30	3354	3.40	46.20						6.50	2.52	3.10	55.80	15.624	64.34	70.0	450	0.12	98.76	0.62	0.66
		231A	232A	1.10				187	50.40	3541	3.38	48.48						6.50	2.52	1.10	56.90	15.932	66.93	55.5	450	0.12	98.76	0.62	0.66
		232A	233A					0	50.40	3541	3.38	48.48						6.50	2.52	0.00	56.90	15.932	66.93	77.0	450	0.12	98.76	0.62	0.66
				0.20				12	50.60	3553								6.50	2.52	0.20	57.10								
		233A	121A	1.20				204	51.80	3757	3.36	51.14						6.50	2.52	1.20	58.30	16.324	69.98	118.5	450	0.12	98.76	0.62	0.67
To Trunk 1 , Pipe 121A - 122A									51.80	3757								6.50			58.30								

DESIGN PARAMETERS

Park Average Flow =	9300	L/ha/da			
Average Daily Flow =	350	l/p/day	350	l/p/day	Industrial Peak Factor = as per MOE Graph
Comm/Inst Flow =	50000	L/ha/da	50000	L/ha/da	Extraneous Flow = 0.280 L/s/ha
Industrial Flow =	35000	L/ha/da	35000	L/ha/da	Minimum Velocity = 0.760 m/s
Max Res. Peak Factor =	4.00		4		Manning's n = 0.013
Commercial/Inst peak Factor =	1.50		2		Townhouse coeff= 2.7
Institutional	0.60	l/s/Ha			Single house coeff= 3.4

Designed: K.M.

Checked: Z.L.

Dwg. Reference: Sanitary Drainage Plan

PROJECT: **MATTAMY - VILLAGE OF RICHMOND - WESTERN DEVELOPMENT LANDS SWM - SUBMISSION 2**

LOCATION: **City of Ottawa**

File Ref: 13-654

Date: March, 2013

Sheet No. 1 of 2

SANITARY SEWER CALCULATION SHEET

Manning's n=0.013

LOCATION				RESIDENTIAL AREA AND POPULATION									COMM		INDUST		INSTIT		C+I+I	INFILTRATION				PIPE					
STREET		FROM M.H.	TO M.H.	AREA	UNITS	UNITS	UNITS*	POP.	CUMULATIVE AREA	CUMULATIVE POP.	PEAK FACT.	PEAK FLOW	AREA	ACCU. AREA	AREA	ACCU. AREA	AREA	ACCU. AREA	PEAK FLOW	TOTAL AREA	ACCU. AREA	INFILT. FLOW	TOTAL FLOW	DIST	DIA	SLOPE	CAP. (FULL)	VEL. (FULL)	VEL. (ACT.)
				(ha)		Towns	(KWR)		(ha)			(l/s)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(l/s)	(ha)	(ha)	(l/s)	(l/s)	(m)	(mm)	(%)	(l/s)	(m/s)	(m/s)
TRUNK 1 (BY OTHERS)																													
		101A	102A	1.30				78	1.30	78	4.00	1.26								1.30	1.30	0.364	1.62	79.0	200	0.65	26.44	0.84	0.46
		102A	103A					0	1.30	78	4.00	1.26								0.00	1.30	0.364	1.62	79.5	200	0.40	20.74	0.66	0.39
		103A	104A	0.90				54	2.20	132	4.00	2.14								0.90	2.20	0.616	2.76	74.0	250	0.25	29.73	0.61	0.38
		104A	105A	0.90				54	3.10	186	4.00	3.01								0.90	3.10	0.868	3.88	66.0	250	0.25	29.73	0.61	0.42
		105A	106A					0	3.10	186	4.00	3.01								0.00	3.10	0.868	3.88	82.0	250	0.25	29.73	0.61	0.42
				0.80				48	3.90	234										0.80	3.90								
		106A	107A	2.30				138	6.20	372	4.00	6.03								2.30	6.20	1.736	7.77	38.5	250	0.25	29.73	0.61	0.51
		107A	108A					0	6.20	372	4.00	6.03								0.00	6.20	1.736	7.77	56.5	250	0.25	29.73	0.61	0.51
		108A	109A	1.60				96	7.80	468	3.99	7.56								1.60	7.80	2.184	9.74	38.0	250	0.25	29.73	0.61	0.54
		109A	110A					0	7.80	468	3.99	7.56								0.00	7.80	2.184	9.74	76.5	250	0.25	29.73	0.61	0.54
		110A	111A	2.10				126	9.90	594	3.94	9.48								2.10	9.90	2.772	12.25	76.0	250	0.25	29.73	0.61	0.58
		111A	112A	6.50				390	16.40	984	3.81	15.19								6.50	16.40	4.592	19.78	120.0	300	0.20	43.25	0.61	0.59
		112A	113A	0.80				48	17.20	1032	3.79	15.84								0.80	17.20	4.816	20.66	119.5	300	0.20	43.25	0.61	0.60
		113A	114A	0.90				54	18.10	1086	3.78	16.63								0.90	18.10	5.068	21.70	112.5	300	0.20	43.25	0.61	0.61
		114A	115A	4.50				270	22.60	1356	3.71	20.38								4.50	22.60	6.328	26.71	79.0	375	0.15	67.91	0.61	0.57
		115A	116A					0	22.60	1356	3.71	20.38								0.00	22.60	6.328	26.71	94.5	375	0.15	67.91	0.61	0.57
		116A	117A	2.80				168	25.40	1524	3.68	22.72								2.80	25.40	7.112	29.83	14.5	375	0.15	67.91	0.61	0.59
		117A	118A					0	25.40	1524	3.68	22.72								0.00	25.40	7.112	29.83	65.0	375	0.15	67.91	0.61	0.59
		118A	119A	1.00				60	26.40	1584	3.66	23.49								1.00	26.40	7.392	30.88	90.5	375	0.15	67.91	0.61	0.59
		119A	120A	6.70				402	33.10	1986	3.59	28.88								6.70	33.10	9.268	38.15	117.0	375	0.15	67.91	0.61	0.63
		120A	121A	6.20				372	39.30	2358	3.53	33.72								6.20	39.30	11.004	44.72	24.5	375	0.15	67.91	0.61	0.65
Contribution From Trunk 2, Pipe 233A - 121A									51.80	3757								6.50		58.30	97.60							
TRUNK 1		121A	122A					0	91.10	6115	3.16	78.28								6.50	2.52	0.00	97.60	27.328	108.13	74.5	525	0.12	148.98	0.69	0.75
		122A	123A					0	91.10	6115	3.16	78.28								6.50	2.52	0.00	97.60	27.328	108.13	60.5	525	0.12	148.98	0.69	0.75
		123A	124A					0	91.10	6115	3.16	78.28								6.50	2.52	0.00	97.60	27.328	108.13	113.5	525	0.12	148.98	0.69	0.75
		124A	125A					0	91.10	6115	3.16	78.28								6.50	2.52	0.00	97.60	27.328	108.13	95.5	525	0.12	148.98	0.69	0.75
		125A	126A					0	91.10	6115	3.16	78.28								6.50	2.52	0.00	97.60	27.328	108.13	64.0	525	0.12	148.98	0.69	0.75

DESIGN PARAMETERS

Average Daily Flow =	350	l/p/day	350 l/p/day	Industrial Peak Factor = as per MOE Graph	
Comm/Inst Flow =	50000	L/ha/da	50000 L/ha/da	Extraneous Flow =	0.280 L/s/ha
Industrial Flow =	35000	L/ha/da	35000 L/ha/da	Minimum Velocity =	0.760 m/s
Max Res. Peak Factor =	4.00		4	Manning's n =	0.013
Commercial/Inst peak Factor =	1.50		2	Townhouse coeff=	2.7
Institutional	0.60			Single house coeff=	3.4

Designed: K.M.

Checked: Z.L.

Dwg. Reference: Sanitary Drainage Plan

PROJECT: **MATTAMY - VILLAGE OF RICHMOND - WESTERN DEVELOPMENT LANDS SWM - SUBMISSION 2**

LOCATION: **City of Ottawa**

File Ref: 13-654

Date: March, 2013

Sheet No. 2 of 2

APPENDIX D

Stormwater Management

J.F. Sabourin and Associates Inc.
WATER RESOURCES AND ENVIRONMENTAL CONSULTANTS

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Ottawa (Stittsville), ON K2S 1B9
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April 9, 2013

David Schaeffer Engineering Ltd.
120 Iber Road, Unit 203
Ottawa, Ontario K2S 1E9

Attention: **Adam Fobert, P.Eng.**

Subject: **Richmond Village (South) Limited Subdivision / Preliminary Stormwater Management Plan** *our file: 922-11*

As requested by your office, we have evaluated, based on the provided information as described below; (i) the adequacy of the proposed minor system to convey the 5- and 100-year storm flows from within the development to the stormwater management (SWM) facilities; (ii) the capacity of the proposed major system to safely convey the excess 100-year flows to the SWM facilities; (iii) the operation of the proposed SWM facilities based on quality, erosion and quantity control requirements; and (iv) the hydraulic impact of the proposed subdivision and SWM facilities on the Van Gaal Drain.

The proposed subdivision consists of approximately 110.64 ha serviced by two SWM facilities; 66.71 ha at 49% imperviousness serviced by SWM Pond 1; and 43.93 ha at 49% imperviousness serviced by SWM Pond 2. Additionally, 114.0 ha of undeveloped lands to the southwest of the proposed subdivision will drain to SWM Pond 1, and 71.8 ha of undeveloped lands to the southwest of the proposed subdivision will drain to SWM Pond 2. Note that 16.5 ha of the 114.0 ha of undeveloped lands draining to SWM Pond 1 will ultimately be developed as a commercial site with flows controlled on-site. Finally, 94.2 ha of undeveloped lands to the southwest of the proposed subdivision will be conveyed through the subject site by a tributary of the Moore Drain. Refer to Figures 1A and 1B of Attachment 1 for the existing and proposed subject site drainage areas, respectively.

SWM Pond 1 discharges to the Van Gaal Drain and requires quality, erosion and quantity control, and SWM Pond 2 discharges to the Jock River and requires quality control only. Quality control will be provided for SWM Ponds 1 and 2 by permanent pools and 40 m^3/ha of active storage volume (released over 24 hours) in accordance with Ministry of the Environment enhanced protection requirements. Erosion control for SWM Pond 1 will be provided by controlling the 2-year release rate from each pond to 330 L/s or less, where 330 L/s is the erosion threshold for the Van Gaal Drain identifed by Parish Geomorphic in the *Natural Environment & Impact Assessment Study for the Mattamy Richmond Lands* (March 2009). Furthermore, the October 26, 2012 *Van Gaal Drain Erosion Assessment* memo by JTB Environmental Systems Inc. indicates that the 2-year outflows from Pond 1 should discharge to the Van Gaal Drain at a velocity of 0.225 m/s or less. This may be achieved by a plunge pool or other velocity reduction measures at the Pond 1 extended detention outlet pipe to the Van Gaal Drain. Quantity control will be provided for SWM Pond 1 to limit the 2- to 100-year release rates to pre-development levels.

The SWMHYMO program was used to simulate the major system flows and minor system inflows for the drainage area to the SWM facilities, to estimate the quantity control target release rates for SWM Pond 1 based on existing conditions, and to simulate proposed conditions flows on the Van Gaal Drain and Jock River. The XPSWMM program was used to model the conveyance of the minor system flows and the operation of the SWM facilities. The HEC-RAS program was used to simulate water levels on the Van Gaal Drain and Jock River. Refer to Attachment 2 for a schematic of the XPSWMM model; digital SWMHYMO, XPSWMM and HEC-RAS models are attached.

PROPOSED MINOR AND MAJOR SYSTEM DRAINAGE

The proposed minor and major system drainage routes are shown in plan view in Figure 1B of Attachment 1. The catchments shown in Figure 1B were divided into front yard / non-residential areas and rear yard areas for the SWMHYMO model, where rear yard areas are equal to approximately 37.5% of residential catchments based on a typical subdivision layout.

In accordance with City of Ottawa standards, the minor system has been designed to accommodate the 5-year post-development flows from within the site. For modelling purposes, minor system captures rates on front yard / non-residential areas were limited to 112% of the 5-year flows simulated in SWMHYMO, in order to account for additional flows captured by standard inlet control devices and catchbasins during the 100-year storm. In accordance with the potential design approach suggested in the January 2012 *City of Ottawa Technical Bulletin ISTB-2012-1*, 100% of the 100-year flows simulated in the rear yard areas are to be captured to the minor system. Additionally, 100% of the 100-year flows on Ottawa Street and Perth Street are to be captured to the minor system to prevent flows from crossing these roads.

The street segments within the proposed development are to be designed using a 'saw tooth' or 'sagged' road profile. The runoff from within front yard / non-residential areas will be conveyed to catchbasins located at low points on the street. Flows in excess of the minor system capture rate are temporarily stored within approximately 30 m^3/ha of surface storage and released slowly to the storm sewers and then, when that storage is surpassed, conveyed overland to the next downstream catchment. A 0.5% longitudinal slope, 3% road cross-slope and 3.5% shoulder cross-slope were assumed for the purposes of modelling the routing of major system flows along the main streets in the development. Road widths are as provided by DSEL. Refer to Table 1A of Attachment 2 for a summary of the subdivision drainage areas as modelled in SWMHYMO.

The proposed storm sewers will convey 100% of the 100-year flows generated on 185.8 ha of undeveloped lands to SWM Ponds 1 and 2. Total drainage areas through the subject site under existing and proposed conditions, including undeveloped lands and the proposed subdivision drainage areas, are summarized in Tables 1B and 1C of Attachment 2.

We understand that homes in the proposed subdivision are to be serviced by sump pumps. It is estimated that sump pumps will contribute approximately 0.23 L/s/ha of flow to the proposed storm sewer based on a average development density of approximately 27.8 lots/ha, where 50% of sump pumps are on at any given time, and a flow contribution of 1.44 m^3/day/lot per the October 3, 2012 *Updated Assessment of Subsurface Drainage and Analysis of 100 Year Flood Event - Proposed Village of Richmond Development* memo by Golder Associates Limited. Sump pump flows have been accounted for in evaluating the operations of the proposed minor system.

In addition to the typical summer design storms, the performances of the SWM facilities were also assessed for the 100-year 10-day spring snowmelt plus rainfall event. This is in keeping with the previous floodplain mapping studies for the Van Gaal Drain and the Jock River, where the spring snowmelt plus rainfall events resulted in the highest flows and water levels on the watercourses, both at the SWM facility outlets and downstream.

Several modifications were made to the drainage area characteristics in the spring SWMHYMO models in order to best represent spring conditions. A curve number (CN) value of 95 was selected for undeveloped lands to model the limited infiltration capacity of the frozen soils. Similarly, the Horton's minimum and maximum infiltration parameters for the sudivision drainage areas were set to 2.4 mm/hour; the lowest infiltration rate in the *SWMHYMO User's Manual* (May 2000, JFSA). Furthermore, it was assumed, according to generally accepted practice, that half of the volume in the snowmelt plus rainfall event may be attributed to snowmelt, and half to rainfall. As it is expected that most of the snow on impervious areas like roads, driveways and roofs would have melted prior to such an event, half of the impervious area was removed from each developed drainage area such that only the runoff resulting from rainfall, not snowmelt, is simulated for impervious areas.

The SWMHYMO and XPSWMM analyses, discussed in the next sections, demonstrate that it is possible for the proposed drainage systems for the development to control the excess flow during a 100-year storm and safely capture and convey the minor system flows to the SWM facility.

ASSUMPTIONS AND SOURCES OF DATA USED

The following parameters and assumptions used in the analysis are based on City of Ottawa standards and generally accepted stormwater management design guidelines.

- Stormwater Management Model:	*SWMHYMO (version 5.02), XPSWMM (version 10), HEC-RAS (version 4.1.0)*
- Minor System Design:	*1:5 year*
- Major System Design:	*1:100 year*
- Max. Allowable Flow Depth:	*30 cm above gutter.*
- Extent of Major System:	*Must be contained within the municipal right-of-way.*
- SWMHYMO Model Parameters:	*Fo = 76.2 mm/hr, Fc = 13.2 mm/hr, DCAY = 4.14/hr, D.Stor.Imp. = 1.57 mm, D.Stor.Per. = 4.67 mm (as per 2004 City of Ottawa Guidelines).*
- Undeveloped Area Characteristics:	*As per "Floodplain Mapping Report for the Van Gaal and Arbuckle Municipal Drains in the Village of Richmond" (November 2009, JFSA).*
- Imperviousness:	*SWM Facilities: based on SWM block layout.* *Front Yard / Non-Residential: based on runoff coefficient (C) where Percent Imperviousness = (C - 0.2) / 0.7 x 100%.* *Rear Yard: equal to half of the front yard percent imperviousness. Half of that rear yard impervious area is assumed to be indirectly connected.*
- Design Storms:	*Chicago 3-hour and SCS Type II 24-hour design storms based on 2004 City of Ottawa Sewer Design Guidelines; maximum intensity averaged over 10 minutes. 10-day snowmelt plus rainfall events based on AES Ottawa CDA snowmelt plus rainfall IDF curves; maximum intensity averaged over 1 hour.*
- Historical Events:	*July 1st, 1979 event per 2004 City of Ottawa Sewer Design Guidelines.*
- Climate Change Street Test:	*20% increase in the 100-year, 3-hour Chicago and 100-year, 24-hour SCS storms, as per January 2012 City of Ottawa Technical Bulletin ISTB-2012-1.*
- Manning's Roughness Coeff.:	*0.013 for concrete pipes (free flow).*
- Minor System Losses:	*Refer to Attachment 2 for manhole loss coefficients.*
- Sump Pump Flows:	*0.23 L/s/ha based on 27.8 lot/ha, 1.44 m^3/day/lot (per October 3, 2012 "Updated Assessment of Subsurface Drainage and Analysis of 100 Year Flood Event - Proposed Village of Richmond Development" memo by Golder Associates Limited), and 50% of sump pumps on.*
- Downstream HGL:	*Jock River water levels at Pond 2 outlet as per "Jock River Flood Risk Mapping (within the City of Ottawa) Hydraulics Report" (November 2004, PSR Group Ltd. and JFSA).* *Van Gaal Drain water levels at Pond 1 outlet as per HEC-RAS models from "Floodplain Mapping Report for the Van Gaal and Arbuckle Municipal Drains in the Village of Richmond" (November 2009, JFSA) with proposed Fortune Street culvert improvements in place.*

MAJOR SYSTEM CONVEYANCE

As per City standards, the total 100-year depth of water (static and dynamic) on the street must be retained within the right-of-way and should not exceed 30 cm. Although static ponding depths are unknown at this stage of the design, the dynamic flow depths at a typical low point were estimated in SWMHYMO based on the excess major system flows in a front yard / non-residential catchment and an assumed longitudinal street slope of 0.15% from high point to high point. The results of this analysis are presented in Table 2A of Attachment 3 for the 100-year 3-hour

Chicago storm. As may be seen in Attachment 3, the dynamic flow depths on all catchments are below 30 cm, allowing for some static ponding depth to be incorporated into the detailed design without exceeding City standards for total depth of water. In general, it may be concluded that it is possible to provide a total 100-year depth of water that is less than 30 cm and retained within the right-of-way, in accordance with City standards.

Table 2B of Attachment 3 presents the simulated dynamic flow depths for the development based on a 20% increase in the 100-year 3-hour Chicago storm, in accordance with the climate change stress test prescribed in the January 2012 *City of Ottawa Technical Bulletin ISTB-2012-1*. As shown in Table 2B, the maximum dynamic flow depth at a typical low point was estimated as approximately 30.6 cm under these conditions.

STORMWATER MANAGEMENT FACILITIES

As previously noted, 66.71 ha of the subdivision at 49% imperviousness are serviced by SWM Pond 1; and 43.93 ha at 49% imperviousness are serviced by SWM Pond 2. Additionally, 114.0 ha of undeveloped lands to the southwest of the proposed subdivision will drain to SWM Pond 1, and 71.8 ha of undeveloped lands to the southwest of the proposed subdivision will drain to SWM Pond 2. Refer to Tables 3A and 3B of Attachment 4 for a summary of the proposed operating conditions for SWM Ponds 1 and 2, respectively.

The permanent pool volumes of SWM Ponds 1 and 2 are sufficient to provide an enhanced protection level (80% long-term suspended solids removal) according to Ministry of the Environment standards. Active storage volumes of 40 m^3/ha minimum were also provided for quality control in SWM Ponds 1 and 2 and detained for approximately 24 hours. Drawdown time calculations for SWM Ponds 1 and 2 are presented in Tables 4A and 4B of Attachment 4.

Erosion control for SWM Pond 1 will be provided by controlling the 2-year release rate from each pond to 330 L/s or less, where 330 L/s is the erosion threshold for the Van Gaal Drain identifed by Parish Geomorphic in the *Natural Environment & Impact Assessment Study for the Mattamy Richmond Lands* (March 2009). Furthermore, the October 26, 2012 *Van Gaal Drain Erosion Assessment* memo by JTB Environmental Systems Inc. indicates that the 2-year outflows from Pond 1 should discharge to the Van Gaal Drain at a velocity of 0.225 m/s or less. This may be achieved by a plunge pool or other velocity reduction measures at the Pond 1 extended detention outlet pipe to the Van Gaal Drain. We understand that erosion control is not required for SWM Pond 2, which discharges to the Jock River.

Quantity control for SWM Pond 1 is to be provided by controlling post-development outflows to pre-development levels for the 2- to 100-year 24-hour SCS design storms. Pre-development flows from the site were estimated in SWMHYMO based on the undeveloped drainage area characteristics presented in Figure 1A of Attachment 1 and Table 1B of Attachment 2. We understand that quantity control is not required for SWM Pond 2, which discharges to the Jock River; however, the 100-year release rate from Pond 2 has been limited to a maximum of 2.235 m^3/s based on the capacity of the 1500 mm diameter (at 0.1% slope) outlet pipe to the Jock River. Refer to Tables 5A and 5B of Attachment 4 for the outlet control design and stage-storage-discharge relationships for SWM Ponds 1 and 2, respectively.

The performances of the SWM facilities were analyzed in XPSWMM based on both free outfall and restrictive downstream conditions. Restrictive downstream conditions for the outlet of SWM Pond 2 to the Jock River are based on the *Jock River Flood Risk Mapping (within the City of Ottawa) Hydraulics Report* (November 2004, PSR Group Ltd. and JFSA). During the 100-year 10-day spring snowmelt plus rainfall event, the water level on the Jock River at the outlet of SWM Pond 2 (Jock River Lower Reach 2 cross-section 19353) is 94.18 m. During the 100-year 24-hour SCS design storm, the water level on the Jock River at this location is below the permanent pool elevation of SWM Pond 2 and therefore does not affect the operation of the pond.

Restrictive downstream conditions for the outlet of SWM Pond 1 to the Van Gaal Drain are based on the existing

conditions HEC-RAS models from *Floodplain Mapping Report for the Van Gaal and Arbuckle Municipal Drains in the Village of Richmond* (November 2009, JFSA) with proposed Fortune Street culvert improvements in place. It is proposed that the width of the Fortune Street culvert on the Van Gaal Drain be increased from 4.2 m to 6.3 m. Under these conditions, the water level on the Van Gaal Drain at the outlet of SWM Pond 1 (Van Gaal Drain Reach 2 cross-section 961) is 93.68 m for the 100-year 24-hour SCS design storm and 94.11 m for the 100-year 10-day spring snowmelt plus rainfall event.

HYDRAULIC GRADELINE ANALYSIS

The minor system and hydraulic gradeline analysis was completed for the proposed systems discharging to SWM Ponds 1 and 2 using the XPSWMM program based on the 100-year 3-hour Chicago and 100-year 24-hour SCS design storms, the 100-year 10-day spring snowmelt plus rainfall event and for the July 1st 1979 historical event. Attachment 5 summarizes the hydraulic simulation results for the proposed systems under restrictive downstream conditions. Note that the flowing full pipe velocities are not less than 0.8 m/s and no greater than 6.0 m/s for all proposed pipes.

Attachment 5 also presents the hydraulic simulation results for the climate change stress test based on a 20% increase in the 100-year 3-hour Chicago and 100-year 24-hour SCS design storms, as per the January 2012 *City of Ottawa Technical Bulletin ISTB-2012-1*.

DOWNSTREAM HYDRAULIC IMPACTS

The impact of the proposed subdivision and SWM facility designs on the flows and flood levels on the downstream Van Gaal Drain was evaluated using the existing conditions SWMHYMO and HEC-RAS models from *Floodplain Mapping Report for the Van Gaal and Arbuckle Municipal Drains in the Village of Richmond* (November 2009, JFSA).

The SWMHYMO models from the November 2009 report were modified to include the proposed subdivision and SWM pond storage-discharge curves, and the resultant proposed conditions flows entered into the HEC-RAS models. The HEC-RAS models were also modified to include the proposed Fortune Street culvert improvements in place; as noted above, it is proposed that the width of the Fortune Street culvert on the Van Gaal Drain be increased from 4.2 m to 6.3 m.

As previously noted, 94.2 ha of undeveloped lands to the southwest of the proposed subdivision will be conveyed through the subject site by a tributary of the Moore Drain. The Moore Drain tributary is to be reconstructed in accordance with the February 22, 2010 *Proposed Channel Cross Section Analysis - Mattamy (Richmond)* by JFSA, and the channel profile and proposed culverts provided by DSEL. Furthermore, the Van Gaal Drain north of Perth Street, currently crossing through the proposed development lands, is to be realigned to follow the boundary of the subject site in accordance with the November 5, 2012 *Richmond Village Development / Proposed Realignment of Van Gaal Drain* memo by JFSA. The November 2009 SWMHYMO and HEC-RAS models have been modified to reflect these proposed conditions.

Attachment 6 presents the existing and proposed conditions 100-year flows and water levels on the Van Gaal Drain. Three different scenarios are considered, as per the November 2009 report; (1) When the Van Gaal Drain 100-year 24-hour SCS peak flow reaches the Jock River; (2) When the Van Gaal Drain 100-year spring snowmelt plus rainfall peak flow reaches the Jock River; and (4) When the Jock River 100-year spring snowmelt plus rainfall peak flow reaches the outlet of the Van Gaal Drain.

Note that flows and water levels on the Van Gaal Drain generally decrease between existing and proposed conditions. This result is expected, as the provided release rates from SWM Pond 1 to the Van Gaal Drain are well

below pre-development levels owing to the real-world limitations of the outlet controls. That is, the 45 m long quantity control weir for SWM Pond 1 is set 1.33 m above the permanent pool elevation at an invert of 93.68 m to match the 100-year 24-hour SCS water level on the Van Gaal Drain (per existing conditions with the Fortune Street culvert improvements in place). This results in minimal head over the quantity control weir and consequently lower release rates; for example, the 100-year 24-hour SCS release rate from SWM Pond 1 is 3.730 m^3/s at a pond level of 93.81 m, while the allowable release rate is 7.867 m^3/s based on existing conditions.

As may be seen from Attachment 6, proposed conditions peak flows on the Van Gaal Drain are equal to or less than existing peak flows, and proposed conditions water levels are a maximum of 1 cm greater than existing water levels at cross-section 647 under Scenario 2; all other proposed conditions water levels are equal to or less than existing water levels on the Van Gaal Drain. Note that proposed conditions water levels on the Moore Drain tributary though the subject site are higher than existing levels; this is not a concern since only the subject site is affected by this increase in water levels.

Yours truly,
J.F. Sabourin and Associates Inc.

Laura Pipkins, P.Eng.

cc: J.F. Sabourin, M.Eng, P.Eng.
Director of Water Resources Projects

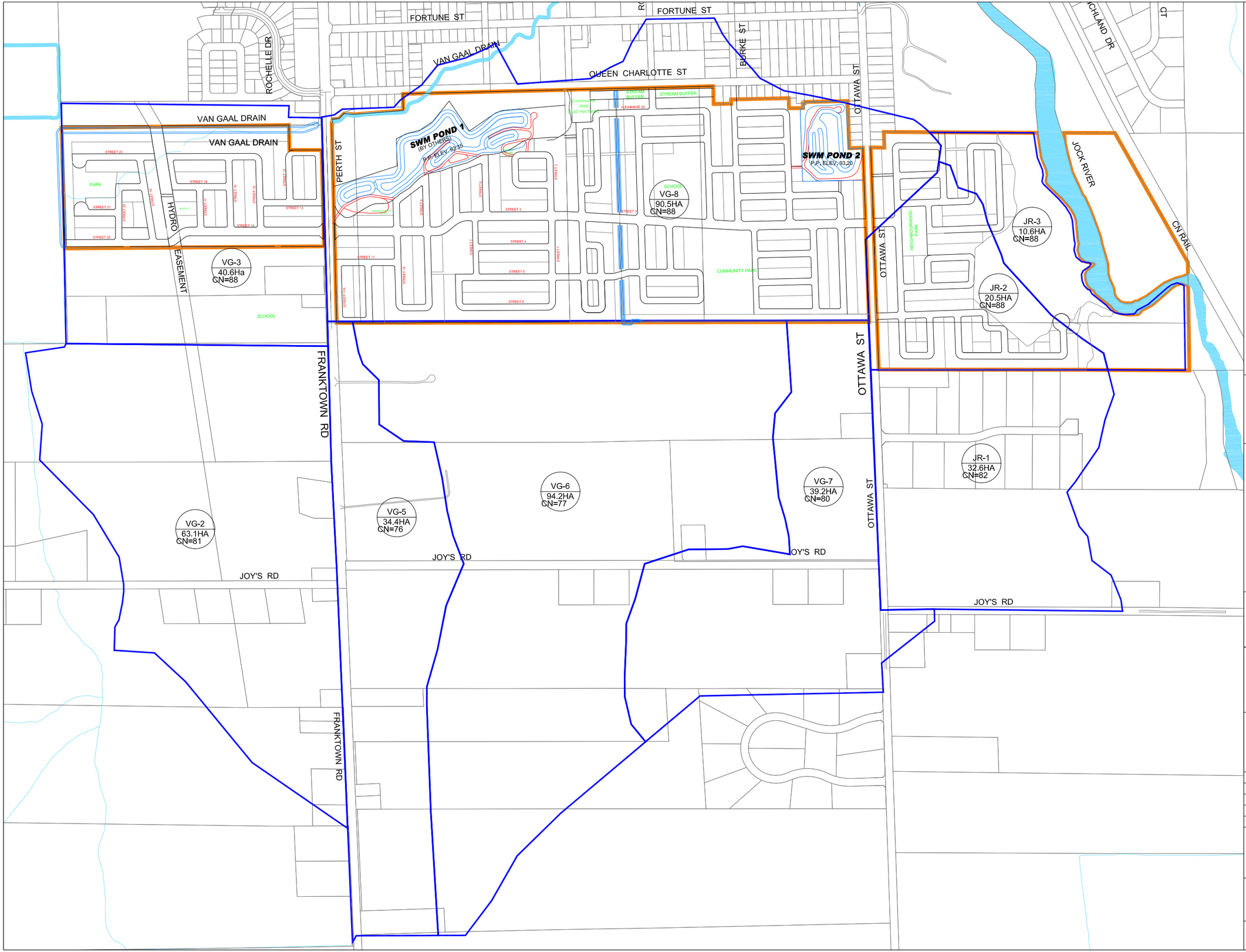
Attachment 1:	Drainage Area to SWM Facilities
Attachment 2:	Summary of Drainage Area to SWM Facilities; XPSWMM Model Schematic; and Minor System Loss Coefficients
Attachment 3:	Major System Results
Attachment 4:	SWM Facility Operating Conditions
Attachment 5:	Pipe Data and Hydraulic Simulation Results
Attachment 6:	Flows and Water Levels on the Van Gaal Drain Under Existing and Proposed Conditions

ATTACHMENT

1

DRAINAGE AREA TO SWM FACILITIES

JFSA Water Resources and Environmental Consultants



LEGEND :

SUBCATCHMENT BOUNDARY (PER DEC 2009 RICHMOND FLOODPLAIN STUDY)

JR-3 10.6HA CN=88
- SUBCATCHMENT ID
- SUBCATCHMENT AREA
- CURVE NUMBER (CN)

SCALE :

0 100 200 300 400 500m

J.F. Sabourin & Associates Inc.
WATER RESOURCES AND ENVIRONMENTAL CONSULTANTS
OTTAWA (613) 836-3884
GATINEAU (819) 243-6858

CLIENT :

david schaeffer engineering ltd
600 ALDEN ROAD., SUITE 500
MARKHAM, ONTARIO., L3R 0E7
(905) 475-3080

PROJECT :

RICHMOND VILLAGE (SOUTH) LIMITED SUBDIVISION

BY	DATE	DESCRIPTION	BY

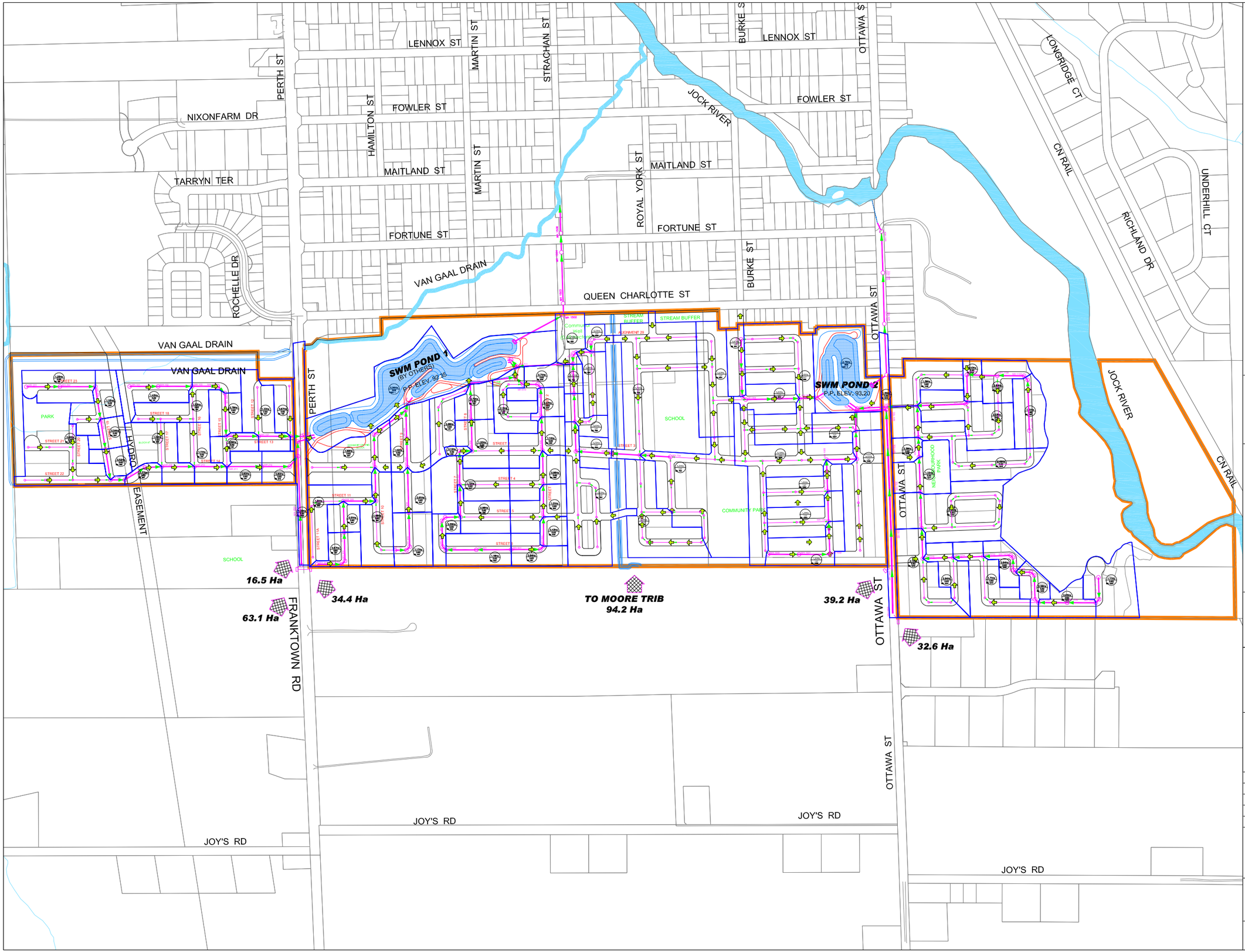
EXISTING DRAINAGE AREAS THROUGH SUBJECT SITE

