WSP #: 131-18048-00

THE PORTSMOUTH PUMPING STATION FLOW DIRECTION ENVIRONMENTAL ASSESSMENT

KINGSTON, ON

PORTSMOUTH PUMPING STATION FLOW DIRECTION HYDRAULIC MODELLING MEMORANDUM

MAY, 2014

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TECHNICAL MEMORANDUM

To: Mike Fischer, M.Sc,. P.Eng, Utilities Kingston
Date: May, 28 2014
From: Michael Flowers, EIT
Matt Morkem, P.Eng
Project: Portsmouth Pumping Station Flow Direction Environmental Assessment
Project No: 131-18048-00
Subject: **Portsmouth Pumping Station Flow Direction Hydraulic Modelling Memorandum**

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Executive Summary

WSP (formally GENVIAR) was retained by Utilities Kingston (UK) to conduct the Portsmouth Pumping Station (PS) Flow Direction Environmental Assessment (EA) where a flow redirection analysis was performed in support of the EA using the UK supplied 2008 Kingston Trunk Sewer InfoSWMM Model to evaluate impacts associated. Prior to the evaluation, a review of the supplied model was completed and a gap analysis was conducted to determine the necessary data required for recalibration to the 2013 trunk sewer conditions to best represent the current day system. The model was then recalibrated and updated to simulate new growth projections based on anticipated development intensification and system upgrades using data supplied from UK and the original calibration documents completed by CH2MHILL/XCG Consultants in 2009 for the Kingston Sewer Master Plan. The new system upgrades included a weir height adjustment to represent the West St. Combined Sewer Overflow (CSO) upgrades and twinning the forcemain crossing the Rideau Canal from the River St. PS.

With the updated model completed; three design scenarios were created to represent the system before development intensification (East 1), with intensification (East 2), and with intensification and flow redirection of the Portsmouth PS service area towards the Cataraqui Bay Wastewater Treatment Plant (West). For each scenario the trunk sewers, PS and wastewater treatment plants (WWTP's) infrastructure was evaluated under a design storm and CSO analysis where the shared impacts of combined sewer separation and flow redirection was observed. The results showed that a majority of net-reductions in flow were achieved through combined sewer separation alone; however the results showed that if flows are maintained to the east, significant upgrades to truck sewers, PS and CSO tanks would be required along the flow path to equal the same level of service (LOS) target originally anticipated in the base case (East 1). In the west scenario, however, net-reduction trends were observed for flows and CSO's in the Kingston Central trunk sewer system immediately downstream from the Portsmouth PS service area during dry-weather, major storm events and a 2008 wet-year simulation as compared to the East 2 scenario. The West scenario, however, presents the Cataraqui Bay WWTP with a substantial increase of dry-weather flow that exceeds the WWTP's current peak capacity for the growth projection scenarios and does not contribute to reductions in observable flow outside the Portsmouth PS service area's influence.

Areas where there is local pipe surcharging, PS firm capacity and WWTP peak capacity exceedences were identified for sewer system upgrades and analyzed to support development intensification. In summary, trunk sewer system upgrades excluding WWTP upgrades for Portsmouth PS routing east was estimated to be $20,650,000 while routing west was estimated to be $9,175,000.

1.0 Introduction

This technical memorandum depicts the review, data collection, and calibration to the City of Kingston trunk sewer InfoSWMM model being used as part of the Portsmouth Pumping Station (PS) Flow Direction Environmental Assessment (EA) to evaluate options and alternatives for assessment. WSP (formally GENVIAR) has been retained by Utilities Kingston (UK) to conduct the EA using the supplied InfoSWMM trunk sewer model which was originally created as part of the Kingston Sewer Master Plan completed by CH2MHILL and XCG Consultants in 2009.

As part of the evaluation process the model was validated and updated to reflect the current sewer infrastructure and pumping station operations. The calibration is a combination of data verification and model revisions using actual flow data provided by UK to represent current 2013 conditions. Growth projections and the impacts of redirecting sanitary flow from the Portsmouth Service area are also analysed in comparison to the Sewer Master Plan to evaluate the impacts on trunk sewer infrastructure and Combined Sewer Overflows (CSO's). The results and findings were then used to evaluate the probable upgrades and costs necessary to address increased sanitary flow from proposed development intensification for Portsmouth PS flow direction options.

2.0 Overview

The provided InfoSWMM model represents a trunk sewer system which divides the City of Kingston into three main collection areas (Kingston West, Kingston Central, Kingston East) that outlet to two separate waste water treatment facilities. The west system, which generally includes the portion of the City within the urban boundary west of Little Cataraqui Creek, collects and conveys flows to Cataraqui Bay WWTP. The central and east systems, which generally include the area east of the Little Cataraqui Creek, discharge to Ranvensview WWTP. The model represents the City's sewer system with a combination of pipe elements (conduits), pipe junctions (nodes), storage nodes (pump stations, CSO tanks and wet wells) and weirs (combined sewer overflow locations). The Portsmouth Pumping Station being considered for assessment is located in the central area and accounts for a service area of approximately 384 ha.

The procedure to evaluate options and alternatives for assessment of the Portsmouth flow redirection from East to West is a multi-stage process which requires the provided InfoSWMM model to be calibrated and validated to represent any new or upgraded infrastructure as well as current growth projections based on the City of Kingston Official Plan, Sewer Master Plan and updates from the City of Kingston planning department. The final model includes three scenario's representing existing 2013 conditions, the 2026 growth projection and a full build-out growth projection while a separate model was created to evaluate the redirection of Portsmouth Pumping Station. Refer to **Figure 2-1** for the Key Map of the Kingston Sewer service.

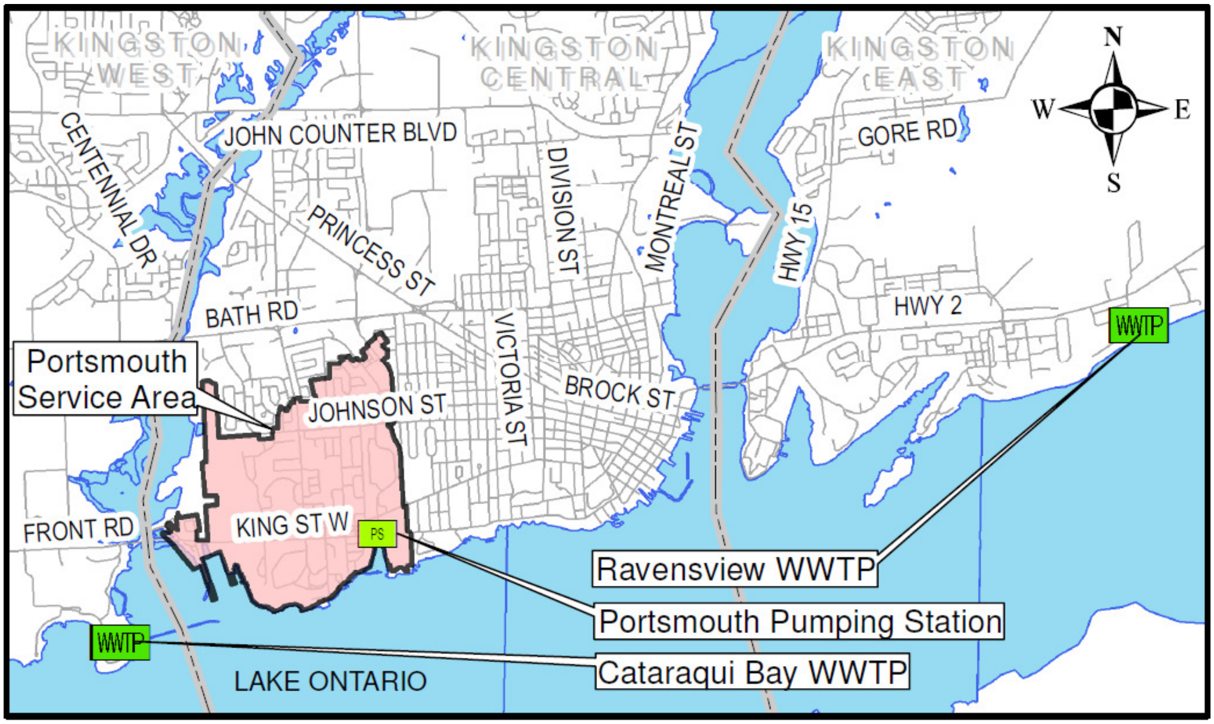


Figure 2 - 1 Key Map

3.0 Review of InfoSWMM Model and Available Data

3.1 2008 InfoSWMM Model Review

Review of the provided InfoSWMM model was conducted in order to determine the extent of calibration required prior to data collection and making model updates. Review was kicked-off by a meeting with UK personale David Fegan and Mike Fischer on August 1st, 2013 to determine the extent of system updates and projections to be considered for the EA. **Table 3-1** represents a summary of the system upgrades to be considered from the discussion. In addition to system upgrades, UK provided the criteria for consideration of future build-out projections based on the City of Kingston Official Plan and Sewer Master Plan. A summary of these projections are presented in **Table 3-2** and include prime development areas located in Kingston central.

Table 3 - 1: Summary of Upgrades to City of Kingston Trunk Sewer System

Location	System Upgrades/Adjustments
River St. Pumping Station and Cataraqui River Crossing	Forcemain Twinning as detailed in the Sewer Master Plan technical memorandum ' River Street Pump Station Capacity Analysis"
West St. CSO Weir	Increase weir height from 74.7m to 75.5m
Kings Street Pumping Station Upgrades	Pumps replaced with like for like.

Table 3 - 2: Summary of Intensification from Development Projections

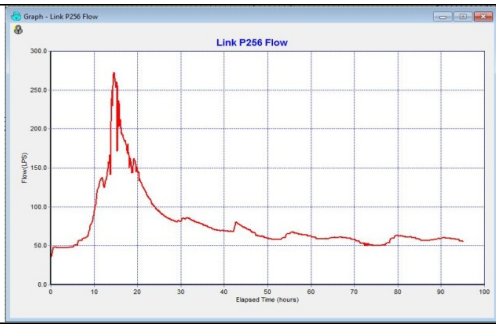
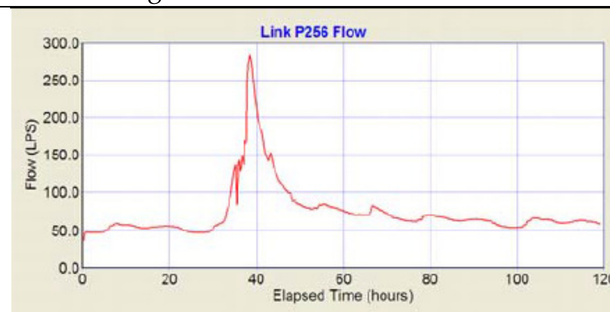
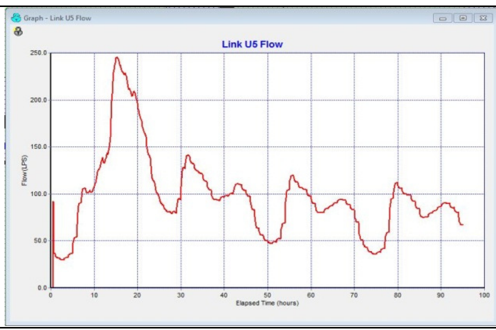
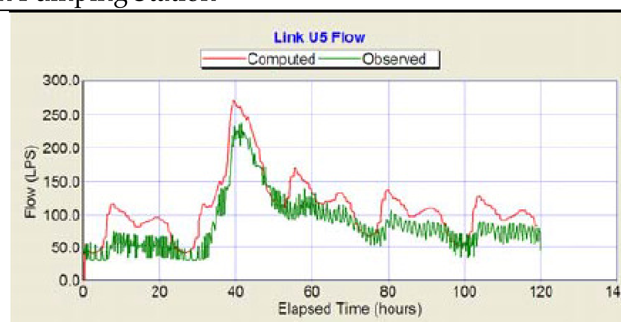
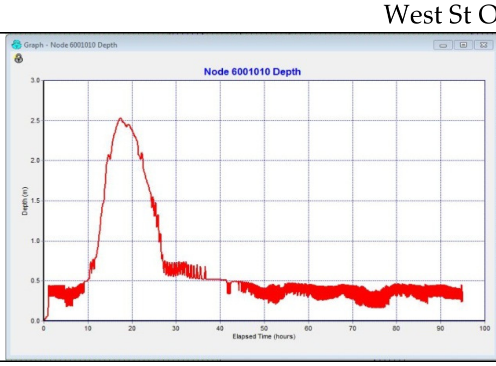
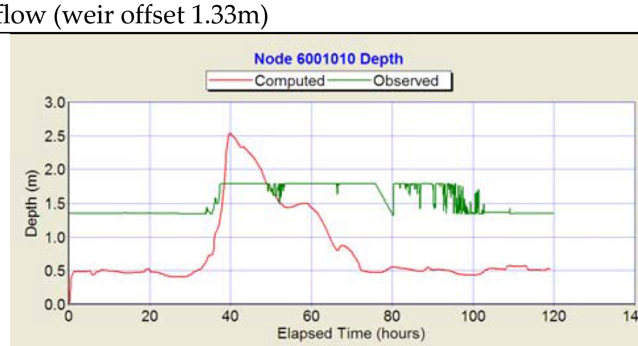
Location	Growth Projection
General Area's	General Development - 2.1 person per unit - Residential Density: Increase of 9% from the current overall density of 21.6 units per hectare within urban boundary to an overall minimum density of 23.5 residential units per net hectare by the Horizon year of 2026. The residential intensification target is to be achieved through larger scale developments, the expansion or conversion of existing buildings, and the redevelopment of vacant, underutilized, or Brownfield sites and infill developments. In addition, in new large scale developments the City seeks a density of 37.5 units per hectare. - 2% per year average growth Avoid double counting – use 2% unless otherwise specified, but not both - Rate of growth vs. Full build-out. - Utilize full build-out to determine preferable flow direction at Portsmouth PS. - Growth projected to be slightly negative beginning in 2030.
Willimsville	Short Term Development - Total Residential Units: 356 - Total Residential Population: 688 - Total Retail Population: 184 - Total Employment Units: 283 Long-Term Development - Total Residential Units: 1674 - Total Residential Population: 3230 - Total Retail Population: 922 - Total Employment Units: 1418
North Block	Full Development - 150 residential units per block with 3 blocks to potentially develop

	- Office space: negligible - Retail Commercial 10-15,000sq.ft. - Other 5,000 – 10,000 sq. ft. restaurant / café
Davis Tannery	Full Development - 300 units (multi's and apartments) and 1,100m^2 of commercial space
IO Psych Hospital	Full Development - 42L/sec sanitary peak flow, and 1033m3/day ADF added by new residential development on this land (Hospital not included). Details from XCG's Report to FoTenn Planning & Urban Design dated September 21, 2012.
St. Mary's Hospital	Full Development - Hospital is moving to a different location. Assume full build out of available land area based on urban lot size density.
Alcan Property	Development in accordance with Official Plan
Novellis	Development in accordance with Official Plan

Beginning with review of the model, WSP first tested the existing InfoSWMM projection scenarios for 2008, 2026 and Build-Out conditions as compared to the original calibration report documented in *CH2MHILL/XCG's Technical Memorandum No. 3, 2009*. Early model testing revealed that the supplied model did not produce the same results. A selection of representative model tests for the October wet weather event is presented in **Table 3-3** showing the varying results between model outputs.