FIGURE 1A

DESIGNED:
DRAWN: LP
VERIFIED: JFS
APPROVED: JFS

DRAWING REF.
922-11\201304 FSR\Design\CAD\JFSA Figures.dwg

DATE	PROJECT No.
Apr/13	922-11



LEGEND :

SUBCATCHMENT BOUNDARY (PER DSEL)

0.43Ha — SUB-CATCHMENT AREA
0.62 — RUNOFF COEFFICIENT
MH 1104 — UPSTREAM MANHOLE

MAJOR SYSTEM FLOW DIRECTION

16.5 Ha — UNDEVELOPED DRAINAGE AREA

SCALE :

0 100 200 300 400 500m

J.F. Sabourin & Associates Inc.
WATER RESOURCES AND ENVIRONMENTAL CONSULTANTS
OTTAWA (613) 836-3884
GATINEAU (819) 243-6858

CLIENT :

david schaeffer engineering ltd
600 ALDEN ROAD., SUITE 500
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(905) 475-3080

PROJECT :

RICHMOND VILLAGE (SOUTH) LIMITED SUBDIVISION

	BY	DATE	DESCRIPTION	BY

PROPOSED DRAINAGE AREA TO SWM FACILITIES

FIGURE 1B

DESIGNED:	
DRAWN:	LP
VERIFIED:	JFS
APPROVED:	JFS

DRAWING REF.	DATE	PROJECT No.
922-11\201304 FSR\Design\CAD\ JFSA Figures.dwg	Apr/13	922-11

ATTACHMENT

2

SUMMARY OF DRAINAGE AREA TO SWM FACILITIES

XPSWMM MODEL SCHEMATIC

MINOR SYSTEM LOSS COEFFICIENTS

JFSA Water Resources and Environmental Consultants

Table 1A: Proposed Subdivision Drainage Area to SWM Ponds 1, 2 and 3

MH	SWMHYMO ID	Total Area (ha)	Front Yard / Non-Resid. (ha)	Rear Yard [1] (ha)	Runoff Coefficient	Front Yard / Non-Residential Area Parameters							Sump Pump Flow [2] (m^3/s)
						Imperviousness (%)	Storage (m^3)	5-Year Flow (m^3/s)	Minor Capture (m^3/s)	Road Width (m)	Length (m)	Downstream Segment	
101	101a	1.43	0.894	0.536	0.62	60	26.82	0.155	0.174	8.5	157	105	0.00033
103	103a	1.53	0.956	0.574	0.62	60	28.68	0.165	0.185	8.5	296	105	0.00035
105	105a	0.78	0.487	0.293	0.62	60	14.61	0.086	0.096	8.5	101	106	0.00018
106	106a	0.59	0.369	0.221	0.62	60	11.07	0.065	0.073	8.5	78	1500	0.00014
107	107a	1.33	0.831	0.499	0.62	60	24.93	0.144	0.161	8.5	203	1500	0.00031
108	108a	0.67	0.544	0.126	0.62	60	16.32	0.096	0.108	8.5	200	1500	0.00015
201	201a	1.25	0.781	0.469	0.62	60	23.43	0.136	0.152	8.5	172	203	0.00029
203	203a	1.1	0.687	0.413	0.62	60	20.61	0.120	0.134	8.5	77	204	0.00025
204	204a	0.54	0.337	0.203	0.62	60	10.11	0.060	0.067	8.5	72	205	0.00012
205	205a	0.52	0.325	0.195	0.62	60	9.75	0.058	0.065	8.5	74	207	0.00012
206	206a	3.04	1.900	1.140	0.62	60	57.00	0.320	0.358	8.5	260	207	0.00070
207	207a	0.37	0.301	0.069	0.62	60	9.03	0.054	0.060	8.5	95	211	0.00009
209	209a	1.54	0.962	0.578	0.62	60	28.86	0.166	0.186	8.5	179	211	0.00035
210	210a	1.11	0.694	0.416	0.62	60	20.82	0.122	0.137	8.5	180	211	0.00026
211	211a	0.6	0.375	0.225	0.62	60	11.25	0.067	0.075	8.5	82	212	0.00014
212	212a	0.6	0.375	0.225	0.62	60	11.25	0.067	0.075	8.5	78	1500	0.00014
301	301a	0.67	0.419	0.251	0.62	60	12.57	0.074	0.083	8.5	140	304	0.00015
304	304a	0.51	0.319	0.191	0.62	60	9.57	0.057	0.064	8.5	73	306	0.00012
305	305a	1.31	1.064	0.246	0.62	60	31.92	0.183	0.205	8.5	294	306	0.00030
306	306a	1.48	0.925	0.555	0.62	60	27.75	0.160	0.179	8.5	80	307	0.00034
307	307a	1.99	1.244	0.746	0.62	60	37.32	0.213	0.239	8.5	87	Pond1	0.00046
401	401a	1.17	0.731	0.439	0.62	60	21.93	0.128	0.143	8.5	121	404	0.00027
404	404a	0.91	0.569	0.341	0.62	60	17.07	0.100	0.112	8.5	107	405	0.00021
405	405a	1.42	0.887	0.533	0.62	60	26.61	0.154	0.172	8.5	144	Pond1	0.00033
500	500a	1.18	0.737	0.443	0.62	60	22.11	0.129	0.144	8.5	153	502	0.00027
502	502a	0.55	0.344	0.206	0.62	60	10.32	0.061	0.068	8.5	117	506	0.00013
506	506a	0.96	0.600	0.360	0.62	60	18.00	0.106	0.119	8.5	77	507	0.00022
507	507a	1.72	1.075	0.645	0.62	60	32.25	0.185	0.207	8.5	66	509	0.00040
508	508a	0.12	0.120	0.000	0.62	60	3.60	0.021	0.024	8.5	62	509	0.00003
509	509a	1.2	0.750	0.450	0.62	60	22.50	0.131	0.147	8.5	73	510	0.00028
510	510a	0.7	0.437	0.263	0.62	60	13.11	0.077	0.086	8.5	83	Pond1	0.00016
511	511a	0.88	0.550	0.330	0.62	60	16.50	0.097	0.109	8.5	222	Pond1	0.00020
601	601a	0.84	0.525	0.315	0.62	60	15.75	0.093	0.104	8.5	79	603	0.00019
603	603a	0.43	0.349	0.081	0.62	60	10.47	0.062	0.069	8.5	68	604	0.00010
604	604a	1.01	0.631	0.379	0.62	60	18.93	0.111	0.124	8.5	76	605	0.00023
605	605a	0.98	0.612	0.368	0.62	60	18.36	0.108	0.121	8.5	80	606	0.00023
606	606a	1.14	0.712	0.428	0.62	60	21.36	0.125	0.140	8.5	78	607	0.00026
607	607a	0.47	0.382	0.088	0.62	60	11.46	0.068	0.076	8.5	69	609	0.00011
609	609a	0.71	0.444	0.266	0.62	60	13.32	0.079	0.088	8.5	41	Pond1	0.00016
610	610a	1.13	0.706	0.424	0.62	60	21.18	0.124	0.139	8.5	179	Pond1	0.00026

Table 1A: Proposed Subdivision Drainage Area to SWM Ponds 1, 2 and 3

MH	SWMHYMO ID	Total Area (ha)	Front Yard / Non-Resid. (ha)	Rear Yard [1] (ha)	Runoff Coefficient	Front Yard / Non-Residential Area Parameters							Sump Pump Flow [2] (m^3/s)
						Imperviousness (%)	Storage (m^3)	5-Year Flow (m^3/s)	Minor Capture (m^3/s)	Road Width (m)	Length (m)	Downstream Segment	
704	704a	4.54	2.837	1.703	0.62	60	85.11	0.460	0.515	8.5	224	706	0.00104
705	705a	5.7	3.562	2.138	0.62	60	106.86	0.569	0.637	8.5	482	706	0.00131
705	705b	2.54	1.587	0.953	0.62	60	47.61	0.269	0.301	8.5	333	706	0.00058
706	706a	0.52	0.325	0.195	0.62	60	9.75	0.058	0.065	8.5	75	708	0.00012
707	707a	2.82	1.762	1.058	0.62	60	52.86	0.297	0.333	8.5	303	708	0.00065
708	708a	0.62	0.387	0.233	0.62	60	11.61	0.069	0.077	8.5	66	709	0.00014
709	709a	0.31	0.194	0.116	0.62	60	5.82	0.035	0.039	8.5	69	Pond1	0.00007
806	806a	0.33	0.206	0.124	0.62	60	6.18	0.037	0.041	8.5	79	808	0.00008
807	807a	0.88	0.550	0.330	0.62	60	16.50	0.097	0.109	8.5	184	808	0.00020
808	808a	0.76	0.475	0.285	0.62	60	14.25	0.084	0.094	8.5	31	Pond1	0.00017
901	901a	0.67	0.544	0.126	0.62	60	16.32	0.096	0.108	8.5	170	904a	0.00015
904	904a	0.9	0.562	0.338	0.62	60	16.86	0.099	0.111	8.5	155	Pond2	0.00021
904	904b	2.02	1.262	0.758	0.62	60	37.86	0.216	0.242	8.5	228	904a	0.00046
906	906a	3.49	2.181	1.309	0.62	60	65.43	0.365	0.409	8.5	370	Pond2	0.00080
1000	1000a	1.3	0.812	0.488	0.62	60	24.36	0.141	0.158	8.5	226	1007	0.00030
1003	1003a	1.28	0.800	0.480	0.62	60	24.00	0.139	0.156	8.5	215	1007	0.00029
1004	1004a	1.26	0.787	0.473	0.62	60	23.61	0.137	0.153	8.5	218	1007	0.00029
1005	1005a	3.16	1.975	1.185	0.62	60	59.25	0.332	0.372	8.5	286	1007	0.00073
1006	1006a	3	1.875	1.125	0.62	60	56.25	0.316	0.354	8.5	345	1007	0.00069
1007	1007a	0.98	0.612	0.368	0.62	60	18.36	0.108	0.121	8.5	106	Pond2	0.00023
1101	1101a	1.21	0.756	0.454	0.62	60	22.68	0.132	0.148	8.5	169	1103	0.00028
1103	1103a	0.89	0.556	0.334	0.62	60	16.68	0.098	0.110	8.5	105	1104	0.00020
1104	1104a	0.43	0.349	0.081	0.62	60	10.47	0.062	0.069	8.5	99	1106	0.00010
1106	1106a	2.03	1.269	0.761	0.62	60	38.07	0.217	0.243	8.5	119	1600	0.00047
1108	1108a	1.39	0.869	0.521	0.62	60	26.07	0.151	0.169	8.5	174	1600	0.00032
1201	1201a	1.71	1.069	0.641	0.62	60	32.07	0.184	0.206	8.5	112	1203	0.00039
1203	1203a	0.85	0.531	0.319	0.62	60	15.93	0.094	0.105	8.5	135	1205	0.00020
1205	1205a	0.58	0.362	0.218	0.62	60	10.86	0.064	0.072	8.5	114	1209	0.00013
1209	1209a	0.64	0.400	0.240	0.62	60	12.00	0.071	0.080	8.5	108	1214	0.00015
1213	1213a	1.71	1.069	0.641	0.62	60	32.07	0.184	0.206	8.5	279	1214	0.00039
1214	1214a	0.94	0.587	0.353	0.62	60	17.61	0.103	0.115	8.5	71	1217	0.00022
1215	1215a	2.13	1.331	0.799	0.62	60	39.93	0.228	0.255	8.5	238	1217	0.00049
1216	1216a	3.05	1.906	1.144	0.62	60	57.18	0.321	0.360	8.5	328	1217	0.00070
1217	1217a	1.33	0.831	0.499	0.62	60	24.93	0.144	0.161	8.5	82	1218	0.00031
1218	1218a	0.39	0.244	0.146	0.62	60	7.32	0.043	0.048	8.5	46	1600	0.00009
1219	1219a	2.49	1.556	0.934	0.62	60	46.68	0.264	0.296	8.5	434	1600	0.00057
1500 [3]	1500a	1.33	1.330	0.000	0.62	60	39.90	0.228	100% Capt.	8.5	N/A	100% Capt.	0.00031
1600 [3]	1600a	1.35	1.350	0.000	0.62	60	40.50	0.231	100% Capt.	8.5	N/A	100% Capt.	0.00031
Pond1	Pond1a	5.94	5.940	0.000	N/A	50	N/A	0.765	N/A	N/A	N/A	N/A	0.00000
Pond2	Pond2a	2.75	2.750	0.000	N/A	45	N/A	0.342	N/A	N/A	N/A	N/A	0.00000

Table 1A: Proposed Subdivision Drainage Area to SWM Ponds 1, 2 and 3

MH	SWMHYMO ID	Total Area (ha)	Front Yard / Non-Resid. (ha)	Rear Yard [1] (ha)	Runoff Coefficient	Front Yard / Non-Residential Area Parameters							Sump Pump Flow [2] (m^3/s)
						Imperviousness (%)	Storage (m^3)	5-Year Flow (m^3/s)	Minor Capture (m^3/s)	Road Width (m)	Length (m)	Downstream Segment	
		110.700	**74.300**	**36.400**									

[1] Rear yard imperviousness is equal to half of the front yard imperviousness, and half of that rear yard impervious area is assumed to be indirectly connected. 100% of the 100-year flows generated on the rear yards are captured to the minor system.

[2] 0.23 L/s/ha based on approximately 1.44 m^3/day/lot (per October 3, 2012 "*Updated Assessment of Subsurface Drainage and Analysis of 100 Year Flood Event - Proposed Village of Richmond Development* " by Golder Associates Limited), 27.8 lots/ha, and 50% of sump pumps on at any given time.

[3] 100% capture of the 100-year flows on Ottawa Street and Perth Street to prevent flow across roads.

Table 1B: Summary of Study Area under Existing Conditions (Drains to SWM Ponds 1 and 2 in Future)

Area ID In future drains to:	VG-2 Pond 1	VG-3 [1] Pond 1	VG-3 [2] Pond 1	VG-5 Pond 1	VG-7 Pond 2	VG-8 [2] Pond 1	VG-8 [2] Pond 2	JR-1 Pond 2	JR-2 [2] Pond 2	JR-3 [2] Pond 2
A (ha)	63.1	16.5	17.090	34.4	39.2	49.680	24.325	32.6	15.770	3.835
CN (-)	81	88	88	76	80	88	88	82	88	88
Ia	2.8	2.5	2.5	3.0	3.5	2.6	2.6	3.5	2.5	2.5
L (m)	1220	660	630	1540	1520	1060	420	790	330	150
S (%)	0.4	0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.1	0.6
Tc (min)	147.6	100.2	96.5	207.1	256.9	146.3	69.8	142.8	81.3	17.7
Tp (hrs)	1.6	1.1	1.1	2.3	2.9	1.6	0.8	1.6	0.9	0.2

[1] To be developed as a commercial site - flows to be controlled on-site

[2] Proposed subdivision drainage area

[3] Characteristics of undeveloped lands as per *Floodplain Mapping Report for the Van Gaal and Arbuckle Municipal Drains in the Village of Richmond* dated November 2009 by JFSA.

Table 1C: Summary of Study Area under Proposed Conditions (Drains to SWM Ponds 1 and 2)

Area ID Drains to:	VG-2 Pond 1	VG-3 [1] Pond 1	VG-5 Pond 1	VG-7 Pond 2	JR-1 Pond 2	Pond 1 [2] Pond 1	Pond 2 [2] Pond 2
A (ha)	63.1	16.5	34.4	39.2	32.6	66.770	43.930
CN (-)	81	88	76	80	82	N/A	N/A
Ia	2.8	2.5	3.0	3.5	3.5	N/A	N/A
L (m)	1220	660	1540	1520	790	N/A	N/A
S (%)	0.4	0.2	0.4	0.2	0.2	0.5	0.5
Tc (min)	147.6	100.2	207.1	256.9	142.8	N/A	N/A
Tp (hrs)	1.6	1.1	2.3	2.9	1.6	N/A	N/A
TIMP	N/A	N/A	N/A	N/A	N/A	49.4	49.0
XIMP	N/A	N/A	N/A	N/A	N/A	44.5	44.0

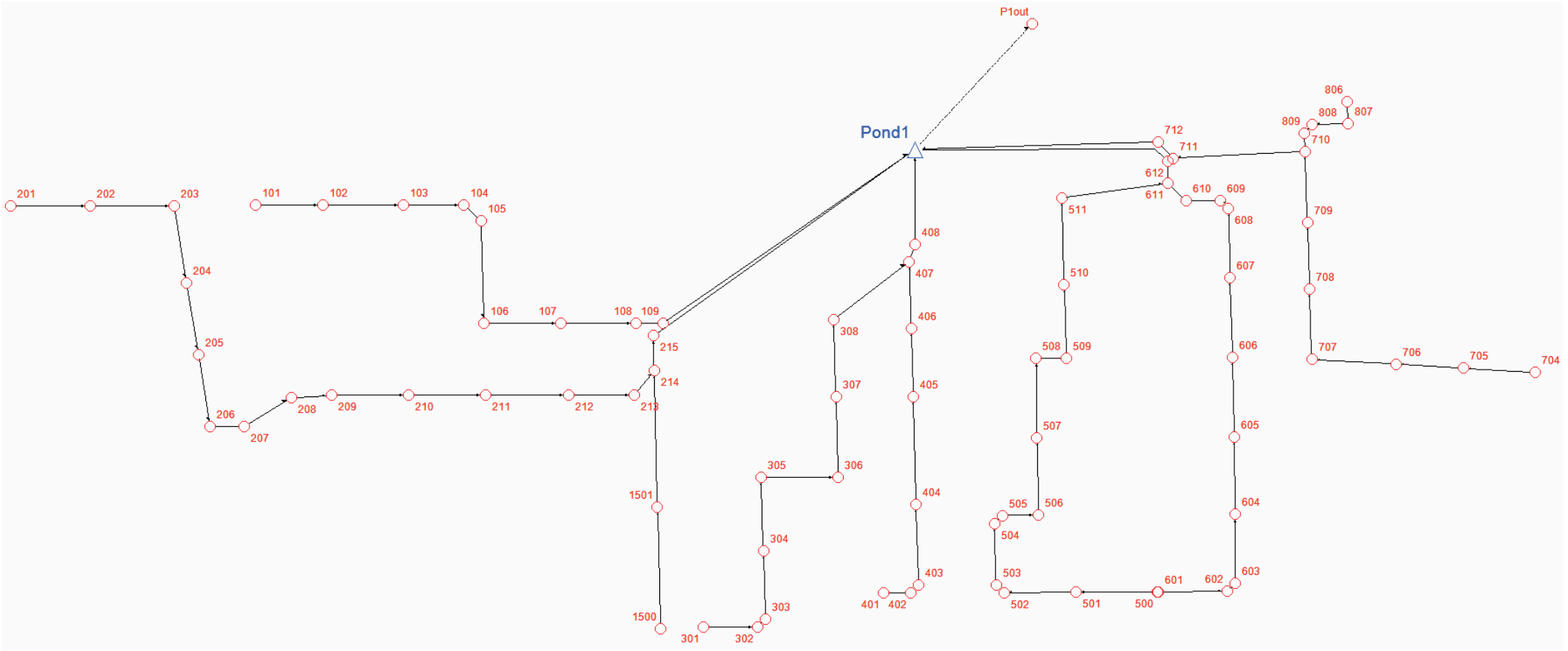
[1] To be developed as a commercial site - flows to be controlled on-site

[2] Proposed subdivision drainage area

[3] Characteristics of undeveloped lands as per *Floodplain Mapping Report for the Van Gaal and Arbuckle Municipal Drains in the Village of Richmond* dated November 2009 by JFSA.

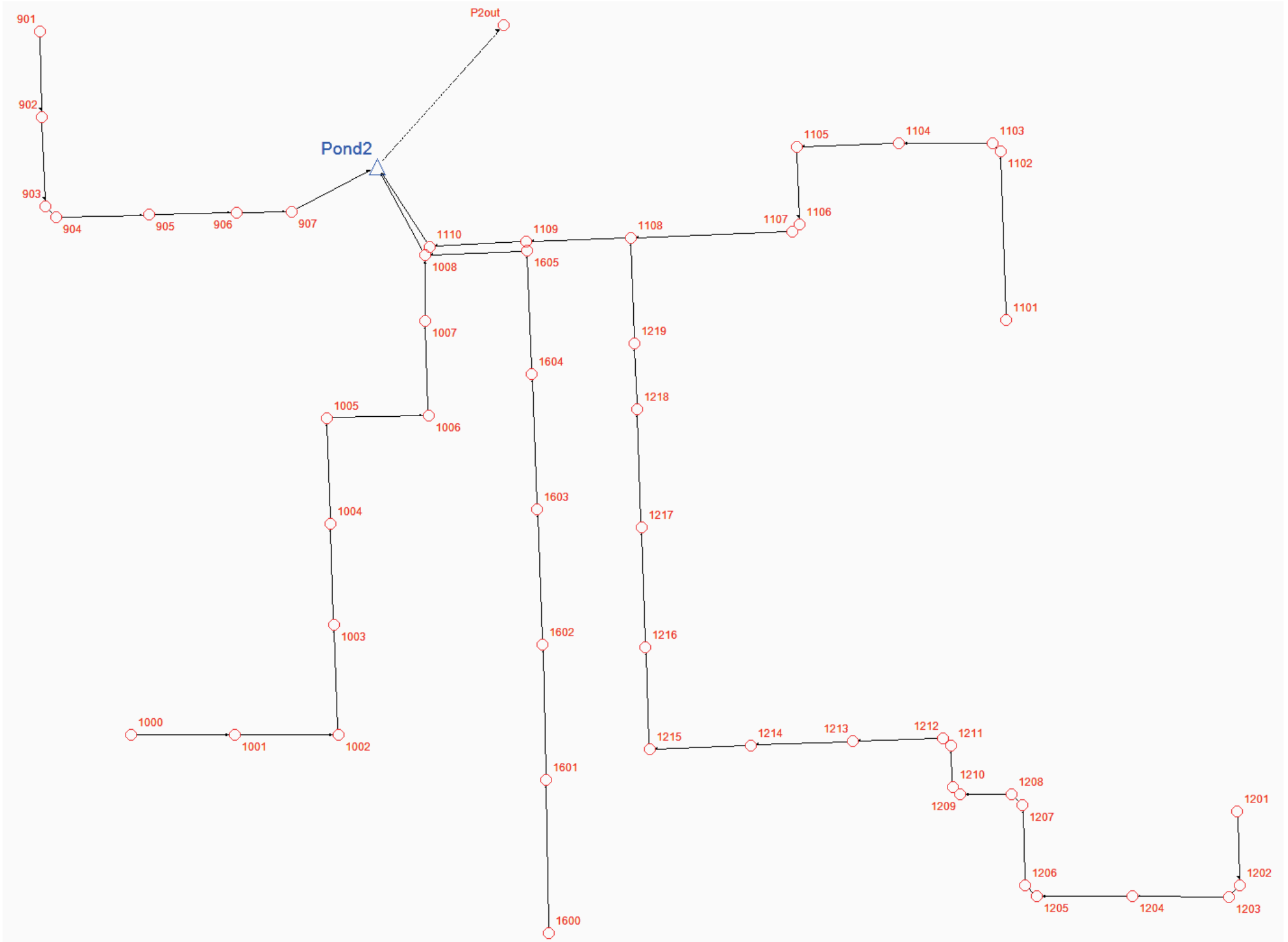
XPSWMM MODEL SCHEMATIC - POND 1

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XPSWMM MODEL SCHEMATIC - POND 2

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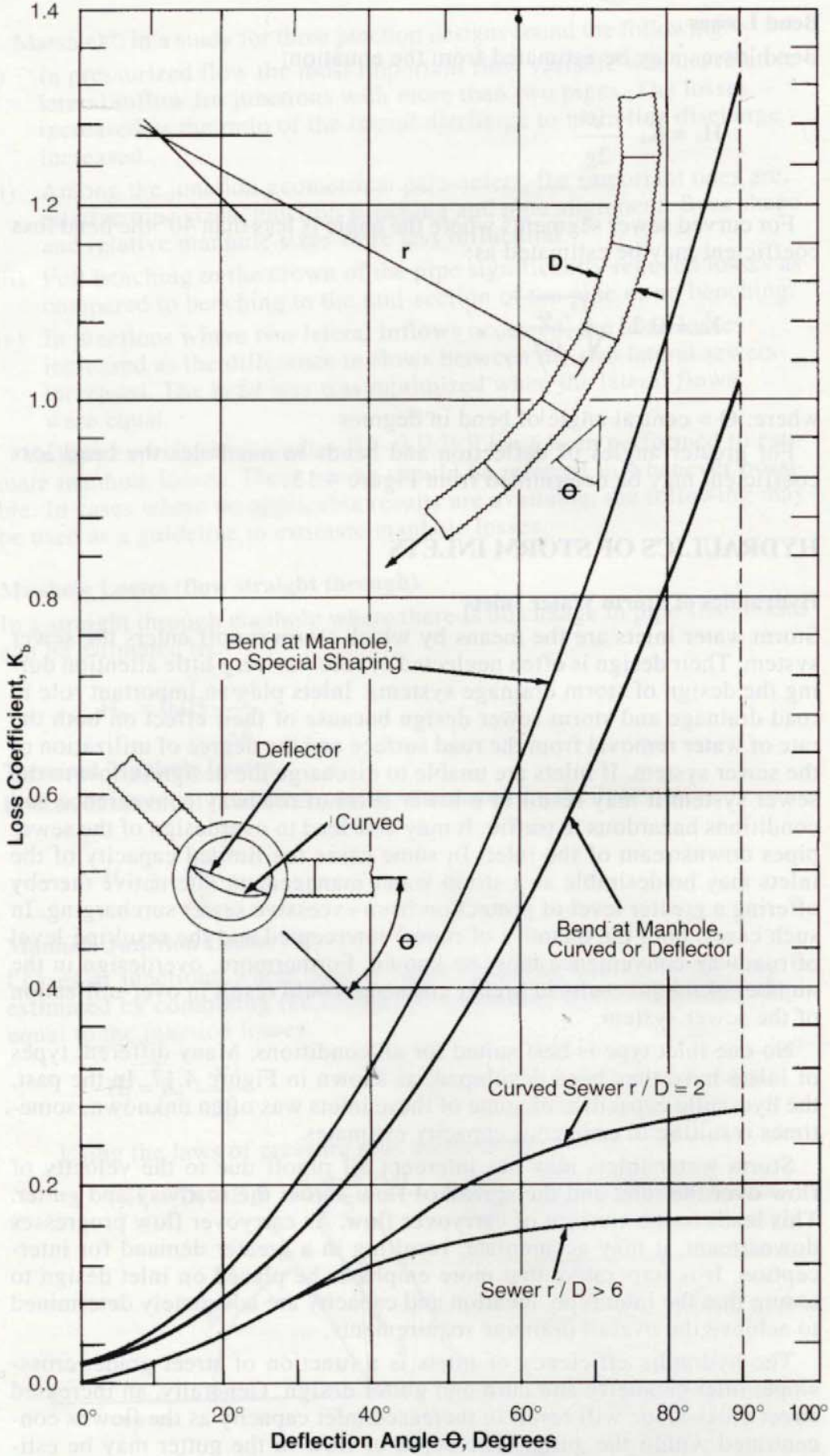


Figure 4.13 Sewer bend loss coefficient[16]

Manhole Loss Coefficient as per Nomograph

Angle (^{o})	MH Loss Coef
0	0.02
5	0.035
10	0.055
15	0.08
20	0.11
25	0.16
30	0.21
35	0.26
40	0.32
45	0.39
50	0.47
55	0.54
60	0.635
65	0.73
70	0.84
75	0.95
80	1.07
85	1.19
90	1.33

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3

MAJOR SYSTEM RESULTS

JFSA Water Resources and Environmental Consultants

Table 2A: Major System Results for the 100-Year, 3-Hour Chicago Storm

MH	SWMHYMO ID	Flow (m^3/s)	Flow Depth (m)	Velocity (m/s)	V*D (m^2/s)
101	101a	0.298	0.133	0.500	0.067
103	103a	0.319	0.136	0.510	0.069
105	105aY	0.413	0.148	0.562	0.083
106	106aY	0.304	0.134	0.503	0.067
107	107a	0.277	0.130	0.489	0.064
108	108a	0.183	0.111	0.432	0.048
201	201a	0.261	0.127	0.478	0.061
203	203aY	0.336	0.138	0.519	0.072
204	204aY	0.248	0.124	0.470	0.058
205	205aY	0.212	0.117	0.448	0.052
206	206a	0.612	0.170	0.654	0.111
207	207aY	0.427	0.150	0.570	0.086
209	209a	0.321	0.136	0.511	0.069
210	210a	0.232	0.121	0.460	0.056
211	211aY	0.485	0.157	0.608	0.095
212	212aY	0.409	0.147	0.559	0.082
301	301a	0.143	0.102	0.406	0.041
304	304aY	0.168	0.108	0.424	0.046
305	305a	0.354	0.140	0.528	0.074
306	306aY	0.523	0.161	0.623	0.100
307	307aY	0.638	0.173	0.663	0.115
401	401a	0.245	0.123	0.467	0.057
404	404aY	0.289	0.132	0.496	0.065
405	405aY	0.391	0.145	0.549	0.080
500	500a	0.247	0.124	0.469	0.058
502	502aY	0.217	0.118	0.451	0.053
506	506aY	0.267	0.128	0.482	0.062
507	507aY	0.460	0.154	0.591	0.091
508	508a	0.041	0.062	0.288	0.018
509	509aY	0.441	0.151	0.579	0.087
510	510aY	0.354	0.140	0.528	0.074
511	511a	0.185	0.111	0.433	0.048
601	601a	0.176	0.110	0.429	0.047
603	603aY	0.190	0.112	0.436	0.049
604	604aY	0.296	0.133	0.499	0.066
605	605aY	0.319	0.136	0.511	0.069
606	606aY	0.369	0.142	0.536	0.076
607	607aY	0.291	0.132	0.497	0.066
609	609aY	0.271	0.129	0.484	0.062
610	610a	0.236	0.122	0.462	0.056
704	704a	0.901	0.198	0.739	0.146
705	705a	1.109	0.215	0.783	0.168
705	705b	0.514	0.160	0.620	0.099
706	706aY	1.150	0.218	0.789	0.172
707	707a	0.569	0.166	0.639	0.106
708	708aY	1.215	0.223	0.799	0.178
709	709aY	1.038	0.210	0.772	0.162
806	806a	0.071	0.078	0.343	0.027
807	807a	0.185	0.111	0.433	0.048
808	808aY	0.262	0.127	0.478	0.061
901	901a	0.183	0.111	0.432	0.048
904	904aY	0.431	0.150	0.573	0.086
904	904b	0.418	0.148	0.565	0.084

Table 2A: Major System Results for the 100-Year, 3-Hour Chicago Storm

MH	SWMHYMO ID	Flow (m^3/s)	Flow Depth (m)	Velocity (m/s)	V*D (m^2/s)
906	906a	0.700	0.179	0.686	0.123
1000	1000a	0.271	0.129	0.485	0.063
1003	1003a	0.267	0.128	0.482	0.062
1004	1004a	0.263	0.127	0.479	0.061
1005	1005a	0.636	0.173	0.662	0.115
1006	1006a	0.604	0.169	0.651	0.110
1007	1007aY	1.023	0.208	0.768	0.160
1101	1101a	0.253	0.125	0.473	0.059
1103	1103aY	0.288	0.132	0.496	0.065
1104	1104aY	0.219	0.118	0.452	0.053
1106	1106aY	0.500	0.159	0.616	0.098
1108	1108a	0.290	0.132	0.496	0.065
1201	1201a	0.356	0.140	0.529	0.074
1203	1203aY	0.323	0.136	0.512	0.070
1205	1205aY	0.231	0.121	0.459	0.056
1209	1209aY	0.216	0.118	0.450	0.053
1213	1213a	0.356	0.140	0.529	0.074
1214	1214aY	0.417	0.148	0.564	0.083
1215	1215a	0.441	0.151	0.579	0.087
1216	1216a	0.614	0.170	0.654	0.111
1217	1217aY	0.902	0.198	0.739	0.146
1218	1218aY	0.629	0.172	0.659	0.113
1219	1219a	0.504	0.159	0.617	0.098
1500	1500aY	0.846	0.193	0.727	0.140
1600	1600aY	1.176	0.220	0.793	0.174

Table 2B: Major System Results for the 100-Year, 3-Hour Chicago Storm +20%

MH	SWMHYMO ID	Flow (m^3/s)	Flow Depth (m)	Velocity (m/s)	V*D (m^2/s)
101	101a	0.373	0.143	0.539	0.077
103	103a	0.399	0.146	0.553	0.081
105	105aY	0.610	0.170	0.653	0.111
106	106aY	0.581	0.167	0.643	0.107
107	107a	0.347	0.139	0.525	0.073
108	108a	0.234	0.121	0.461	0.056
201	201a	0.334	0.138	0.518	0.071
203	203aY	0.470	0.155	0.598	0.093
204	204aY	0.440	0.151	0.578	0.087
205	205aY	0.430	0.150	0.572	0.086
206	206a	0.782	0.187	0.713	0.133
207	207aY	0.789	0.188	0.714	0.134
209	209a	0.401	0.146	0.554	0.081
210	210a	0.297	0.133	0.500	0.067
211	211aY	1.114	0.215	0.784	0.169
212	212aY	1.078	0.213	0.779	0.166
301	301a	0.180	0.110	0.431	0.047
304	304aY	0.232	0.121	0.460	0.056
305	305a	0.443	0.151	0.580	0.088
306	306aY	0.760	0.185	0.708	0.131
307	307aY	1.004	0.207	0.763	0.158
401	401a	0.313	0.135	0.507	0.068
404	404aY	0.409	0.147	0.559	0.082
405	405aY	0.608	0.170	0.652	0.111
500	500a	0.315	0.135	0.509	0.069
502	502aY	0.314	0.135	0.508	0.069
506	506aY	0.441	0.151	0.579	0.087
507	507aY	0.699	0.179	0.686	0.123
508	508a	0.052	0.068	0.306	0.021
509	509aY	0.763	0.186	0.709	0.132
510	510aY	0.720	0.181	0.694	0.126
511	511a	0.236	0.122	0.462	0.056
601	601a	0.225	0.119	0.456	0.054
603	603aY	0.268	0.128	0.483	0.062
604	604aY	0.443	0.152	0.580	0.088
605	605aY	0.522	0.161	0.623	0.100
606	606aY	0.629	0.172	0.660	0.114
607	607aY	0.562	0.165	0.636	0.105
609	609aY	0.566	0.165	0.638	0.105
610	610a	0.302	0.134	0.502	0.067
704	704a	1.127	0.216	0.786	0.170
705	705a	1.403	0.237	0.830	0.197
705	705b	0.656	0.175	0.669	0.117
706	706aY	1.813	0.264	0.875	0.231
707	707a	0.726	0.182	0.697	0.127
708	708aY	2.224	0.287	0.910	0.261
709	709aY	2.109	0.281	0.900	0.253
806	806a	0.089	0.084	0.358	0.030
807	807a	0.236	0.122	0.462	0.056
808	808aY	0.374	0.143	0.539	0.077
901	901a	0.234	0.121	0.461	0.056
904	904aY	0.636	0.173	0.662	0.115
904	904b	0.524	0.161	0.624	0.100

Table 2B: Major System Results for the 100-Year, 3-Hour Chicago Storm +20%

MH	SWMHYMO ID	Flow (m^3/s)	Flow Depth (m)	Velocity (m/s)	V*D (m^2/s)
906	906a	0.890	0.197	0.736	0.145
1000	1000a	0.347	0.139	0.525	0.073
1003	1003a	0.342	0.139	0.522	0.073
1004	1004a	0.336	0.138	0.519	0.072
1005	1005a	0.808	0.189	0.718	0.136
1006	1006a	0.772	0.186	0.710	0.132
1007	1007aY	1.629	0.252	0.854	0.215
1101	1101a	0.323	0.136	0.513	0.070
1103	1103aY	0.408	0.147	0.559	0.082
1104	1104aY	0.390	0.145	0.548	0.079
1106	1106aY	0.748	0.184	0.705	0.130
1108	1108a	0.363	0.141	0.533	0.075
1201	1201a	0.445	0.152	0.581	0.088
1203	1203aY	0.460	0.154	0.591	0.091
1205	1205aY	0.411	0.147	0.560	0.082
1209	1209aY	0.393	0.145	0.550	0.080
1213	1213a	0.445	0.152	0.581	0.088
1214	1214aY	0.669	0.176	0.674	0.119
1215	1215a	0.552	0.164	0.633	0.104
1216	1216a	0.784	0.187	0.713	0.133
1217	1217aY	1.500	0.243	0.840	0.204
1218	1218aY	1.326	0.231	0.817	0.189
1219	1219a	0.643	0.173	0.665	0.115
1500	1500aY	1.916	0.269	0.884	0.238
1600	1600aY	2.579	0.306	0.933	0.285

0.306	Flow depth greater than 0.30 m.

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4

SWM FACILITY OPERATING CONDITIONS

JFSA Water Resources and Environmental Consultants

Table 3A: Summary of SWM Pond 1 Operating Characteristics [1]

Pond Component	Pre-Development Outflow (m^3/s)	Pond Level (m)	Pond Outflow (m^3/s)	Volume Used [2] (m^3)
Permanent Pool	N/A	92.35	N/A	28659
Quality Control	N/A	92.45	0.025	3083
2-Year, 24-Hour SCS	2.427	93.08	0.281	25261
5-Year, 24-Hour SCS	3.774	93.43	0.363	39534
10-Year, 24-Hour SCS	4.712	93.65	0.407	49370
25-Year, 24-Hour SCS	5.908	93.74	1.566	51691
50-Year, 24-Hour SCS	6.847	93.77	2.557	54939
100-Year, 24-Hour SCS	7.867	93.80	3.521	56185
100-Year, 24-Hour SCS [3]	7.867	93.81	3.730	56855
100-Year, 10-Year Spring [3]	N/A	94.22	2.948	76593

[1] Based on 24 hour detention of 40 m^3/ha quality control volume, erosion control of 2-year release rate to 330 L/s (as per Parish Geomorphic threshold) and quantity control of 5- to 100-year release rates to pre-development levels.

[2] Volumes used are active storage only for all pond components except the permanent pool.

[3] Restrictive downstream conditions; Summer = 93.68 m, Spring = 94.11 m. All other results based on free outfall conditions.

Table 3B: Summary of SWM Pond 2 Operating Characteristics [1]

Pond Component	Pre-Development Outflow (m^3/s)	Pond Level (m)	Pond Outflow (m^3/s)	Volume Used [2] (m^3)
Permanent Pool	N/A	93.20	N/A	17136
Quality Control	N/A	93.35	0.047	1983
2-Year, 24-Hour SCS	1.292	93.70	0.611	7570
5-Year, 24-Hour SCS	1.983	93.87	0.983	10445
10-Year, 24-Hour SCS	2.458	93.97	1.236	12286
25-Year, 24-Hour SCS	3.058	94.10	1.561	14597
50-Year, 24-Hour SCS	3.525	94.19	1.818	16393
100-Year, 24-Hour SCS	4.029	94.30	2.095	18337
100-Year, 10-Year Spring [3]	N/A	94.90	1.479	30401

[1] Based on 24 hour detention of 40 m^3/ha quality control volume and quantity control of 100-year release rate to capacity of 1500 mm outlet pipe at 0.1% slope (2.235 m^3/s). No erosion control is provided.

[2] Volumes used are active storage only for all pond components except the permanent pool.

[3] Restrictive downstream conditions; Spring = 94.18 m. All other results based on free outfall conditions.

Table 4A: Extended Detention Parameters for SWM Pond 1

Permanent Pool Parameters			Quality Orifice Parameters		
Area (C3)	28659.10	m^2	Diameter	0.300	m
Volume	41287.00	m^3			
PP Elev	92.35	m	Area	0.07069	m^2
QC Elev	92.45	m	Invert	92.35	m
h (m)	0.10	m	C_o	0.620	

Notes: C3 is the intercept from the area-depth linear regression
PP Elev indicates the elevation of the permanent pool
QC Elev indicates the elevation of the storage volume required by MOE for quality control
h is the maximum water elevation above the orifice (m)

Table 4B: Extended Detention Drawdown Time for SWM Pond 1

Elev.	Active Storage			C2	Drawdown Time	Drawdown Time	Flow	Demarkation
(m)	V (m^3)	A (m^2)	depth (m)	(m^2/m)	(h)	(days)	(m^3/s)	Point
92.35	**0.00**	**28659.10**	**0.00**				**0.000**	**PP Elev**
92.40	1511.60	30423.40	0.05	35286	18.69	0.78	0.013	
92.45	**3083.40**	**31527.80**	**0.10**	**28687**	**26.76**	**1.11**	**0.025**	**QC Elev**
92.50	4677.30	32110.90	0.15	23012	32.98	1.37	0.038	
92.55	6307.20	32880.20	0.20	21105	38.41	1.60	0.050	

Notes: C2 is the slope coefficient from the area-depth linear regression
QC Elev indicates the elevation of the quality control volume required by MOE

Table 4C: Extended Detention Parameters for SWM Pond 2

Permanent Pool Parameters			Quality Orifice Parameters		
Area (C3)	12146.70	m^2	Diameter	0.350	m
Volume	17135.70	m^3			
PP Elev	93.20	m	Area	0.09621	m^2
QC Elev	93.35	m	Invert	93.20	m
h (m)	0.15	m	C_o	0.620	

Notes: C3 is the intercept from the area-depth linear regression
PP Elev indicates the elevation of the permanent pool
QC Elev indicates the elevation of the storage volume required by MOE for quality control
h is the maximum water elevation above the orifice (m)

Table 4D: Extended Detention Drawdown Time for SWM Pond 2

Elev.	Active Storage			C2	Drawdown Time	Drawdown Time	Flow	Demarkation
(m)	V (m^3)	A (m^2)	depth (m)	(m^2/m)	(h)	(days)	(m^3/s)	Point
93.20	**0.00**	**12146.70**	**0.00**				**0.000**	**PP Elev**
93.25	630.10	12828.30	0.90	757	24.64	1.03	0.016	
93.30	1298.00	13497.00	0.95	1421	25.77	1.07	0.032	
93.35	**1983.40**	**13935.60**	**1.00**	**1789**	**26.74**	**1.11**	**0.047**	**QC Elev**
93.40	2702.40	14502.40	1.05	2244	27.81	1.16	0.063	

Notes: C2 is the slope coefficient from the area-depth linear regression
QC Elev indicates the elevation of the quality control volume required by MOE

Table 5A: Stage-Storage-Outflow Curve for SWM Pond 1

			Quality Control 1		Erosion Control 1		Quantity Control 1			
			Vertical Orifice		Vertical Orifice		Rectangular Weir			
			Dia (m)	0.300	Dia (m)	0.300	L (m)	45.000		
			Area (m^2)	0.071	Area (m^2)	0.071				
			Invert (m)	92.35	Invert (m)	92.45	C_w	1.700		
			C_o	0.62	C_o	0.62	Invert (m)	93.68		
			Q @ D	0.075	Q @ D	0.075	n contr.	2		
Elevation	Active Sto.	Demarkation	Head	Outflow	Head	Outflow	Head	Outflow	Outflow	Storage
(m)	(m^3)	Points	(m)	(m^3/s)	(m)	(m^3/s)	(m)	(m^3/s)	(m^3/s)	(ha·m)
92.35	**0**	**PP Elev**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
92.40	1512		0.050	0.013	0.000	0.000	0.000	0.000	0.013	0.151
92.45	**3083**	**QC Elev**	**0.100**	**0.025**	**0.000**	**0.000**	**0.000**	**0.000**	**0.025**	**0.308**
92.50	4677		0.150	0.038	0.050	0.013	0.000	0.000	0.050	0.468
92.55	6307		0.200	0.050	0.100	0.025	0.000	0.000	0.075	0.631
92.60	7958		0.250	0.063	0.150	0.038	0.000	0.000	0.100	0.796
92.65	9651		0.300	0.075	0.200	0.050	0.000	0.000	0.125	0.965
92.70	11371		0.350	0.087	0.250	0.063	0.000	0.000	0.149	1.137
92.75	13114		0.400	0.097	0.300	0.075	0.000	0.000	0.172	1.311
92.80	14893		0.450	0.106	0.350	0.087	0.000	0.000	0.193	1.489
92.85	16702		0.500	0.115	0.400	0.097	0.000	0.000	0.212	1.670
92.90	18547		0.550	0.123	0.450	0.106	0.000	0.000	0.229	1.855
92.95	20411		0.600	0.130	0.500	0.115	0.000	0.000	0.245	2.041
93.00	22313		0.650	0.137	0.550	0.123	0.000	0.000	0.260	2.231
93.05	24240		0.700	0.144	0.600	0.130	0.000	0.000	0.274	2.424
93.10	26204		0.750	0.150	0.650	0.137	0.000	0.000	0.288	2.620
93.15	28188		0.800	0.157	0.700	0.144	0.000	0.000	0.300	2.819
93.20	30211		0.850	0.162	0.750	0.150	0.000	0.000	0.313	3.021
93.25	32247		0.900	0.168	0.800	0.157	0.000	0.000	0.325	3.225
93.30	34302		0.950	0.174	0.850	0.162	0.000	0.000	0.336	3.430
93.35	36367		1.000	0.179	0.900	0.168	0.000	0.000	0.347	3.637
93.40	38470		1.050	0.184	0.950	0.174	0.000	0.000	0.358	3.847
93.45	40589		1.100	0.189	1.000	0.179	0.000	0.000	0.368	4.059
93.50	42780		1.150	0.194	1.050	0.184	0.000	0.000	0.378	4.278
93.55	44966		1.200	0.199	1.100	0.189	0.000	0.000	0.388	4.497
93.60	47181		1.250	0.204	1.150	0.194	0.000	0.000	0.398	4.718
93.65	49433		1.300	0.208	1.200	0.199	0.000	0.000	0.407	4.943
93.68	**50788**	**Ext. Det.**	**1.330**	**0.211**	**1.230**	**0.202**	**0.000**	**0.000**	**0.413**	**5.079**
93.70	51691		1.350	0.213	1.250	0.204	0.020	0.216	0.633	5.169
93.75	54014		1.400	0.217	1.300	0.208	0.070	1.416	1.842	5.401
93.80	56304		1.450	0.221	1.350	0.213	0.120	3.178	3.612	5.630
93.85	58788		1.500	0.226	1.400	0.217	0.170	5.358	5.801	5.879
93.90	61860		1.550	0.230	1.450	0.221	0.220	7.886	8.337	6.186
93.95	63288		1.600	0.234	1.500	0.226	0.270	10.720	11.179	6.329
94.00	**65687**	**Top of Berm**	**1.650**	**0.238**	**1.550**	**0.230**	**0.320**	**13.828**	**14.296**	**6.569**
94.05	68093		1.700	0.242	1.600	0.234	0.370	17.189	17.664	6.809
94.10	70551		1.750	0.246	1.650	0.238	0.420	20.784	21.267	7.055
94.11	**71045**	**100-Yr Spr**	**1.760**	**0.246**	**1.660**	**0.239**	**0.430**	**21.529**	**22.014**	**7.105**
94.15	73023		1.800	0.249	1.700	0.242	0.470	24.598	25.089	7.302
94.20	75523		1.850	0.253	1.750	0.246	0.520	28.619	29.118	7.552
94.25	78034		1.900	0.257	1.800	0.249	0.570	32.838	33.344	7.803
94.30	80530		1.950	0.260	1.850	0.253	0.620	37.244	37.757	8.053
94.35	83095		2.000	0.264	1.900	0.257	0.670	41.829	42.350	8.310
94.40	85643		2.050	0.268	1.950	0.260	0.720	46.587	47.115	8.564
94.45	88166		2.100	0.271	2.000	0.264	0.770	51.512	52.047	8.817
94.50	90763		2.150	0.275	2.050	0.268	0.820	56.597	57.140	9.076

Notes :
- PP Elev indicates the elevation of the permanent pool.
- QC Elev indicates the elevation of the storage volume provided for quality control according to MOE requirements.
- Ext. Det. indicates the elevation of extended detention provided, and of the Van Gaal Drain floodplain during the 100-year summer (SCS) event.
- 100-Yr Spr indicates the elevation of the Van Gaal Drain floodplain during the 100-year spring (snow+rain) event.
- Top of Berm indicates the elevation at the top of the berm.

Table 5B: Stage-Storage-Outflow Curve for SWM Pond 2

			Quality Control 1		Quantity Control 1			
			Vertical Orifice		Rectangular Weir			
			Dia (m)	0.350	L (m)	1.300		
			Area (m^2)	0.096				
			Invert (m)	93.20	C_w	1.800		
			C_o	0.62	Invert (m)	93.35		
			Q @ D	0.111	n contr.	2		
Elevation	Active Sto.	Demarkation	Head	Outflow	Head	Outflow	Outflow	Storage
(m)	(m^3)	Points	(m)	(m^3/s)	(m)	(m^3/s)	(m^3/s)	(ha·m)
93.20	**0**	**PP Elev**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
93.25	630		0.050	0.016	0.000	0.000	0.016	0.063
93.30	1298		0.100	0.032	0.000	0.000	0.032	0.130
93.35	**1983**	**QC Elev**	**0.150**	**0.047**	**0.000**	**0.000**	**0.047**	**0.198**
93.40	2702		0.200	0.063	0.050	0.026	0.089	0.270
93.45	3438		0.250	0.079	0.100	0.073	0.152	0.344
93.50	4207		0.300	0.095	0.150	0.133	0.228	0.421
93.55	5026		0.350	0.111	0.200	0.203	0.313	0.503
93.60	5857		0.400	0.125	0.250	0.281	0.407	0.586
93.65	6701		0.450	0.139	0.300	0.367	0.505	0.670
93.70	7555		0.500	0.151	0.350	0.458	0.609	0.755
93.75	8417		0.550	0.162	0.400	0.556	0.717	0.842
93.80	9290		0.600	0.172	0.450	0.657	0.830	0.929
93.85	10168		0.650	0.182	0.500	0.764	0.946	1.017
93.90	11054		0.700	0.191	0.550	0.874	1.065	1.105
93.95	11941		0.750	0.200	0.600	0.987	1.188	1.194
94.00	12840		0.800	0.209	0.650	1.104	1.313	1.284
94.05	13747		0.850	0.217	0.700	1.223	1.440	1.375
94.10	14654		0.900	0.225	0.750	1.345	1.569	1.465
94.15	15575		0.950	0.233	0.800	1.468	1.701	1.557
94.18	**16132**	**100-Yr Spr**	**0.980**	**0.237**	**0.830**	**1.543**	**1.781**	**1.613**
94.20	16503		1.000	0.240	0.850	1.594	1.834	1.650
94.25	17446		1.050	0.247	0.900	1.721	1.968	1.745
94.30	18402		1.100	0.254	0.950	1.850	2.104	1.840
94.35	19356		1.150	0.261	1.000	1.980	2.241	1.936
94.40	20310		1.200	0.268	1.050	2.111	2.378	2.031
94.45	21272		1.250	0.274	1.100	2.243	2.517	2.127
94.50	22254		1.300	0.280	1.150	2.375	2.655	2.225
94.55	23238		1.350	0.286	1.200	2.508	2.795	2.324
94.60	24230		1.400	0.292	1.250	2.641	2.934	2.423
94.65	25235		1.450	0.298	1.300	2.775	3.073	2.523
94.70	26242		1.500	0.304	1.350	2.908	3.212	2.624
94.75	27258		1.550	0.310	1.400	3.041	3.351	2.726
94.80	28240		1.600	0.315	1.450	3.174	3.490	2.824
94.85	29270		1.650	0.321	1.500	3.307	3.628	2.927
94.90	30303		1.700	0.326	1.550	3.439	3.765	3.030
94.95	31347		1.750	0.332	1.600	3.570	3.902	3.135
95.00	32403		1.800	0.337	1.650	3.701	4.037	3.240
95.05	33469		1.850	0.342	1.700	3.830	4.172	3.347
95.10	34532		1.900	0.347	1.750	3.959	4.306	3.453
95.15	35614		1.950	0.352	1.800	4.086	4.438	3.561
95.20	36693		2.000	0.357	1.850	4.212	4.569	3.669
95.25	37801		2.050	0.362	1.900	4.337	4.699	3.780
95.30	38904		2.100	0.367	1.950	4.460	4.827	3.890
95.35	39997		2.150	0.371	2.000	4.582	4.953	4.000
95.40	41109		2.200	0.376	2.050	4.702	5.078	4.111
95.45	42227		2.250	0.381	2.100	4.820	5.201	4.223
95.50	43375		2.300	0.385	2.150	4.937	5.322	4.338
95.55	44523		2.350	0.390	2.200	5.051	5.441	4.452
95.60	45673		2.400	0.394	2.250	5.164	5.558	4.567
95.65	46751		2.450	0.399	2.300	5.274	5.673	4.675

Table 5B: Stage-Storage-Outflow Curve for SWM Pond 2

			Quality Control 1		Quantity Control 1			
			Vertical Orifice		Rectangular Weir			
			Dia (m)	0.350	L (m)	1.300		
			Area (m^2)	0.096				
			Invert (m)	93.20	C_w	1.800		
			C_o	0.62	Invert (m)	93.35		
			Q @ D	0.111	n contr.	2		
Elevation (m)	Active Sto. (m^3)	Demarkation Points	Head (m)	Outflow (m^3/s)	Head (m)	Outflow (m^3/s)	Outflow (m^3/s)	Storage (ha·m)
95.70	47875		2.500	0.403	2.350	5.382	5.785	4.788
95.75	49039		2.550	0.407	2.400	5.488	5.895	4.904
95.80	50236		2.600	0.411	2.450	5.591	6.003	5.024
95.85	51668		2.650	0.416	2.500	5.692	6.108	5.167
95.90	53716		2.700	0.420	2.550	5.790	6.210	5.372
95.95	53724		2.750	0.424	2.600	5.886	6.310	5.372
96.00	**54933**	**Top of Berm**	**2.800**	**0.428**	**2.650**	**5.979**	**6.407**	**5.493**

Notes :
- PP Elev indicates the elevation of the permanent pool.
- QC Elev indicates the elevation of the storage volume provided for quality control according to MOE requirements.
- 100-Yr Spr indicates the elevation of the Jock River floodplain during the 100-year spring (snow+rain) event.
- Top of Berm indicates the elevation at the top of the berm.

ATTACHMENT

5

PIPE DATA AND HYDRAULIC SIMULATION RESULTS

JFSA Water Resources and Environmental Consultants

Table 6: Pipe Data and Hydraulic Simulation Results [1]

U/S MH	D/S MH	U/S Invert (m)	D/S Invert (m)	Pipe Diameter / Height (m)	Pipe Width (m)	Pipe Length (m)	Pipe Slope (%)	n	U/S MH Cover Elev. (m)	D/S MH Cover Elev. (m)	Design Velocity (m/s)	Design Flow (m^3/s)	100-year, 3-hour Chicago Storm							100-year, 12-hour SCS Type II Storm							100-year, 10-day Spring Snowmelt + Rainfall Event						
													Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)
101	102	93.428	93.361	0.825	0.050	67.0	0.1	0.013	95.812	95.887	0.20	0.01	0.29	35.16	-0.33	1.1	93.92	93.86	1.89	0.29	35.16	-0.34	12.0	93.91	93.85	1.90	0.02	2.42	-0.03	109.0	94.22	94.22	1.59
102	103	93.341	93.261	0.825	0.050	80.0	0.1	0.013	95.887	95.770	0.20	0.01	0.29	35.16	-0.31	1.1	93.86	93.80	2.03	0.28	33.94	-0.32	12.0	93.85	93.81	2.04	0.02	2.42	0.06	109.0	94.22	94.22	1.66
103	104	93.111	93.050	0.975	0.050	60.5	0.1	0.013	95.770	95.673	0.20	0.01	0.60	61.18	-0.29	1.1	93.80	93.76	1.97	0.58	59.14	-0.27	12.0	93.81	93.81	1.96	0.04	4.08	0.14	109.0	94.22	94.22	1.55
104	105	93.000	92.976	0.975	0.050	23.5	0.1	0.013	95.673	95.631	0.20	0.01	0.60	61.18	-0.21	1.1	93.76	93.76	1.91	0.58	59.14	-0.16	12.1	93.81	93.81	1.86	0.04	4.08	0.25	109.0	94.22	94.22	1.45
105	106	92.901	92.799	1.050	0.050	101.5	0.1	0.013	95.631	95.480	0.20	0.01	0.76	71.80	-0.19	1.1	93.76	93.76	1.87	0.74	69.91	-0.14	12.1	93.81	93.81	1.82	0.05	4.72	0.27	109.0	94.22	94.22	1.41
106	107	92.649	92.573	1.200	0.050	76.5	0.1	0.013	95.480	95.370	0.20	0.01	0.88	72.47	-0.09	1.2	93.76	93.76	1.72	0.85	70.00	-0.04	12.1	93.81	93.81	1.67	0.05	4.12	0.37	109.0	94.22	94.22	1.26
107	108	92.553	92.478	1.200	0.050	74.5	0.1	0.013	95.370	95.342	0.20	0.01	1.14	93.88	0.01	1.1	93.76	93.76	1.61	1.10	90.58	0.06	12.1	93.81	93.81	1.56	0.07	5.76	0.47	109.0	94.22	94.22	1.15
108	109	92.458	92.431	1.200	0.050	26.5	0.1	0.013	95.342	95.511	0.20	0.01	1.28	105.41	0.10	1.1	93.76	93.76	1.58	1.23	101.29	0.15	12.1	93.81	93.81	1.53	0.08	6.59	0.56	109.0	94.22	94.22	1.12
109	Pond1	92.381	92.350	1.200	0.050	31.0	0.1	0.013	95.511	94.500	0.20	0.01	1.28	105.41	0.18	1.1	93.76	93.76	1.75	1.22	100.46	0.23	12.1	93.81	93.81	1.70	0.08	6.6	0.64	109.0	94.22	94.22	1.29
201	202	94.167	94.088	0.750	0.050	79.0	0.1	0.013	96.639	96.523	0.20	0.01	0.25	33.46	-0.23	1.1	94.69	94.63	1.95	0.25	33.46	-0.24	12.0	94.68	94.62	1.96	0.02	2.68	-0.61	109.0	94.31	94.29	2.33
202	203	94.068	93.985	0.750	0.050	83.0	0.1	0.013	96.523	96.400	0.20	0.01	0.25	33.46	-0.19	1.1	94.63	94.56	1.89	0.25	33.46	-0.20	12.1	94.62	94.54	1.90	0.02	2.68	-0.53	109.1	94.29	94.29	2.23
203	204	93.905	93.828	0.825	0.050	77.0	0.1	0.013	96.400	96.280	0.20	0.01	0.47	56.98	-0.17	1.1	94.56	94.46	1.85	0.46	55.76	-0.19	12.1	94.54	94.45	1.86	0.03	3.64	-0.44	109.1	94.29	94.29	2.11
204	205	93.753	93.681	0.900	0.050	72.0	0.1	0.013	96.280	96.172	0.20	0.01	0.58	64.25	-0.19	1.2	94.46	94.38	1.82	0.57	63.14	-0.21	12.1	94.45	94.36	1.83	0.03	3.32	-0.37	109.1	94.29	94.29	1.99
205	206	93.606	93.533	0.975	0.050	73.0	0.1	0.013	96.172	96.060	0.20	0.01	0.69	70.36	-0.21	1.2	94.38	94.20	1.80	0.67	68.32	-0.22	12.1	94.36	94.19	1.81	0.04	4.08	-0.29	109.1	94.29	94.29	1.88
206	207	93.308	93.274	1.200	0.050	34.0	0.1	0.013	96.060	96.017	0.20	0.01	1.28	105.41	-0.30	1.1	94.20	94.13	1.86	1.26	103.76	-0.31	12.1	94.19	94.12	1.87	0.08	6.59	-0.22	109.1	94.29	94.29	1.77
207	208	93.224	93.168	1.200	0.050	55.5	0.1	0.013	96.017	95.927	0.20	0.01	1.36	111.99	-0.30	1.2	94.13	94.01	1.89	1.33	109.52	-0.31	12.1	94.12	94.00	1.90	0.08	6.59	-0.14	109.1	94.29	94.29	1.73
208	209	93.118	93.078	1.200	0.050	39.5	0.1	0.013	95.927	95.870	0.20	0.01	1.36	111.99	-0.31	1.2	94.01	93.93	1.92	1.33	109.52	-0.32	12.1	94.00	93.98	1.93	0.08	6.59	-0.03	109.1	94.29	94.29	1.64
209	210	93.028	92.952	1.200	0.050	76.5	0.1	0.013	95.870	95.760	0.20	0.01	1.66	136.70	-0.30	1.2	93.93	93.81	1.94	1.62	133.40	-0.25	12.1	93.98	93.98	1.89	0.10	8.23	0.06	109.1	94.29	94.29	1.58
210	211	92.932	92.856	1.200	1.800	76.5	0.1	0.013	95.760	95.640	1.23	2.66	1.89	0.71	-0.33	1.2	93.81	93.81	1.95	1.84	0.69	-0.15	12.1	93.98	93.98	1.78	0.11	0.04	0.15	109.1	94.29	94.29	1.48
211	212	92.836	92.754	1.200	1.800	82.0	0.1	0.013	95.640	95.515	1.23	2.66	2.01	0.76	-0.23	1.2	93.81	93.81	1.83	1.96	0.74	-0.06	12.1	93.98	93.98	1.66	0.12	0.05	0.25	109.1	94.29	94.29	1.36
212	213	92.734	92.668	1.200	1.800	65.5	0.1	0.013	95.515	95.466	1.23	2.66	2.13	0.80	-0.13	1.2	93.81	93.81	1.71	2.07	0.78	0.05	12.1	93.98	93.98	1.53	0.13	0.05	0.35	109.0	94.29	94.29	1.23
213	214	92.588	92.556	1.200	1.800	31.5	0.1	0.013	95.466	95.617	1.23	2.66	2.13	0.80	0.02	1.2	93.81	93.81	1.66	2.06	0.77	0.19	12.1	93.98	93.98	1.49	0.13	0.05	0.50	109.0	94.29	94.29	1.18
214	215	92.426	92.392	1.200	2.400	34.5	0.1	0.013	95.617	95.511	1.32	3.80	3.28	0.86	0.18	2.8	93.81	93.77	1.81	4.05	1.06	0.35	13.6	93.98	93.85	1.64	2.31	0.61	0.66	110.4	94.29	94.24	1.33
215	Pond1	92.392	92.350	1.200	2.400	42.5	0.1	0.013	95.511	94.500	1.32	3.80	3.27	0.86	0.18	2.8	93.77	93.76	1.74	4.05	1.06	0.26	13.6	93.85	93.81	1.66	2.31	0.61	0.64	110.4	94.24	94.22	1.27
301	302	93.548	93.494	0.600	0.050	54.0	0.1	0.013	95.814	95.720	0.20	0.01	0.14	23.67	-0.26	1.1	93.89	93.78	1.92	0.14	23.67	-0.26	12.0	93.89	93.81	1.92	0.01	1.69	0.08	109.0	94.22	94.22	1.59
302	303	93.419	93.408	0.675	0.050	11.0	0.1	0.013	95.720	95.670	0.20	0.01	0.14	20.92	-0.31	1.1	93.78	93.76	1.94	0.14	20.92	-0.28	12.0	93.81	93.81	1.91	0.01	1.49	0.13	109.0	94.22	94.22	1.50
303	304	93.358	93.290	0.675	0.050	67.5	0.1	0.013	95.670	95.603	0.20	0.01	0.14	20.92	-0.27	1.1	93.76	93.76	1.91	0.14	20.92	-0.22	12.0	93.81	93.81	1.86	0.01	1.49	0.19	109.0	94.22	94.22	1.45
304	305	93.215	93.141	0.750	0.050	73.5	0.1	0.013	95.603	95.490	0.20	0.01	0.24	32.13	-0.20	1.1	93.76	93.76	1.84	0.24	32.13	-0.15	12.1	93.81	93.81	1.79	0.01	1.34	0.26	109.0	94.22	94.22	1.38
305	306	92.991	92.915	0.900	0.050	76.5	0.1	0.013	95.490	95.380	0.20	0.01	0.50	55.39	-0.13	1.1	93.76	93.76	1.73	0.49	54.28	-0.08	12.1	93.81	93.81	1.68	0.03	3.32	0.33	109.0	94.22	94.22	1.27
306	307	92.835	92.755	0.900	1.800	79.5	0.1	0.013	95.380	95.260	1.09	1.77	0.80	0.45	0.03	1.1	93.76	93.76	1.62	0.78	0.44	0.08	12.0	93.81	93.81	1.57	0.05	0.03	0.49	109.0	94.22	94.22	1.16
307	308	92.735	92.658	0.900	1.800	77.0	0.1	0.013	95.260	95.159	1.09	1.77	1.19	0.67	0.13	1.1	93.76	93.76	1.50	1.15	0.65	0.18	12.0	93.81	93.81	1.45	0.07	0.04	0.59	109.0	94.22	94.22	1.04
308	407	92.578	92.484	0.900	1.800	94.5	0.1	0.013	95.159	95.156	1.09	1.77	1.19	0.67	0.28	1.2	93.76	93.76	1.40	1.13	0.64	0.33	12.0	93.81	93.81	1.35	0.07	0.04	0.74	109.0	94.22	94.22	0.94
401	402	93.167	93.140	0.750	0.050	26.5	0.1	0.013	95.686	95.662	0.20	0.01	0.24	32.13	-0.15	1.1	93.76	93.76	1.92	0.24	32.13	-0.10	12.0	93.81	93.81	1.87	0.01	1.34	0.31	109.0	94.22	94.22	1.46
402	403	93.090	93.079	0.750	0.050	11.0	0.1	0.013	95.662	95.654	0.20	0.01	0.24	32.13	-0.08	1.1	93.76	93.76	1.90	0.24	32.13	-0.03	12.0	93.81	93.81	1.85	0.01	1.34	0.38	108.9	94.22	94.22	1.44
403	404	93.029	92.949	0.750	0.050	80.0	0.1	0.013	95.654	95.512	0.20	0.01	0.24	32.13	-0.02	1.1	93.76	93.76	1.89	0.23	30.79	0.03	12.0	93.81	93.81	1.84	0.01	1.34	0.44	109.0	94.22	94.22	1.43
404	405	92.799	92.692	0.900	0.050	106.5	0.1	0.013	95.512	95.350	0.20	0.01	0.42	46.52	0.06	1.1	93.76	93.76	1.75	0.41	45.42	0.11	12.0	93.81	93.81	1.70	0.03	3.32	0.52	109.0	94.22	94.22	1.29
405	406	92.672	92.570	0.900	0.050	68.0	0.2	0.013	95.350	95.251	0.25	0.01	0.71	64.22	0.19	1.1	93.76	93.76	1.59	0.69	62.41	0.24	12.0	93.81	93.81	1.54	0.04	3.62	0.65	109.0	94.22	94.22	1.13
406	407	92.550	92.484	0.900	0.050	66.5	0.1	0.013	95.251	95.156	0.20	0.01	0.71	78.65	0.31	1.1	93.76	93.76	1.49	0.68	75.32	0.36	12.0	93.81	93.81	1.44	0.04	4.43	0.77	109.0	94.22	94.22	1.03
407	408	92.434	92.416	0.900	1.800	17.5	0.1	0.013	95.156	95.163	1.09	1.77	1.90	1.08	0.43	1.2	93.76	93.76	1.40	1.78	1.01	0.48	12.0	93.81	93.81	1.35	0.12	0.07	0.89	109.0	94.22	94.22	0.93
408	Pond1	92.366	92.350	0.900	1.800	16.5	0.1	0.013	95.163	94.500	1.09	1.77	1.90	1.08	0.49	1.2	93.76	93.76	1.40	1.77	1.00	0.55	12.1	93.81	93.81	1.35	0.12	0.07	0.96	109.0	94.22	94.22	0.94
500	501	93.825	93.744	0.750	0.050	81.0	0.1	0.013	96.057	95.933	0.20	0.01	0.24	32.13	-0.26	1.1	94.32	94.26	1.74	0.24	32.13	-0.27	12.0	94.30	94.25	1.76	0.01	1.34	-0.35	109.0	94.23	94.23	1.83
501	502	93.724	93.652	0.750	0.050	71.5	0.1	0.013	95.933	95.825	0.20	0.01	0.23	30.79	-0.21	1.2	94.26	94.21	1.67	0.22	29.45	-0.23	12.2	94.25	94.20	1.69	0.01	1.34	-0.25	109.1	94.23	94.23	1.71
502	503	93.572	93.561	0.825	0.050	11.0	0.1	0.013	95.825	95.801	0.20	0.01	0.34	41.22	-0.18	1.2	94.21	94.19	1.61	0.33	40.00	-0.20	12.1	94.20	94.18	1.63	0.02	2.42	-0.17	109.0	94.23	94.23	1.60
503	504	93.511	93.450	0.825	0.050	61.0	0.1	0.013	95.801	95.693	0.20	0.01	0.34	41.22	-0.14	1.2	94.19	94.15	1.61	0.33	40.00	-0.16	12.2	94.18	94.14	1.62	0.02	2.42	-0.11	109.1	94.23	94.22	1.58
504	505	93.400	93.389	0.825	0.050	11.0	0.1	0.013	95.693	95.684	0.20	0.01	0.35	42.43	-0.07	1.2	94.15	94.14	1.54	0.34	41.22	-0.09	12.2	94.14	94.12	1.56	0.02	2.42	0.00	109.1	94.22	94.22	1.47
505	506	93.339	93.303	0.825	0.050	36.0	0.1	0.013	95.684	95.652	0.20	0.01	0.35	42.43	-0.03	1.2	94.14	94.09	1.55	0.35	42.43	-0.04	12.2	94.12	94.08	1.56	0.02	2.42	0.06	109.1	94.22	94.22	1.46
506	507	93.223	93.147	0.900	0.050	76.0	0.1	0.013	95.652	95.540	0.20	0.01	0.53	58.71	-0.03	1.2	94.09	94.03	1.56	0.51	56.49	-0.04	12.2	94.08	94.03	1.57	0.03	3.32	0.10	109.0	94.22	94.22	1.43
507	508	92.997	92.917	1.050	0.050	79.5	0.1	0.013	95.540	95.420	0.20	0.01	0.86	81.24	-0.01	1.2	94.03	93.89	1.51	0.84	79.35	-0.02	12.1	94.03	93.89	1.52	0.05	4.72	0.18	109.0	94.22	94.22	1.32
508	509	92.897	92.867	1.050	0.050	30.0	0.1	0.013	95.420	95.371	0.20	0.01	0.88	83.13	-0.06	1.2	93.89	93.78	1.53	0.86	81.24	-0.06	12.1	93.89	93.81	1.53	0.06	5.67	0.28	109.0	94.22	94.22	1.20
509	510	92.717	92.644	1.200	0.050	72.5	0.1	0.013	95.371	95.266	0.20	0.01	1.12	92.23	-0.14	1.2	93.78	93.76	1.59	1.09	89.76	-0.11	12.1	93.81	93.81	1.56	0.07	5.76	0.31	109.0	94.22	94.22	1.15
510	511	92.624	92.537	1.200	0.050	86.5	0.1	0.013	95.266	95.070	0.20	0.01	1.26	103.76	-0.06	1.2	93.76	93.76	1.51	1.22	100.46	-0.01	12.1	93.81	93.81	1.46	0.08	6.59	0.40	109.0	94.22	94.22	1.04
511	611	92.517	92.410	1.200	0.050	106.5	0.1	0.013	95.070	95.018	0.20	0.01	1.43	117.76	0.04	1.2	93.76	93.76	1.31	1.38	113.64	0.09	12.1	93.81	93.81	1.26	0.09	7.41	0.51	109.0	94.22	94.22	0.85
601	602	93.612	93.544	0.600	0.050	68.5	0.1	0.013	96.059	95.737	0.20	0.01	0.17	28.74	-0.20	1.1	94.01	93.86	2.05	0.17	28.74	-0.21	12.0	94.01	93.86	2.05	0.01	1.69	0.01	108.9	94.22	94.22	1.84
602	603	93.469	93.458	0.675	0.050	11.0	0.1	0.013	95.737	95.682	0.20	0.01	0.17	25.40	-0.28	1.1	93.86	93.84	1.87	0.17	25.40	-0.29	12.0	93.86	93.83	1.88	0.01	1.49	0.08	109.0	94.22	94.22	1.51
603	604	93.383	93.315	0.750	0.050	68.5	0.1	0.013	95.682	95.700	0.20	0.01	0.26	34.80	-0.30	1.1	93.84	93.76	1.85	0.26	34.80	-0.30	12.0	93.83	93.81	1.85	0.02	2.68	0.09	109.0	94.22	94.22	1.46
604	605	93.165	93.089	0.900	0.050	76.5	0.1	0.013	95.700	95.590	0.20	0.01	0.46	50.95	-0.30	1.1	93.76	93.76	1.94	0.45	49.85	-0.25	12.0	93.81	93.81	1.89	0.03	3.32	0.16	109.0	94.22	94.22	1.48