Table 3 - 3: Documented vs Model Simulation Outputs for 2008 InfoSWMM Model

**Source: CH2MHILL/XCG Technical Memorandum No#3, May 2009*

<table>
<tr><th colspan="2">October 25 -28, 2008
Total rainfall 53.4mm; maximum one-hour amount = 10.8mm</th></tr>
<tr><td>Provided Model Simulation Outputs</td><td>Documented Calibration*</td></tr>
<tr><td colspan="2">C2: Collingwood St at King St. W.</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Portsmouth Pumping Station</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">West St Overflow (weir offset 1.33m)</td></tr>
<tr><td>
</td><td>
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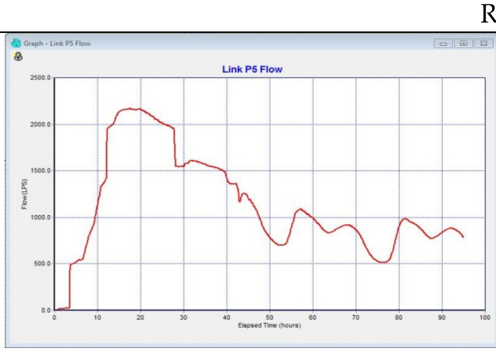
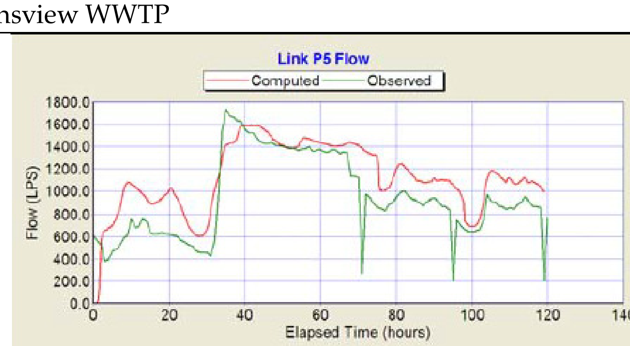
<tr><td colspan="2">Ravensview WWTP</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

In addition to model tests, WSP reviewed the model representations of the pumping stations, forcemains, sub-catchment areas, CSOs and trunk sewers as compared to the *Technical Memorandum No. 3* calibration report to ensure 2008 conditions were being represented appropriately. A summary of the observations are presented on **Drawings 3-1 and 3-2** in **Appendix A** where a few inconsistences are noted.

In summary, it was observed from the results that the diurnal dry-weather flow patterns suspected were still representative of the original documented results; however there were reductions to the total observable flow at peak conditions as compared to the actual flow data. There were also a few model results where flow conveyed through pumping stations, such as the Portsmouth Ave. PS and King St. PS, were consistent with dry-weather events but not with wet-weather events which may indicate that these systems were altered after the original calibration. Furthermore, it was observed that there were a series of infrastructure assumptions that were not optimized or represented in the original model; most specifically in Kingston East where the James St. and Hwy 15 (B64) PS do not have any sanitary inflow represented despite being in developed areas. Since system upgrades and projection scenarios are included in the recalibration process to the 2013 scenario as part of the scope for the environmental assessment the original calibration assumptions for representing the Portsmouth PS service area were found to be adequate without reproduction of the entire model.

3.2 Data Collection and Validation

To supplement recalibration of the original InfoSWMM model as well as updating the model for the current 2013 scenario a gap analysis was conducted to determine what information would be required as outlined in **Figure 3-1**.

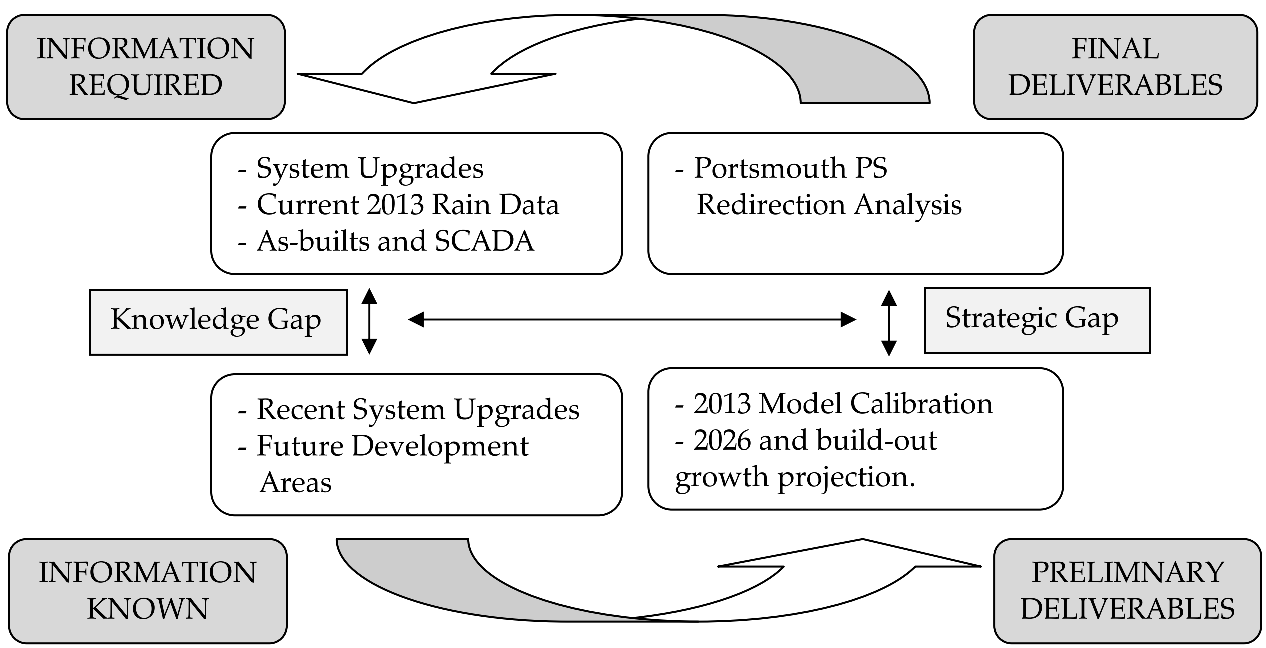


Figure 3 - 1 Gap Analysis for 2013 InfoSWMM Model Update and Portsmouth PS Analysis

The purpose of the gap analysis approach is to identify specific information required to reduce the information required for recalibration (knowledge gaps) and model simulation (strategic gaps) in order to perform the analysis. WSP identified and requested UK for available as-builts, rainfall, flow and water consumption data records in addition to the growth projection and system upgrades information provided at the project kick-off meeting. A summary of the information received is outlined in **Table 3-4**.

Table 3 - 4: Summary of Data Received from Utilities Kingston

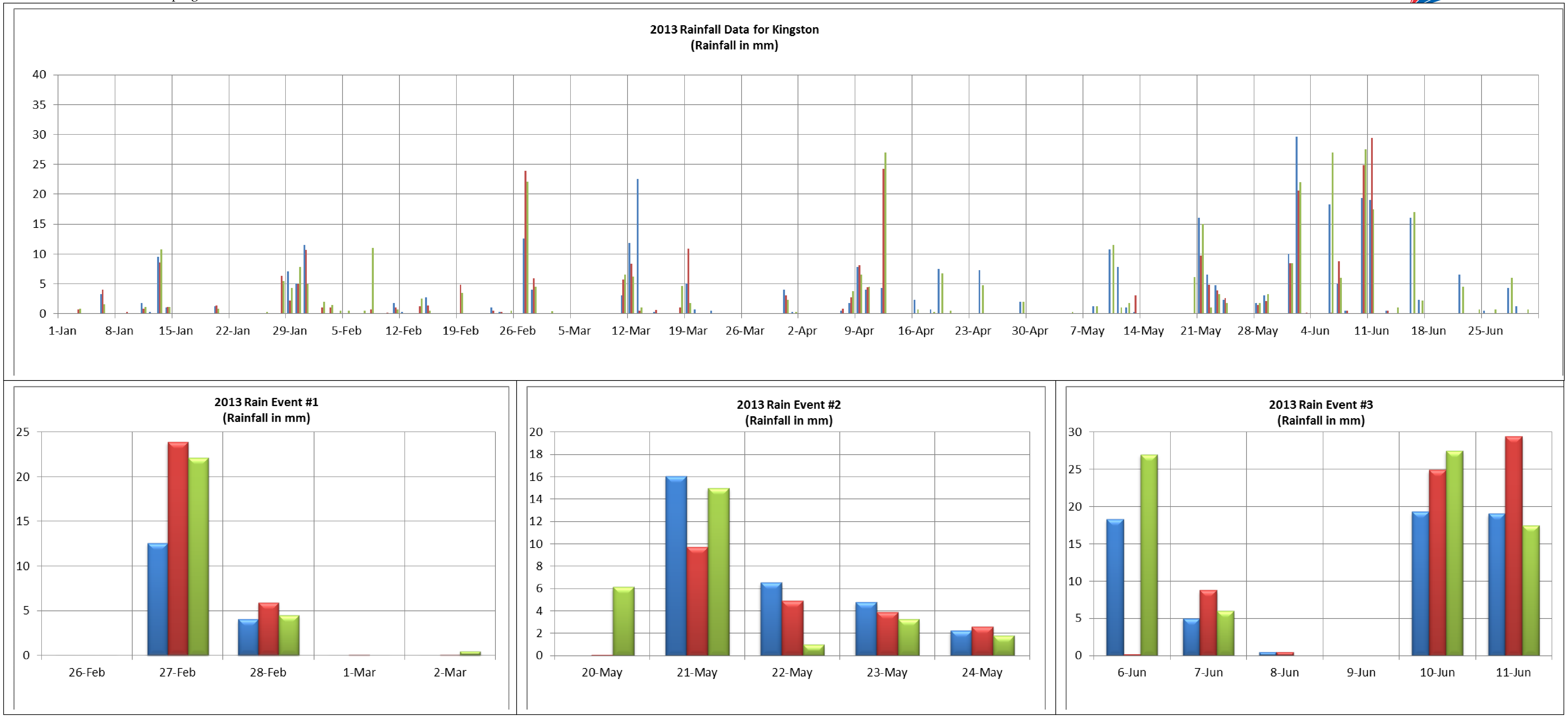
Requested Data Received
Flow Monitor ID Info: C1 – Process and Parkway C3 – Belle Park C6 C7 – Rideau Heights Tr W3 – Days road at P5 W7 – Off Princess near Costco W14– Princess Street adjacent to Winchester Lane W13 – Off Gardiners Road near Cataraqui Mall Storm Pond W10 – Off Tanner Drive behind McGinnis Landing E1 – Hwy 15 near Barrett Court Mona Drive Days Road Front Street Butternut Creek B40 B64 Portsmouth O'Kill (King Street) West (Cataraqui Bay) Ravensview
Current Billed Water Consumption Water Consumption Distribution Areas
Combined Drainage Area's Update Growth projections summary Williamsville build-out MOE Sewage Overflow Summary Report Report to Planning Committee - Projected Development River Street Pump Station Capacity Analysis
Forcemain as-built information for pumping stations System SCADA (Supervisory Control and Data Acquisition) for treatment facilities, CSO's and pumping stations.

3.2.1 Rainfall Data

Rainfall data for 2013 was provided by UK for the River Street PS Weather Station between the months of January-June. In addition to the provided information both Queen's University and Environment Canada rainfall data was collected from two additional weather stations to verify the data collected and to determine suitable rain events to be used for wet-weather calibration of the InfoSWMM model. A summary of the information collected is shown in **Figure 3-2**.

Comparing all weather data, three distinct wet-weather events were selected for model calibration for the months of February, May and June. Observing the data, it was noted that overall there was consistent representation of rainfall between all three weather stations; however the River St PS Weather Station reported periodically no rainfall on days where both of the other stations did report rainfall. To represent the gaps in data and to provide the best representation of rainfall for model input the Queen's University data was combined with the River St PS data since both datasets had the highest frequency of reported rainfall. The Mean Areal Precipitation (MAP) was computed to generate the model inputs to represent the most realistic simulation result for dynamic flows. The final modified rain gauge information used is presented in **Appendix B**.

In addition to the 2013 rain data. UK also provided WSP with the 2008 rain data and AES design storm data for 12-hr events. Both sets of data is appended in **Appendix B** and was used for the Portsmouth PS flow redirection analysis as presented in section 6.0 of this memo.



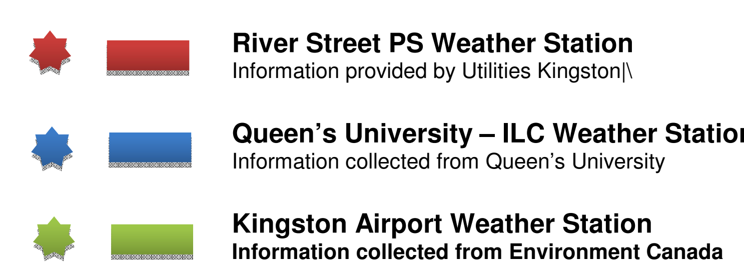


Figure 3 – 2: 2013 Rainfall Data Summary for Kingston Rain Gauge Stations

3.2.2 Flow Data

UK has provided actual 2013 flow observations from various pumping stations, trunk sewers and sewage treatment plants as indicated in **Table 3-3**. The data collected is used for the purposes of validating the inflows for the existing InfoSWMM model and for updating them during dry-weather and wet-weather calibration. The results and information is summarized in **Appendix C and D**. The data is further analysed as detailed in section 4.0 of this memo.

3.2.3 Water Consumption Data

Water consumption data was provided by UK for all billed water distribution areas for Kingston as complemented with the tri-services GIS map. This information is only used as part of the calibration process for dry-weather flow optimization and used in determination of suitable pipe infiltration for verification purposes.

3.2.4 As-Builts and SCADA information

For the purposes of updating and validating the existing and new infrastructure represented in the model both as-builts and SCADA information was used to validate pumping station details and forcemains currently in use. As previously identified in section 3.1, much of the forcemains were not represented in the model. **Drawing 3-2** of **Appendix A** depicts the forcemains and pumping stations updated from the information. Provided SCADA details are also included in **Appendix A** for reference.

3.2.5 System Upgrades, Growth Projection and Sewer Separation Reports

The system upgrade information as summarized in **Table 3-1** was provided by UK and is used for updating the model to reflect 2013 trunk sewer system conditions. In addition to the direct system upgrades WSP was also provided with an updated combined drainage area's map, development intensification details (**Table 3-2**) and reports/EA's outlining new build-out areas and future upgrades to existing infrastructure (**Table 3-4**). The reports and data provided complement the cities density intensification efforts as well as outlines the CSO reduction efforts in relation to MOE F-5-5 regulations and sewer separation progress. In general the reports are used to identify areas in the model for analysis. This information was used specifically for updating the 2013, 2026 and build-out scenario's which is used in the final analysis of the trunk sewer system when evaluating impacts for Portsmouth Pumping Station alterations. **Table 3-5** shows the combined sewer area reduction summary from the Utilities Kingston *Sewer Separation Progress, 2013* memo used in model calibration.

Table 3 - 5: Combined Sewer Separation Areas

2013 Combined Sewer Separation - No Area Separation (Approx. 160 Hectares of Combined Sewer Area)
2026 Combined Sewer Separation - 61% Area separation (Approx. 98 Hectares of Combined Sewer Area)
Build-out Combined Sewer Separation - 100% Area Separation

4.0 2013 Model Calibration

4.1 Calibration Process

The calibration process includes updating dry-weather and wet-weather sewage inflows as compared to actual flow data as a means to ensure effective representation of the trunk sewer system. The process selected is consistent with the original calibration process as outlined in CH2MHILL/XCG Consultants *Technical Memorandum's #2 and #3, 2009*. This is an iterative process involving the evaluation of the current 2008 output data, updating the model representations under dry-weather calibration and then updating the system representations for infrastructure and inflow's under a wet-weather calibration.

To update the InfoSWMM Model to 2013 the requested system upgrades were first incorporated into the model from **Table 3-1** and then new system representations were incorporated to correct the inconsistencies discussed in section 3 between the simulated and actual flow data. By following this process the method allows the benefit of 2008 model information to be updated and interpolated to 2013 for calibration in conjunction with the required data formatting to represent the design scenarios as part of the Portsmouth PS redirection analysis.

4.2 Calibration Targets

The model calibration/validation targets were selected based on the original calibration conducted by CH2MHILL/XCG Consultants as detailed in *Technical Memorandum #2, 2009* and summarized in **Table 4-1**. Emphasis is made towards more accurate representation of the wet-weather conditions for the purposes of evaluating peak flow system conditions.

Table 4 - 1: Dry and Wet Weather Calibration Criteria

Dry-Weather Flow Targets - Simulated dry-weather peak flows and volumes to be within 10% of observed values - The timing of simulated peak dry-weather flows will be within 1 hour of observed values.
Wet-Weather Flow Targets - Simulated peak wet-weather flows will be within -15% to +25% of observed values - Simulated wet-weather events volumes will be within -10% to +20% of observed values.

4.3 Dry-Weather Calibration

Dry-weather calibration accounts for solely the sanitary system loadings when no rain or extraneous flow is to be observed. The original calibration documented in CH2MHILL/XCG Consultants *Technical Memorandum #3, 2009* included a dry-weather flow optimization to determine the sanitary loadings with the absence of pipe infiltration during 2008; therefore the dry-weather recalibration was initiated by updating the model to 2013 inflow conditions and then running model simulations by selecting a period where no rainfall was observed from weather stations in order to compare to actual flow data. The model was updated to 2013 inflow conditions by interpolating between base 2008 conditions to 2026 growth projections already calibrated by using the 2% per year growth scenario from the City of Kingston Official Plan. A summary of the updated inflow parameters from the interpolation is presented in **Table C2** in **Appendix C**.

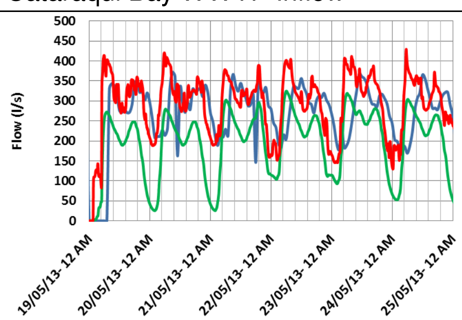
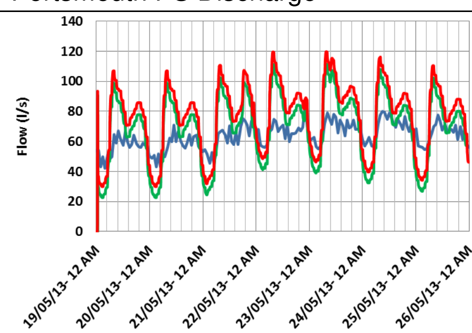
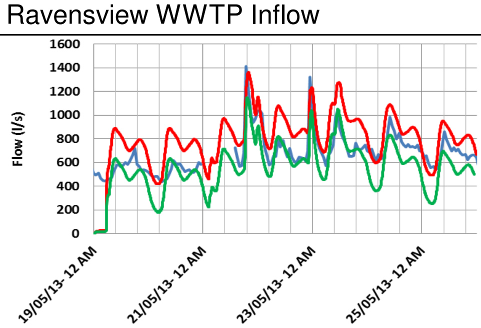
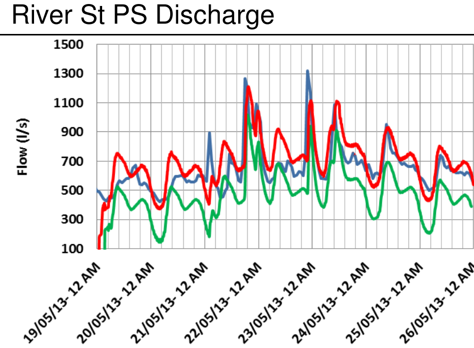
The next step in the recalibration was to determine if the original model calibration assumptions were adequate based on the dry-weather flow optimization documented in CH2MHILL/XCG consultants *Technical Memorandum #3, 2009*. Model tests were first computed for the dry weather period between March24-30, 2013 where the outputs were compared to actual flow data. The majority of the results were found to be within the target calibration ranges presented in **Table 4-1**, however prior to altering the previously developed diurnal patterns for Kingston West, Central and East areas there were notable peak dry-weather flows that were outside of the flow targets; specifically the Portsmouth PS and River St. PS which showed peaking factors that were 25% over or under actual flow values, with intermediate peaks they were found within the 10% target. The simulated King St. PS Inflow also showed a lot of 'scatter' as a result of flow assumptions for the various pumps as documented in the original calibration. At this point the model was updated with new system representations based on observations in section 3.0 before system upgrades were applied to avoid any misrepresentations observed in the 2008 model review. Once these updates were completed using available as-built information the results were compared to the actual 2013 flow data again where results were found to be within the target calibration ranges from **Table 4-1** including Portsmouth PS, River St. PS and King St. PS. This indicated that a new flow optimization would not be required and billed water consumption information would not be utilized for recalibration. The results of these tests are shown for the dry-weather period of March 24-30, 2013 is presented in **Appendix C**.

From these results a wet-weather calibration was conducted next to adjust the infiltration from wet-weather storm events.

4.4 Wet-Weather Calibration

Wet-weather calibration includes the adjustment of model variables related to pipe infiltration from extraneous flow. This includes the creation and adjustment of sub-catchment areas to represent the combined sewers in the Kingston trunk sewer system. The InfoSWMM model was originally calibrated to various rain events during 2008 which was considered a wet-year. To recalibrate to 2013 conditions, rain events were selected using gathered information as summarized in section 3.2.1 for February, May and June. The MAP rain events were inputted into the model and tests were run to compare the diurnal and peaking factors (peakiness) of total inflow/discharge for pumping stations, pipes and sewage treatment facilities. The results varied across each storm event. Overall the results as summarized in **Drawings 4.1-4.2** and **Tables D1-D3** in **Appendix D** showed that sewer system updates made during the dry-weather calibration provided a good representation of the 2013 conditions especially in comparison with pre-calibration reported values prior to the model updates. A summary of the main calibration results for the May wet-weather event calibration is shown in **Table 4-2**

Table 4 - 2: 2013 Wet Weather Calibration Comparison to Pre-Calibration

May 19-25, 2013 Rain Event —— -Computed (2008 Pre-Calibration) —— - Computed (2013) —— - Actual	
Cataraqui Bay WWTP Inflow	Portsmouth PS Discharge
	
Ravensview WWTP Inflow	River St PS Discharge
	

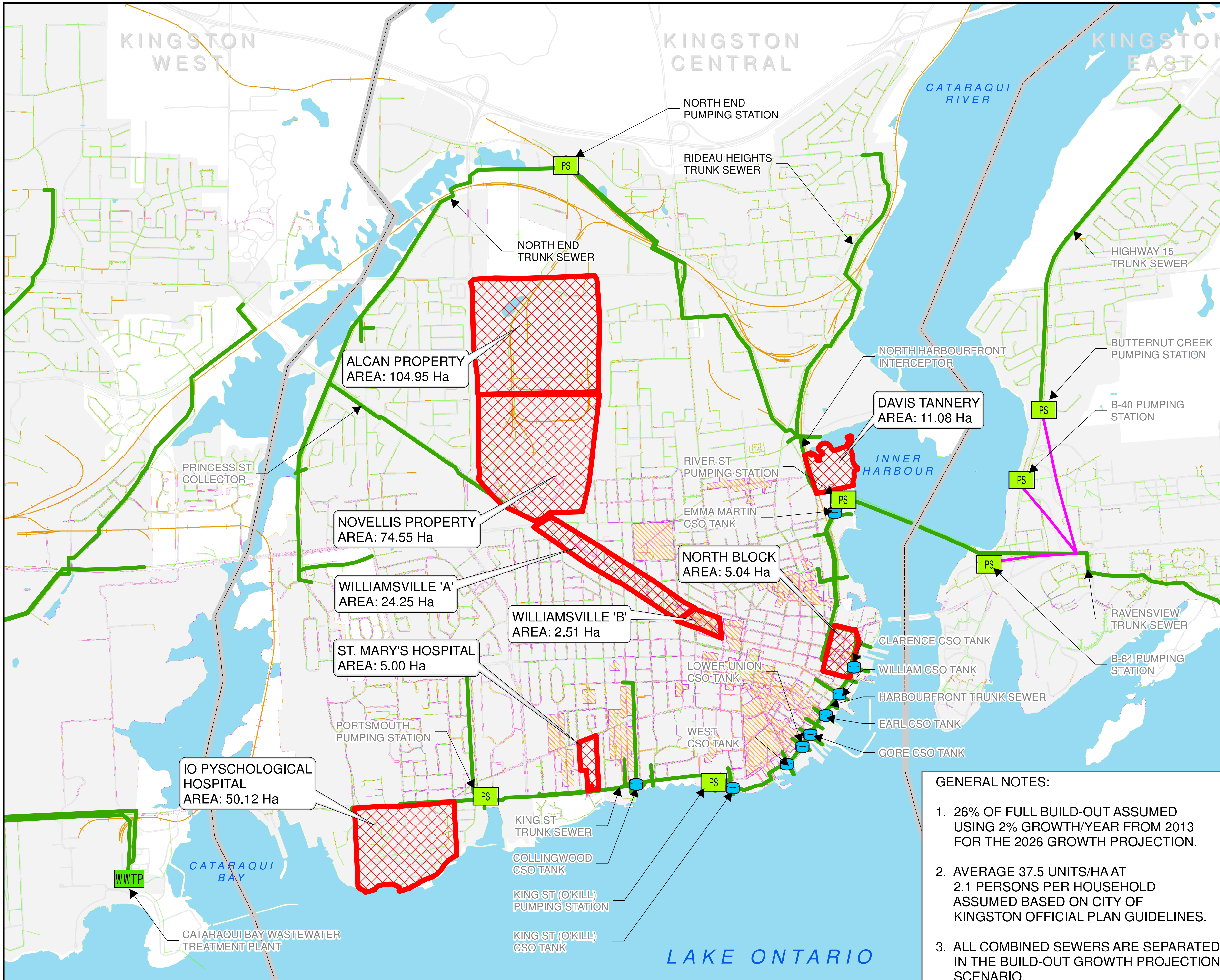
Anomalies were observed during the major June rain event simulation where there was a large peaking event on June 12th that was not being represented appropriately by the model simulations. This event was found to be unique and two different conditions were observed to represent the suspected anomaly. Firstly, the rain gauge information for this event showed largely varying results between River St PS Weather Station and the ILC Beamish-Munroe Weather station where the mean areal projected value may not have been an appropriate representation for parts of the City during this time period. Secondly, the modelling software is limited in its projection of longer term rain events where lag effects may occur. These effects are the conditions when water that doesn't escape the sewer system in the occurrence of prolonged surcharging and capacity accidence where the modelling software assumes pressurized conditions in pipes. Based on this, the final wet-weather calibration was compared to the May and February event where computed findings in comparison with actual flow data yielded simulations within the calibration targets presented in **Table 4-1**.