Table 6: Pipe Data and Hydraulic Simulation Results [1]

U/S MH	D/S MH	U/S Invert (m)	D/S Invert (m)	Pipe Diameter / Height (m)	Pipe Width (m)	Pipe Length (m)	Pipe Slope (%)	n	U/S MH Cover Elev. (m)	D/S MH Cover Elev. (m)	Design Velocity (m/s)	Design Flow (m^3/s)	100-year, 3-hour Chicago Storm							100-year, 12-hour SCS Type II Storm							100-year, 10-day Spring Snowmelt + Rainfall Event						
													Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)
605	606	92.939	92.859	1.050	0.050	79.5	0.1	0.013	95.590	95.470	0.20	0.01	0.66	62.35	-0.23	1.1	93.76	93.76	1.83	0.64	60.46	-0.18	12.0	93.81	93.81	1.78	0.04	3.78	0.23	108.9	94.22	94.22	1.37
606	607	92.709	92.629	1.200	0.050	79.5	0.1	0.013	95.470	95.350	0.20	0.01	0.89	73.29	-0.15	1.1	93.76	93.76	1.71	0.86	70.82	-0.10	12.0	93.81	93.81	1.66	0.05	4.12	0.31	109.0	94.22	94.22	1.25
607	608	92.609	92.540	1.200	0.050	69.0	0.1	0.013	95.350	95.247	0.20	0.01	0.99	81.52	-0.05	1.2	93.76	93.76	1.59	0.95	78.23	0.00	12.1	93.81	93.81	1.54	0.06	4.94	0.41	108.9	94.22	94.22	1.13
608	609	92.520	92.509	1.200	0.050	11.0	0.1	0.013	95.247	95.245	0.20	0.01	0.99	81.52	0.04	1.2	93.76	93.76	1.49	0.94	77.41	0.09	12.1	93.81	93.81	1.44	0.06	4.94	0.50	109.0	94.22	94.22	1.02
609	610	92.489	92.455	1.200	0.050	34.5	0.1	0.013	95.245	95.186	0.20	0.01	1.13	93.05	0.07	1.2	93.76	93.76	1.49	1.08	88.94	0.12	12.1	93.81	93.81	1.43	0.07	5.76	0.53	109.0	94.22	94.22	1.02
610	611	92.435	92.410	1.200	0.050	25.0	0.1	0.013	95.186	95.018	0.20	0.01	1.36	111.99	0.13	1.1	93.76	93.76	1.43	1.30	107.05	0.18	12.1	93.81	93.81	1.38	0.08	6.59	0.59	108.9	94.22	94.22	0.96
611	612	92.390	92.368	1.200	1.800	22.0	0.1	0.013	95.018	94.849	1.23	2.66	2.79	1.05	0.17	1.2	93.76	93.76	1.26	2.66	1.00	0.22	12.1	93.81	93.81	1.21	0.17	0.06	0.63	109.0	94.22	94.22	0.80
612	Pond1	92.368	92.350	1.200	1.800	18.0	0.1	0.013	94.849	94.500	1.23	2.66	2.79	1.05	0.19	1.2	93.76	93.76	1.09	2.65	1.00	0.24	12.1	93.81	93.81	1.04	0.17	0.06	0.65	109.0	94.22	94.22	0.63
704	705	93.440	93.368	1.200	0.050	71.5	0.1	0.013	96.440	96.330	0.20	0.01	0.87	71.64	-0.45	1.1	94.19	94.12	2.25	0.86	70.82	-0.46	12.0	94.18	94.11	2.26	0.06	4.94	-0.41	109.0	94.23	94.23	2.21
705	706	93.348	93.281	0.900	2.400	67.0	0.1	0.013	96.330	96.233	1.16	2.50	2.44	0.98	-0.13	1.1	94.12	94.07	2.21	2.41	0.97	-0.14	12.0	94.11	94.05	2.22	0.16	0.06	-0.02	108.8	94.23	94.22	2.11
706	707	93.161	93.077	1.200	2.400	83.5	0.1	0.013	96.233	96.110	1.32	3.80	2.54	0.67	-0.29	1.1	94.07	93.92	2.16	2.50	0.66	-0.31	12.1	94.05	93.91	2.18	0.17	0.04	-0.14	109.1	94.22	94.22	2.01
707	708	92.997	92.927	1.200	2.400	70.0	0.1	0.013	96.110	96.000	1.32	3.80	3.09	0.81	-0.27	1.2	93.92	93.87	2.19	3.03	0.80	-0.29	12.1	93.91	93.86	2.20	0.20	0.05	0.03	109.1	94.22	94.22	1.89
708	709	92.907	92.841	1.200	2.400	66.0	0.1	0.013	96.000	95.901	1.32	3.80	3.21	0.84	-0.24	1.2	93.87	93.82	2.13	3.15	0.83	-0.25	12.1	93.86	93.81	2.14	0.21	0.06	0.12	109.1	94.22	94.22	1.78
709	710	92.821	92.751	1.200	2.400	70.5	0.1	0.013	95.901	95.796	1.32	3.80	3.27	0.86	-0.20	1.2	93.82	93.76	2.08	3.21	0.84	-0.21	12.1	93.81	93.81	2.09	0.21	0.06	0.20	109.1	94.22	94.22	1.68
710	711	92.671	92.540	1.200	2.400	131.0	0.1	0.013	95.796	94.828	1.32	3.80	3.67	0.96	-0.11	1.2	93.76	93.76	2.04	3.59	0.94	-0.06	12.1	93.81	93.81	1.98	0.24	0.06	0.35	109.1	94.22	94.23	1.57
711	712	92.460	92.438	1.200	2.400	21.5	0.1	0.013	94.828	94.704	1.32	3.80	3.66	0.96	0.10	1.2	93.76	93.78	1.07	3.56	0.94	0.15	12.1	93.81	93.81	1.02	0.24	0.06	0.57	108.9	94.23	94.23	0.60
712	Pond1	92.358	92.350	1.200	2.400	8.5	0.1	0.013	94.704	94.500	1.32	3.80	3.66	0.96	0.22	1.2	93.78	93.76	0.92	3.55	0.93	0.25	12.1	93.81	93.81	0.89	-0.28	-0.07	0.67	192.0	94.23	94.22	0.47
806	807	93.455	93.423	0.675	0.050	21.5	0.2	0.013	96.004	95.954	0.24	0.01	0.07	8.54	-0.28	1.1	93.85	93.84	2.15	0.07	8.54	-0.29	12.0	93.84	93.83	2.16	-0.01	-1.22	0.09	95.5	94.23	94.23	1.78
807	808	93.343	93.290	0.675	0.050	35.5	0.2	0.013	95.954	95.872	0.24	0.01	0.25	30.50	-0.17	1.1	93.84	93.79	2.11	0.25	30.50	-0.19	12.0	93.83	93.81	2.12	0.02	2.44	0.21	109.0	94.23	94.23	1.73
808	809	93.215	93.199	0.750	0.050	11.0	0.2	0.013	95.872	95.844	0.24	0.01	0.41	44.81	-0.18	1.1	93.79	93.76	2.08	0.40	43.72	-0.15	12.0	93.81	93.81	2.06	0.03	3.28	0.26	109.0	94.23	94.22	1.65
809	710	93.149	93.121	0.750	0.050	18.5	0.2	0.013	95.844	95.796	0.24	0.01	0.41	44.81	-0.14	1.1	93.76	93.76	2.08	0.40	43.72	-0.09	12.0	93.81	93.81	2.03	0.03	3.28	0.33	108.9	94.22	94.22	1.62
901	902	94.241	94.180	0.600	0.050	60.5	0.1	0.013	96.649	96.550	0.20	0.01	0.14	23.67	-0.18	1.1	94.66	94.63	1.99	0.13	21.98	-0.18	12.0	94.66	94.62	1.99	0.01	1.69	0.06	109.0	94.91	94.91	1.74
902	903	94.130	94.068	0.600	0.050	62.5	0.1	0.013	96.550	96.461	0.20	0.01	0.14	23.67	-0.10	1.2	94.63	94.59	1.93	0.13	21.98	-0.11	12.1	94.62	94.58	1.93	0.01	1.69	0.18	109.5	94.91	94.91	1.65
903	904	93.993	93.982	0.675	0.050	11.0	0.1	0.013	96.461	96.443	0.20	0.01	0.14	20.92	-0.08	1.2	94.59	94.59	1.87	0.14	20.92	-0.09	12.2	94.58	94.58	1.88	0.01	1.49	0.24	110.0	94.91	94.91	1.56
904	905	93.907	93.842	0.750	0.050	65.0	0.1	0.013	96.443	96.344	0.20	0.01	0.54	72.28	-0.07	1.1	94.59	94.43	1.86	0.53	70.94	-0.08	12.0	94.58	94.42	1.87	0.03	4.02	0.25	109.0	94.91	94.91	1.54
905	906	93.822	93.760	0.750	0.050	61.5	0.1	0.013	96.344	96.250	0.20	0.01	0.54	72.28	-0.14	1.1	94.43	94.11	1.91	0.53	70.94	-0.15	12.0	94.42	94.30	1.92	0.03	4.02	0.33	109.4	94.91	94.91	1.44
906	907	93.310	93.272	1.200	0.050	38.5	0.1	0.013	96.250	96.174	0.20	0.01	1.22	100.46	-0.40	1.1	94.11	94.11	2.14	1.20	98.82	-0.21	12.0	94.30	94.30	1.95	0.07	5.76	0.39	109.0	94.91	94.91	1.35
907	Pond2	93.222	93.200	1.200	0.050	21.5	0.1	0.013	96.174	96.000	0.20	0.01	1.22	100.46	-0.31	1.1	94.11	94.11	2.06	1.19	97.99	-0.13	12.0	94.30	94.30	1.88	0.07	5.76	0.48	109.0	94.91	94.91	1.27
1001	1002	94.612	94.539	0.750	0.050	72.5	0.1	0.013	96.925	96.816	0.20	0.01	0.26	34.80	-0.22	1.1	95.14	95.03	1.78	0.25	33.46	-0.23	12.1	95.13	95.02	1.80	0.02	2.68	-0.45	108.4	94.91	94.91	2.02
1002	1003	94.459	94.382	0.750	0.050	77.0	0.1	0.013	96.816	96.699	0.20	0.01	0.26	34.80	-0.18	1.2	95.03	94.99	1.78	0.27	36.14	-0.19	12.2	95.02	94.97	1.80	0.01	1.34	-0.30	108.0	94.91	94.91	1.91
1003	1004	94.232	94.160	0.900	0.050	71.5	0.1	0.013	96.699	96.591	0.20	0.01	0.52	57.60	-0.15	1.2	94.99	94.93	1.71	0.51	56.49	-0.16	12.1	94.97	94.91	1.73	0.03	3.32	-0.23	108.4	94.91	94.91	1.79
1004	1005	94.010	93.936	1.050	0.050	74.0	0.1	0.013	96.591	96.478	0.20	0.01	0.77	72.74	-0.13	1.2	94.93	94.81	1.66	0.75	70.85	-0.15	12.1	94.91	94.79	1.68	0.04	3.78	-0.15	108.4	94.91	94.91	1.68
1005	1006	93.786	93.715	1.200	0.050	71.0	0.1	0.013	96.478	96.370	0.20	0.01	1.39	114.46	-0.18	1.1	94.81	94.51	1.67	1.36	111.99	-0.20	12.1	94.79	94.50	1.69	0.08	6.59	-0.08	109.1	94.91	94.91	1.57
1006	1007	93.565	93.499	1.350	0.050	66.5	0.1	0.013	96.370	96.311	0.20	0.01	1.98	144.50	-0.40	1.1	94.51	94.33	1.86	1.94	141.58	-0.41	12.0	94.50	94.32	1.87	0.11	8.03	-0.01	109.1	94.91	94.91	1.46
1007	1008	93.349	93.303	1.500	0.050	46.0	0.1	0.013	96.311	96.054	0.20	0.02	2.18	142.85	-0.52	1.1	94.33	94.12	1.98	2.14	140.23	-0.53	12.1	94.32	94.30	1.99	0.12	7.86	0.06	109.4	94.91	94.91	1.41
1008	Pond2	93.223	93.200	1.500	2.400	23.0	0.1	0.013	96.054	96.000	1.45	5.23	3.18	0.61	-0.60	1.1	94.12	94.11	1.94	2.86	0.55	-0.42	12.1	94.30	94.30	1.75	1.40	0.27	0.18	111.1	94.91	94.91	1.15
1101	1102	94.790	94.671	0.675	0.050	119.0	0.1	0.013	97.020	96.819	0.20	0.01	0.25	37.35	-0.20	1.1	95.27	95.06	1.75	0.24	35.86	-0.20	12.0	95.26	95.06	1.76	0.01	1.49	-0.55	109.0	94.92	94.91	2.10
1102	1103	94.596	94.588	0.750	0.050	8.0	0.1	0.013	96.819	96.790	0.20	0.01	0.25	33.46	-0.28	1.1	95.06	95.04	1.76	0.24	32.13	-0.29	12.0	95.06	95.03	1.76	0.01	1.34	-0.44	109.0	94.91	94.91	1.91
1103	1104	94.438	94.372	0.900	0.050	65.5	0.1	0.013	96.790	96.731	0.20	0.01	0.43	47.63	-0.30	1.1	95.04	94.98	1.75	0.42	46.52	-0.31	12.0	95.03	94.97	1.76	0.02	2.22	-0.43	108.9	94.91	94.91	1.89
1104	1105	94.322	94.250	0.900	0.050	71.5	0.1	0.013	96.731	96.602	0.20	0.01	0.52	57.60	-0.25	1.1	94.98	94.76	1.76	0.51	56.49	-0.25	12.0	94.97	94.75	1.76	0.03	3.32	-0.32	109.1	94.91	94.91	1.83
1105	1106	94.200	94.146	0.900	0.050	54.5	0.1	0.013	96.602	96.521	0.20	0.01	0.52	57.60	-0.34	1.1	94.76	94.56	1.84	0.51	56.49	-0.35	12.1	94.75	94.55	1.85	0.03	3.32	-0.20	109.2	94.91	94.91	1.70
1106	1107	93.846	93.839	1.200	0.050	7.0	0.1	0.013	96.521	96.505	0.20	0.01	0.92	75.76	-0.49	1.1	94.56	94.50	1.96	0.90	74.11	-0.49	12.0	94.55	94.50	1.97	0.05	4.12	-0.14	109.1	94.91	94.91	1.62
1107	1108	93.819	93.705	1.200	0.050	113.5	0.1	0.013	96.505	96.334	0.20	0.01	0.92	75.76	-0.52	1.1	94.50	94.26	2.01	0.89	73.29	-0.52	12.1	94.50	94.31	2.01	0.05	4.12	-0.11	109.2	94.91	94.91	1.60
1108	1109	93.405	93.331	1.500	2.400	73.5	0.1	0.013	96.334	96.509	1.45	5.23	4.26	0.81	-0.64	1.2	94.26	94.11	2.07	4.14	0.79	-0.59	12.1	94.31	94.30	2.02	0.23	0.04	0.00	109.2	94.91	94.91	1.43
1109	1110	93.311	93.243	1.500	3.000	67.5	0.1	0.013	96.509	96.079	1.53	6.90	4.26	0.62	-0.70	1.2	94.11	94.11	2.40	4.10	0.59	-0.51	12.1	94.30	94.30	2.21	0.23	0.03	0.09	109.2	94.91	94.91	1.60
1110	Pond2	93.223	93.200	1.500	3.000	22.5	0.1	0.013	96.079	96.000	1.53	6.90	4.25	0.62	-0.61	1.2	94.11	94.11	1.96	4.05	0.59	-0.43	12.1	94.30	94.30	1.78	0.22	0.03	0.18	109.2	94.91	94.91	1.17
1201	1202	95.621	95.569	0.825	0.050	51.5	0.1	0.013	97.701	97.772	0.20	0.01	0.35	42.43	-0.32	1.1	96.12	96.02	1.58	0.34	41.22	-0.33	12.0	96.11	96.01	1.59	0.02	2.42	-0.70	109.0	95.74	95.63	1.96
1202	1203	95.519	95.508	0.825	0.050	11.0	0.1	0.013	97.772	97.736	0.20	0.01	0.34	41.22	-0.32	1.1	96.02	95.98	1.75	0.34	41.22	-0.34	12.0	96.01	95.96	1.77	0.02	2.42	-0.72	109.0	95.63	95.50	2.14
1203	1204	95.358	95.290	0.975	0.050	67.5	0.1	0.013	97.736	97.517	0.20	0.01	0.52	53.03	-0.36	1.1	95.98	95.91	1.76	0.51	52.01	-0.37	12.0	95.96	95.90	1.77	0.03	3.06	-0.84	109.0	95.50	95.41	2.24
1204	1205	95.270	95.196	0.975	0.050	67.5	0.1	0.013	97.517	97.421	0.21	0.01	0.51	49.59	-0.33	1.1	95.91	95.84	1.60	0.50	48.61	-0.35	12.0	95.90	95.82	1.62	0.03	2.92	-0.83	109.1	95.41	95.28	2.11
1205	1206	95.146	95.135	0.975	0.050	11.0	0.1	0.013	97.421	97.398	0.20	0.01	0.63	64.24	-0.29	1.1	95.84	95.79	1.59	0.61	62.20	-0.31	12.0	95.82	95.77	1.61	0.04	4.08	-0.84	109.0	95.28	95.24	2.14
1206	1207	95.085	95.029	0.975	0.050	56.0	0.1	0.013	97.398	96.759	0.20	0.01	0.62	63.22	-0.27	1.1	95.79	95.71	1.61	0.61	62.20	-0.29	12.1	95.77	95.68	1.63	0.04	4.08	-0.82	109.1	95.24	95.12	2.16
1207	1208	94.979	94.968	0.975	0.050	11.0	0.1	0.013	96.759	97.245	0.20	0.01	0.62	63.22	-0.25	1.2	95.71	95.67	1.05	0.61	62.20	-0.27	12.1	95.68	95.64	1.08	0.04	4.08	-0.84	109.1	95.12	95.07	1.64
1208	1209	94.918	94.882	0.975	0.050	36.0	0.1	0.013	97.245	97.244	0.20	0.01	0.62	63.22	-0.22	1.2	95.67	95.62	1.58	0.61	62.20	-0.25	12.1	95.64	95.59	1.60	0.04	4.08	-0.83	109.1	95.07	94.95	2.18
1209	1210	94.807	94.799	1.050	0.050	7.5	0.1	0.013	97.244	97.231	0.20	0.01	0.75	70.85	-0.24	1.2	95.62	95.58	1.63	0.73	68.96	-0.27	12.1	95.59	95.55	1.66	0.05	4.72	-0.91	109.0	94.95	94.92	2.29
1210	1211	94.749	94.720	1.050	0.050	29.0	0.1	0.013	97.231	96.720	0.20	0.01	0.75	70.85	-0.21	1.2	95.58	95.54	1.65	0.73	68.96	-0.25	12.1	95.55	95.51	1.68	0.05	4.72	-0.88	109.0	94.92	94.91	2.32

Table 6: Pipe Data and Hydraulic Simulation Results [1]

U/S MH	D/S MH	U/S Invert (m)	D/S Invert (m)	Pipe Diameter / Height (m)	Pipe Width (m)	Pipe Length (m)	Pipe Slope (%)	n	U/S MH Cover Elev. (m)	D/S MH Cover Elev. (m)	Design Velocity (m/s)	Design Flow (m^3/s)	100-year, 3-hour Chicago Storm							100-year, 12-hour SCS Type II Storm							100-year, 10-day Spring Snowmelt + Rainfall Event						
													Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)
1211	1212	94.670	94.662	1.050	0.050	7.5	0.1	0.013	96.720	96.710	0.20	0.01	0.75	70.85	-0.18	1.2	95.54	95.51	1.18	0.73	68.96	-0.22	12.1	95.51	95.48	1.22	0.05	4.72	-0.81	109.0	94.91	94.91	1.81
1212	1213	94.582	94.518	1.050	0.050	64.0	0.1	0.013	96.710	97.080	0.20	0.01	0.76	71.80	-0.12	1.3	95.51	95.47	1.20	0.73	68.96	-0.15	12.2	95.48	95.44	1.23	0.05	4.72	-0.72	109.0	94.91	94.91	1.80
1213	1214	94.368	94.296	1.200	0.050	71.5	0.1	0.013	97.080	96.970	0.20	0.01	1.08	88.94	-0.10	1.2	95.47	95.42	1.61	1.06	87.29	-0.13	12.1	95.44	95.39	1.65	0.07	5.76	-0.66	109.0	94.91	94.91	2.17
1214	1215	94.276	94.204	1.200	0.050	71.5	0.1	0.013	96.970	96.870	0.20	0.01	1.26	103.76	-0.05	1.2	95.42	95.26	1.55	1.24	102.11	-0.09	12.1	95.39	95.23	1.58	0.07	5.76	-0.57	108.9	94.91	94.91	2.06
1215	1216	94.054	93.982	1.350	0.050	71.5	0.1	0.013	96.870	96.760	0.20	0.01	1.68	122.61	-0.15	1.2	95.26	95.19	1.61	1.64	119.69	-0.18	12.1	95.23	95.16	1.64	0.10	7.30	-0.50	108.9	94.91	94.91	1.97
1216	1217	93.832	93.748	1.500	0.050	84.5	0.1	0.013	96.760	96.630	0.20	0.02	2.26	148.09	-0.14	1.2	95.19	95.12	1.57	2.21	144.81	-0.17	12.1	95.16	95.09	1.60	0.13	8.52	-0.43	109.1	94.91	94.91	1.86
1217	1218	93.728	93.645	1.500	0.050	83.0	0.1	0.013	96.630	96.510	0.20	0.02	2.52	165.13	-0.11	1.2	95.12	95.02	1.51	2.47	161.85	-0.14	12.1	95.09	95.00	1.54	0.14	9.17	-0.32	109.1	94.91	94.91	1.72
1218	1219	93.625	93.579	1.500	0.050	46.5	0.1	0.013	96.510	96.440	0.20	0.02	2.60	170.37	-0.10	1.2	95.02	94.96	1.49	2.54	166.44	-0.13	12.1	95.00	94.94	1.51	0.15	9.83	-0.22	109.2	94.91	94.91	1.61
1219	1108	93.559	93.485	1.500	0.050	74.0	0.1	0.013	96.440	96.334	0.20	0.02	3.08	201.82	-0.10	1.2	94.96	94.26	1.48	3.01	197.23	-0.12	12.1	94.94	94.31	1.50	0.17	11.14	-0.15	109.1	94.91	94.91	1.54
1500	1501	92.698	92.577	1.200	1.800	120.0	0.1	0.013	95.911	95.724	1.23	2.66	3.28	1.23	0.15	2.9	94.05	93.92	1.86	4.04	1.52	0.64	13.6	94.54	94.27	1.37	2.19	0.82	0.56	110.5	94.46	94.38	1.45
1501	214	92.577	92.442	1.200	1.800	135.0	0.1	0.013	95.724	95.617	1.23	2.66	3.27	1.23	0.14	3.0	93.92	93.81	1.81	4.04	1.52	0.50	13.6	94.27	93.98	1.45	2.19	0.82	0.60	110.5	94.38	94.29	1.35
1600	1601	94.197	94.025	1.200	1.800	107.6	0.2	0.013	96.992	96.885	1.56	3.36	1.60	0.48	-0.61	3.4	94.78	94.62	2.21	2.02	0.60	-0.49	14.0	94.91	94.76	2.08	1.31	0.39	-0.34	111.2	95.05	95.03	1.94
1601	1602	94.025	93.783	1.200	1.800	95.0	0.2	0.013	96.885	96.790	1.56	3.36	1.60	0.48	-0.61	3.4	94.62	94.51	2.27	2.02	0.60	-0.47	14.0	94.76	94.67	2.13	1.30	0.39	-0.20	111.3	95.03	95.01	1.86
1602	1603	93.783	93.721	1.200	1.800	95.0	0.2	0.013	96.790	96.695	1.56	3.36	1.60	0.48	-0.47	3.4	94.51	94.42	2.28	2.02	0.60	-0.31	14.1	94.67	94.59	2.12	1.30	0.39	0.03	111.5	95.01	94.99	1.78
1603	1604	93.721	93.569	1.200	1.800	95.0	0.2	0.013	96.695	96.600	1.56	3.36	1.60	0.48	-0.50	3.4	94.42	94.35	2.27	2.02	0.60	-0.33	14.1	94.59	94.52	2.10	1.30	0.39	0.07	111.3	94.99	94.97	1.71
1604	1605	93.569	93.431	1.200	1.800	86.5	0.2	0.013	96.600	96.513	1.56	3.36	1.60	0.48	-0.42	3.4	94.35	94.20	2.25	2.02	0.60	-0.25	14.1	94.52	94.37	2.08	1.30	0.39	0.20	111.3	94.97	94.93	1.63
1605	1008	93.431	93.359	1.200	1.800	71.9	0.1	0.013	96.513	96.054	1.23	2.66	1.60	0.60	-0.44	3.4	94.20	94.12	2.32	2.02	0.76	-0.26	14.1	94.37	94.30	2.14	1.30	0.49	0.30	111.5	94.93	94.91	1.59
Pond1	P1out	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.77	N/A	N/A	N/A	N/A	N/A	N/A	3.73	N/A	N/A	N/A	N/A	N/A	N/A	2.95	N/A	N/A	N/A	N/A	N/A	N/A
Pond2	P2out	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.61	N/A	N/A	N/A	N/A	N/A	N/A	2.09	N/A	N/A	N/A	N/A	N/A	N/A	1.48	N/A	N/A	N/A	N/A	N/A	N/A
1000	1001	94.705	94.632	0.750	N/A	72.5	0.1	0.013	97.034	96.925	0.80	0.35	0.26	0.74	-0.25	1.1	95.20	95.14	1.83	0.26	0.74	-0.26	12.0	95.19	95.13	1.84	0.02	0.06	-0.55	109.0	94.91	94.91	2.13

Note: [1] Based on restrictive downstream conditions; Summer = 93.68 m / Spring = 94.11 m for Pond 1, and Spring = 94.18 for Pond 2. All other results based on free outfall conditions.

[2] A negative surcharge implies that the pipe is not flowing full

0.47 Freeboard less than 0.5 m.

Table 6: Pipe Data and Hydraulic Simulation Results [1]

U/S MH	D/S MH	U/S Invert (m)	D/S Invert (m)	Pipe Diameter / Height (m)	Pipe Width (m)	Pipe Length (m)	Pipe Slope (%)	n	U/S MH Cover Elev. (m)	D/S MH Cover Elev. (m)	Design Velocity (m/s)	Design Flow (m^3/s)	100-year, 3-hour Chicago Storm + 20%							100-year, 12-hour SCS Type II Storm + 20%							July 1st, 1979 Historical Event						
													Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)
101	102	93.428	93.361	0.825	0.050	67.0	0.1	0.013	95.812	95.887	0.20	0.01	0.33	40.00	-0.27	1.1	93.98	93.93	1.83	0.32	38.79	-0.30	12.0	93.96	93.90	1.86	0.27	32.73	-0.36	1.7	93.90	93.83	1.92
102	103	93.341	93.261	0.825	0.050	80.0	0.1	0.013	95.887	95.770	0.20	0.01	0.33	40.00	-0.24	1.1	93.93	93.87	1.96	0.31	37.58	-0.27	12.0	93.90	93.85	1.99	0.27	32.73	-0.33	1.7	93.83	93.81	2.05
103	104	93.111	93.050	0.975	0.050	60.5	0.1	0.013	95.770	95.673	0.20	0.01	0.68	69.34	-0.21	1.1	93.87	93.82	1.90	0.64	65.26	-0.23	12.0	93.85	93.85	1.92	0.56	57.11	-0.27	1.7	93.81	93.81	1.96
104	105	93.000	92.976	0.975	0.050	23.5	0.1	0.013	95.673	95.631	0.20	0.01	0.68	69.34	-0.16	1.1	93.82	93.82	1.86	0.64	65.26	-0.12	12.1	93.85	93.85	1.82	0.57	58.13	-0.16	1.7	93.81	93.81	1.86
105	106	92.901	92.799	1.050	0.050	101.5	0.1	0.013	95.631	95.480	0.20	0.01	0.86	81.24	-0.14	1.1	93.82	93.81	1.82	0.81	76.52	-0.10	12.1	93.85	93.85	1.78	0.71	67.07	-0.14	1.7	93.81	93.81	1.82
106	107	92.649	92.573	1.200	0.050	76.5	0.1	0.013	95.480	95.370	0.20	0.01	1.00	82.35	-0.04	1.1	93.81	93.81	1.67	0.93	76.58	0.00	12.1	93.85	93.85	1.63	0.82	67.53	-0.04	1.7	93.81	93.81	1.67
107	108	92.553	92.478	1.200	0.050	74.5	0.1	0.013	95.370	95.342	0.20	0.01	1.30	107.05	0.06	1.1	93.81	93.81	1.56	1.21	99.64	0.10	12.0	93.85	93.85	1.52	1.07	88.11	0.06	1.7	93.81	93.81	1.56
108	109	92.458	92.431	1.200	0.050	26.5	0.1	0.013	95.342	95.511	0.20	0.01	1.44	118.58	0.15	1.1	93.81	93.81	1.53	1.33	109.52	0.19	12.0	93.85	93.85	1.49	1.19	97.99	0.15	1.7	93.81	93.81	1.53
109	Pond1	92.381	92.350	1.200	0.050	31.0	0.1	0.013	95.511	94.500	0.20	0.01	1.44	118.58	0.23	1.1	93.81	93.81	1.70	1.32	108.70	0.27	12.0	93.85	93.85	1.66	1.18	97.17	0.23	1.7	93.81	93.81	1.70
201	202	94.167	94.088	0.750	0.050	79.0	0.1	0.013	96.639	96.523	0.20	0.01	0.29	38.82	-0.14	1.1	94.78	94.73	1.86	0.28	37.48	-0.17	12.0	94.74	94.69	1.90	0.24	32.13	-0.26	1.7	94.66	94.60	1.98
202	203	94.068	93.985	0.750	0.050	83.0	0.1	0.013	96.523	96.400	0.20	0.01	0.28	37.48	-0.09	1.1	94.73	94.65	1.80	0.27	36.14	-0.13	12.0	94.69	94.62	1.83	0.25	33.46	-0.22	1.7	94.60	94.52	1.92
203	204	93.905	93.828	0.825	0.050	77.0	0.1	0.013	96.400	96.280	0.20	0.01	0.53	64.25	-0.08	1.1	94.65	94.56	1.75	0.51	61.83	-0.11	12.1	94.62	94.52	1.78	0.45	54.55	-0.21	1.7	94.52	94.43	1.88
204	205	93.753	93.681	0.900	0.050	72.0	0.1	0.013	96.280	96.172	0.20	0.01	0.66	73.11	-0.09	1.1	94.56	94.47	1.72	0.63	69.79	-0.13	12.1	94.52	94.44	1.76	0.55	60.92	-0.23	1.7	94.43	94.34	1.85
205	206	93.606	93.533	0.975	0.050	73.0	0.1	0.013	96.172	96.060	0.20	0.01	0.78	79.54	-0.11	1.1	94.47	94.30	1.70	0.74	75.46	-0.14	12.1	94.44	94.28	1.73	0.65	66.28	-0.24	1.7	94.34	94.17	1.83
206	207	93.308	93.274	1.200	0.050	34.0	0.1	0.013	96.060	96.017	0.20	0.01	1.45	119.40	-0.21	1.1	94.30	94.23	1.76	1.39	114.46	-0.23	12.1	94.28	94.20	1.78	1.22	100.46	-0.33	1.7	94.17	94.10	1.89
207	208	93.224	93.168	1.200	0.050	55.5	0.1	0.013	96.017	95.927	0.20	0.01	1.53	125.99	-0.20	1.1	94.23	94.10	1.79	1.46	120.23	-0.22	12.1	94.20	94.18	1.81	1.29	106.23	-0.33	1.7	94.10	94.01	1.92
208	209	93.118	93.078	1.200	0.050	39.5	0.1	0.013	95.927	95.870	0.20	0.01	1.54	126.82	-0.22	1.1	94.10	94.03	1.82	1.45	119.40	-0.14	12.1	94.18	94.18	1.75	1.29	106.23	-0.31	1.7	94.01	94.01	1.92
209	210	93.028	92.952	1.200	0.050	76.5	0.1	0.013	95.870	95.760	0.20	0.01	1.88	154.81	-0.20	1.1	94.03	94.00	1.84	1.78	146.58	-0.05	12.0	94.18	94.18	1.69	1.58	130.11	-0.22	1.7	94.01	94.01	1.87
210	211	92.932	92.856	1.200	1.800	76.5	0.1	0.013	95.760	95.640	1.23	2.66	2.14	0.80	-0.13	1.1	94.00	94.00	1.76	2.01	0.76	0.05	12.1	94.18	94.18	1.58	1.78	0.67	-0.13	1.7	94.01	94.01	1.76
211	212	92.836	92.754	1.200	1.800	82.0	0.1	0.013	95.640	95.515	1.23	2.66	2.29	0.86	-0.04	1.1	94.00	94.00	1.64	2.13	0.80	0.14	12.1	94.18	94.18	1.46	1.88	0.71	-0.03	1.7	94.01	94.01	1.64
212	213	92.734	92.668	1.200	1.800	65.5	0.1	0.013	95.515	95.466	1.23	2.66	2.44	0.92	0.07	1.1	94.00	94.00	1.52	2.27	0.85	0.24	12.1	94.18	94.18	1.34	1.98	0.74	0.07	1.7	94.01	94.01	1.51
213	214	92.588	92.556	1.200	1.800	31.5	0.1	0.013	95.466	95.617	1.23	2.66	2.45	0.92	0.21	1.1	94.00	94.00	1.47	2.27	0.85	0.39	12.1	94.18	94.18	1.29	1.96	0.74	0.22	1.7	94.01	94.01	1.46
214	215	92.426	92.392	1.200	2.400	34.5	0.1	0.013	95.617	95.511	1.32	3.80	4.32	1.14	0.37	2.9	94.00	93.85	1.62	5.28	1.39	0.55	13.5	94.18	93.93	1.44	4.39	1.15	0.38	3.0	94.01	93.86	1.61
215	Pond1	92.392	92.350	1.200	2.400	42.5	0.1	0.013	95.511	94.500	1.32	3.80	4.32	1.14	0.26	2.9	93.85	93.81	1.66	5.28	1.39	0.34	13.5	93.93	93.85	1.58	4.39	1.15	0.27	3.0	93.86	93.81	1.65
301	302	93.548	93.494	0.600	0.050	54.0	0.1	0.013	95.814	95.720	0.20	0.01	0.16	27.05	-0.22	1.1	93.93	93.82	1.89	0.15	25.36	-0.23	12.0	93.92	93.85	1.90	0.13	21.98	-0.27	1.7	93.88	93.81	1.93
302	303	93.419	93.408	0.675	0.050	11.0	0.1	0.013	95.720	95.670	0.20	0.01	0.16	23.91	-0.27	1.1	93.82	93.82	1.90	0.15	22.41	-0.24	12.0	93.85	93.85	1.87	0.13	19.42	-0.28	1.7	93.81	93.81	1.91
303	304	93.358	93.290	0.675	0.050	67.5	0.1	0.013	95.670	95.603	0.20	0.01	0.16	23.91	-0.22	1.1	93.82	93.82	1.85	0.15	22.41	-0.18	12.0	93.85	93.85	1.82	0.13	19.42	-0.22	1.7	93.81	93.81	1.86
304	305	93.215	93.141	0.750	0.050	73.5	0.1	0.013	95.603	95.490	0.20	0.01	0.28	37.48	-0.15	1.1	93.82	93.82	1.79	0.26	34.80	-0.11	12.0	93.85	93.85	1.75	0.23	30.79	-0.15	1.7	93.81	93.81	1.79
305	306	92.991	92.915	0.900	0.050	76.5	0.1	0.013	95.490	95.380	0.20	0.01	0.55	60.92	-0.08	1.1	93.82	93.81	1.68	0.53	58.71	-0.04	12.0	93.85	93.85	1.64	0.48	53.17	-0.08	1.7	93.81	93.81	1.68
306	307	92.835	92.755	0.900	1.800	79.5	0.1	0.013	95.380	95.260	1.09	1.77	0.89	0.50	0.08	1.1	93.81	93.81	1.57	0.84	0.48	0.12	12.0	93.85	93.85	1.53	0.76	0.43	0.08	1.7	93.81	93.81	1.57
307	308	92.735	92.658	0.900	1.800	77.0	0.1	0.013	95.260	95.159	1.09	1.77	1.34	0.76	0.18	1.1	93.81	93.81	1.45	1.26	0.71	0.22	12.0	93.85	93.85	1.41	1.12	0.63	0.18	1.7	93.81	93.81	1.45
308	407	92.578	92.484	0.900	1.800	94.5	0.1	0.013	95.159	95.156	1.09	1.77	1.34	0.76	0.33	1.1	93.81	93.81	1.35	1.21	0.69	0.37	12.0	93.85	93.85	1.31	1.10	0.62	0.33	1.7	93.81	93.81	1.35
401	402	93.167	93.140	0.750	0.050	26.5	0.1	0.013	95.686	95.662	0.20	0.01	0.27	36.14	-0.11	1.0	93.81	93.81	1.87	0.27	36.14	-0.06	12.0	93.85	93.85	1.83	0.22	29.45	-0.10	1.7	93.81	93.81	1.87
402	403	93.090	93.079	0.750	0.050	11.0	0.1	0.013	95.662	95.654	0.20	0.01	0.27	36.14	-0.03	1.1	93.81	93.81	1.85	0.26	34.80	0.01	12.0	93.85	93.85	1.81	0.22	29.45	-0.03	1.7	93.81	93.81	1.85
403	404	93.029	92.949	0.750	0.050	80.0	0.1	0.013	95.654	95.512	0.20	0.01	0.27	36.14	0.03	1.1	93.81	93.81	1.84	0.26	34.80	0.08	12.0	93.85	93.85	1.80	0.22	29.45	0.03	1.7	93.81	93.81	1.84
404	405	92.799	92.692	0.900	0.050	106.5	0.1	0.013	95.512	95.350	0.20	0.01	0.48	53.17	0.11	1.1	93.81	93.81	1.70	0.45	49.85	0.15	12.0	93.85	93.85	1.66	0.39	43.20	0.11	1.7	93.81	93.81	1.70
405	406	92.672	92.570	0.900	0.050	68.0	0.2	0.013	95.350	95.251	0.25	0.01	0.81	73.26	0.24	1.1	93.81	93.81	1.54	0.75	67.83	0.28	12.0	93.85	93.85	1.50	0.66	59.69	0.24	1.7	93.81	93.81	1.54
406	407	92.550	92.484	0.900	0.050	66.5	0.1	0.013	95.251	95.156	0.20	0.01	0.81	89.72	0.36	1.1	93.81	93.81	1.44	0.74	81.97	0.40	12.0	93.85	93.85	1.40	0.65	72.00	0.36	1.7	93.81	93.81	1.44
407	408	92.434	92.416	0.900	1.800	17.5	0.1	0.013	95.156	95.163	1.09	1.77	2.15	1.22	0.48	1.1	93.81	93.81	1.34	1.90	1.08	0.52	12.0	93.85	93.85	1.31	1.72	0.97	0.48	1.7	93.81	93.81	1.34
408	Pond1	92.366	92.350	0.900	1.800	16.5	0.1	0.013	95.163	94.500	1.09	1.77	2.14	1.21	0.55	1.1	93.81	93.81	1.35	1.89	1.07	0.58	12.0	93.85	93.85	1.31	1.71	0.97	0.55	1.7	93.81	93.81	1.35
500	501	93.825	93.744	0.750	0.050	81.0	0.1	0.013	96.057	95.933	0.20	0.01	0.27	36.14	-0.05	1.0	94.52	94.49	1.53	0.25	33.46	-0.10	12.0	94.48	94.45	1.58	0.22	29.45	-0.29	1.7	94.28	94.22	1.77
501	502	93.724	93.652	0.750	0.050	71.5	0.1	0.013	95.933	95.825	0.20	0.01	0.26	34.80	0.01	1.2	94.49	94.44	1.45	0.24	32.13	-0.03	12.2	94.45	94.41	1.49	0.22	29.45	-0.25	1.7	94.22	94.17	1.71
502	503	93.572	93.561	0.825	0.050	11.0	0.1	0.013	95.825	95.801	0.20	0.01	0.38	46.07	0.04	1.2	94.44	94.42	1.38	0.36	43.64	0.01	12.1	94.41	94.39	1.42	0.32	38.79	-0.23	1.7	94.17	94.14	1.66
503	504	93.511	93.450	0.825	0.050	61.0	0.1	0.013	95.801	95.693	0.20	0.01	0.38	46.07	0.09	1.2	94.42	94.37	1.38	0.36	43.64	0.06	12.2	94.39	94.35	1.41	0.32	38.79	-0.19	1.7	94.14	94.10	1.66
504	505	93.400	93.389	0.825	0.050	11.0	0.1	0.013	95.693	95.684	0.20	0.01	0.39	47.28	0.15	1.2	94.37	94.36	1.32	0.36	43.64	0.12	12.3	94.35	94.34	1.34	0.33	40.00	-0.13	1.7	94.10	94.09	1.59
505	506	93.339	93.303	0.825	0.050	36.0	0.1	0.013	95.684	95.652	0.20	0.01	0.39	47.28	0.19	1.2	94.36	94.30	1.33	0.38	46.07	0.17	12.3	94.34	94.29	1.35	0.33	40.00	-0.08	1.7	94.09	94.04	1.60
506	507	93.223	93.147	0.900	0.050	76.0	0.1	0.013	95.652	95.540	0.20	0.01	0.60	66.46	0.18	1.2	94.30	94.22	1.35	0.55	60.92	0.16	12.2	94.29	94.22	1.36	0.50	55.39	-0.08	1.7	94.04	93.99	1.61
507	508	92.997	92.917	1.050	0.050	79.5	0.1	0.013	95.540	95.420	0.20	0.01	0.97	91.64	0.18	1.2	94.22	94.06	1.32	0.91	85.97	0.17	12.1	94.22	94.07	1.32	0.82	77.47	-0.05	1.7	93.99	93.86	1.55
508	509	92.897	92.867	1.050	0.050	30.0	0.1	0.013	95.420	95.371	0.20	0.01	0.99	93.53	0.11	1.2	94.06	93.93	1.36	0.93	87.86	0.13	12.1	94.07	93.97	1.35	0.84	79.35	-0.09	1.7	93.86	93.81	1.56
509	510	92.717	92.644	1.200	0.050	72.5	0.1	0.013	95.371	95.266	0.20	0.01	1.25	102.93	0.01	1.2	93.93	93.86	1.44	1.18	97.17	0.05	12.1	93.97	93.91	1.40	1.07	88.11	-0.11	1.7	93.81	93.81	1.56
510	511	92.624	92.537	1.200	0.050	86.5	0.1	0.013	95.266	95.070	0.20	0.01	1.41	116.11	0.03	1.1	93.86	93.81	1.41	1.32	108.70	0.08	12.1	93.91	93.85	1.36	1.20	98.82	-0.01	1.7	93.81	93.81	1.45
511	611	92.517	92.410	1.200	0.050	106.5	0.1	0.013	95.070	95.018	0.20	0.01	1.61	132.58	0.09	1.1	93.81	93.81	1.26	1.50	123.52	0.13	12.1	93.85	93.85	1.22	1.36	111.99	0.09	1.7	93.81	93.81	1.26
601	602	93.612	93.544	0.600	0.050	68.5	0.1	0.013	96.059	95.737	0.20	0.01	0.20	33.81	-0.16	1.1	94.05	93.91	2.01	0.19	32.12	-0.17	12.0	94.04	93.90	2.02	0.16	27.05	-0.22	1.7	93.99	93.85	2.07
602	603	93.469	93.458	0.675	0.050	11.0	0.1	0.013	95.737	95.682	0.20	0.01	0.20	29.88	-0.23	1.1	93.91	93.89	1.82	0.19	28.39	-0.24	12.0	93.90	93.88	1.83	0.16	23.91	-0.30	1.7	93.85	93.82	1.89
603	604	93.383	93.315	0.750	0.050	68.5	0.1	0.013	95.682	95.700	0.20	0.01	0.29	38.82	-0.25	1.1	93.89	93.82	1.80	0.28	37.48	-0.25	12.0	93.88	93.85	1.80	0.25	33.46	-0.31	1.7	93.82	93.81	1.86
604	605	93.165	93.089	0.900	0.050	76.5	0.1	0.013	95.700	95.590	0.20	0.01	0.52	57.60	-0.25	1.1	93.82	93.82	1.88	0.50	55.39	-0.21	12.0	93.85	93.85	1.85	0.44	48.74	-0.25	1.7	93.81	93.81	1.89

Table 6: Pipe Data and Hydraulic Simulation Results [1]

U/S MH	D/S MH	U/S Invert (m)	D/S Invert (m)	Pipe Diameter / Height (m)	Pipe Width (m)	Pipe Length (m)	Pipe Slope (%)	n	U/S MH Cover Elev. (m)	D/S MH Cover Elev. (m)	Design Velocity (m/s)	Design Flow (m^3/s)	100-year, 3-hour Chicago Storm + 20%							100-year, 12-hour SCS Type II Storm + 20%							July 1st, 1979 Historical Event						
													Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)
605	606	92.939	92.859	1.050	0.050	79.5	0.1	0.013	95.590	95.470	0.20	0.01	0.74	69.91	-0.17	1.1	93.82	93.81	1.78	0.70	66.13	-0.14	12.0	93.85	93.85	1.74	0.62	58.57	-0.18	1.7	93.81	93.81	1.78
606	607	92.709	92.629	1.200	0.050	79.5	0.1	0.013	95.470	95.350	0.20	0.01	1.00	82.35	-0.10	1.1	93.81	93.81	1.66	0.94	77.41	-0.06	12.0	93.85	93.85	1.62	0.84	69.17	-0.10	1.7	93.81	93.81	1.66
607	608	92.609	92.540	1.200	0.050	69.0	0.1	0.013	95.350	95.247	0.20	0.01	1.10	90.58	0.00	1.1	93.81	93.81	1.54	1.03	84.82	0.04	12.0	93.85	93.85	1.50	0.92	75.76	0.00	1.7	93.81	93.81	1.54
608	609	92.520	92.509	1.200	0.050	11.0	0.1	0.013	95.247	95.245	0.20	0.01	1.10	90.58	0.09	1.1	93.81	93.81	1.44	1.02	83.99	0.13	12.1	93.85	93.85	1.40	0.92	75.76	0.09	1.7	93.81	93.81	1.44
609	610	92.489	92.455	1.200	0.050	34.5	0.1	0.013	95.245	95.186	0.20	0.01	1.26	103.76	0.12	1.1	93.81	93.81	1.43	1.18	97.17	0.16	12.1	93.85	93.85	1.40	1.05	86.47	0.12	1.7	93.81	93.81	1.43
610	611	92.435	92.410	1.200	0.050	25.0	0.1	0.013	95.186	95.018	0.20	0.01	1.52	125.17	0.18	1.1	93.81	93.81	1.38	1.42	116.93	0.21	12.1	93.85	93.85	1.34	1.26	103.76	0.18	1.7	93.81	93.81	1.37
611	612	92.390	92.368	1.200	1.800	22.0	0.1	0.013	95.018	94.849	1.23	2.66	3.11	1.17	0.22	1.1	93.81	93.81	1.21	2.90	1.09	0.26	12.1	93.85	93.85	1.17	2.60	0.98	0.22	1.7	93.81	93.81	1.21
612	Pond1	92.368	92.350	1.200	1.800	18.0	0.1	0.013	94.849	94.500	1.23	2.66	3.11	1.17	0.24	1.1	93.81	93.81	1.04	2.89	1.09	0.28	12.1	93.85	93.85	1.00	2.60	0.98	0.25	1.7	93.81	93.81	1.04
704	705	93.440	93.368	1.200	0.050	71.5	0.1	0.013	96.440	96.330	0.20	0.01	1.00	82.35	-0.32	1.1	94.32	94.26	2.12	0.97	79.88	-0.37	12.0	94.27	94.21	2.17	0.82	67.53	-0.48	1.7	94.16	94.09	2.28
705	706	93.348	93.281	0.900	2.400	67.0	0.1	0.013	96.330	96.233	1.16	2.50	2.81	1.13	0.01	1.1	94.26	94.17	2.07	2.68	1.07	-0.04	12.0	94.21	94.14	2.13	2.32	0.93	-0.16	1.7	94.09	94.03	2.24
706	707	93.161	93.077	1.200	2.400	83.5	0.1	0.013	96.233	96.110	1.32	3.80	2.92	0.77	-0.19	1.1	94.17	94.03	2.06	2.78	0.73	-0.23	12.1	94.14	93.99	2.10	2.42	0.64	-0.33	1.7	94.03	93.89	2.20
707	708	92.997	92.927	1.200	2.400	70.0	0.1	0.013	96.110	96.000	1.32	3.80	3.54	0.93	-0.17	1.1	94.03	93.97	2.08	3.37	0.89	-0.21	12.1	93.99	93.94	2.12	2.95	0.78	-0.31	1.7	93.89	93.83	2.22
708	709	92.907	92.841	1.200	2.400	66.0	0.1	0.013	96.000	95.901	1.32	3.80	3.67	0.96	-0.13	1.1	93.97	93.93	2.03	3.49	0.92	-0.17	12.1	93.94	93.89	2.06	3.05	0.80	-0.27	1.7	93.83	93.81	2.17
709	710	92.821	92.751	1.200	2.400	70.5	0.1	0.013	95.901	95.796	1.32	3.80	3.74	0.98	-0.10	1.1	93.93	93.81	1.98	3.55	0.93	-0.13	12.1	93.89	93.85	2.01	3.11	0.82	-0.21	1.7	93.81	93.81	2.09
710	711	92.671	92.540	1.200	2.400	131.0	0.1	0.013	95.796	94.828	1.32	3.80	4.19	1.10	-0.06	1.2	93.81	93.81	1.98	3.95	1.04	-0.02	12.1	93.85	93.85	1.95	3.48	0.92	-0.06	1.7	93.81	93.81	1.98
711	712	92.460	92.438	1.200	2.400	21.5	0.1	0.013	94.828	94.704	1.32	3.80	4.18	1.10	0.15	1.2	93.81	93.82	1.02	3.90	1.03	0.19	12.1	93.85	93.85	0.98	3.47	0.91	0.15	1.7	93.81	93.83	1.02
712	Pond1	92.358	92.350	1.200	2.400	8.5	0.1	0.013	94.704	94.500	1.32	3.80	4.18	1.10	0.26	1.2	93.82	93.81	0.88	3.88	1.02	0.29	12.1	93.85	93.85	0.85	3.46	0.91	0.28	1.7	93.83	93.81	0.87
806	807	93.455	93.423	0.675	0.050	21.5	0.2	0.013	96.004	95.954	0.24	0.01	0.08	9.76	-0.21	1.1	93.92	93.91	2.08	0.07	8.54	-0.23	12.0	93.90	93.89	2.11	0.07	8.54	-0.30	1.7	93.83	93.82	2.18
807	808	93.343	93.290	0.675	0.050	35.5	0.2	0.013	95.954	95.872	0.24	0.01	0.28	34.16	-0.10	1.1	93.91	93.86	2.04	0.27	32.94	-0.13	12.0	93.89	93.85	2.06	0.23	28.06	-0.20	1.7	93.82	93.81	2.13
808	809	93.215	93.199	0.750	0.050	11.0	0.2	0.013	95.872	95.844	0.24	0.01	0.46	50.27	-0.10	1.1	93.86	93.81	2.01	0.45	49.18	-0.11	12.0	93.85	93.85	2.02	0.38	41.53	-0.15	1.7	93.81	93.81	2.06
809	710	93.149	93.121	0.750	0.050	18.5	0.2	0.013	95.844	95.796	0.24	0.01	0.46	50.27	-0.09	1.1	93.81	93.81	2.03	0.45	49.18	-0.05	12.0	93.85	93.85	1.99	0.38	41.53	-0.09	1.7	93.81	93.81	2.03
901	902	94.241	94.180	0.600	0.050	60.5	0.1	0.013	96.649	96.550	0.20	0.01	0.14	23.67	-0.09	1.1	94.75	94.72	1.90	0.14	23.67	-0.14	12.1	94.71	94.67	1.94	0.13	21.98	-0.20	1.7	94.65	94.60	2.00
902	903	94.130	94.068	0.600	0.050	62.5	0.1	0.013	96.550	96.461	0.20	0.01	0.15	25.36	-0.01	1.2	94.72	94.68	1.83	0.14	23.67	-0.06	12.1	94.67	94.64	1.88	0.13	21.98	-0.13	1.7	94.60	94.57	1.95
903	904	93.993	93.982	0.675	0.050	11.0	0.1	0.013	96.461	96.443	0.20	0.01	0.16	23.91	0.01	1.2	94.68	94.67	1.78	0.14	20.92	-0.03	12.1	94.64	94.63	1.82	0.13	19.42	-0.10	1.7	94.57	94.56	1.89
904	905	93.907	93.842	0.750	0.050	65.0	0.1	0.013	96.443	96.344	0.20	0.01	0.60	80.31	0.02	1.1	94.67	94.48	1.77	0.58	77.64	-0.02	12.0	94.63	94.50	1.81	0.51	68.27	-0.09	1.7	94.56	94.41	1.88
905	906	93.822	93.760	0.750	0.050	61.5	0.1	0.013	96.344	96.250	0.20	0.01	0.60	80.31	-0.09	1.1	94.48	94.30	1.87	0.58	77.64	-0.07	12.0	94.50	94.50	1.84	0.51	68.27	-0.16	1.7	94.41	94.34	1.93
906	907	93.310	93.272	1.200	0.050	38.5	0.1	0.013	96.250	96.174	0.20	0.01	1.38	113.64	-0.21	1.1	94.30	94.30	1.95	1.33	109.52	-0.01	12.0	94.50	94.50	1.75	1.16	95.52	-0.17	1.7	94.34	94.34	1.91
907	Pond2	93.222	93.200	1.200	0.050	21.5	0.1	0.013	96.174	96.000	0.20	0.01	1.38	113.64	-0.12	1.1	94.30	94.30	1.87	1.32	108.70	0.08	12.0	94.50	94.50	1.67	1.14	93.88	-0.08	1.7	94.34	94.34	1.83
1001	1002	94.612	94.539	0.750	0.050	72.5	0.1	0.013	96.925	96.816	0.20	0.01	0.30	40.16	-0.11	1.2	95.26	95.17	1.67	0.28	37.48	-0.16	12.1	95.20	95.11	1.72	0.25	33.46	-0.25	1.7	95.11	94.99	1.82
1002	1003	94.459	94.382	0.750	0.050	77.0	0.1	0.013	96.816	96.699	0.20	0.01	0.31	41.50	-0.04	1.2	95.17	95.12	1.64	0.29	38.82	-0.10	12.1	95.11	95.06	1.71	0.26	34.80	-0.22	1.7	94.99	94.94	1.82
1003	1004	94.232	94.160	0.900	0.050	71.5	0.1	0.013	96.699	96.591	0.20	0.01	0.59	65.35	-0.01	1.2	95.12	95.05	1.58	0.56	62.03	-0.07	12.1	95.06	95.00	1.64	0.49	54.28	-0.19	1.7	94.94	94.89	1.76
1004	1005	94.010	93.936	1.050	0.050	74.0	0.1	0.013	96.591	96.478	0.20	0.01	0.87	82.19	-0.01	1.1	95.05	94.91	1.54	0.84	79.35	-0.06	12.1	95.00	94.87	1.59	0.73	68.96	-0.17	1.7	94.89	94.77	1.70
1005	1006	93.786	93.715	1.200	0.050	71.0	0.1	0.013	96.478	96.370	0.20	0.01	1.57	129.29	-0.08	1.1	94.91	94.59	1.57	1.51	124.34	-0.12	12.1	94.87	94.57	1.61	1.31	107.88	-0.22	1.7	94.77	94.48	1.71
1006	1007	93.565	93.499	1.350	0.050	66.5	0.1	0.013	96.370	96.311	0.20	0.01	2.25	164.21	-0.32	1.1	94.59	94.41	1.78	2.15	156.91	-0.35	12.0	94.57	94.51	1.80	1.87	136.47	-0.43	1.7	94.48	94.35	1.89
1007	1008	93.349	93.303	1.500	0.050	46.0	0.1	0.013	96.311	96.054	0.20	0.02	2.47	161.85	-0.44	1.1	94.41	94.31	1.91	2.37	155.30	-0.34	12.0	94.51	94.51	1.80	2.06	134.98	-0.50	1.7	94.35	94.35	1.96
1008	Pond2	93.223	93.200	1.500	2.400	23.0	0.1	0.013	96.054	96.000	1.45	5.23	4.67	0.89	-0.42	1.1	94.31	94.30	1.75	4.27	0.82	-0.22	12.1	94.51	94.50	1.55	2.42	0.46	-0.38	1.7	94.35	94.34	1.71
1101	1102	94.790	94.671	0.675	0.050	119.0	0.1	0.013	97.020	96.819	0.20	0.01	0.28	41.84	-0.15	1.0	95.32	95.12	1.70	0.27	40.34	-0.16	12.0	95.30	95.10	1.72	0.23	34.37	-0.22	1.7	95.25	95.04	1.77
1102	1103	94.596	94.588	0.750	0.050	8.0	0.1	0.013	96.819	96.790	0.20	0.01	0.28	37.48	-0.23	1.1	95.12	95.09	1.70	0.27	36.14	-0.25	12.0	95.10	95.07	1.72	0.24	32.13	-0.31	1.7	95.04	95.01	1.78
1103	1104	94.438	94.372	0.900	0.050	65.5	0.1	0.013	96.790	96.731	0.20	0.01	0.49	54.28	-0.25	1.1	95.09	95.03	1.70	0.47	52.06	-0.27	12.0	95.07	95.01	1.72	0.40	44.31	-0.33	1.7	95.01	94.95	1.78
1104	1105	94.322	94.250	0.900	0.050	71.5	0.1	0.013	96.731	96.602	0.20	0.01	0.58	64.25	-0.19	1.1	95.03	94.80	1.70	0.56	62.03	-0.21	12.0	95.01	94.79	1.72	0.49	54.28	-0.27	1.7	94.95	94.74	1.78
1105	1106	94.200	94.146	0.900	0.050	54.5	0.1	0.013	96.602	96.521	0.20	0.01	0.58	64.25	-0.30	1.1	94.80	94.61	1.80	0.56	62.03	-0.31	12.1	94.79	94.61	1.81	0.49	54.28	-0.36	1.7	94.74	94.55	1.86
1106	1107	93.846	93.839	1.200	0.050	7.0	0.1	0.013	96.521	96.505	0.20	0.01	1.04	85.64	-0.43	1.1	94.61	94.55	1.91	0.99	81.52	-0.44	12.0	94.61	94.56	1.91	0.87	71.64	-0.50	1.7	94.55	94.49	1.97
1107	1108	93.819	93.705	1.200	0.050	113.5	0.1	0.013	96.505	96.334	0.20	0.01	1.04	85.64	-0.47	1.1	94.55	94.33	1.95	0.99	81.52	-0.46	12.0	94.56	94.50	1.94	0.87	71.64	-0.53	1.7	94.49	94.34	2.01
1108	1109	93.405	93.331	1.500	2.400	73.5	0.1	0.013	96.334	96.509	1.45	5.23	4.79	0.92	-0.57	1.1	94.33	94.30	2.00	4.53	0.87	-0.40	12.1	94.50	94.50	1.83	4.05	0.77	-0.56	1.7	94.34	94.34	1.99
1109	1110	93.311	93.243	1.500	3.000	67.5	0.1	0.013	96.509	96.079	1.53	6.90	4.79	0.69	-0.51	1.1	94.30	94.30	2.21	4.47	0.65	-0.31	12.1	94.50	94.50	2.01	4.01	0.58	-0.47	1.7	94.34	94.34	2.17
1110	Pond2	93.223	93.200	1.500	3.000	22.5	0.1	0.013	96.079	96.000	1.53	6.90	4.77	0.69	-0.42	1.1	94.30	94.30	1.78	4.41	0.64	-0.22	12.1	94.50	94.50	1.58	3.96	0.57	-0.38	1.7	94.34	94.34	1.74
1201	1202	95.621	95.569	0.825	0.050	51.5	0.1	0.013	97.701	97.772	0.20	0.01	0.40	48.49	-0.23	1.0	96.22	96.16	1.49	0.38	46.07	-0.28	12.0	96.16	96.09	1.54	0.32	38.79	-0.34	1.7	96.10	96.00	1.60
1202	1203	95.519	95.508	0.825	0.050	11.0	0.1	0.013	97.772	97.736	0.20	0.01	0.39	47.28	-0.19	1.0	96.16	96.13	1.62	0.37	44.85	-0.26	12.0	96.09	96.06	1.69	0.32	38.79	-0.35	1.7	96.00	95.95	1.78
1203	1204	95.358	95.290	0.975	0.050	67.5	0.1	0.013	97.736	97.517	0.20	0.01	0.58	59.14	-0.20	1.0	96.13	96.09	1.60	0.56	57.11	-0.28	12.0	96.06	96.01	1.68	0.49	49.97	-0.38	1.7	95.95	95.88	1.79
1204	1205	95.270	95.196	0.975	0.050	67.5	0.1	0.013	97.517	97.421	0.21	0.01	0.57	55.42	-0.15	1.0	96.09	96.04	1.43	0.55	53.48	-0.24	12.0	96.01	95.95	1.51	0.49	47.64	-0.36	1.7	95.88	95.80	1.63
1205	1206	95.146	95.135	0.975	0.050	11.0	0.1	0.013	97.421	97.398	0.20	0.01	0.69	70.36	-0.08	1.0	96.04	96.01	1.38	0.66	67.30	-0.17	12.0	95.95	95.92	1.47	0.60	61.18	-0.32	1.7	95.80	95.75	1.62
1206	1207	95.085	95.029	0.975	0.050	56.0	0.1	0.013	97.398	96.759	0.20	0.01	0.68	69.34	-0.05	1.2	96.01	95.95	1.39	0.65	66.28	-0.14	12.0	95.92	95.85	1.48	0.60	61.18	-0.31	1.7	95.75	95.66	1.65
1207	1208	94.979	94.968	0.975	0.050	11.0	0.1	0.013	96.759	97.245	0.20	0.01	0.69	70.36	0.00	1.2	95.95	95.93	0.81	0.66	67.30	-0.10	12.2	95.85	95.83	0.91	0.60	61.18	-0.30	1.7	95.66	95.62	1.10
1208	1209	94.918	94.882	0.975	0.050	36.0	0.1	0.013	97.245	97.244	0.20	0.01	0.69	70.36	0.03	1.2	95.93	95.88	1.32	0.67	68.32	-0.07	12.2	95.83	95.78	1.42	0.60	61.18	-0.28	1.7	95.62	95.56	1.63
1209	1210	94.807	94.799	1.050	0.050	7.5	0.1	0.013	97.244	97.231	0.20	0.01	0.83	78.41	0.02	1.2	95.88	95.85	1.37	0.80	75.58	-0.07	12.2	95.78	95.76	1.46	0.71	67.07	-0.30	1.7	95.56	95.52	1.69
1210	1211	94.749	94.720	1.050	0.050	29.0	0.1	0.013	97.231	96.720	0.20	0.01	0.83	78.41	0.05	1.2	95.85	95.81	1.38	0.81	76.52	-0.04	12.2	95.76	95.72	1.47	0.71	67.07	-0.28	1.7	95.52	95.47	1.71

Table 6: Pipe Data and Hydraulic Simulation Results [1]

U/S MH	D/S MH	U/S Invert (m)	D/S Invert (m)	Pipe Diameter / Height (m)	Pipe Width (m)	Pipe Length (m)	Pipe Slope (%)	n	U/S MH Cover Elev. (m)	D/S MH Cover Elev. (m)	Design Velocity (m/s)	Design Flow (m^3/s)	100-year, 3-hour Chicago Storm + 20%							100-year, 12-hour SCS Type II Storm + 20%							July 1st, 1979 Historical Event						
													Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)	Peak Pipe Flow (m^3/s)	Peak / Design Flow	Surcharge U/S [2] (m)	Time to Peak (h)	Max. U/S HGL (m)	Max. D/S HGL (m)	Freeboard U/S HGL and MH Cover (m)
1211	1212	94.670	94.662	1.050	0.050	7.5	0.1	0.013	96.720	96.710	0.20	0.01	0.83	78.41	0.09	1.2	95.81	95.79	0.91	0.82	77.47	0.00	12.2	95.72	95.70	1.00	0.71	67.07	-0.25	1.7	95.47	95.45	1.25
1212	1213	94.582	94.518	1.050	0.050	64.0	0.1	0.013	96.710	97.080	0.20	0.01	0.84	79.35	0.16	1.3	95.79	95.74	0.92	0.85	80.30	0.07	12.2	95.70	95.65	1.01	0.71	67.07	-0.19	1.7	95.45	95.40	1.26
1213	1214	94.368	94.296	1.200	0.050	71.5	0.1	0.013	97.080	96.970	0.20	0.01	1.19	97.99	0.17	1.2	95.74	95.67	1.35	1.16	95.52	0.08	12.2	95.65	95.59	1.43	1.03	84.82	-0.16	1.7	95.40	95.36	1.68
1214	1215	94.276	94.204	1.200	0.050	71.5	0.1	0.013	96.970	96.870	0.20	0.01	1.39	114.46	0.20	1.2	95.67	95.50	1.30	1.35	111.17	0.11	12.2	95.59	95.42	1.38	1.20	98.82	-0.12	1.7	95.36	95.20	1.61
1215	1216	94.054	93.982	1.350	0.050	71.5	0.1	0.013	96.870	96.760	0.20	0.01	1.85	135.01	0.09	1.2	95.50	95.42	1.37	1.79	130.64	0.01	12.2	95.42	95.34	1.45	1.60	116.77	-0.20	1.7	95.20	95.14	1.67
1216	1217	93.832	93.748	1.500	0.050	84.5	0.1	0.013	96.760	96.630	0.20	0.02	2.52	165.13	0.08	1.2	95.42	95.31	1.35	2.41	157.92	0.01	12.1	95.34	95.24	1.42	2.17	142.19	-0.19	1.7	95.14	95.07	1.62
1217	1218	93.728	93.645	1.500	0.050	83.0	0.1	0.013	96.630	96.510	0.20	0.02	2.81	184.13	0.08	1.1	95.31	95.18	1.32	2.69	176.27	0.01	12.1	95.24	95.11	1.39	2.42	158.57	-0.16	1.7	95.07	94.98	1.57
1218	1219	93.625	93.579	1.500	0.050	46.5	0.1	0.013	96.510	96.440	0.20	0.02	2.90	190.03	0.05	1.2	95.18	95.10	1.33	2.77	181.51	-0.01	12.1	95.11	95.04	1.40	2.49	163.16	-0.15	1.7	94.98	94.92	1.53
1219	1108	93.559	93.485	1.500	0.050	74.0	0.1	0.013	96.440	96.334	0.20	0.02	3.45	226.07	0.04	1.1	95.10	94.33	1.34	3.29	215.58	-0.02	12.1	95.04	94.50	1.40	2.95	193.30	-0.14	1.7	94.92	94.34	1.52
1500	1501	92.698	92.577	1.200	1.800	120.0	0.1	0.013	95.911	95.724	1.23	2.66	4.30	1.62	0.75	2.9	94.65	94.34	1.27	5.20	1.96	1.26	13.5	95.16	94.70	0.76	4.40	1.65	0.78	3.0	94.68	94.36	1.23
1501	214	92.577	92.442	1.200	1.800	135.0	0.1	0.013	95.724	95.617	1.23	2.66	4.30	1.62	0.56	2.9	94.34	94.00	1.39	5.20	1.96	0.92	13.5	94.70	94.18	1.03	4.40	1.65	0.58	3.0	94.36	94.01	1.37
1600	1601	94.197	94.025	1.200	1.800	107.6	0.2	0.013	96.992	96.885	1.56	3.36	2.58	0.77	-0.41	1.0	94.99	94.78	2.01	2.61	0.78	-0.26	14.0	95.14	95.03	1.86	2.12	0.63	-0.46	3.5	94.94	94.80	2.05
1601	1602	94.025	93.783	1.200	1.800	95.0	0.2	0.013	96.885	96.790	1.56	3.36	2.50	0.74	-0.44	1.0	94.78	94.69	2.10	2.61	0.78	-0.20	14.0	95.03	94.96	1.86	2.12	0.63	-0.43	3.5	94.80	94.71	2.09
1602	1603	93.783	93.721	1.200	1.800	95.0	0.2	0.013	96.790	96.695	1.56	3.36	2.40	0.71	-0.29	1.0	94.69	94.61	2.10	2.61	0.78	-0.03	14.1	94.96	94.86	1.83	2.12	0.63	-0.27	3.5	94.71	94.63	2.08
1603	1604	93.721	93.569	1.200	1.800	95.0	0.2	0.013	96.695	96.600	1.56	3.36	2.30	0.68	-0.31	1.1	94.61	94.54	2.08	2.61	0.78	-0.06	14.1	94.86	94.78	1.83	2.12	0.63	-0.29	3.5	94.63	94.57	2.07
1604	1605	93.569	93.431	1.200	1.800	86.5	0.2	0.013	96.600	96.513	1.56	3.36	2.24	0.67	-0.23	1.1	94.54	94.38	2.06	2.60	0.77	0.01	14.1	94.78	94.60	1.82	2.12	0.63	-0.20	3.5	94.57	94.41	2.04
1605	1008	93.431	93.359	1.200	1.800	71.9	0.1	0.013	96.513	96.054	1.23	2.66	2.22	0.83	-0.25	1.1	94.38	94.31	2.13	2.60	0.98	-0.03	14.1	94.60	94.51	1.92	2.12	0.80	-0.22	3.5	94.41	94.35	2.10
Pond1	P1out	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.68	N/A	N/A	N/A	N/A	N/A	N/A	5.45	N/A	N/A	N/A	N/A	N/A	N/A	3.69	N/A	N/A	N/A	N/A	N/A	N/A
Pond2	P2out	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.10	N/A	N/A	N/A	N/A	N/A	N/A	2.66	N/A	N/A	N/A	N/A	N/A	N/A	2.23	N/A	N/A	N/A	N/A	N/A	N/A
1000	1001	94.705	94.632	0.750	N/A	72.5	0.1	0.013	97.034	96.925	0.80	0.35	0.30	0.85	-0.15	1.1	95.31	95.26	1.73	0.29	0.82	-0.19	12.0	95.26	95.20	1.77	0.25	0.71	-0.28	1.7	95.18	95.11	1.86

Note: [1] Based on restrictive downstream conditions; Summer = 93.68 m / Spring = 94.11 m for Pond 1, and Spring = 94.18 for Pond 2. All other results based on free outfall conditions.