5.0 Projection Scenarios

5.1 Methodology and Assumptions

The methods and assumptions followed for developing future projection scenarios are built upon CH2MHILL/XCG Consultants *Technical Memorandum #4, 2009*. Further to the memo, which details the growth methods and assumptions represented in the model from known development in 2008, additional development intensification details for the City of Kingston Urban Area were provided by UK to represent the 2026 and Build-out scenarios as previously shown in **Table 3-2** of section 3.0. The current UK CSO reduction plan was also provided which showed the phased reduction of CSO catchment areas within Kingston Central where the ultimate build-out goal is to help eliminate existing CSO's by means of combined sewer separation. The assumptions and methods documented in the reports were used to develop growth projection scenario's that reflect the current 2013 objectives and each growth projection identified by first calculating the suspected dry-weather inflow generated as presented in **Tables E1-E3** of **Appendix E**.

It is to be noted that the 2026 and build-out projections were updated from the previously calibrated dry-weather inflows in CH2MHILL/XCG Consultants *Technical Memorandum #3, 2009*. The sub-catchment areas were updated during the recalibration using the information provided in the mapping information included in the UK *CSO Reduction Plan, 2012*.



GENERAL NOTES:

1. 26% OF FULL BUILD-OUT ASSUMED USING 2% GROWTH/YEAR FROM 2013 FOR THE 2026 GROWTH PROJECTION.
2. AVERAGE 37.5 UNITS/HA AT 2.1 PERSONS PER HOUSEHOLD ASSUMED BASED ON CITY OF KINGSTON OFFICIAL PLAN GUIDELINES.
3. ALL COMBINED SEWERS ARE SEPARATED IN THE BUILD-OUT GROWTH PROJECTION SCENARIO.

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Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- CSO TANK
- EXISTING SANITARY SEWER
- EXISTING COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- CATCHMENT AREA
- PORTSMOUTH PS SERVICE AREA
- INTENSIFICATION AREAS
- 2026 REMAINING COMBINED SEWERS

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Sewer System, Utilties Kingston, July 2013, City of Kingston.

Scale: 0 245 490 980 Meters
1:30,000

N W E S

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: GROWTH PROJECTION SUMMARY MAP

Project No.:		Date:
131-18048-00		MARCH, 2014
Drawn By: MF	Checked By: MM	Drawing No.: 5-1

5.2 2026 Growth Scenario

The 2026 growth projection scenario was created using the inflow growth rates in the original calibration and the model adjustments are summarized on **Drawing 5-1**. This scenario accounts for 26% growth within the identified development areas using the City of Kingston Official plan guidelines (as summarised in **Table 3-2** in section 3.0 and includes partial combined sewer separation. The original dry-weather inflow parameters from the first 2026 growth projection calibration conducted in the CH2MHILL/XCG Consultants *Technical Memorandum #3, 2009* were updated to reflect the increases in population while development area's not represented were provided with a new sub-catchment representation.

Specific considerations were made for intensification area's where known development or servicing plans have already been produced. The servicing plans considered are included in **Appendix E** for reference and includes the Williamsville service area where the short-term phasing was incorporated by dividing the development into two separate areas (Williamsville 'A' and 'B').

5.3 Build-out Growth Scenario

Similar to the 2026 growth scenario, the build-out scenario was created using the model parameter inputs in the provided InfoSWMM model with specific updates to each development area as outlined in **Tables E1-E3** in **Appendix E**. Additional to the 2026 growth scenario was the complete separation of all combined sewers to coincide with the sewer separation planned for Kingston Central. The final summary of full build-out growth projection updates to the model are presented on **Drawing 5-1.**

Once both the 2026 and build-out growth scenarios were updated all additional upgrades including the forcemain twinning of River St. pumping station and the weir height adjustment for West St. were completed to finalize the model before design storm analysis for evaluating the Portsmouth PS flow redirection to the West.

6.0 Portsmouth Pumping Station Flow Direction Analysis

6.1 Analysis Set-Up

The redirection of sanitary flow from the Portsmouth PS service area was first analyzed in CH2MHILL/XCG Consultants *Technical Memorandum #5* where the InfoSWMM model was used to evaluate the potential reductions in CSO overflows by the combination of different scenario's including combined sewer separation. The scope of this new model analysis was to evaluate impacts to the sewer system from redirection of the Portsmouth PS service area which includes the system upgrades and growth projections updated to represent the current 2013 trunk sewer conditions as well as the effects of development intensification. A single route for the forcemain connecting Portsmouth PS to the Cataraqui Bay WWTP was created in a new model which contained all of the recalibrated parameters from the 2013 model. The original forcemain connecting Portsmouth PS to the King St. trunk sewer was then deleted since no flow was to be represented. The new forcemain for analysis was represented as a single 500mm diameter forcemain with the same pumping parameters of the original station set 2m below the existing centre line road profile of King St. W/Front Rd. This representation adequately conveys all of the Portsmouth PS service area inflow to the Cataraqui Bay WWTP. The analysis was then divided into three sub-scenario's as summarised in **Table 6-1**.

Table 6 - 1: Portsmouth Pumping Station Flow Direction Analysis Scenarios

Scenario Name	Description
East 1	-Portsmouth PS flow directed towards Ravensview WWTP -Includes current upgrades -Does not include development intensification
East 2	-Portsmouth PS flow directed towards Ravensview WWTP -Includes current upgrades -Includes development intensification
West	-Portsmouth PS flow directed towards Cataraqui Bay WWTP -Includes current upgrades -Includes development intensification

6.1.1 Base Case Scenario

The base case scenario depicts a level of service (LOS) or baseline for the current growth projections which were calibrated in the original model through public input and Utilities Kingston before being adapted into the Sewer Master Plan for evaluating the Kingston Trunk Sewer System. The East 1 scenario was developed to represent the existing 2013 condition prior to any development intensification and is used as the base case or target for the purposes of analysis.

6.2 Design Storm Evaluation

To compare the impacts of the Portsmouth PS service area being directed east or west for the Kingston trunk sewer system both AES 12-Hr design storm scenarios and the dry-weather scenario were simulated using the updated InfoSWMM model. This evaluation is consistent with the reported methodology in *CH2MHILL/XCGL's Technical Memorandum #5* where the base case scenario (East 1) is used to compare each scenario after changes in development intensification and flow diversion. The extent of upgrades to the trunk sewer system required are based on these comparisons to provide the same LOS that was originally anticipated from the Sewer Master Plan or at least to the level equal to what the redirection would provide.

6.2.1 Results

The results of the design storm analysis are presented in **Appendix F** and were divided into two (2) categories; Pump Stations (**Table F1**) & WWTP, and trunk sewers (**Table F2**). Outputs for pumping stations and wastewater treatment facilities were compared to firm and documented capacities where any peak inflow outputs higher than these quantities indicated either an overflow or blockage event. For trunk sewers individual conduits/pipes represented in the model were each analyzed for surcharging where combined sewers including King St, the North Harboufront Interceptor and the Harbourfront Trunk Sewers were analyzed for changes in CSO tank conditions.

6.2.2 Discussion

6.2.2.1 Portsmouth PS Flow Directed East towards Ravensview WWTP

Analysing the results summarized in **Appendix F** the reduction in combined sewer areas from the growth projection scenario's provided the greatest reductions in trunk sewer pumping station & WWTP flows during major storm events which was represented in both the base case (East 1) and the development intensification case (East 2).

In the majority of the simulations the dry-weather event did not exceed the firm capacity of the majority of PS and WWTP except for the full build-out scenario where firm capacity exceedance was observed at the River St. PS as summarised in **Table 6-2**.

Table 6 - 2: River St PS Dry-Weather Storm Analysis East 1 vs. East 2

Route Direction	Firm Capacity (L/s)	2026 Peak Inflow (L/s)	Build-Out Peak Inflow (L/s)
East 1	1,425	1,221	1,311
East 2	1,425	1,302	2,021

Notes:
- [green] = Flow under firm capacity
- [red] = Flow exceeds firm capacity

It is to be noted that a few anomalies were observed at the King St. PS that showed firm capacity exceedences even in the dry-weather conditions. It is predicted that this is mainly due to the dynamic interaction between the PS and the King St CSO tank. However, the trends observed at the King St PS with respect to reductions from combined sewer separation were realised.

Examining the Portsmouth PS inflows from development intensification during the design analysis it was observed that there were net-increases in total inflow as summarized in **Table 6-3**.

Table 6 - 3: Portsmouth PS Design Storm Analysis East 1 vs East 2

Route Direction	DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 Yr
2013 Peak Inflow (L/s)							
East 1	128	190	231	261	302	332	364
East 2	128	190	231	261	302	332	364
2026 Peak Inflow (L/s)							
East 1	132	193	235	265	305	336	365
East 2	145	206	247	277	317	348	380
Build-out Peak Inflow (L/s)							
East 1	152	213	255	285	325	356	387
East 2	194	255	297	327	367	395	424

Notes:

- Portsmouth PS Reported Firm Capacity = 285 L/s (Ministry of Environment Certificate of Approval)
- [green] = Flow under firm capacity
- [red] = Flow exceeds firm capacity

These results for the Portsmouth PS show that current LOS for dry-weather and design storms are exceeded in the East 2 scenario as compared to the base case (East 1).

Table F2 of **Appendix F** demonstrates how sewer separation for all major design storm events between the existing 2013 scenario and growth projection scenarios show reductions in pipe surcharging. In the 2026 scenario, surcharging differences were observed between the base case (East 1) and the development intensification case (East 2) in both the King Street and Ravensview Trunk Sewer as seen in **Table 6-4**. The values indicating the percentage of pipes surcharged represents the amount of conduits/pipes in the trunk sewer and is a reflection of total surcharging. The severity of surcharging was also evaluated by observing the Hydraulic Grade Line (HGL) in relation to the existing ground profile where HGL 0.3m above the pipe and 2m below ground elevation, and within 2m of the existing ground elevation, which presents a risk for sanitary back-up in houses, were indicated. It can be seen that the base case (East 1) did have some severe surcharging in the King Street (1:25 yr design storm scenario and beyond) and the Ravensview (1:50 yr design storm scenario and beyond) trunk sewers. However, this is exacerbated with development intensification (East 2) and would require approximately 14% (33% - 19%) of the pipes to be upgraded in the King Street Trunk Sewer case and 21% (30% - 9%) of the pipes in the Ravensview Trunk Sewer case to meet the same LOS originally targeted.

Table 6 - 4: Trunk Sewer Design Storm Analysis for 2026 Conditions East 1 vs. East 2

Trunk Sewer	Route Direction	2026 Peak Inflow (L/s) Pipe Surcharging						
		DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 Yr
King Street Trunk	East 1					19%	19%	43%
	East 2					33%	33%	48%
Ravensview Trunk	East 1						9%	48%
	East 2						30%	52%

Notes:
- [green] = No pipe surcharging
- [yellow] = Pipe surcharging greater than 0.3m above pipe and 2m below ground elevation.*
- [red] = Pipe surcharging within 2m of ground elevation.*
- *Values indicate percentage of pipes surcharged

In the build-out scenario significant surcharging differences were observe between the base case (East 1) and the development intensification case (East 2) in both the North Harbourfront Interceptor and Harbourfront Trunk sewers as seen in **Table 6-5**. It can be observed that base case (East 1) did not have surcharging during the dry-weather events, however did experience surcharging with the development intensification case (East 2); 14% and 21% respectively. Although these trunk sewer systems use CSO tanks to control overflows by storage, this is a stronger indication that even with full sewer separation there will be local pipe infrastructure that will experience surcharging with the proposed development intensification.