[2] A negative surcharge implies that the pipe is not flowing full

0.47	Freeboard less than 0.5 m.

ATTACHMENT

6

FLOWS AND WATER LEVELS ON THE VAN GAAL DRAIN UNDER EXISTING AND PROPOSED CONDITIONS

JFSA Water Resources and Environmental Consultants

Table 7A: Existing and Proposed Conditions Flows on the Van Gaal Drain, Arbuckle Drain and Jock River [1]

River	Reach	River Station	Flow (m^3/s)						Difference in Flow (%)		
			Existing Conditions			Proposed Conditions					
			1	2	4	1	2	4	1	2	4
Jock River	Reach 1	22026	5.540	167.682	156.00	5.611	162.984	156.00	1.3	-2.8	0.0
Jock River	Reach 2	21359	5.773	74.628	161.76	5.869	72.528	161.76	1.7	-2.8	0.0
Jock River	Reach 3	18677	17.624	88.341	166.76	16.476	86.722	166.76	-6.5	-1.8	0.0
Jock River	Reach 4	16872	15.385	85.979	181.76	14.226	84.621	181.76	-7.5	-1.6	0.0
Jock River	Reach 5	16112	16.168	143.467	180.00	14.972	142.622	180.00	-7.4	-0.6	0.0
Jock River	Reach 6	11769	10.864	153.565	185.00	10.459	152.944	185.00	-3.7	-0.4	0.0
Jock River	Reach 7	10144	8.741	152.939	196.00	8.675	152.211	196.00	-0.8	-0.5	0.0
Jock River	Reach 7	6550	9.652	189.823	201.00	9.584	189.856	201.00	-0.7	0.0	0.0
Jock River	Reach 7	3699	5.067	211.402	205.00	5.285	210.382	205.00	4.3	-0.5	0.0
Joys Road Trib	Reach 1	705	2.619	3.166	0.883	1.890	3.160	0.883	-27.8	-0.2	0.0
Moore Drain	Reach 2	555	0.9	0.683	0.033	0.046	0.074	0.001	-94.9	-89.2	-97.0
Moore Drain	Reach 1	298	2.172	2.132	0.322	1.426	1.671	0.143	-34.3	-21.6	-55.6
Moore Drain Trib	Reach 1	311 / 599	1.866	1.594	0.259	1.360	1.586	0.122	-27.1	-0.5	-52.8
Van Gaal Drain	Reach 3	3494	3.701	4.228	1.636	2.535	4.073	1.636	-31.5	-3.7	0.0
Van Gaal Drain	Reach 3	3322	4.021	4.588	1.651	2.857	4.488	1.651	-29.0	-2.2	0.0
Van Gaal Drain	Reach 3	3175	4.813	5.235	1.653	3.601	5.225	1.653	-25.2	-0.2	0.0
Van Gaal Drain	Reach 2	2554	7.272	8.316	2.857	5.289	8.182	2.857	-27.3	-1.6	0.0
Van Gaal Drain	Reach 2	2076	9.543	10.808	3.286	7.109	9.973	3.286	-25.5	-7.7	0.0
Van Gaal Drain	Reach 2	1340	11.434	11.619	3.426	7.141	10.024	3.424	-37.5	-13.7	-0.1
Van Gaal Drain	Reach 2	1312	12.2	12.204	3.439	7.141	10.024	3.424	-41.5	-17.9	-0.5
Van Gaal Drain	Reach 1	746	16.377	15.739	4.056	10.199	13.887	4.235	-37.7	-11.8	4.4
Van Gaal Drain	Reach 1	666	16.377	15.739	4.056	10.199	13.887	4.235	-37.7	-11.8	4.4
Van Gaal Drain	Reach 1	226	16.419	15.777	4.371	10.231	13.948	4.506	-37.7	-11.6	3.1

[1] Scenario Descriptions:

1. The Van Gaal Drain 100-year 24-hour SCS peak flow reaches the Jock River.
2. The Van Gaal Drain 100-year spring snowmelt plus rainfall peak flow reaches the Jock River.
4. The Jock River 100-year spring snowmelt plus rainfall peak flow reaches the outlet of the Van Gaal Drain.

Table 7B: Existing and Proposed Conditions Water Levels on the Van Gaal and Arbuckle Drains [(1)]

River	Reach	River Station	Maximum Water Surface Elevation (m)								
			Existing Conditions			Proposed Conditions			Difference		
			1	*2*	*4*	*1*	*2*	*4*	*1*	*2*	*4*
Van Gaal Drain	Reach 3	3494	97.56	97.60	97.16	97.39	97.59	97.16	-0.17	-0.01	0.00
Van Gaal Drain	Reach 3	3322	97.43	97.47	97.06	97.27	97.47	97.06	-0.16	0.00	0.00
Van Gaal Drain	Reach 3	3312	97.42	97.45	97.05	97.26	97.45	97.05	-0.16	0.00	0.00
Van Gaal Drain	Reach 3	3311	Culvert								
Van Gaal Drain	Reach 3	3302	97.33	97.35	97.01	97.17	97.35	97.01	-0.16	0.00	0.00
Van Gaal Drain	Reach 3	3297	97.27	97.32	96.98	97.11	97.32	96.98	-0.16	0.00	0.00
Van Gaal Drain	Reach 3	3185	97.17	97.26	96.56	96.94	97.26	96.56	-0.23	0.00	0.00
Van Gaal Drain	Reach 3	3175	97.16	97.23	96.59	96.94	97.23	96.59	-0.22	0.00	0.00
Van Gaal Drain	Reach 3	3174	Culvert								
Van Gaal Drain	Reach 3	3165	96.75	96.74	96.55	96.72	96.74	96.55	-0.03	0.00	0.00
Van Gaal Drain	Reach 3	3149	96.72	96.72	96.51	96.67	96.72	96.51	-0.05	0.00	0.00
Van Gaal Drain	Reach 3	3086	96.65	96.63	96.40	96.59	96.63	96.40	-0.06	0.00	0.00
Van Gaal Drain	Reach 3	3016	96.61	96.59	96.33	96.55	96.59	96.32	-0.06	0.00	-0.01
Van Gaal Drain	Reach 3	2980	96.57	96.56	96.28	96.52	96.56	96.27	-0.05	0.00	-0.01
Van Gaal Drain	Reach 3	2851	96.41	96.42	96.03	96.30	96.41	95.99	-0.11	-0.01	-0.04
Van Gaal Drain	Reach 3	2808	96.38	96.39	96.01	96.26	96.39	95.95	-0.12	0.00	-0.06
Van Gaal Drain	Reach 3	2658	96.28	96.29	95.95	96.15	96.28	95.88	-0.13	-0.01	-0.07
Van Gaal Drain	Reach 2	2554	96.27	96.29	95.94	96.14	96.28	95.86	-0.13	-0.01	-0.08
Van Gaal Drain	Reach 2	2478	96.16	96.15	95.88	96.03	96.14	95.77	-0.13	-0.01	-0.11
Van Gaal Drain	Reach 2	2427.58*	N/A	N/A	N/A	95.95	96.04	95.71	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2377.17*	N/A	N/A	N/A	95.86	95.95	95.63	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2326.76*	N/A	N/A	N/A	95.77	95.87	95.53	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2276.35*	N/A	N/A	N/A	95.34	95.65	95.14	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2252	N/A	N/A	N/A	95.40	95.40	94.95	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2237	N/A	N/A	N/A	95.38	95.38	94.93	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2217	N/A	N/A	N/A	95.35	95.35	94.90	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2197	N/A	N/A	N/A	95.33	95.32	94.87	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2177	N/A	N/A	N/A	95.30	95.29	94.83	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2157	95.47	95.48	95.03	95.28	95.26	94.80	-0.19	-0.22	-0.23
Van Gaal Drain	Reach 2	2154	N/A	N/A	N/A	95.25	95.23	94.77	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2153	N/A	N/A	N/A	95.21	95.18	94.73	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2152	N/A	N/A	N/A	95.17	95.14	94.69	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2132	N/A	N/A	N/A	95.13	95.10	94.64	N/A	N/A	N/A

Table 7B: Existing and Proposed Conditions Water Levels on the Van Gaal and Arbuckle Drains [(1)]

River	Reach	River Station	Maximum Water Surface Elevation (m)								
			Existing Conditions			Proposed Conditions			Difference		
			1	*2*	*4*	*1*	*2*	*4*	*1*	*2*	*4*
Van Gaal Drain	Reach 2	2112	N/A	N/A	N/A	95.09	95.06	94.60	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2092	N/A	N/A	N/A	95.05	95.02	94.57	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2072	N/A	N/A	N/A	95.01	94.98	94.53	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2052	N/A	N/A	N/A	94.97	94.94	94.49	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2032	N/A	N/A	N/A	94.93	94.90	94.45	N/A	N/A	N/A
Van Gaal Drain	Reach 2	2002	N/A	N/A	N/A	94.87	94.85	94.40	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1982	N/A	N/A	N/A	94.83	94.81	94.37	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1962	N/A	N/A	N/A	94.79	94.77	94.34	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1942	N/A	N/A	N/A	94.75	94.73	94.32	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1922	N/A	N/A	N/A	94.71	94.70	94.29	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1902	N/A	N/A	N/A	94.67	94.66	94.27	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1882	N/A	N/A	N/A	94.64	94.63	94.25	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1862	N/A	N/A	N/A	94.60	94.60	94.23	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1842	N/A	N/A	N/A	94.57	94.56	94.22	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1822	N/A	N/A	N/A	94.53	94.53	94.21	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1802	N/A	N/A	N/A	94.50	94.50	94.20	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1782	N/A	N/A	N/A	94.47	94.48	94.19	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1762	N/A	N/A	N/A	94.43	94.45	94.18	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1742	N/A	N/A	N/A	94.40	94.42	94.17	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1722	N/A	N/A	N/A	94.38	94.40	94.17	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1702	N/A	N/A	N/A	94.35	94.38	94.16	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1682	N/A	N/A	N/A	94.32	94.36	94.16	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1662	N/A	N/A	N/A	94.30	94.34	94.15	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1642	N/A	N/A	N/A	94.27	94.32	94.15	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1622	N/A	N/A	N/A	94.25	94.30	94.15	N/A	N/A	N/A
Van Gaal Drain	Reach 2	1615	94.60	94.61	94.24	94.24	94.30	94.15	-0.36	-0.31	-0.09
Van Gaal Drain	Reach 2	1555	94.53	94.55	94.21	94.19	94.26	94.14	-0.34	-0.29	-0.07
Van Gaal Drain	Reach 2	1488	94.45	94.45	94.18	94.14	94.22	94.14	-0.31	-0.23	-0.04
Van Gaal Drain	Reach 2	1416	94.39	94.41	94.14	94.10	94.19	94.13	-0.29	-0.22	-0.01
Van Gaal Drain	Reach 2	1400	94.36	94.36	94.14	94.08	94.18	94.13	-0.28	-0.18	-0.01
Van Gaal Drain	Reach 2	1364	94.31	94.29	94.13	94.07	94.17	94.13	-0.24	-0.12	0.00
Van Gaal Drain	Reach 2	1340	94.21	94.19	94.13	94.00	94.06	94.12	-0.21	-0.13	-0.01
Van Gaal Drain	Reach 2	1339	Culvert								

Table 7B: Existing and Proposed Conditions Water Levels on the Van Gaal and Arbuckle Drains [(1)]

River	Reach	River Station	Maximum Water Surface Elevation (m)								
			Existing Conditions			Proposed Conditions			Difference		
			1	*2*	*4*	*1*	*2*	*4*	*1*	*2*	*4*
Van Gaal Drain	Reach 2	1312	94.14	94.12	94.12	93.99	94.04	94.12	-0.15	-0.08	0.00
Van Gaal Drain	Reach 2	1302	94.15	94.14	94.12	93.97	94.04	94.12	-0.18	-0.10	0.00
Van Gaal Drain	Reach 2	1268	94.14	94.14	94.12	93.93	94.01	94.12	-0.21	-0.13	0.00
Van Gaal Drain	Reach 2	1212	94.10	94.11	94.12	93.84	93.96	94.11	-0.26	-0.15	-0.01
Van Gaal Drain	Reach 2	1169	94.04	94.08	94.12	93.76	93.89	94.11	-0.28	-0.19	-0.01
Van Gaal Drain	Reach 2	1091	93.97	94.04	94.12	93.63	93.83	94.11	-0.34	-0.21	-0.01
Van Gaal Drain	Reach 2	1002	93.93	94.02	94.12	93.45	93.78	94.11	-0.48	-0.24	-0.01
Van Gaal Drain	Reach 2	961	93.92	94.02	94.12	93.37	93.77	94.11	-0.55	-0.25	-0.01
Van Gaal Drain	Reach 2	910	93.91	94.02	94.12	93.30	93.77	94.11	-0.61	-0.25	-0.01
Van Gaal Drain	Reach 2	840	93.91	94.02	94.12	93.27	93.76	94.11	-0.64	-0.26	-0.01
Van Gaal Drain	Reach 1	746	93.90	94.01	94.12	93.25	93.76	94.11	-0.65	-0.25	-0.01
Van Gaal Drain	Reach 1	705	93.89	94.01	94.11	93.20	93.76	94.11	-0.69	-0.25	0.00
Van Gaal Drain	Reach 1	668	93.84	93.99	94.11	92.79	93.73	94.11	-1.05	-0.26	0.00
Van Gaal Drain	Reach 1	666	93.32	93.68	94.10	92.71	93.59	94.10	-0.61	-0.09	0.00
Van Gaal Drain	Reach 1	656	Culvert								
Van Gaal Drain	Reach 1	647	93.07	93.58	94.10	92.85	93.59	94.10	-0.22	0.01	0.00
Van Gaal Drain	Reach 1	645	93.23	93.67	94.10	92.85	93.61	94.10	-0.38	-0.06	0.00
Van Gaal Drain	Reach 1	592	93.28	93.70	94.10	92.84	93.63	94.10	-0.44	-0.07	0.00
Van Gaal Drain	Reach 1	521	93.26	93.70	94.10	92.82	93.63	94.10	-0.44	-0.07	0.00
Van Gaal Drain	Reach 1	277	92.96	93.66	94.10	92.58	93.60	94.10	-0.38	-0.06	0.00
Van Gaal Drain	Reach 1	275	92.87	93.51	94.09	92.55	93.48	94.09	-0.32	-0.03	0.00
Van Gaal Drain	Reach 1	269	Culvert								
Van Gaal Drain	Reach 1	263	92.58	93.39	94.09	92.43	93.39	94.09	-0.15	0.00	0.00
Van Gaal Drain	Reach 1	226	92.40	93.44	94.09	92.06	93.43	94.09	-0.34	-0.01	0.00
Van Gaal Drain	Reach 1	0	91.28	93.45	94.09	91.25	93.44	94.09	-0.03	-0.01	0.00
Moore Drain Trib	Reach 1	600	N/A	N/A	N/A	96.47	96.52	95.21	N/A	N/A	N/A
Moore Drain Trib	Reach 1	553	N/A	N/A	N/A	96.47	96.52	95.20	N/A	N/A	N/A
Moore Drain Trib	Reach 1	503	N/A	N/A	N/A	96.47	96.52	95.19	N/A	N/A	N/A
Moore Drain Trib	Reach 1	492	N/A	N/A	N/A	96.42	96.48	95.18	N/A	N/A	N/A
Moore Drain Trib	Reach 1	477	Culvert								
Moore Drain Trib	Reach 1	462	N/A	N/A	N/A	96.06	96.27	95.05	N/A	N/A	N/A
Moore Drain Trib	Reach 1	453	N/A	N/A	N/A	96.09	96.31	95.05	N/A	N/A	N/A
Moore Drain Trib	Reach 1	403	N/A	N/A	N/A	96.09	96.31	95.04	N/A	N/A	N/A

Table 7B: Existing and Proposed Conditions Water Levels on the Van Gaal and Arbuckle Drains [(1)]

River	Reach	River Station	Maximum Water Surface Elevation (m)								
			Existing Conditions			Proposed Conditions			Difference		
			1	*2*	*4*	*1*	*2*	*4*	*1*	*2*	*4*
Moore Drain Trib	Reach 1	353	N/A	N/A	N/A	96.01	96.23	95.01	N/A	N/A	N/A
Moore Drain Trib	Reach 1	338.5	Culvert								
Moore Drain Trib	Reach 1	324	N/A	N/A	N/A	95.47	95.72	94.80	N/A	N/A	N/A
Moore Drain Trib	Reach 1	311	94.60	94.58	94.48	95.54	95.78	94.77	0.94	1.20	0.29
Moore Drain Trib	Reach 1	290	N/A	N/A	N/A	95.54	95.78	94.73	N/A	N/A	N/A
Moore Drain Trib	Reach 1	240	N/A	N/A	N/A	95.53	95.78	94.63	N/A	N/A	N/A
Moore Drain Trib	Reach 1	190	N/A	N/A	N/A	95.53	95.77	94.54	N/A	N/A	N/A
Moore Drain Trib	Reach 1	140	N/A	N/A	N/A	95.52	95.77	94.51	N/A	N/A	N/A
Moore Drain Trib	Reach 1	90	94.20	94.18	94.11	95.52	95.77	94.51	1.32	1.59	0.40
Moore Drain Trib	Reach 1	83	N/A	N/A	N/A	95.44	95.70	94.49	N/A	N/A	N/A
Moore Drain Trib	Reach 1	68	Culvert								
Moore Drain Trib	Reach 1	53	N/A	N/A	N/A	94.76	94.80	94.25	N/A	N/A	N/A
Moore Drain Trib	Reach 1	14	N/A	N/A	N/A	94.21	94.24	94.11	N/A	N/A	N/A
Moore Drain	Reach 2	555	94.67	94.63	94.33	94.35	94.38	94.21	-0.32	-0.25	-0.12
Moore Drain	Reach 2	500	94.44	94.41	94.23	94.24	94.26	94.17	-0.20	-0.15	-0.06
Moore Drain	Reach 1	298	93.90	94.02	94.12	93.82	93.82	94.11	-0.08	-0.20	-0.01
Moore Drain	Reach 1	130	93.91	94.02	94.12	93.27	93.77	94.11	-0.64	-0.25	-0.01
Joys Road Trib	Reach 1	705	97.59	97.79	97.11	97.35	97.78	97.11	-0.24	-0.01	0.00
Joys Road Trib	Reach 1	664	97.60	97.79	97.04	97.36	97.79	97.04	-0.24	0.00	0.00
Joys Road Trib	Reach 1	635	97.50	97.68	97.00	97.28	97.67	97.00	-0.22	-0.01	0.00
Joys Road Trib	Reach 1	634	Culvert								
Joys Road Trib	Reach 1	622	97.21	97.26	96.96	97.13	97.26	96.96	-0.08	0.00	0.00
Joys Road Trib	Reach 1	602	97.21	97.27	96.95	97.12	97.27	96.95	-0.09	0.00	0.00
Joys Road Trib	Reach 1	322	96.65	96.71	96.45	96.57	96.71	96.45	-0.08	0.00	0.00
Joys Road Trib	Reach 1	275	96.50	96.56	96.20	96.37	96.56	96.20	-0.13	0.00	0.00
Joys Road Trib	Reach 1	30	96.29	96.30	95.95	96.16	96.29	95.88	-0.13	-0.01	-0.07

[(1)] Scenario Descriptions:

1. The Van Gaal Drain 100-year 24-hour SCS peak flow reaches the Jock River.
2. The Van Gaal Drain 100-year spring snowmelt plus rainfall peak flow reaches the Jock River.
4. The Jock River 100-year spring snowmelt plus rainfall peak flow reaches the outlet of the Van Gaal Drain.

TECHNICAL MEMORANDUM

DATE October 3, 2012 **PROJECT No.** 12-1127-0062/4000

TO Frank Cairo
Richmond Village (South) Limited

CC Mike Green
Mattamy (Jock River) Limited

FROM Brian Byerley, P.Eng. **EMAIL** bbyerley@golder.com

UPDATED ASSESSMENT OF SUBSURFACE DRAINAGE AND ANALYSIS OF 100 YEAR FLOOD EVENT PROPOSED VILLAGE OF RICHMOND DEVELOPMENT OTTAWA, ONTARIO

Golder Associates Ltd. (Golder) was retained by Richmond Village (South) Limited (RVSL) to assess the hydrogeological effects of subsurface drainage for the proposed development by RVSL and Mattamy (Jock River) Limited (Mattamy) in the Village of Richmond, in Ottawa, Ontario. The development site extends northwesterly from the Jock River, on the west side of Richmond, for a distance of about 2.5 km. The overall objective of this work was to evaluate the suitability of the proposed drainage plan for the development (completed by David Schaeffer Engineering Ltd. (DSEL)) with respect to the hydrogeological conditions encountered at the site.

The current assessment was undertaken in order to estimate:

- The average long term groundwater conditions based on the proposed site drainage plan;
- The time to achieve the long term groundwater conditions;
- groundwater levels and groundwater inflows to the foundation drains during the 100 year storm event superimposed on the spring freshet; and,
- The maximum expected sump pump pumping rate (including snow melt and roof discharge).

The tasks involved in this assessment included a review of the available drainage plans, hydrogeological data, and previous work completed at the site. This technical memorandum includes a summary of the information that was reviewed and summarizes the results of the groundwater modelling analyses completed for this assessment.

Data Sources

Available data that was reviewed as a part of this study is summarized as follows:

- DSEL design drawings relating to the Richmond Village storm water management ponds (DSEL project 11-486, Figures 12 and 13), surface grading plan (DSEL project 11-486, Figure 3), storm servicing plan (DSEL project 11-486, Figure 4), and storm trunk profiles (DSEL project 11-486, Figures 5, 6, and 7);
- DSEL Storm Water Management Report (DSEL Project 11-486) dated April 2012 (DSEL, 2012);
- Borehole logs (Golder 2010a) and test pit logs (Jacques-Whitford, 2007);

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- Monthly groundwater elevations collected from site piezometers between April 2010 and April 2011, as summarized in Golder's August 11, 2011 technical memorandum to Susan Murphy (Golder, 2011);
- Results of hydraulic testing of the overburden and bedrock across the site, as summarized in Golder's July 16, 2010 memo to Susan Murphy (Golder, 2010a); and,
- Results of a previous modelling assessment of groundwater inflow to building foundations (Golder, 2010b).

In addition to the above, supplementary groundwater elevation data and hydraulic response testing data were collected in May 2012. Groundwater elevation data are included in Table 1 and shown in Figure 2, attached. Hydraulic response testing date are presented in the following section of this technical memorandum.

Hydraulic Testing

Single well response tests were conducted in on-site monitoring wells on May 3, 2010 as part of a previous hydrogeological investigation. Additional hydraulic testing was carried out on a subset of these monitoring wells on May 1, 2012 to confirm hydraulic conductivity (K) estimates of the overburden and shallow bedrock material within the study area. Static groundwater levels were established prior to testing. The rate of water level recovery in the monitoring well was measured following the addition (falling head test) or removal (rising head test) of a slug, displacing the water column by a known amount. Water level recovery in each monitoring well was measured manually and continuously (0.5 to 2 second interval) with a pressure transducer.

The data collected were then analyzed by using the Hvorslev Method (Hvorslev, 1951). The hydraulic conductivities estimated from the 2012 in-situ hydraulic testing are consistent with the results of the 2010 hydrogeological investigation, as summarized in the table below.

Summary of In-Situ Hydraulic Conductivity Estimates (Hvorslev Analysis)

Well ID	May 3, 2010 K (m/s)	May 1, 2012 K (m/s)	Stratigraphy at Well Screen
MW10-1A	$5x10^{-6}$	$5x10^{-6}$	Grey silty Clay
MW10-1B	$8x10^{-6}$	$6x10^{-6}$	Grey Brown silty Clay (Weathered Crust)
MW10-2	$1x10^{-6}$	--	Grey Brown silty fine Sand
MW10-3A	$2x10^{-5}$	$1x10^{-5}$	fresh Grey Dolomite
MW10-3B	$4x10^{-6}$	--	Grey Brown silty Clay (Weathered Crust)
MW10-4A	$3x10^{-6}$	--	Grey Brown fine sandy Silt
MW10-4B	$1x10^{-5}$	$1x10^{-5}$	Grey Brown silty Clay (Weathered Crust)
MW10-5A	$5x10^{-6}$	--	Grey sandy silt some gravel trace clay (Glacial Till)
MW10-5B	$2x10^{-6}$	--	Grey Brown silty fine Sand
MW10-6A	$4x10^{-6}$	$5x10^{-6}$	fresh Grey Dolomite
MW10-6B	$7x10^{-6}$	--	Grey Brown silty Sand trace Clay
MW10-7	$3x10^{-6}$	--	Grey Brown silty fine Sand
MW10-8	*	$1x10^{-4}$	Weathered to fresh Grey Dolomite

Notes: * Water level recovery too fast to measure manually, K value could not be estimated.
-- In-situ hydraulic conductivity was not completed at the monitoring well on May 1, 2012

Site Drainage Plan

Based on a review of the site drainage plan, it is Golder's understanding that the initial groundwater drainage of the site will occur through the granular backfill material within service trenches, which are completed along the roadway centre lines. Groundwater collected by the service trenches will discharge at ground surface near surface water control features (storm water management ponds). The foundation drains of each dwelling will be connected to sumps. Sump pumps, connected to the storm sewer, are a component of the proposed servicing plan; however, granular material will not be used as backfill around service connections to the dwellings (i.e. the granular material will not connect service trenches to foundation drains). Because of the open connection between the service trench backfill and the surface water bodies proposed under the current drainage plan, it was assumed that groundwater elevations in the service trench backfill will be controlled by surface water elevations at the trench discharge point.

Model Construction

Two numerical groundwater flow (MODFLOW) models were developed to complete the hydrogeological assessment. The construction of these models was based on previously constructed models that provided estimates of groundwater inflow to basement foundation drains (Golder, 2010b). Details regarding the previous model construction and parameterization can be found in the March 2010 Technical Memorandum (Golder, 2010b). As a part of the current assessment, one model, representative of a large portion of the proposed development, was used to predict the long-term groundwater levels at the Site based on the proposed drainage plan. This model is referred to herein as the "Long-Term Drainage Model". A second model, representative of a single lot, was used to evaluate the short-term sump pump response to the 100 year storm and the spring freshet. This model is referred to herein as the "100 year Storm Event Model".

Parameterization of both models is summarized as follows:

- The representative horizontal hydraulic conductivity of the overburden, weathered bedrock, and competent bedrock were $5x10^{-6}$ m/s, $5x10^{-5}$ m/s, and $5x10^{-7}$ m/s, respectively. The representative horizontal hydraulic conductivity of the overburden was increased from $1x10^{-6}$ m/s in the original analysis to $5x10^{-6}$ m/s based on the results of hydraulic testing (described above). A horizontal to vertical anisotropy ratio of 10:1 was maintained for each hydrostratigraphic unit; and,
- The specific yield of the overburden material was 0.2. The specific storage of the overburden and rock units was $1x10^{-5}$ m^{-1}. These values are considered representative of the materials encountered during subsurface investigations at the site, and are not based on results of hydraulic testing.

Long-Term Drainage Model

The following assumptions were used in the construction of the long-term drainage model:

- The model domain was defined based on the centre portion of the proposed development, bounded on the east by Strachan Street and on the west by Perth Street (Shown in Figure 1). This domain was chosen to represent the "worst case" conditions for the construction of the first houses (approximately 150 houses);
- Overburden thickness varied linearly from 6 metres (m) at the Perth St. Boundary to 3 m at the Ottawa Street Boundary based on test pit logs by Jacques Whitford (2007);
- Groundwater was assumed to flow to the north-east towards the Arbuckle Municipal Drain. Constant head boundaries were specified through all model layers to create an average horizontal hydraulic gradient of 0.002 m/m and an average groundwater elevation of 94.2 masl (value in the centre of the modelled portion

of the development). These values correspond to groundwater elevations measured at the Site in April 2011, which were the highest recorded groundwater elevations observed during the monthly monitoring summarized in the August 2011 Technical Memorandum (Golder, 2011);

- Recharge of 25 mm/year was applied over the entire model domain. The value was adjusted to limit mounding of groundwater;
- Storm sewer invert elevations were assigned based on drawings provided to Golder by DSEL. Drain boundary elevations were specified at an elevation of 0.05 m above the storm sewer invert elevation to represent the potential flowing water depth in the sewer;
- Storm Water Management Pond 1 was specified as a constant head boundary at an elevation of 92.35 m, which represents the normal operating level of the pond (based on information provided by DSEL);
- No backyard ditches or sump pumps were included in the simulation;
- Infiltration to the groundwater table from surface recharge was assumed to be consistent with current conditions (i.e., reduction in recharge following placement of hard surfaces – roofs, pavement, etc. – was not considered); and,
- It was assumed that no short circuiting of flow between the service trench fill and the storm sewer pipe would occur. Equivalent porous media assumptions apply at this interface.

The Long-Term Drainage Model was initially run without using the drain boundaries that represent the service trenches and Storm Water Management Pond 1, to establish an initial groundwater condition approximating conditions observed in April 2011. The drain boundaries were then 'switched-on', and transiently allowed to drain the site.

100 Year Storm Event Model

The following assumptions were used in the construction of the long-term drainage model:

- The ground surface at the road centre line (post-grading) elevation was assigned as 95.15 m, and the elevation of the top of rock was assigned as 89.95 masl. These values correspond to the area (see Figure 1) identified as the "worst case" in terms of the 100 year storm event given the difference between the proposed underside of footing (USF; i.e. foundation drain) elevations (93.08 m) and the expected surface water level during the 100 year storm event (94.11 m);
- The foundation drain elevation (93.08 masl) was assigned at 2.07 m below the graded road elevation. This assumes a 3% surface grade across the lot, an 11 m set-back from the centreline of the road, and a 2.4 m depth from ground surface to the foundation drain elevation;
- The Storm sewer elevation (92.98 masl) was assigned using a constant head boundary set to an elevation of 0.1 m below the foundation drain elevation. This is representative of a 0.15 m separation between the storm sewer invert and the foundation drain elevations (DSEL, 2012), and assumes 0.05 m depth of water in the sewer;
- A service stub was specified using a constant head boundary from the storm sewer to towards the house. The stub was terminated at a distance of 3 m from the house. A 2 m width was assumed for the stub trench. The constant head boundary was assigned at the same elevation as the storm sewer trench;

- It was assumed that the portions of the storm sewer and foundation drain specified in the model only draw water from areas located within the model domain (i.e. it is assumed that the sump pumps, and service stubs will generate groundwater flow divides at each property boundary);
- No backyard ditches or basement drains were included in the simulation; and,
- It was assumed that no short circuiting of flow between the service trench fill and the storm sewer pipe would occur. Equivalent porous media assumptions apply at this interface.

In order to establish an initial groundwater condition, the model recharge was adjusted until the simulated groundwater elevation was directly beneath the foundation drains (which occurred at a recharge rate of 90 mm/yr). Using this initial condition, the 100 year storm was simulated transiently over a 24 hour period, during which time groundwater elevations in the storm sewer trench and service stub were increased from 92.98 masl to 94.11 masl. Water levels were assumed to increase instantaneously at the onset of the storm. To simulate the additional impact of the 100 year storm occurring concurrently with the spring freshet, the recharge was increased to 2000 mm/year during the same 24 hour period. This value of recharge resulted in an average head throughout the model domain that approximated the 100 year storm water level. The magnitude and duration of the spring freshet used for the modelling were assumed values; however, the selected parameters are considered to be conservative.

Following the storm event, groundwater elevations in the storm sewer and service stub were lowered to 92.98 m, and the recharge was reduced to 90 mm/year. Groundwater elevations within the service trenches were assumed to decrease instantaneously 24 hours after the start of the storm based on information provided by DSEL. The instantaneous rise and fall of groundwater elevations is expected to generate more inflow to the foundation drains than would be generated by the expected gradual changes that are more likely to occur within the same 24 hour time period.

Results

Long Term Drainage Model

The simulated average long-term (steady-state) groundwater elevation within the proposed development was 93.15 masl. Simulated groundwater elevations varied from 93.91 masl in the southeastern corner of the site to 92.35 masl along the edge of Storm Water Management Pond 1. These conditions were achieved approximately 475 days following the initiation of drainage by the storm sewer network. It is noted that at steady state, simulated groundwater elevations in a small area in the south-western corner of the modelled portion of the development (see Figure 1) were 0.05 to 0.20 m above the proposed USF elevation. In all other areas, the long term drainage model predicts groundwater elevations to be below the proposed USF elevations. Given the period of time required to achieve the steady-state groundwater elevations it is likely that short term dewatering activities will be required during construction.

100 Year Storm Event Model

Using the 100 Year Storm Event Model, the simulated peak inflow to the foundation drain during the 100 year storm event was 1.07 m^3/day. This value represents the maximum expected sump pump pumping rate. It is noted that a small portion of the flow out of the model domain was through the sewer trenches (0.37 m^3/day), due to the high level of recharge applied to simulate freshet conditions. The simulated peak groundwater elevation in the model cell adjacent to the foundation drains (0.1 m from the drains) was 0.09 m above the USF elevation, and was 0.48 m above the USF elevation at 1 m from the drains. Following the storm event, flow to the foundation drains ended instantly as gradients were reversed towards the storm sewer. Simulated groundwater elevations fell below the USF elevation within 1 hour after the end of the storm event.