Table 6 - 5: Trunk Sewer Design Storm Analysis for Build-Out Conditions EAST 1 vs. EAST 2

Trunk Sewer	Route Direction	Build-Out Peak Inflow (L/s) Pipe Surcharging						
		DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 Yr
North Harbourfront Interceptor	East 1		14%	29%	29%	29%	29%	71%
	East 2	14%	29%	29%	29%	29%	71%	100%
Harbourfront Trunk	East 1		19%	21%	25%	93%	93%	93%
	East 2	21%	21%	21%	79%	93%	93%	100%

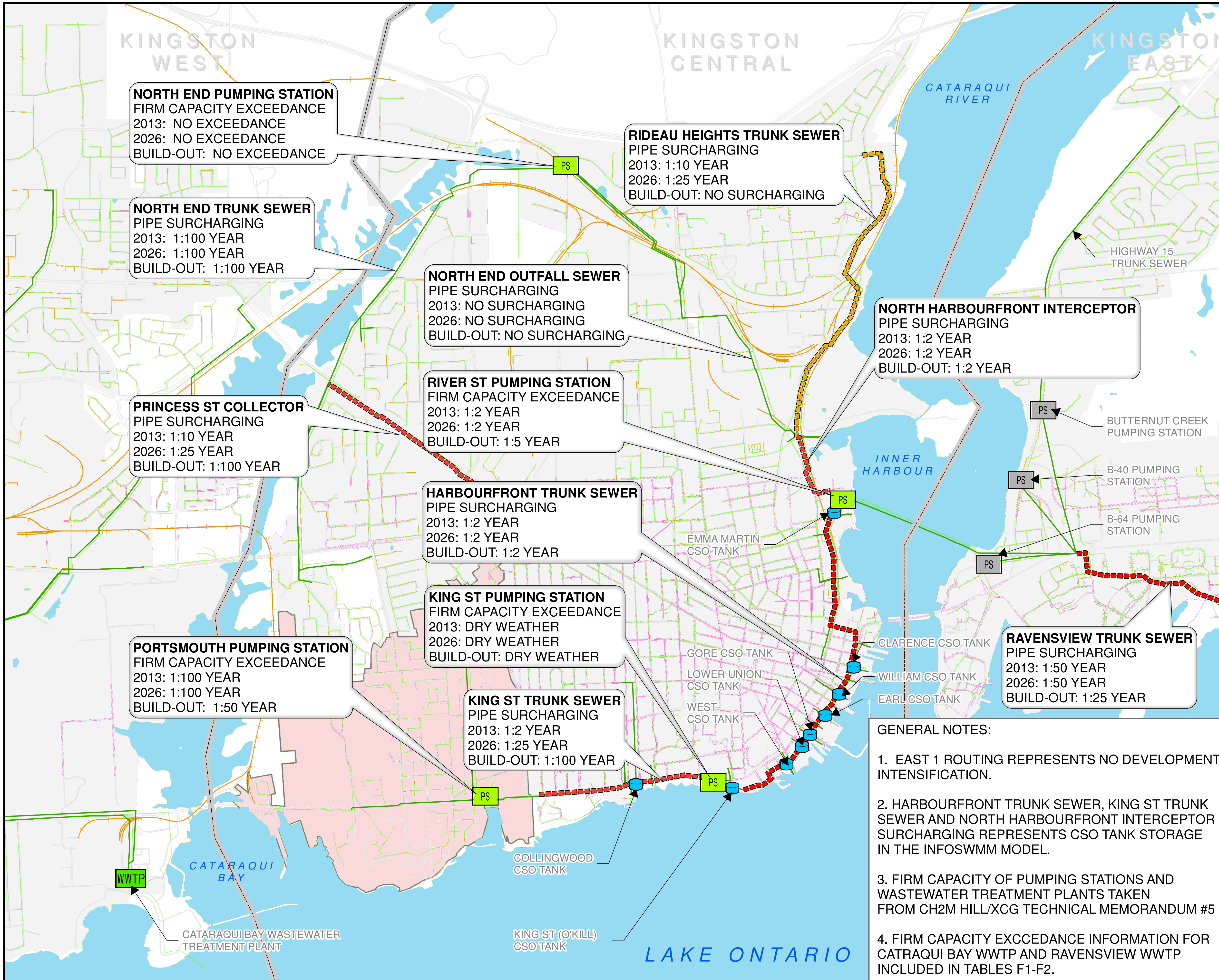
Notes:

- [green] = No pipe surcharging
- [yellow] = Pipe surcharging greater than 0.3m above pipe and 2m below ground elevation.*
- [red] = Pipe surcharging within 2m of ground elevation.*
- *Values indicate percentage of pipes surcharged

In this case the North Harbourfront Interceptor would require around 42% of the pipes to be upgraded under the 1:50yr design storm scenario to meet the same LOS target and prevent sever surcharging while the Harbourfront trunk sewer would require approximately 54% of the pipes to be upgraded under the 1:10yr storm scenario.

Pipe surcharging is even more apparent with the Princess St. Collector where the combination of the proposed development intensification for the Alcan/Novelis Property and Williamsville development will surcharge pipes within 2m of the existing ground even in the dry-weather rainfall event in the build-out projection; however this trunk sewer is not influenced by the Portsmouth PS redirection and was therefore not evaluated further.

The capacity of the linear infrastructure as compared to the base case LOS is summarised in **Drawings 6-1 and 6-2** which represent the trunk sewer system results for the East 1 and East 2 simulations respectively.



GENERAL NOTES:

1. EAST 1 ROUTING REPRESENTS NO DEVELOPMENT INTENSIFICATION.

2. HARBOURFRONT TRUNK SEWER, KING ST TRUNK SEWER AND NORTH HARBOURFRONT INTERCEPTOR SURCHARGING REPRESENTS CSO TANK STORAGE IN THE INFOSWMM MODEL.

3. FIRM CAPACITY OF PUMPING STATIONS AND WASTEWATER TREATMENT PLANTS TAKEN FROM CH2M HILL/XCG TECHNICAL MEMORANDUM #5

4. FIRM CAPACITY EXCCEDANCE INFORMATION FOR CATRAQUI BAY WWTP AND RAVENSVIEW WWTP INCLUDED IN TABLES F1-F2.

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Legend:
- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- CSO TANK
- EXISTING SANITARY SEWER
- EXISTING COMBINED SEWER
- TRUNK SEWER/FORCEMAIN
- SURCHARGING WITHIN 2m OF EXISTING GROUND FOR 2013, 2026 AND BUILD-OUT CONDITIONS
- SURCHARGING WITHIN 2m OF EXISTING GROUND FOR 2013, AND 2026 CONDITIONS
- SURCHARGING WITHIN 2m OF EXISTING GROUND FOR 2013 CONDITIONS.
- CATCHMENT AREA
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utiltiies Kingston, July 2013, City of Kingston.

Scale: 0 250 500 1,000 Meters
1:30,000

N S E W

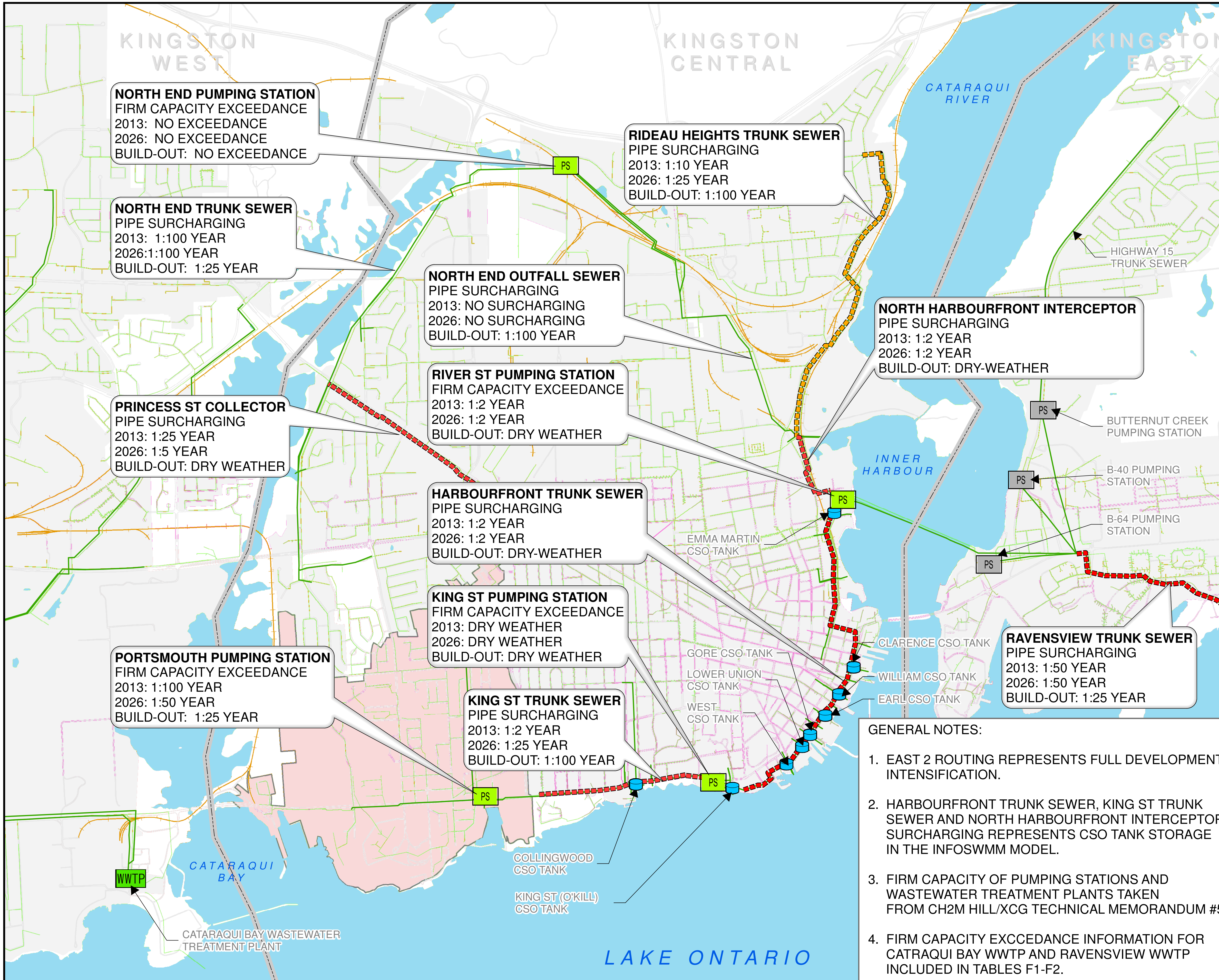
Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: DESIGN STORM ANALYSIS: PORTSMOUTH PS ROUTING EAST 1

Project No.:	Date:
131-18048-00	MARCH, 2014

Drawn By:	Checked By:	Drawing No.:
MF	MM	6-1



GENERAL NOTES:

1. EAST 2 ROUTING REPRESENTS FULL DEVELOPMENT INTENSIFICATION.
2. HARBOURFRONT TRUNK SEWER, KING ST TRUNK SEWER AND NORTH HARBOURFRONT INTERCEPTOR SURCHARGING REPRESENTS CSO TANK STORAGE IN THE INFOSWMM MODEL.
3. FIRM CAPACITY OF PUMPING STATIONS AND WASTEWATER TREATMENT PLANTS TAKEN FROM CH2M HILL/XCG TECHNICAL MEMORANDUM #5
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Legend:

- WWTP - WASTEWATER TREATMENT PLANT
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- CATCHMENT AREA
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utilties Kingston, July 2013, City of Kingston.

Scale:
0 245 490 980 Meters
1:30,000

N E S W

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: DESIGN STORM ANALYSIS: PORTSMOUTH PS ROUTING EAST 2

Project No.:	Date:
131-18048-00	MARCH, 2014

Drawn By:	Checked By:	Drawing No.:
MF	MM	6-2

6.2.2.2 Portsmouth PS Flow Directed West towards Cataraqui Bay WWTP

Reviewing the results for the Portsmouth PS flow directed west towards Cataraqui Bay WWTP there were multiple trends observed. Overall the flow generated from the Portsmouth PS service area being directed to the west provided net reductions in surcharging in the Kingston Central trunk sewers and reductions in peak inflows into pumping stations. Incidentally the peak inflows into the Cataraqui Bay WWTP experienced a dramatic increase while the immediate downstream King St. Trunk Sewer received a dramatic decrease as summarised in **Table 6-6 and 6-7** respectively.

Table 6 - 6: Cataraqui Bay WWTP Storm Analysis East 1 vs West

Route Direction	DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 Yr
2013 Peak Inflow (L/s)							
East 1	439	649	815	904	1,033	1,140	1,277
West	545	953	1,012	1,143	1,315	1,455	1,624
2026 Peak Inflow (L/s)							
East 1	512	760	894	1,014	1,118	1,250	1.377
West	666	953	1.095	1,265	1,424	1,581	1,744
Build-out Peak Inflow (L/s)							
East 1	709	954	1,1099	1,196	1,335	1,432	1,571
West	948	1,164	1,375	1,495	1.672	1,808	1,944

Notes:
- Cataraqui bay WWTP Peak Instantaneous Capacity = 799 L/s (Peak process instantaneous flows based on Kingston Sewer Master Plan)
- [green] = Flow under peak instantaneous capacity
- [red] = Flow exceeds peak instantaneous capacity

Table 6 - 7: Trunk Sewer Design Storm Analysis for 2013 Conditions East 1 vs. West

Trunk Sewer	Route Direction	2013 Peak Inflow (L/s) Pipe Surcharging						
		DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 Yr
King St Trunk Sewer	East 1		10%	24%	38%	48%	57%	62%
	West					33%	38%	62%

Notes:
- = No pipe surcharging
- = Pipe surcharging greater than 0.3m above pipe and 2m below ground elevation.*
- = Pipe surcharging within 2m of ground elevation.*
- *Values indicate percentage of pipes surcharged

Similar to the examination in section 6.2.2.1 the Portsmouth PS peak inflow design storm simulation results for the West scenario were observed to match the East 2 scenario for development intensification conditions as shown in **Table 6-8**. Therefore, the peak inflow LOS observed in the base case (East 1) scenario is exceeded for the West scenario.