Summary and Conclusion

The results of the modelling assessment indicate the following:

- The simulated long-term (steady-state) groundwater elevations were below the USF elevations, with the exception a small area in the south-western corner of the modelled portion of the development. The constant head boundaries were selected to approximate groundwater elevations observed in April 2011 (the highest groundwater elevations measured on-site). Based on the groundwater level monitoring data (see Figure 2), lower groundwater elevations occur during dryer times of year;
- It is expected that sump pumps would be required to operate during a 100 year storm event; however, the duration of operation would not be expected to extend beyond the duration of the 100 year storm event. Sump pump operation may also be required during the spring freshet, or during any period of high recharge, as is typical for dwellings designed for sump pumps. Based on the results of the groundwater modelling, the expected volume of water that would be pumped at each dwelling would be easily handled by standard commercially available residential-type sump pumps;
- Based on the site's subsurface conditions and the results of the groundwater modelling, it is expected that the amount of groundwater lowering that would occur through the granular backfill material within the service trenches and the storm water management ponds would not adversely affect base flow to adjacent water courses, water levels in water supply wells, or existing and future residential foundations; and,
- The modelling assumed that groundwater drainage of the site will occur through the granular backfill material within service trenches, and groundwater collected by the service trenches will discharge at ground surface near the storm water management pond. The modeling also assumed that the granular material within the service trenches will not directly connect to foundation drains. Inspection during construction, to ensure implementation of this design, is recommended.

Limitations

This report was prepared for the use of Richmond Village (South) Limited and Mattamy (Jock River) Limited. The report, which specifically includes all tables, figures and appendices, is based on data gathered by Golder Associates Ltd., and information provided to Golder Associates Ltd. by others. The information provided by others has not been independently verified or otherwise examined by Golder Associates Ltd. to determine the accuracy or completeness. Golder Associates Ltd. has relied in good faith on this information and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the information as a result of omissions, misinterpretation or fraudulent acts.

The assessment of environmental conditions and possible hazards at this site has been made using the results of physical measurements from a number of locations. The site conditions between testing locations have been inferred based on conditions observed at the testing locations. Actual conditions may deviate from the inferred values.

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time, and in the sense that the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that groundwater systems are complicated beyond human capability to evaluate them comprehensively in detail, and we invariably do not have sufficient data to do so. A groundwater model uses the laws of science and mathematics to draw together the available data into a mathematical or computer-based representation of the essential features of an existing hydrogeological system. While the model itself obviously lacks the detailed reality of the existing

hydrogeological system, the behaviour of a valid groundwater model reasonably approximates that of the real system. The validity and accuracy of the model depends on the amount of data available relative to the degree of complexity of the geologic formations and on the quality and degree of accuracy of the data entered. Therefore, every groundwater model is a simplification of a reality and the model described in this report is not an exception.

The professional groundwater modelling services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practising under similar conditions, subject to the quality and quality of available data, the time limits and financial and physical constraints applicable to the services. Unless otherwise specified, the results of previous or simultaneous work provided by sources other than Golder Associates Ltd. and quoted and/or used herein are considered as having been obtained according to recognized and accepted professional rules and practices, and therefore deemed valid. This model provides a predictive scientific tool to evaluate the impacts on a real groundwater system of specified hydrological stresses and/or to compare various scenarios in a decision-making process. However and despite the professional care taken during the construction of the model and in conducting the simulations, its accuracy is bound to the normal uncertainty associated to groundwater modelling and no warranty, express or implied, is made.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken based on this report.

Closure

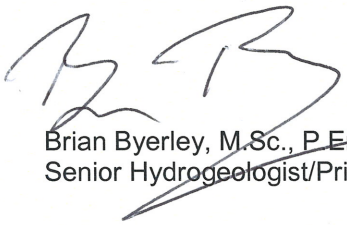
We trust that this memo is adequate for your current needs. Please contact the undersigned if you have any questions.

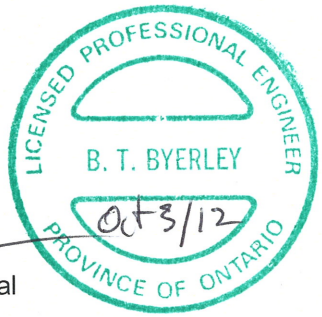
Yours truly,

GOLDER ASSOCIATES LTD.



Melissa Bunn, Ph.D.
Environmental Consultant





Brian Byerley, M.Sc., P.Eng.
Senior Hydrogeologist/Principal

MIB/BTB/SRW/sg
n:\active\2012\1127 - geosciences\12-1127-0062 richmond village drainage and sump design\reporting\phase 4000 reporting\12-1127-0062 tech memo 3oct2012 phase 4000 100 yr flood modelling.docx

Attachments: Table 1 – Groundwater Monitoring Data
Figure 1 – Site Plan
Figure 2 – Observed Groundwater Levels

References

Golder Associates Ltd., 2011. Groundwater Monitoring Program Proposed Mattamy Homes Development, Richmond (Ottawa), Ontario. Technical Memorandum No. 08-1122-0078/9600, August 2011.

Golder Associates Ltd., 2010a. Hydrogeological Investigation Proposed Mattamy Homes Development, Richmond (Ottawa), Ontario. Technical Memorandum No. 08-1122-0078/9600, July 2010.

Golder Associates Ltd., 2010b. Draft Preliminary Groundwater Modelling Assessment of Potential Shallow Groundwater Inflow to Building Foundations. Technical Memorandum No. 08-1122-0078/9500, March 2010.

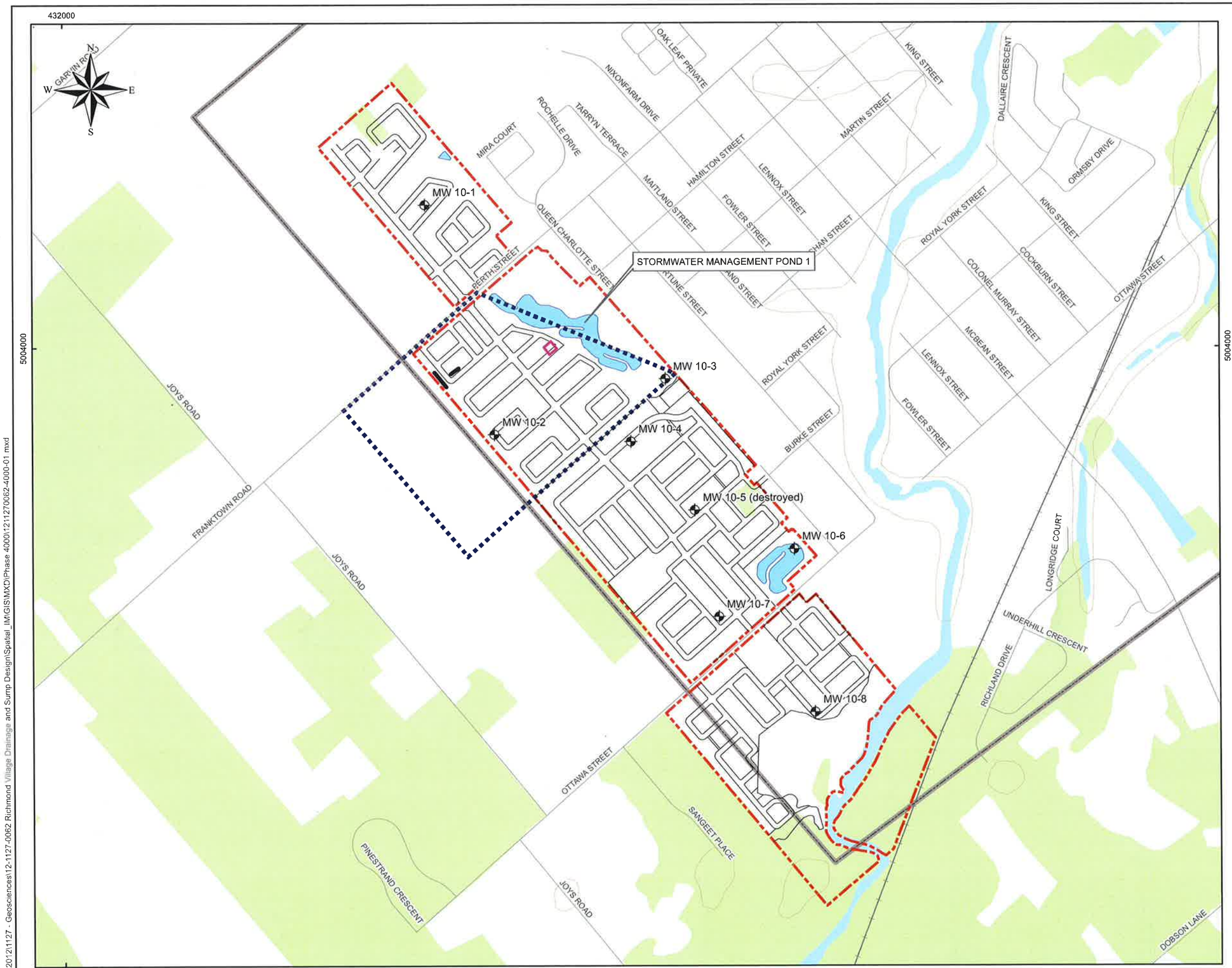
Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Groundwater Observations. U.S. Army Corps Engrs. Water ways Exp. Sta. Bull. 36, Vicksburg, Miss.

Jacques Whitford Limited., 2007. Preliminary Geotechnical Investigation Proposed Residential Subdivision, Perth and Ottawa Streets, Richmond Area Ottawa, Ontario. Report No. 1026929, June 2007.

Table 1: Groundwater Monitoring Data

Well ID	Ground Surface Elevation (geodetic)	Screen depth (middle of screen) (mbgs)	Soil/rock at depth of well screen	Groundwater Level (mbgs)														
				Apr.29 & 30, 2010	May 14, 2010	Jun.16, 2010	Jul. 15, 2010	Aug. 20, 2010	Sept. 16, 2010	Oct. 1, 2010	Oct 18, 2010	Nov. 19, 2010	Dec. 15, 2010	Jan. 18, 2011	Feb. 14, 2011	Mar. 15, 2011	Apr. 15, 2011	May 1, 2012
MW10-1A	94.55	1.11	Grey silty Clay	0.73	0.78	0.80	0.81	0.78	0.81	0.61	0.77	0.72	0.78	1.00	1.21	0.89	0.64	0.83
MW10-1B	94.55	1.21	Grey brown silty Clay (weathered crust)	0.74	0.77	0.80	0.79	0.79	0.81	0.62	0.75	0.72	0.78	0.97	1.17	0.90	0.66	0.83
MW10-2	94.90	2.12	Grey brown silty find Sand	0.73	0.67	0.86	0.66	0.96	0.94	0.17	0.59	0.34	0.55	0.78	0.89	0.56	0.13	--[4]
MW10-3A	94.0	4.55	Fresh grey Dolomite	0.22	0.26	0.58	0.28	0.23	0.25	-0.09[1]	0.08	-0.06[1]	--[3]	--[3]	--[3]	--[3]	-0.21[1]	0.25
MW10-3B	94.0	2.12	Grey brown silty Clay (weathered crust)/grey brown fine sandy Silt	0.82	0.81	0.87	0.79	0.87	0.85	0.44	0.72	0.56	0.73	0.90	0.77	0.69	0.29	0.95
MW10-4A	94.34	3.03	Grey brown fine sandy Silt	0.48	0.47	0.56	0.49	0.64	0.62	0.11	0.47	0.27	0.44	0.53	0.64	0.41	0.21	--[4]
MW10-4B	94.34	1.21	Grey brown silty Clay (weathered crust)	0.47	0.49	0.56	0.49	0.64	0.62	0.08	0.46	0.25	0.44	0.56	0.65	--[3]	0.26	0.78
MW10-5A	95.65	3.03	Glacial Till	0.82	0.79	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[4]
MW10-5B	95.65	1.21	Grey brown silty find Sand	0.89	0.88	1.33	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[4]
MW10-6A	95.67	4.24	Fresh grey Dolomite	1.38	1.38	1.98	1.34	1.31	1.52	0.66	0.84	0.67	0.68	1.22	1.44	0.56	0.46	1.21
MW10-6B	95.67	1.52	Grey brown silty Sand trace Clay	1.29	1.28	1.84	1.59	1.12	1.55	0.31	0.62	0.26	0.50	1.16	1.42	--[3]	0.05	1.15
MW10-7	95.36	2.42	Grey brown silty fine Sand	0.51	0.49	1.09	0.98	0.38	0.47	0.03	0.06	0.04	0.03	--[3]	--[3]	--[3]	0.02	--[4]
MW10-8	93.32	2.42	Weathered to fresh grey Dolomite	1.02	1.15	1.52	1.39	1.24	1.29	0.23	0.31	0.26	0.27	0.80	0.81	--[3]	0.19	0.74

Notes:
[1] Artesian conditions exist. Groundwater level above ground surface.
[2] Monitoring well MW 10-5 A and B vandalized and groundwater levels not available after May 14, 2010.
[3] Groundwater in monitoring well frozen. Depth to groundwater level could not be measured.
[4] Only select wells were monitored in May 2012 as a component of a hydraulic response testing program



LEGEND

- MONITORING WELL LOCATION
- PROPOSED ROAD
- RAILWAY
- ROAD
- TOPOGRAPHIC CONTOUR (m)
- PROPOSED STORMWATER MANAGEMENT POND
- RICHMOND VILLAGE/MATTAMY RICHMOND LANDS
- RICHMOND VILLAGE BOUNDARY
- WATERBODY
- VEGETATION
- APPROXIMATE BOUNDARY OF LONG-TERM DRAINAGE MODEL DOMAIN
- 100 YEAR STORM EVENT MODEL DOMAIN
- APPROXIMATE AREA WHERE ESTIMATED STEADY - STATE GROUNDWATER ELEVATIONS EXCEED USF ELEVATION

NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LIMITED REPORT NO. 12-1127-0062 PHASE 4000

REFERENCE

BASE DATA - CANVEC PROVIDED BY HER MAJESTY THE QUEEN IN RIGHT OF CANADA, DEPARTMENT OF NATURAL RESOURCES
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 18

480 240 0 480
Meters
1:12,000

PROJECT
RICHMOND VILLAGE
ASSESSMENT OF SUBSURFACE DRAINAGE

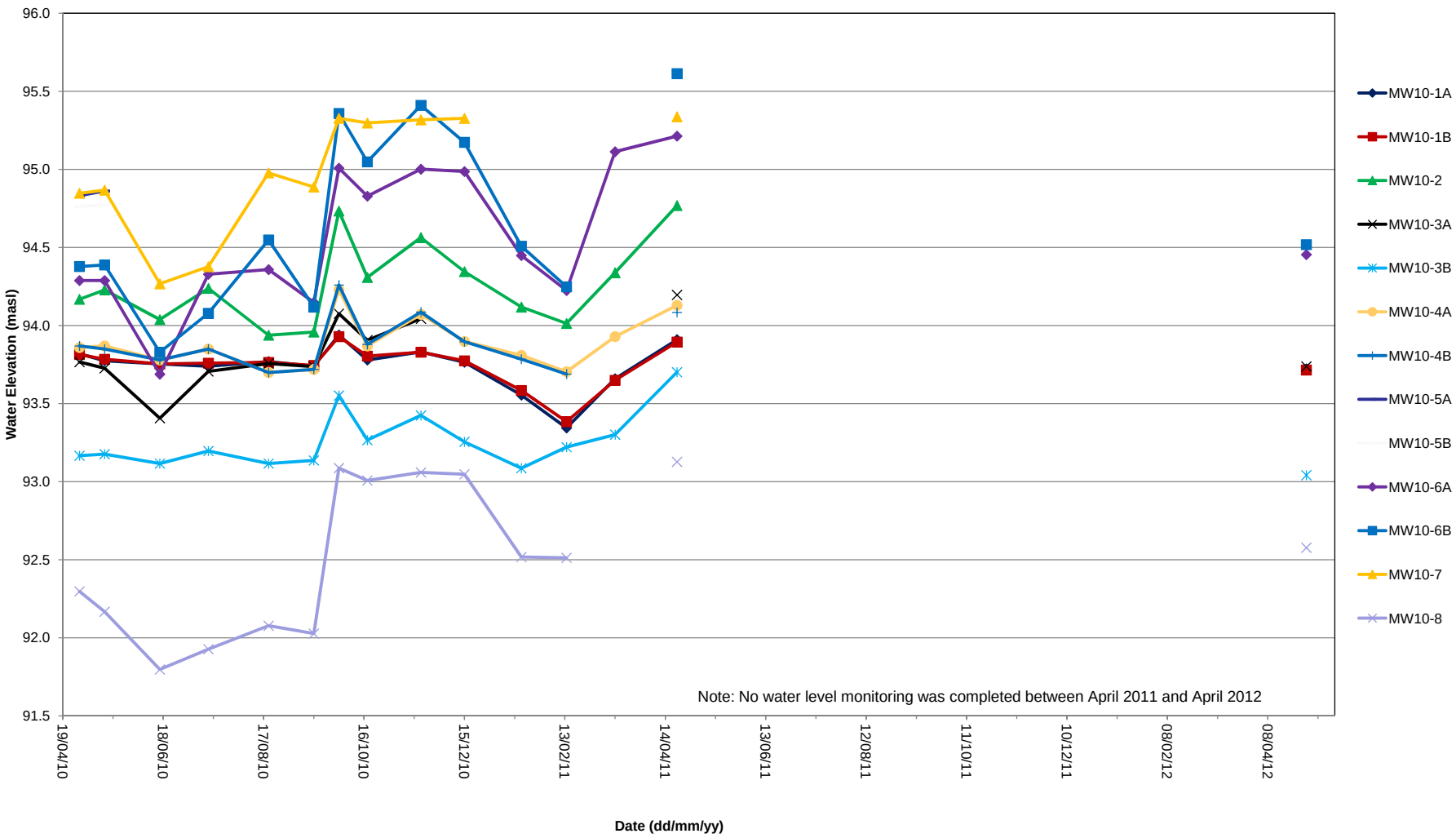
TITLE
SITE PLAN

Golder Associates
Ottawa, Ontario

PROJECT No. 12-1127-0062			SCALE AS SHOWN	REV. 0.0
DESIGN	NB	May 2012		
GIS	ABD	July 2012		
CHECK	MB	JULY 31/12		
REVIEW	CSB	08/15/12		

FIGURE 1

N:\Active\2012\1127 - Geosciences\12-1127-0062 Richmond Village Drainage and Sump Design\Spatial_IM\GIS\MXD\Phase 4000\12112700662-4000-01.mxd



RICHMOND VILLAGE ASSESSMENT OF SUBSURFACE DRAINAGE

OBSERVED GROUNDWATER ELEVATIONS

Golder Associates Ltd.

OCTOBER 2012	PROJECT: 12-1127-0062	FIGURE 2

High Performance

Emergency Battery Backup

Sump Pump System

High Performance

Operates automatically in an emergency and runs at full capacity to keep up with incoming water

Smart Charging Technology

Innovative smart chip technology charges in stages to maintain 90% charge. Prolongs battery life beyond where others fail!

Audio and Visual Alarms

State-of-the-art diagnostics alert you when system is running, power has failed or system needs maintenance, and warns you if a battery replacement is needed



Heavy-Duty 3000 GPH

12V **3000 GPH**
FP2800DCC

PERFORMANCE (GPH)						CHARGER OUTPUT (AMPS)	SOLIDS HANDLING
DISCHARGE HEIGHT ABOVE PUMPING LEVEL	0'	5'	10'	15'	MAX. LIFT		
FP2800DCC	3000	2550	2000	1000	18'	8.0	3/16"

MODEL	WARRANTY	UPC	CARTON DIMENSIONS	PALLET QTY.	WEIGHT
FP2800DCC	2 YEAR	022315166479	16.9" x 9.6" x 20.3"	24	21.9 LBS.

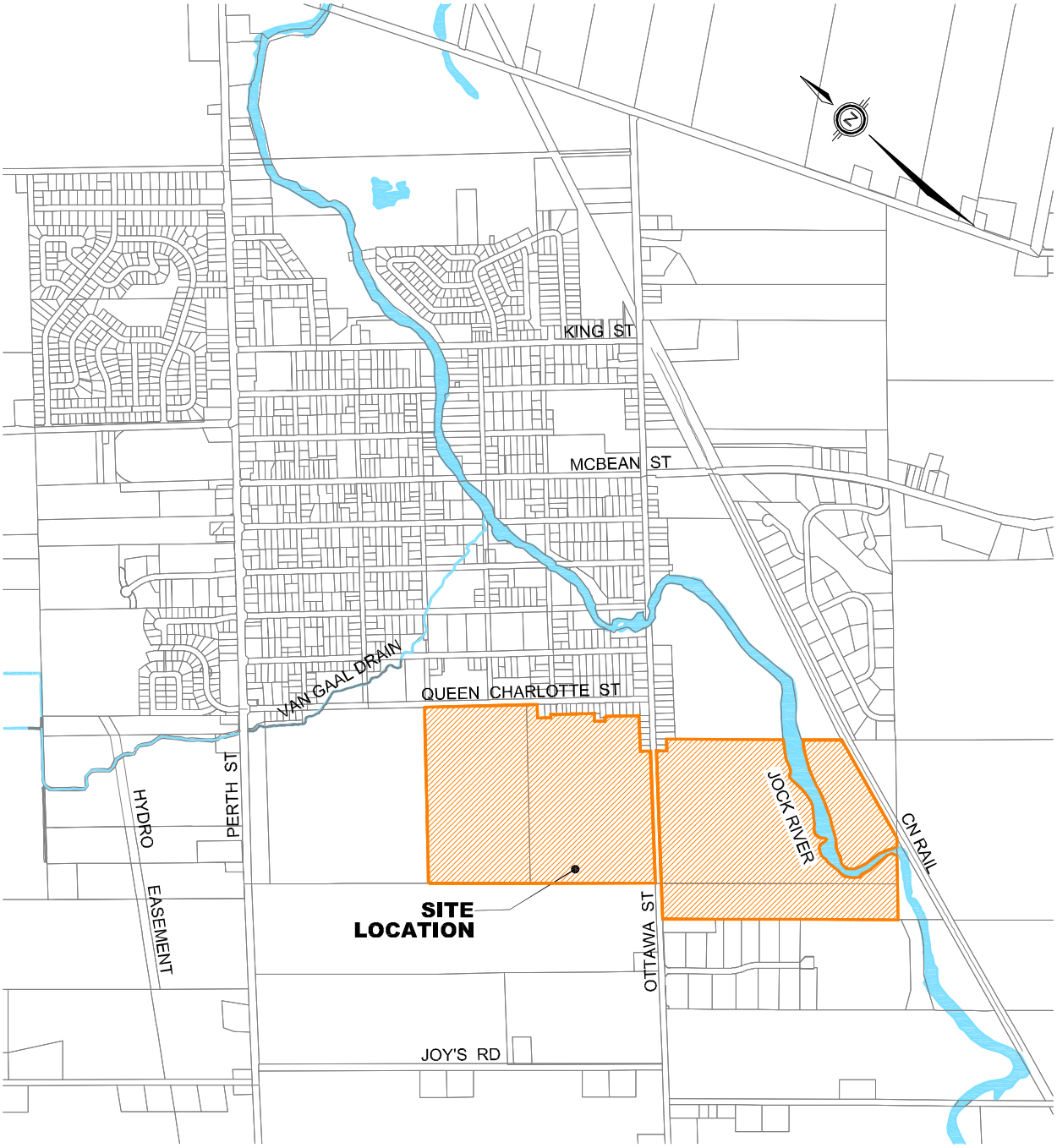


Includes:

Detailed owner's manual.

Pump mounting tee, check valve for backup pump, fittings for 1-1/4" and 1-1/2" piping, check valve for primary pump

Figures



LEGEND

SITE BOUNDARY

MATTAMY - VILLAGE OF RICHMOND WESTERN DEVELOPMENT LANDS	SITE LOCATION	SCALE: 1:20,000
		DATE: MARCH 2013
		PROJECT No.: 13-654
		FIGURE: 2

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MATTAMY - VILLAGE OF RICHMOND WESTERN DEVELOPMENT LANDS

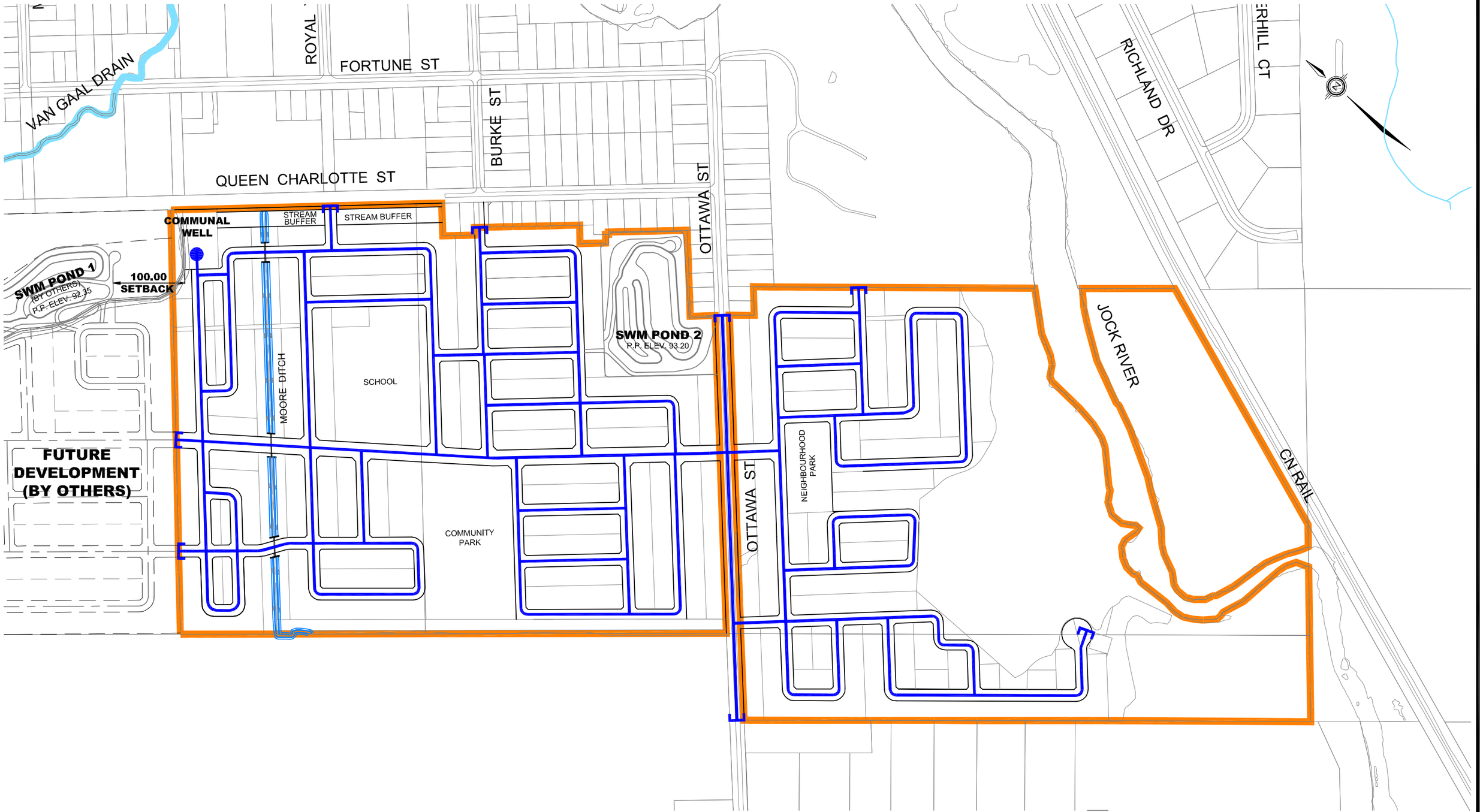
DRAFT PLAN

CITY OF OTTAWA

LEGEND

- SITE BOUNDARY
- SINGLE RESIDENTIAL
- TOWNHOUSE RESIDENTIAL
- BACK-TO-BACK RESIDENTIAL
- PARK
- SCHOOL
- POND
- WELL
- STREAM SETBACK TERRESTRIAL FEATURES
- TERRESTRIAL FEATURES
- FLOODPLAIN

PROJECT No.:	13-654
DATE:	MARCH 2013
DRAWN BY:	KM / ADF
SCALE:	1:5000
FIGURE:	4



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MATTAMY - VILLAGE OF RICHMOND WESTERN DEVELOPMENT LANDS

CONCEPTUAL WATERMAIN

CITY OF OTTAWA

LEGEND

- SITE BOUNDARY
- LOCAL WATERMAIN
- COMMUNAL WELL
- PLUG

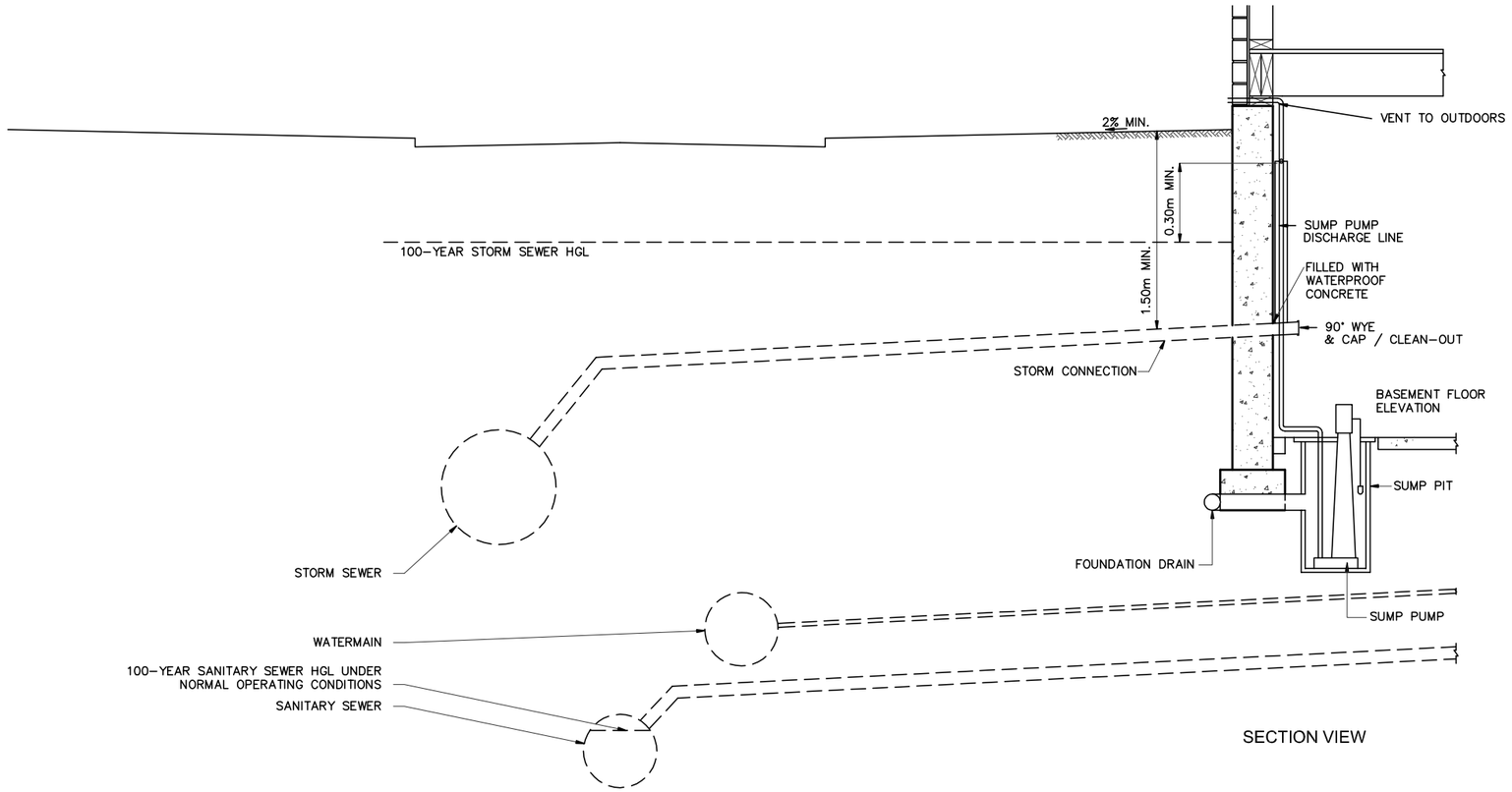
PROJECT No.: 13-654

DATE: MARCH 2013

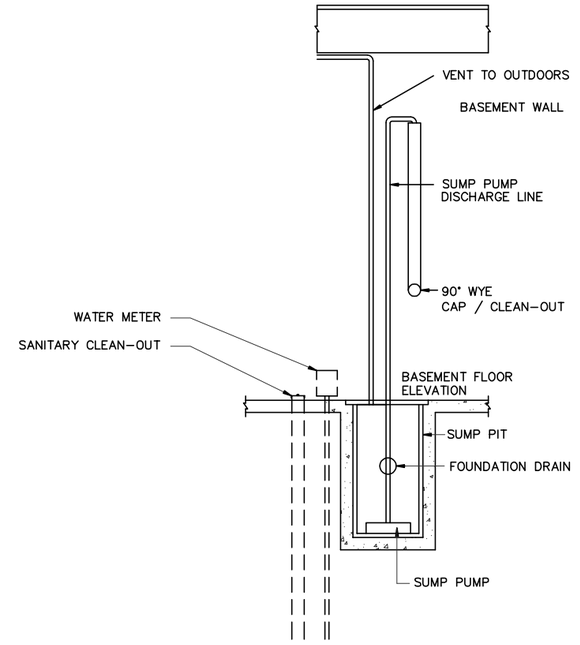
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SCALE: 1:5000

FIGURE: 5



SECTION VIEW



FRONT VIEW

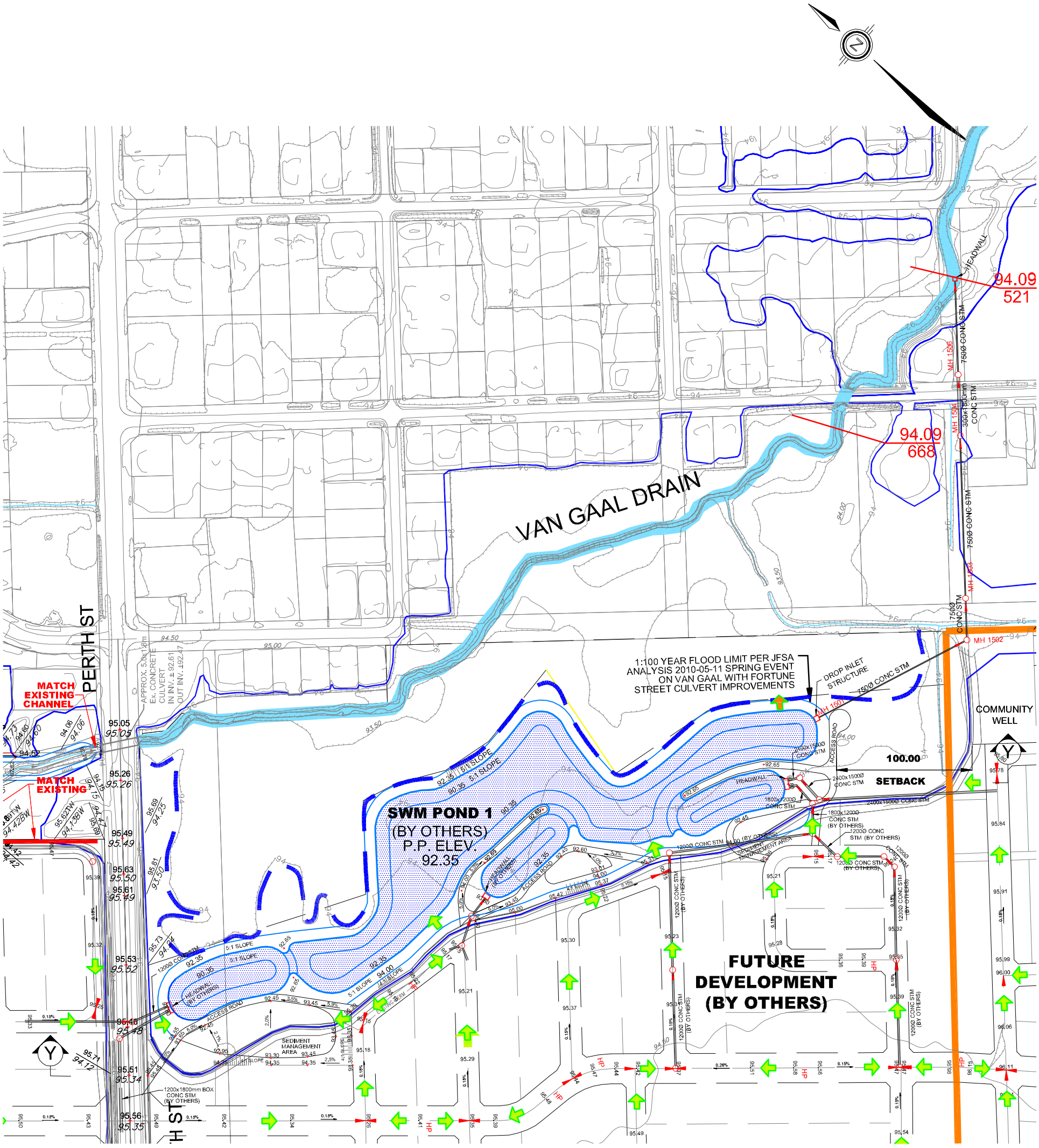
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SUMP PUMP - DETAIL