Table 6 - 8: Portsmouth PS Design Storm Analysis East 1 vs West

Route Direction	DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 Yr
2013 Peak Inflow (L/s)							
East 1	128	190	231	261	302	332	364
West	128	190	231	261	302	332	364
2026 Peak Inflow (L/s)							
East 1	132	193	235	265	305	336	365
West	145	206	247	277	317	348	380
Build-out Peak Inflow (L/s)							
East 1	152	213	255	285	325	356	387
West	194	255	297	327	367	395	424

Notes:
- Portsmouth PS Reported Firm Capacity = 285 L/s (Ministry of Environment Certificate of Approval)
- = Flow under firm capacity
- = Flow exceeds firm capacity

Another important observation to describe is that even with separation of the service area, which provided reductions in peak inflows into Kingston Central, the peak flows going into Ravensview WWTP were almost unchanged since the loadings of the Ravensview Trunk sewer are mostly dictated by the River St. PS which pumps at capacity continuously during the major storm events. This process creates bottlenecks further upstream of the River St. PS which is either collected in CSO tanks (represented as surcharging in the Harbourfront sewer in the model simulation) or overflows out of the sewer system. Other observations show that the bottlenecks are limited only to Harbourfront Interceptor, King St Trunk Sewer, Rideau St Trunk Sewer and the Harbourfront Trunk Sewer. Although bottlenecks are observed there are total flow reductions and reduced surcharging as compared to the base case LOS as summarised in **Table 6-9**.

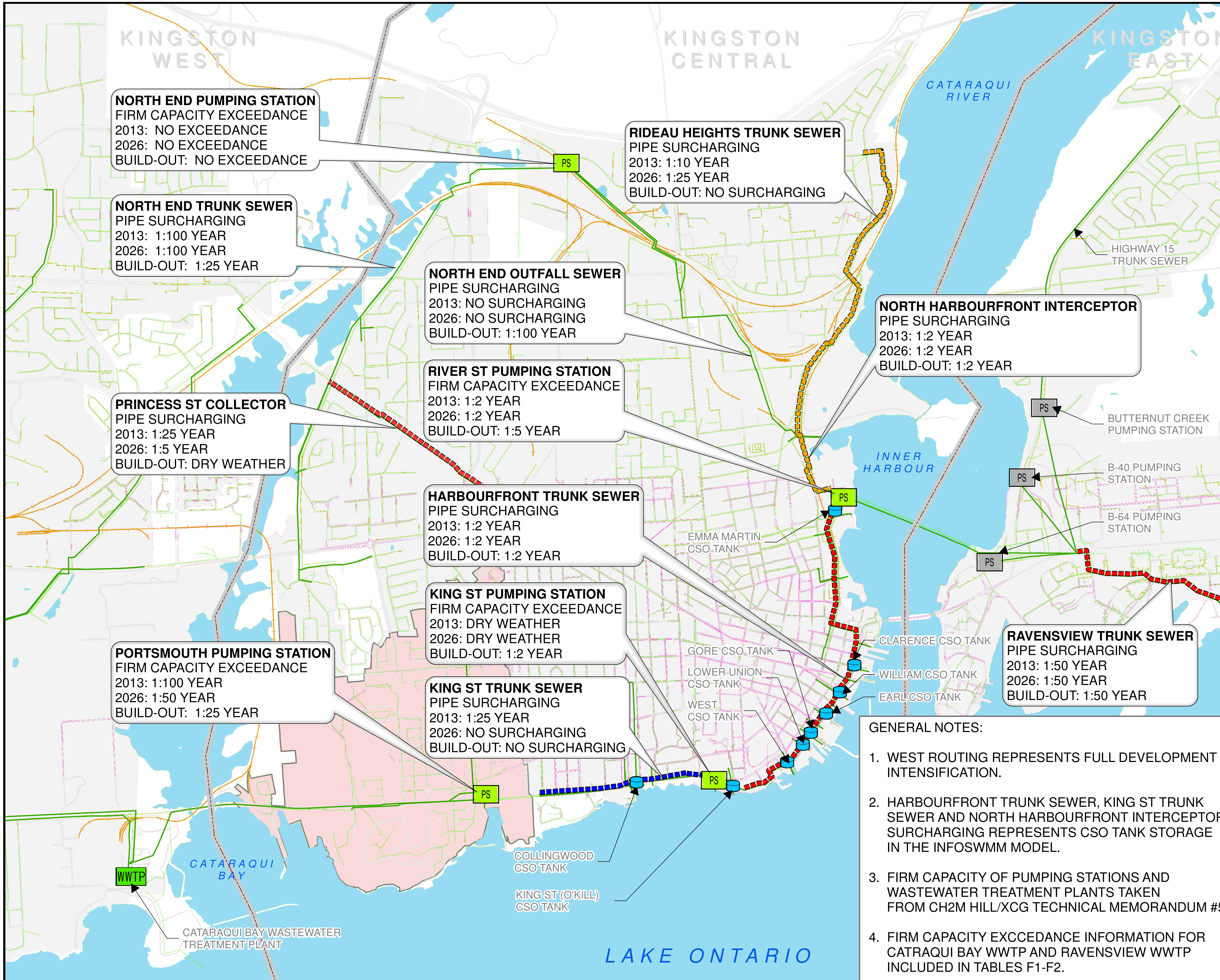
Table 6 - 9: Trunk Sewer Design Storm Analysis for Build-Out Conditions East 1 vs. West

Trunk Sewer	Route Direction	Build-out Peak Inflow (L/s) Pipe Surcharging						
		DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 Yr
North Harbourfront Interceptor	East 1		14%	29%	29%	29%	29%	71%
	West		14%	29%	29%	29%	29%	29%
King St Trunk Sewer	East 1							5%
	West							
Harbourfront Trunk	East 1					9%	43%	52%
	West						49%	52%

Notes:

- (green) = No pipe surcharging
- (yellow) = Pipe surcharging greater than 0.3m above pipe and 2m below ground elevation.*
- (red) = Pipe surcharging within 2m of ground elevation.*
- *Values indicate percentage of pipes surcharged

There were no flow reductions observed for the Princess St. Collector, North End Trunk Sewer and North End Outlet Trunk Sewer from Portsmouth PS service area redirection as this area does not have a direct link to these sewers. Overall the redirection of the Portsmouth PS service area west increases the required capacity at Cataraqui Bay WWTP, but provides a significant net reduction in the loadings to the Kingston Central and Kingston East sewer systems which bring the observable flows closer to the East 1 scenario results. This indicates that the combination of system upgrades, planned sewer separation and flow redirection reduces overall peak flows closer to pre-development intensification flows save and except areas unaffected by the redirection. **Drawing 6-3** summarises the results for west scenario



GENERAL NOTES:

1. WEST ROUTING REPRESENTS FULL DEVELOPMENT INTENSIFICATION.
2. HARBOURFRONT TRUNK SEWER, KING ST TRUNK SEWER AND NORTH HARBOURFRONT INTERCEPTOR SURCHARGING REPRESENTS CSO TANK STORAGE IN THE INFOSWMM MODEL.
3. FIRM CAPACITY OF PUMPING STATIONS AND WASTEWATER TREATMENT PLANTS TAKEN FROM CH2M HILL/XCG TECHNICAL MEMORANDUM #5
4. FIRM CAPACITY EXCCEDANCE INFORMATION FOR CATRAQUI BAY WWTP AND RAVENSVIEW WWTP INCLUDED IN TABLES F1-F2.

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Legend:
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- SURCHARGING WITHIN 2m OF EXISTING GROUND FOR 2013 CONDITIONS.
- CATCHMENT AREA
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Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Sewer System, Utilties Kingston, July 2013, City of Kingston.

Scale: 0 250 500 1,000 Meters
1:30,000

N E S W

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: DESIGN STORM ANALYSIS: PORTSMOUTH PS ROUTING WEST

Project No.:		Date:
131-18048-00		MARCH, 2014
Drawn By: MF	Checked By: MM	Drawing No.: 6-3

6.3 Combined Sewer Overflows

To further compare the impacts associated with flow redirection of the Portsmouth PS service area for the Kingston trunk sewer system the 2008 wet-weather year scenario was simulated using the InfoSWMM model for a period from April 1 to October 31. This period was selected to represent comparisons between the original sewer master plan analysis conducted in *CH2MHILL/XCG Consultants Technical Memorandum #5* and the calibrated base scenario for 2013 conditions.

6.3.1 Results

The results of the CSO analysis are presented in **Table 6-10** which shows the total volume of CSO's at various overflow locations for the Kingston Central system. CSO's were compared to the base case scenario for the existing 2013 conditions before development intensification to determine the net reductions in CSO volume from sewer separation and flow redirection towards the West for the Portsmouth PS. These findings are further summarised in **Figure 6-1.**

Table 6 - 10: CSO Summary – Portsmouth Service Area Routed East vs. West

		Evaluation of CSO with Upgrades and Portsmouth Flow Direction East Vs. West Volume (m^3) (Using rain data for April 1 to October 31, 2008)							
Location	**Model I.D.**	**Existing Condition (2013)**		**Growth Scenario (2026)**			**Growth Scenario (Build-Out)**		
		EAST[1,2] *	**WEST**	**EAST[1]**	**EAST[2]**	**WEST**	**EAST[1]**	**EAST[2]**	**WEST**
Harbourfront Trunk at West St CSO	O9	51,795	40,017	36,131	40,137	24,869	23	65	0
Collingwood CSO	CELL3TOCELL4	7,417	808	803	946	0	0	0	0
King St PS (O'Kill) CSO	O36	6,540	3,780	0	0	0	0	0	0
King St (O'Kill) CSO	O28	12,284	6,768	0	0	0	0	0	0
Belle Park local 1200 Overflow	O34	3,250	3,179	2,346	3,062	2,733	0	0	0
Barrack Street CSO	O15	1,670	1,470	1,074	1,232	977	0	0	0
Queen Street CSO	O14	1,603	1,436	994	1,141	907	0	0	0
Princess Street CSO	O13	1,411	1,375	1	8	7	0	0	0
Belle Park Trunk Overflow	O20	1,202	1,170	180	426	355	0	0	0
River Street PS Overflow	O19	447	410	0	0	0	0	0	0
Lower Union St CSO	O30	756	752	612	678	613	0	0	0
Earl St CSO	O32	528	526	740	756	754	0	0	0
Gore St CSO	O31	40	35	0	0	0	0	0	0
West Street Local Sewer Overflow	O29	61	56	402	404	385	0	0	0
William St	O33	0	0	316	316	316	0	0	0
Clarence St CSO	O11	33	34	0	0	0	0	0	0
Cataraqui St CSO	O17	**Reported no CSO - (NOT GRAPHED)**							
Brock St CSO	O12								
North Street	O35								
Johnson St	O10								
Albert N of King	O27								
Portsmouth Pump Station Overflow	O5								
North End Pump Station Overflow	O21								
North End Trunk at Sherwood Overflow	O22								
North End Trunk at Parkway St Overflow	O23								
	TOTAL CSO	**89,038**	**61,817**	**43,598**	**49,105**	**31,916**	**23**	**65**	**0**
	% Reduction from Base	**0%**	**31%**	**51%**	**45%**	**64%**	**99.97%**	**99.92%**	**100%**