DATE:	MAR 2012
SCALE:	N.T.S.
PROJECT No.:	13-654
FIGURE	6

z:\projects\11-468 caivan - richmond\b_design\b2_drawings\b2-2_main (dsel)\swm_alternatives\sump-pump_detail_v2.dwg



SWM POND 1
SECTION Y-Y
SCALE HOR. 1:3000
VER. 1:300

LEGEND

- STUDY LIMIT
- EXISTING DITCH
- REGULATORY FLOOD LINE
- EXISTING ELEVATION CONTOUR
- OVERLAND FLOW DIRECTION
- EMERGENCY OVERFLOW DIRECTION

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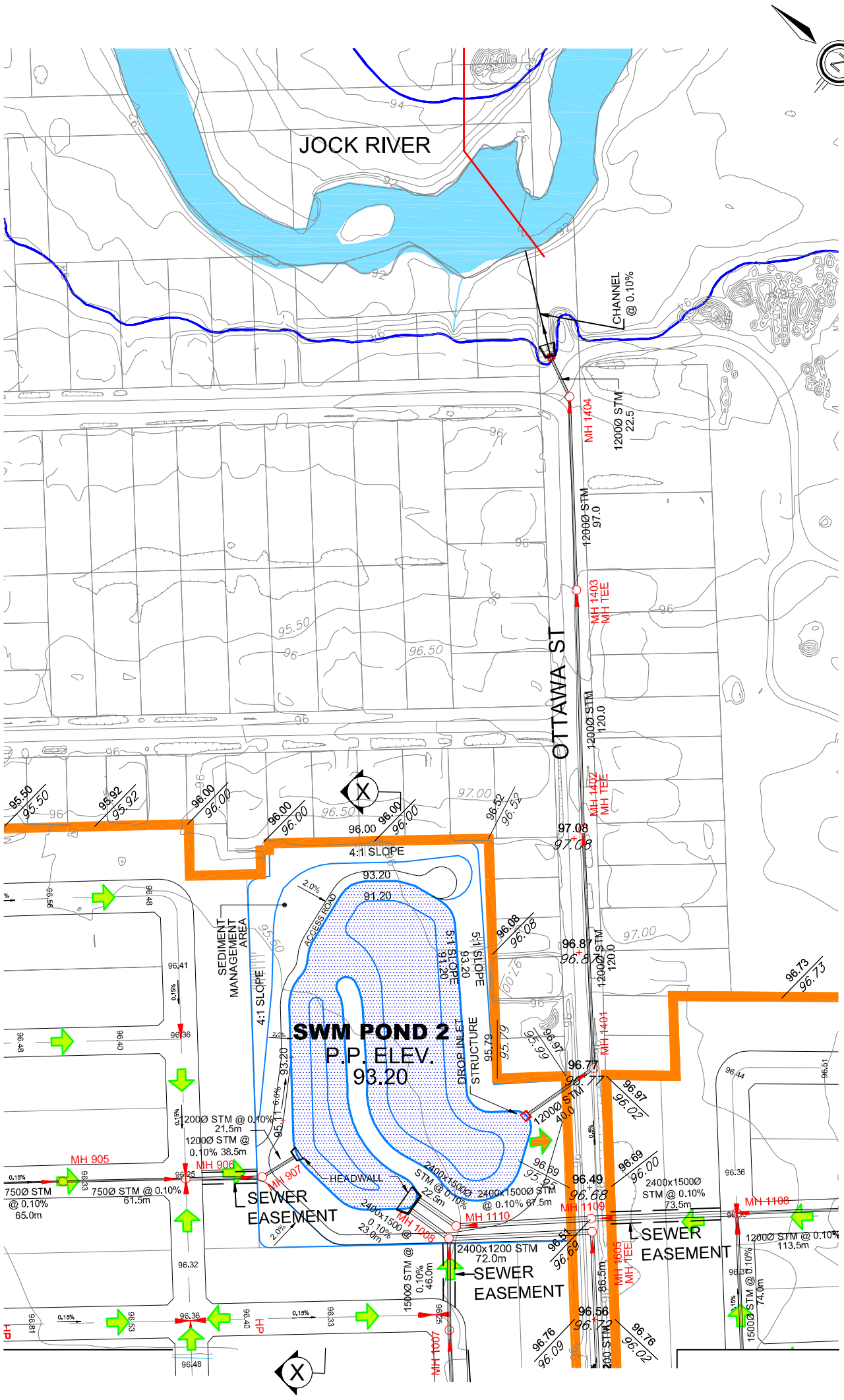
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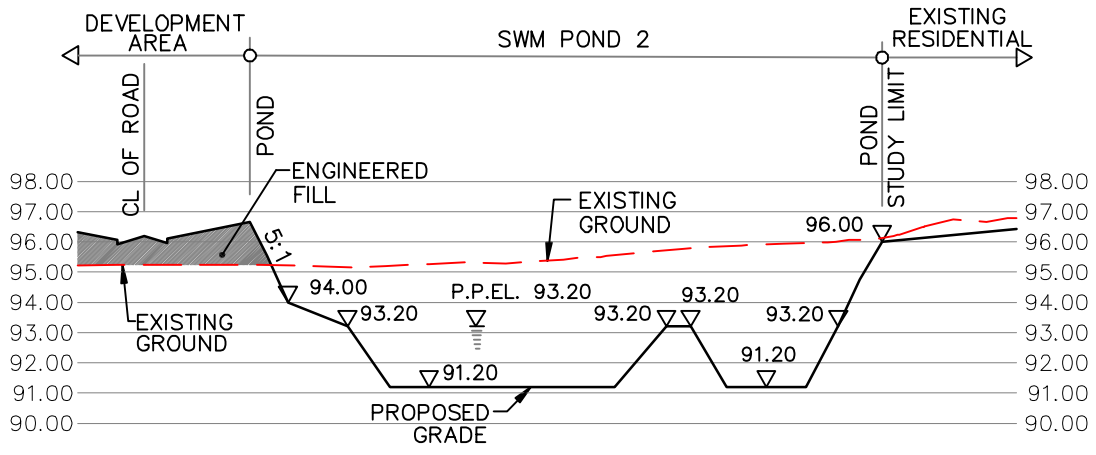
MATTAMY - VILLAGE OF RICHMOND
WESTERN DEVELOPMENT LANDS

SWM POND 1

CITY OF OTTAWA

PROJECT No.: 13-654
DATE: MARCH 2013
DRAWN BY: KM / ADF
SCALE: 1:3000
FIGURE: 7





SWM POND
SECTION X-X
SCALE HOR. 1:2500
VER. 1:250

LEGEND

- STUDY LIMIT
- REGULATORY FLOOD LINE
- OVERLAND FLOW DIRECTION
- EMERGENCY OVERFLOW DIRECTION
- EXISTING DITCH
- 95.00 EXISTING ELEVATION CONTOUR

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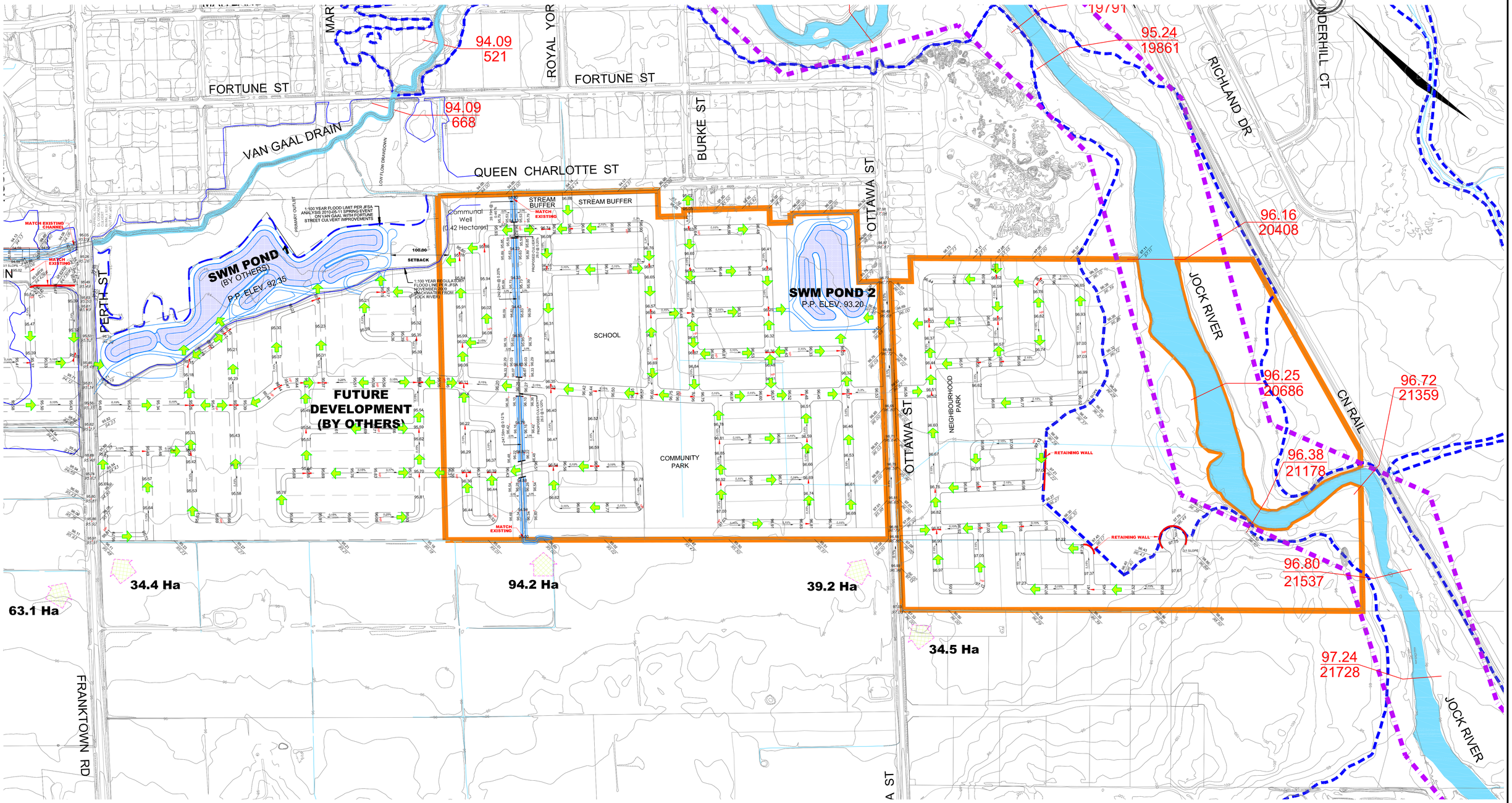
MATTAMY - VILLAGE OF RICHMOND
WESTERN DEVELOPMENT LANDS

SWM POND 2

CITY OF OTTAWA

PROJECT No.: 13-654
DATE: MARCH 2013
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SCALE: 1:2500
FIGURE: 8

Drawings



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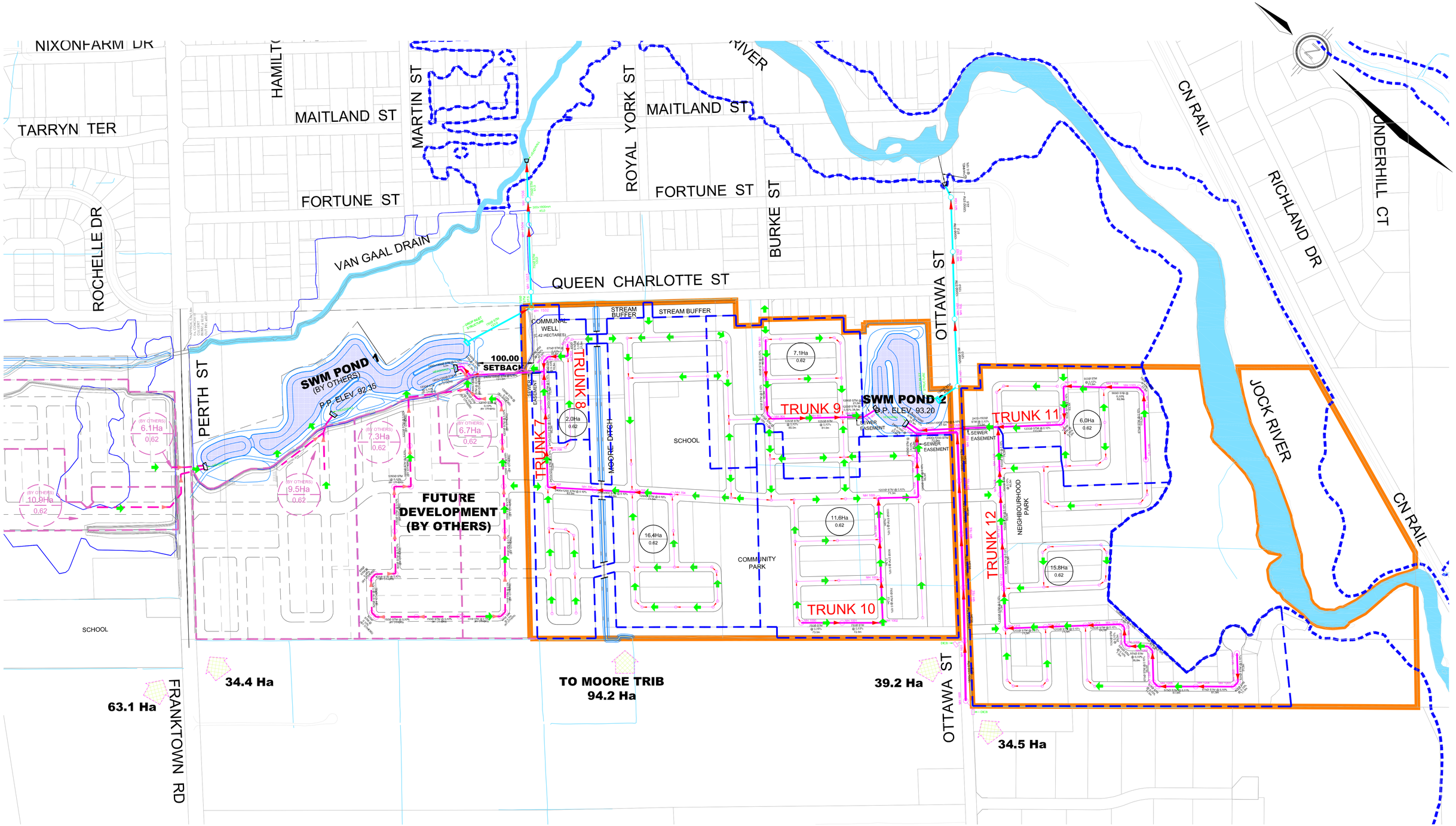
GRADING PLAN

CITY OF OTTAWA

LEGEND

- STUDY LIMIT
- EXISTING DITCH
- EXISTING ELEVATION CONTOUR
- MAJOR OVERLAND FLOW
- EXTERNAL DRAINAGE

PROJECT No.:	13-654
DATE:	MARCH 2013
DRAWN BY:	KM / ADF
SCALE:	1:3000
DRAWING:	1



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MATTAMY - VILLAGE OF RICHMOND WESTERN DEVELOPMENT LANDS

STORM SERVICING PLAN

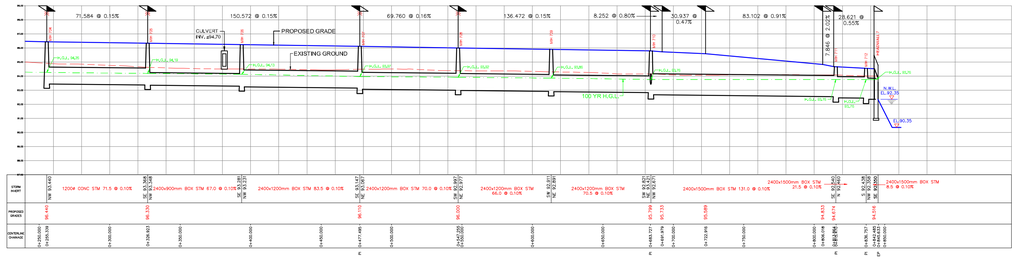
CITY OF OTTAWA

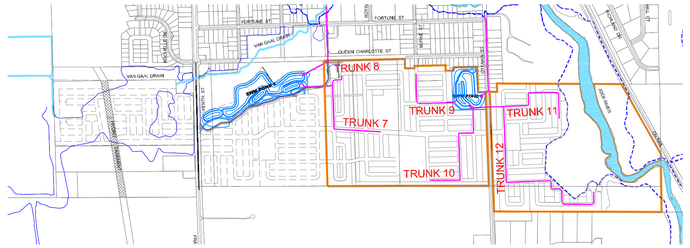
LEGEND

- STUDY LIMIT
- EXISTING DITCH
- STORM SEWER TRIBUTARY AREA
- STORM SEWER TRUNK
- LOCAL STORM SEWER
- STORM SEWER TRIBUTARY AREA BY OTHERS
- STORM SEWER TRUNK BY OTHERS
- 8.26Ha / 0.62 — DRAINAGE AREA / IMPERVIOUSNESS
- OVERLAND FLOW ROUTE
- EXTERNAL DRAINAGE

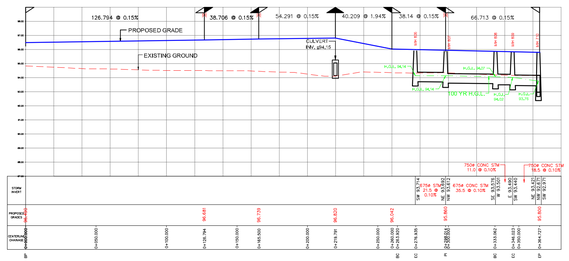
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DATE:	MARCH 2013
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DRAWING:	2

STORM TRUNK 7

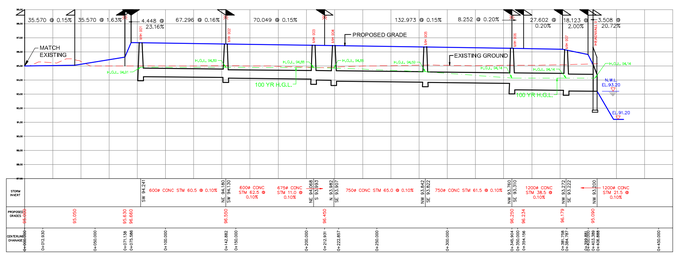




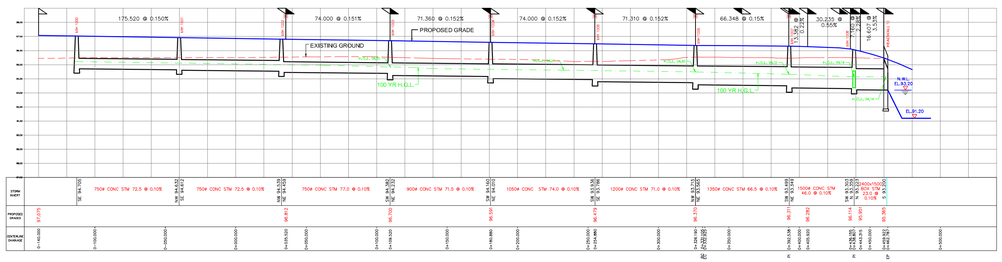
STORM TRUNK 8



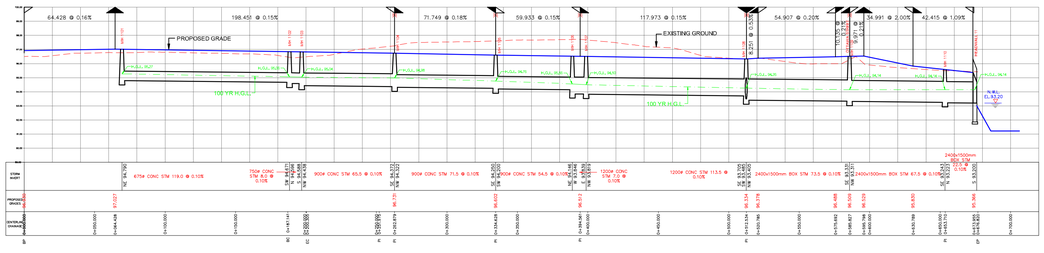
STORM TRUNK 9



STORM TRUNK 10



STORM TRUNK 11



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MATTAMY - VILLAGE OF RICHMOND
WESTERN DEVELOPMENT LANDS

STORM SERVICING PROFILES

CITY OF OTTAWA

PROJECT No.: 13-654

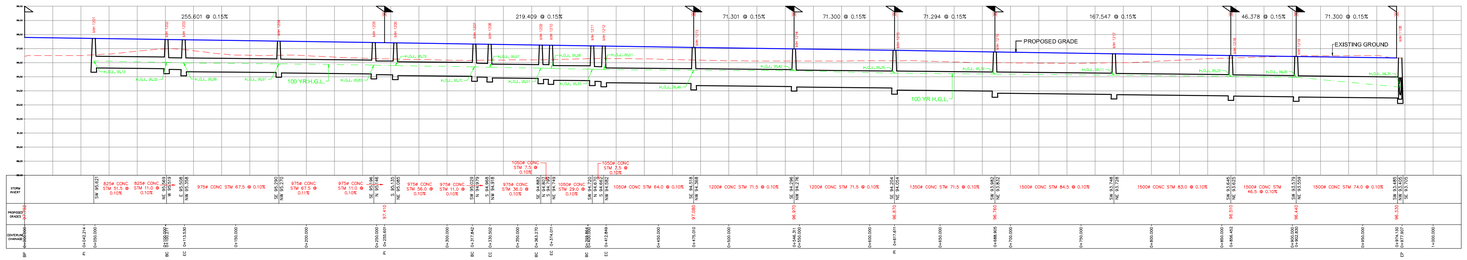
DATE: MARCH 2013

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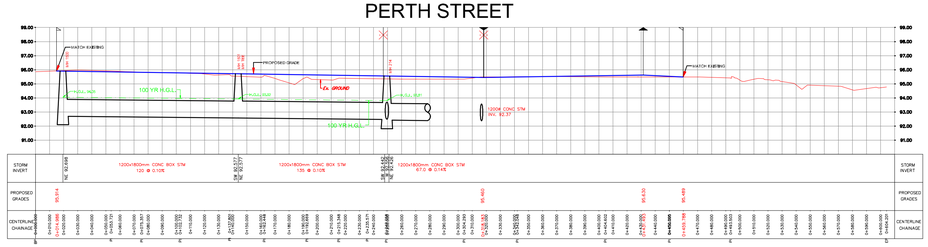
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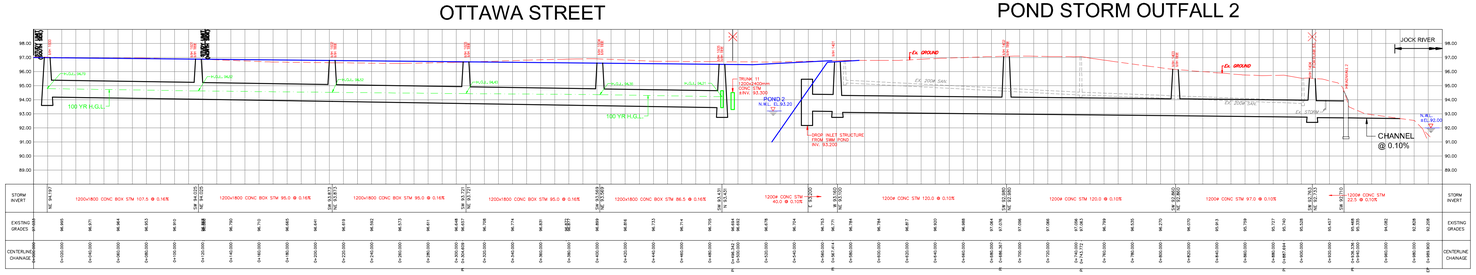
STORM TRUNK 12



PERTH STREET

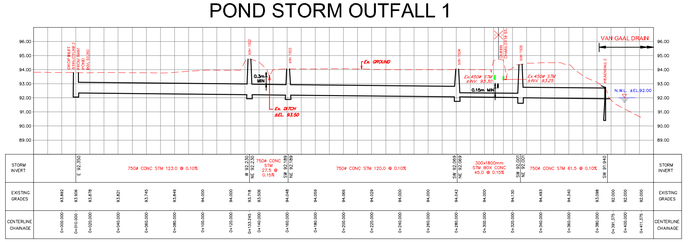


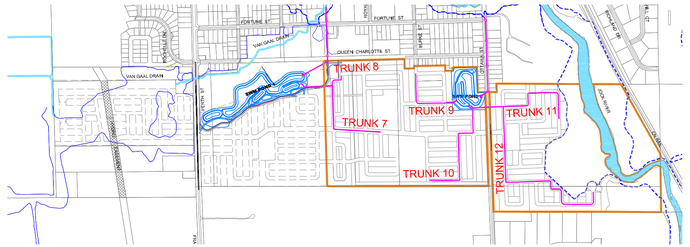
OTTAWA STREET



POND STORM OUTFALL 2

POND STORM OUTFALL 1





PROFILES KEYPLAN SCALE: 1:8000

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STORM SERVICING PROFILES

CITY OF OTTAWA

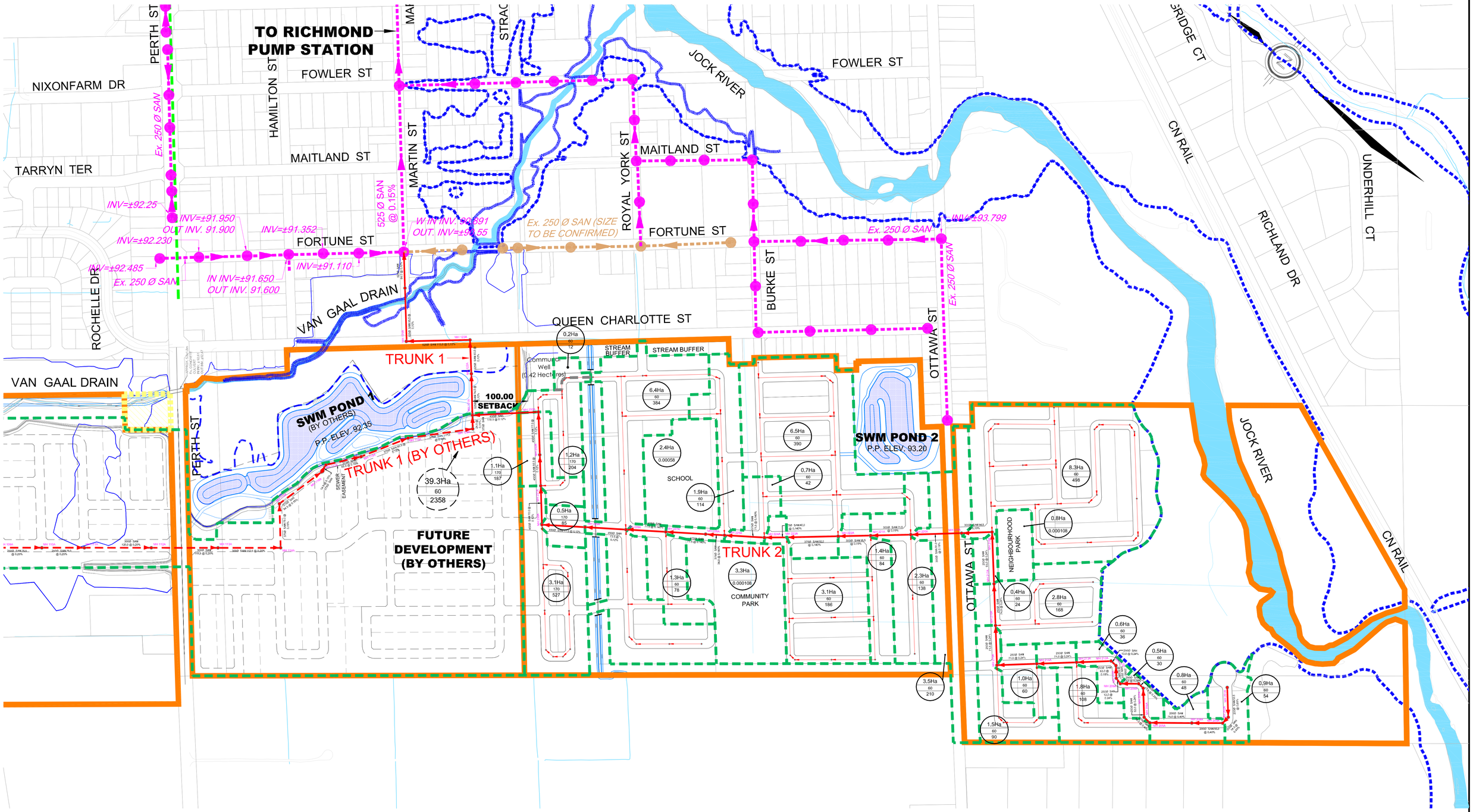
PROJECT No.: 13-654

DATE: MARCH 2013

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SCALE: 1:2000

DRAWING: 4



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MATTAMY - VILLAGE OF RICHMOND WESTERN DEVELOPMENT LANDS

SANITARY SERVICING PLAN

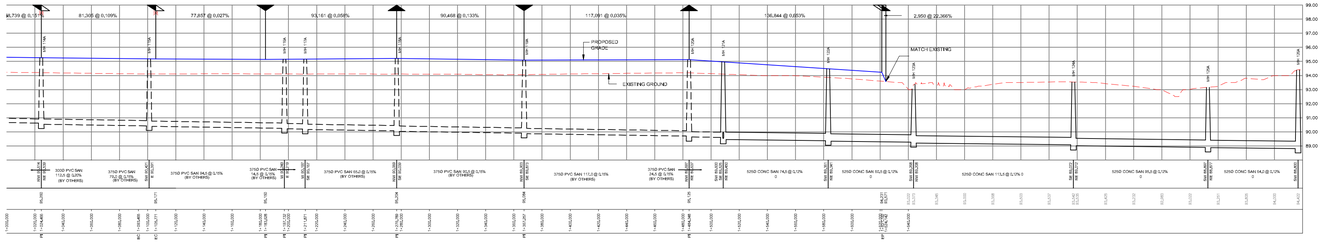
CITY OF OTTAWA

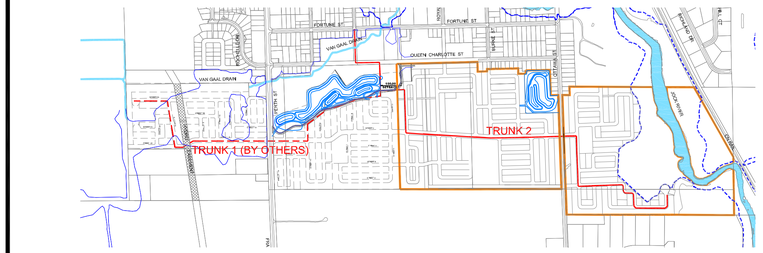
LEGEND

- STUDY LIMIT
- 1.63Ha / 60 / 98 — DRAINAGE AREA, POPULATION PER HECTARE, TOTAL POPULATION
- SANITARY DRAINAGE BOUNDARY
- SANITARY SUB-CATCHMENT BOUNDARY
- PROPOSED SANITARY TRUNK
- PROPOSED SANITARY SEWER
- EXISTING SANITARY SEWER
- EXISTING SANITARY FORCEMAIN

PROJECT No.:	13-654
DATE:	MARCH 2013
DRAWN BY:	KM / ADF
SCALE:	1:3000
DRAWING:	7

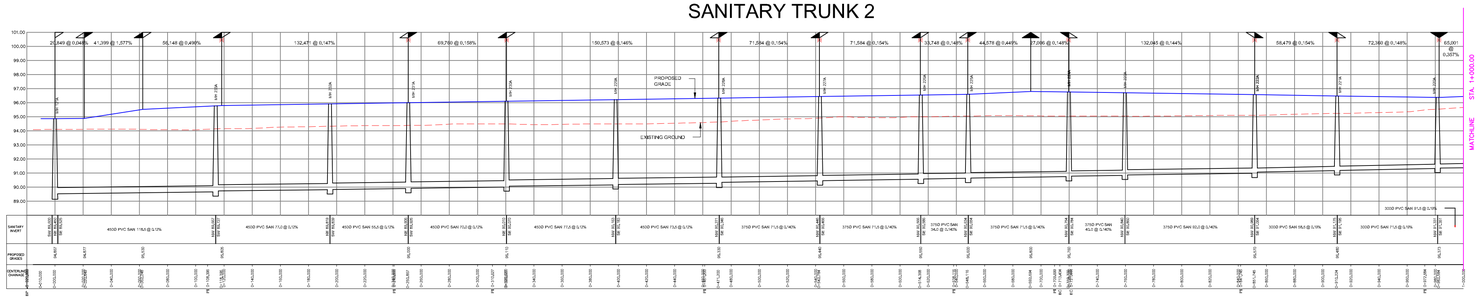
SANITARY TRUNK 1



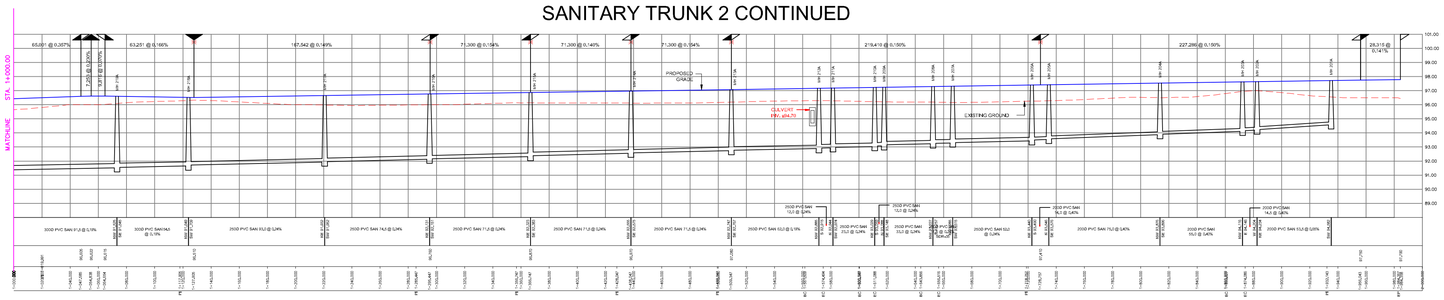


PROFILES KEYPLAN SCALE: 1:8000

SANITARY TRUNK 2



SANITARY TRUNK 2 CONTINUED



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MATTAMY - VILLAGE OF RICHMOND WESTERN DEVELOPMENT LANDS

SANITARY TRUNK PROFILES

CITY OF OTTAWA

PROJECT No.: 13-654

DATE: MARCH 2013

DRAWN BY: KM / ADF

SCALE: 1:2000

DRAWING: 6