*Baseline CSO Condition

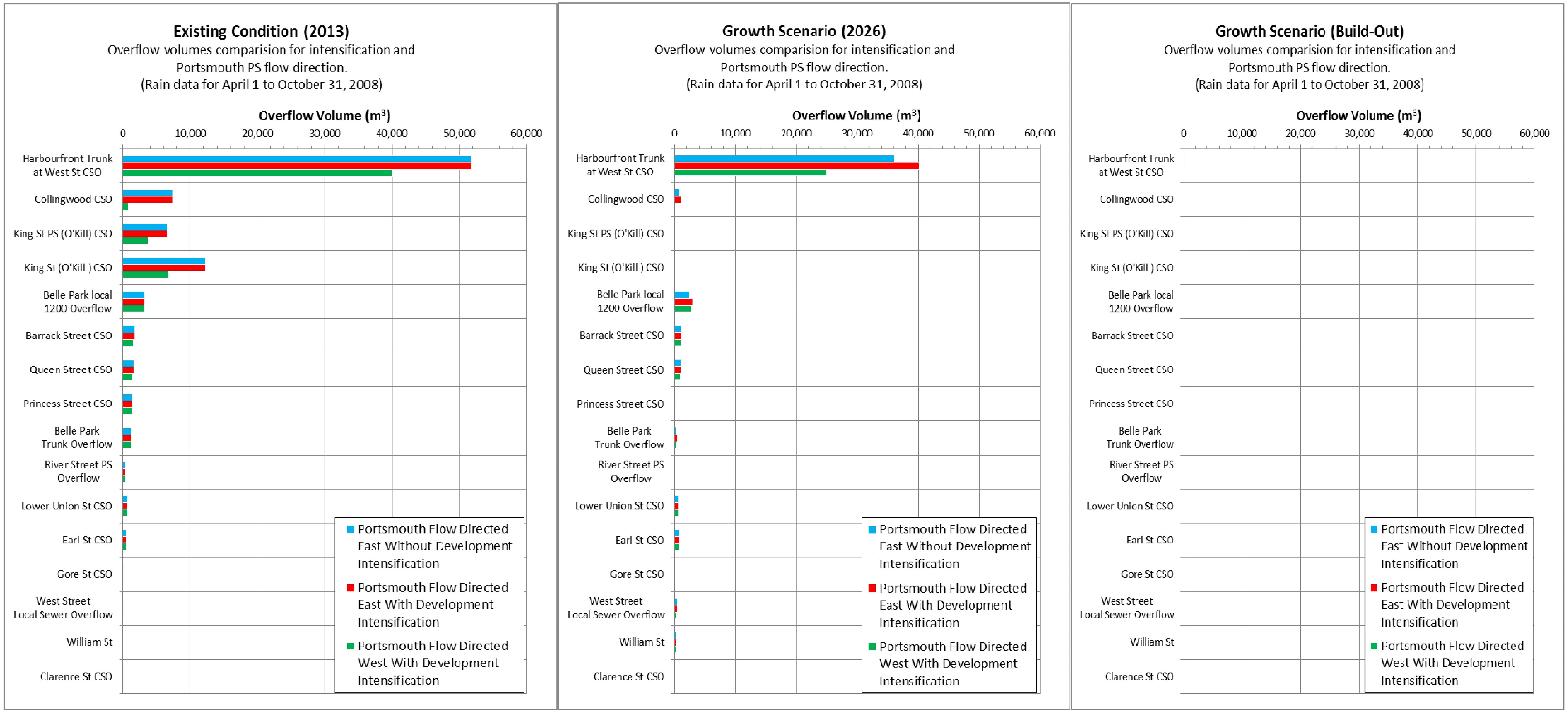

Figure 6 - 1 Combined Sewer Overflow Comparison: East 1 vs. East 2 vs. West Scenario's

6.3.2 Discussion

6.3.2.1 Portsmouth PS Flow Directed East Towards Ravensview WWTP

The most dominate trend observed between growth scenarios is the decrease in CSO's from sewer separation. This trend results in 51% reductions of total CSO's in the 2026 growth scenario and nearly a 100% reduction in CSO's in the build-out condition even with development intensification as compared to the 2013 base case. This observed trend is consistent with the sewer master plan where similar reductions were achieved while simulating the 2008 wet-year flow condition for combined sewer separation scenarios. The total CSO volume results for East 2 as compared to the baseline are summarised in **Table 6-11**.

Table 6 - 11: CSO Summary: East 1 vs East 2

	Existing Condition (2013)		Growth Scenario (2026)		Growth Scenario (Build-Out)	
	East 1	East 2	East 1	East 2	East 1	East 2
Total CSO Volume (m^3)	89,038*	89,038	43,598	49,105	23	65
% Reduction from Base	0%	0%	51%	45%	99.97%	99.92%

Notes:
- * Baseline CSO Condition

Examining specific CSO tanks it is apparent that the increase in development intensification causes additional CSO volume for the trunk sewer systems in Kingston Central. Overall reductions are shown in the 2026 growth scenario resulting in elimination of CSO for the King St PS and King St CSO tank, however the West St, Barrack St. and Queen Street CSO tanks all experienced increases in CSO which are mostly contributed by the Williamsville and North Block proposed development intensification. One other location which received increases in CSO from development intensification was the Bellepark local 1200mm overflow. At this location the combination of the proposed Williamsville, Novelis and Alcan development intensification are all contributing factors, while sewer separation is less effective in reducing CSO's upstream along the Rideau Heights trunk sewer. This observation is consistent with the bottlenecks observed in the North Harbourfront Interceptor from River St. PS operating at continuous capacity.

Overall with the current upgrades and planned sewer separation, the CSO's are observed to be eliminated for the build-out growth scenario and there were observed net-reductions in CSO's for the short term and the 2026 growth projection in comparison to the base case (East 1); however with intensification there is an increase in comparison to the planned reduction without intensification (East 1 – 2026 growth scenario) and many upgrades would be necessary in order to reduce CSO's down to the baseline LOS observed.

6.3.2.2 Portsmouth PS Flow Directed West Towards Cataraqui Bay WWTP

Reductions in total CSO's volumes were observed when the Portsmouth PS service area inflows were redirected towards Cataraqui Bay including 31% reductions under existing conditions prior to development intensification. Up to 64% reductions were further observed as compared to the base scenario in 2026 when the current proposed combined sewer separation was also included with the redirection of the Portsmouth PS service area flow. In the build-out growth scenario there was no observable CSO in the Harbourfront Trunk Sewer which is concurrent with East 1 and East 2 development intensification scenarios that show similar results after full combined sewer separation. The total CSO volume results for West scenario as compared to the baseline is summarised in **Table 6-12**.

Table 6 - 12: CSO Summary: East 1 vs West

	Existing Condition (2013)		Growth Scenario (2026)		Growth Scenario (Build-Out)	
	East 1	West	East 1	West	East 1	West
Total CSO Volume (m^3)	89,038*	61,817	43,598	31,916	23	0
% Reduction from Base	0%	31%	51%	64%	99.97%	100%

Notes:
- * Baseline CSO Condition

Examining specific CSO locations it was made apparent that the Harbourfront Trunk at West St. and the Collingwood CSO tank receives the greatest reduction of CSO's under existing conditions as compared to the base 2013 scenario from the Portsmouth PS service area flow redirection. This trend in major CSO reduction is also realised for downstream locations to the Collingwood CSO tank including the King St PS, and King St, West St, Barrack St. and Queen Street CSO tanks where CSO is reduced to almost pre-development intensification levels in the 2026 growth scenario.

In summary the reductions observed, although less substantial then complete combined sewer separation, show immediate reductions to CSO's across the Kingston Central Trunk sewer system. It is to be noted though that the overflow locations located along the Harbourfront Interceptor and North End Outlet are unaffected by the Portsmouth Service Area separation and any development intensification that contributes to the Princess St. Collector, North End Trunk Sewer, North End Outlet Sewer and Rideau Heights Trunk Sewer is also unaffected by the redirection.

7.0 Upgrades and Costs

With the analysis of the Portsmouth PS flow direction simulation for East and West options the comparisons to the base case was conducted to determine the level of upgrades necessary to meet the current baseline LOS or at least to the level that the redirection would provide. Refer to Appendix G for cost estimate of upgrades.

7.1 Portsmouth PS Flow Directed East Towards Ravensview WWTP

Considerations to support the current trunk sewer system layout would be to upgrade the capacity of existing pumping stations and associated trunk sewers and forcemains as necessary to match the baseline LOS or redirection, whichever is greater) to help reduce flow capacity exceedences and pipe surcharging during major storm events. The system upgrades based on the model simulation would include local trunk sewer upsizing and PS capacity increases as summarised in **Table 7-1**.

Table 7 - 1: Sewer System Upgrades for Reducing Flow Capacity Exceedance: East Routing

Pumping Stations		
Pumping Station	Upgrades Required to Match Base Case LOS	Opinion of Probable Cost (OPC)
River Street PS	Additional capacity to accommodate full Build-out Growth Projection ~ 424L/s peak instantaneous flow*	$3,600,000
Trunk Sewers		
Pumping Station	Upgrades Required to Match Base Case LOS	Opinion of Probable Cost (OPC)
North Harbourfront Interceptor	Additional pipe capacity upgrades to accommodate 2026 Growth Projection ~ 15% of Trunk Sewer Pipes Additional pipe capacity upgrades to accommodate Build-out Growth Projection ~ 40% of Trunk Sewer Pipes (Max. Upgrade Size - 1,200mmø)	N/A $1,100,000
King Street Trunk Sewer	Additional pipe capacity upgrades to accommodate 2026 Growth Projection ~ 15% of Trunk Sewer Pipes (Max. Upgrade Size - 1,050mmø)	$900,000
Harbourfront Trunk Sewer	Additional pipe capacity upgrades to accommodate 2026 Growth Projection ~ 55% of Trunk Sewer Pipes (Max. Upgrade Size - 1,200mmø)	$6,500,000

Ravesnview Trunk Sewer	Additional pipe capacity upgrades to accommodate 2026 and Build-out growth projection ~ 20% of Trunk Sewer Pipes (Max. Upgrade Size - 1,350mmø)	$2,400,000

Notes:

* values calculated from comparing to redirection values

- Ravensview WWTP upgrades are not included. Separate Environmental Assessments due to the complexity of the upgrades required. A detailed analysis would be required to determine cost.
- Upgrades to trunk sewers identified to be outside the service area redirection area of influence including the North End Outfall, North End, Princess St Collector and Rideau Heights trunk sewers are not included.
- Percent value of trunk sewer pipes represents the amount of trunk sewer upgrades necessary to reduce pipe surcharging to match the baseline LOS conditions.
- For the purposes of calculating comparison upgrade cost for trunk sewers, it was assumed that the upgrades would be completed starting at the downstream end for the percentage of pipes indicated. The average size for that section was determined and it was then assumed at a maximum of 2 pipes size increase would be required for the upgrades.

In order to accommodate for the increase in development many parts of the CSO system would need to be upgraded to provide a reduction in volume from 45% to 51% to match the baseline reduction. The additional 6% in CSO reductions would need to be achievable by providing additional CSO storage tanks to the Harbourfront Trunk at West St, Collingwood, Belle Park Local 1200mm, Barrack St, Queen St., Belle Park Trunk and Lower Union St. CSO's. A summary and upgrades and probable costs are summarised in **Table 7-2**.

Table 7 - 2: Sewer System Upgrades for Reducing Combined Sewer Overflows: East Routing

CSO Location	Upgrades Required to Match Base Case LOS in 2026 Growth Projection	Opinion of Probable Cost (OPC)
Harbourfront Trunk at West St. CSO	Storage Increase ~ 4,006m^3	$4,000,000
Collingwood CSO	Storage Increase ~ 143m^3	$400,000
Belle Park Local 1200 Overflow*	Storage Increase ~ 329m^3	$600,000
Barrack Street CSO	Storage Increase ~ 158m^3	$400,000
Queen Street CSO	Storage Increase ~ 147m^3	$400,000
Belle Park trunk Overflow*	Storage Increase ~ 71m^3	$300,000
Lower Union St CSO	Storage Increase ~ 65m^3	$200,000

Notes: * values calculated from comparing to redirection values

- Additional CSO capacity under 50m^3 from the base case LOS not included

It should be noted that the required capacity increase at the Harbourfront Trunk at West St. CSO is significant and based on the location of this infrastructure would be difficult to provide the required storage due to the approximate size of the tank.

7.2 Portsmouth PS Flow Directed West Towards Cataraqui Bay WWTP

In accordance with the model simulation analysis it was determined that the majority of reductions in sanitary flow towards the East by the West routing option provided conditions where the baseline LOS was either met or surpassed. In this case the only necessary upgrades would be to the Portsmouth PS and for infrastructure required to convey flows to the Cataraqui Bay WWTP in support of development intensification. **Table 7-3** summarises these upgrades.

Table 7 - 3: Sewer System Upgrades for

Pumping Station	Upgrades Required to Match Base Case LOS	Opinion of Probable Cost (OPC)
Portsmouth PS	New forcemain and larger pumping station required to convey Portsmouth PS service area flows West towards Cataraqui Bay WWTP ~ Total 424L/s Peak Instantaneous (for full Build-out growth projection)	$9,175,000

Notes:

- Cataraqui Bay WWTP upgrades are not included. Separate Environmental Assessments due to the complexity of the upgrades required. A detailed analysis would be required to determine cost.
- Upgrades to trunk sewers identified to be outside the service area redirection area of influence including the North End Outfall, North End, Princess St Collector and Rideau Heights trunk sewers are not included.

Major upgrades for CSO tank infrastructure would not be necessary for the sewer system since net-reductions are greater than the LOS observed in the base case scenario by 13%.

8.0 Conclusion

The provided InfoSWMM model for the Kingston trunk sewer system was recalibrated to the 2013 conditions after review and data collection which included remodeling growth projection scenarios to represent the suspected development intensification in Kingston Central. From this recalibration new system upgrades including a weir height adjustment to represent the West St. CSO tank upgrades and twinning the forcemain crossing the Rideau Canal from the River St. PS were completed before conducting a design storm and CSO analysis of the Portsmouth PS service area redirection.

The simulated results of the recalibrated trunk sewer model represent the shared impacts of combined sewer separation and flow redirection for the current 2013 trunk sewer conditions. The design storm and CSO analysis results for the sewer system showed that if flows are maintained to the east, significant upgrades to truck sewers, PS and CSO tanks would be required along the flow path to equal the same LOS target originally anticipated. If flows are redirected to the west, significant new infrastructure would be required to convey flows to the west; however, there is a net-reductions observed in the Kingston Central trunk sewer system immediately downstream from the Portsmouth PS service area when flows were redirected towards the Cataraqui Bay WWTP during dry-weather and major storm events. The results also show that there are net-reductions in total CSO's as compared to the base case scenario representing a relief for development intensification. The flow redirection, however, presents the Cataraqui Bay WWTP with a substantial increase in flows and would not contribute to reductions in the Princess St. Collector, North End Trunk Sewer, North End Outlet Sewer and Rideau Heights Trunk Sewer located upstream to the River St. PS.

A summary of the total upgrade costs between the East and West routing options are presented in **Table 8-1**.

Table 8 - 1: Summary of Trunk Sewer System Upgrades: East vs. West Routing of Portsmouth PS

Portsmouth PS Routing	Opinion of Probable Cost (OPC)
East Routing	$20,650,000
West Routing	$9,175,000

Notes:
- East routing excludes CSO capacity increases at CSO locations under 50m^3 since the net-reductions in CSO volume are minimal.
- Cataraqui Bay and Ravensview WWTP upgrades are not included. Separate Environmental Assessments have been conducted

9.0 References

Annual Summary Report to the Ministry of the Environment "*City of Kingston Combined Sewer Overflow Reduction & Investigation Program 2012 Summary* ", Utilities Kingston, April 2013

Former Davis Tannery *"Infrastructure Servicing Study",* WSP Canada Inc., January 2014
North Block District *"Block 4 Design Guidelines"* CIMA/NORR Consultants, October 2013

Report to Planning Committee No. PC-13-034 *"Pending and Committed Residential Development Supply – January 1, 2012 to December 31, 2013"*, City of Kingston, February 2013

Sewage Infrastructure Master Plan for the City of Kingston Urban Area, *"Final Report",* CH2MHill/XCG Consultants, September 2010
Sewage Infrastructure Master Plan for the City of Kingston Urban Area, *"Data Collection and Review -Memorandum No. 2"*, CH2MHILL/XCG Consultants, March 2009

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Sewer Separation Progress Memorandum, Utilities Kingston, September 2013

Technical memorandum *"River Street Pump Station Capacity Analysis"*, CH2MHILL Consultants, June 2010

Williamsville Re-Development Memorandum, *"Impact on Utilities"*, Utilities Kingston, December 2011

Williamsville Main Street Study Memorandum, McCormick Rankin Corporation, December 2011

Respectfully submitted,

WSP Canada Inc.

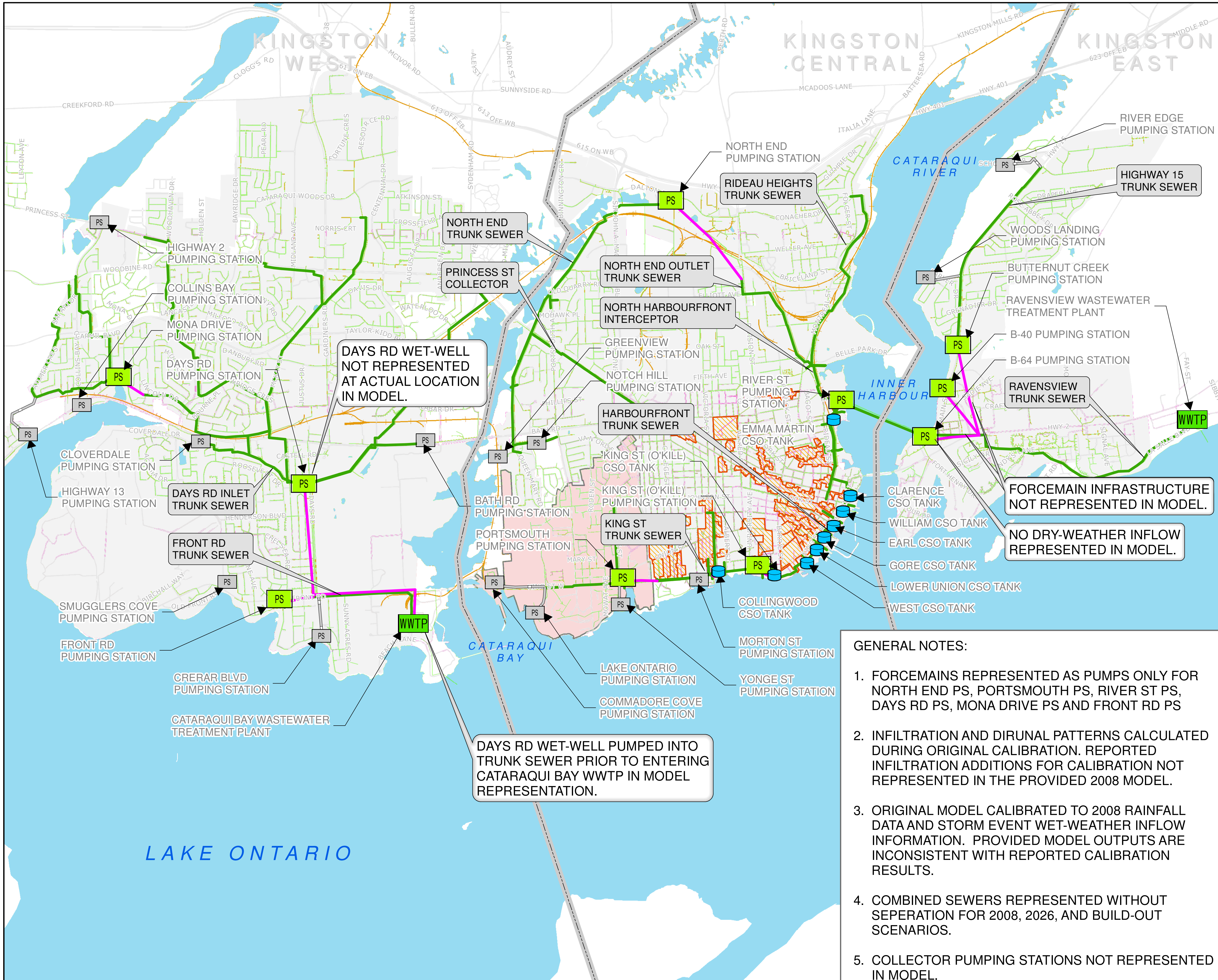
Matt Morkem, P.Eng.
Municipal Engineer

Michael Flowers, EIT
Municipal Designer

X:\2013\131-18048-00 UK Front Rd\Class EA\Model Calibration-Analysis\131-18048-00_memo_InfoSWMM.doc

APPENDIX A

2008 Model Observations and System Upgrades



GENERAL NOTES:

1. FORCEMAINS REPRESENTED AS PUMPS ONLY FOR NORTH END PS, PORTSMOUTH PS, RIVER ST PS, DAYS RD PS, MONA DRIVE PS AND FRONT RD PS
2. INFILTRATION AND DIRUNAL PATTERNS CALCULATED DURING ORIGINAL CALIBRATION. REPORTED INFILTRATION ADDITIONS FOR CALIBRATION NOT REPRESENTED IN THE PROVIDED 2008 MODEL.
3. ORIGINAL MODEL CALIBRATED TO 2008 RAINFALL DATA AND STORM EVENT WET-WEATHER INFLOW INFORMATION. PROVIDED MODEL OUTPUTS ARE INCONSISTENT WITH REPORTED CALIBRATION RESULTS.
4. COMBINED SEWERS REPRESENTED WITHOUT SEPERATION FOR 2008, 2026, AND BUILD-OUT SCENARIOS.
5. COLLECTOR PUMPING STATIONS NOT REPRESENTED IN MODEL.

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Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- PS - PUMPING STATION (COLLECTOR)
- CSO TANK
- SANITARY SEWER
- COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- COLLECTOR FORCEMAIN/SEWER
- CATCHMENT AREA
- COMBINED SEWER CATCHMENT
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utilties Kingston, July 2013, City of Kingston.

Scale:
0 500 1,000 2,000 Metres
1:50,000

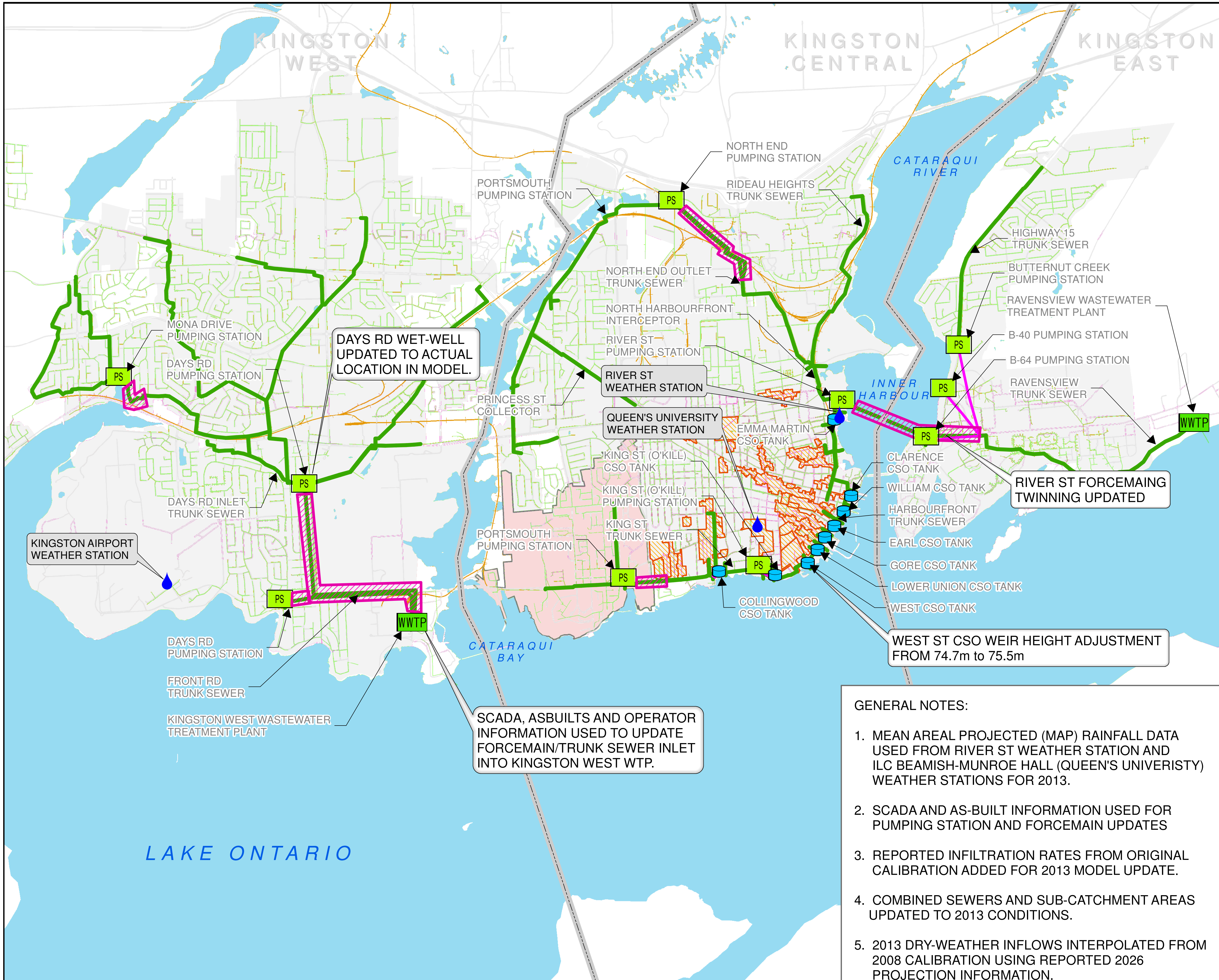
N E S W

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title:
2008 TRUNK SEWER MODEL OVERVIEW MAP

Project No.:		Date:
131-18048-00		MARCH, 2014
Drawn By: MF	Checked By: MM	Drawing No.: 3-1



GENERAL NOTES:

1. MEAN AREAL PROJECTED (MAP) RAINFALL DATA USED FROM RIVER ST WEATHER STATION AND ILC BEAMISH-MUNROE HALL (QUEEN'S UNIVERISTY) WEATHER STATIONS FOR 2013.
2. SCADA AND AS-BUILT INFORMATION USED FOR PUMPING STATION AND FORCEMAIN UPDATES
3. REPORTED INFILTRATION RATES FROM ORIGINAL CALIBRATION ADDED FOR 2013 MODEL UPDATE.
4. COMBINED SEWERS AND SUB-CATCHMENT AREAS UPDATED TO 2013 CONDITIONS.
5. 2013 DRY-WEATHER INFLOWS INTERPOLATED FROM 2008 CALIBRATION USING REPORTED 2026 PROJECTION INFORMATION.

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Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- WEATHER STATION
- CSO TANK
- SANITARY SEWER
- COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- UPDATED FORCEMAIN
- CATCHMENT AREA
- COMBINED SEWER CATCHMENT
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Sewer System, Utilities Kingston, July 2013, City of Kingston.

Scale:
0 500 1,000 2,000 Meters
1:50,000

N W E S

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title:
DATA REVIEW: SEWER SYSTEMS UPGRADES MAP

Project No.:		Date:
131-18048-00		MARCH, 2014
Drawn By: MF	Checked By: MM	Drawing No.: 3-2

APPENDIX B

Rainfall and Design Strom Data

;2013 MAP for Kingston
;Includes MAP of Queen's Univeristy ILC Beamish-Munroe Hall and River St. Weather Station Data

;Location	Year	Month	Day	Hour	Minute	Rain (mm)
Kingston	2013	1	6	6	15	0.502
Kingston	2013	1	6	6	30	0.251
Kingston	2013	1	6	7	0	0.251
Kingston	2013	1	6	8	45	0.251
Kingston	2013	1	6	12	15	0.251
Kingston	2013	1	6	12	30	0.251
Kingston	2013	1	6	12	45	0.251
Kingston	2013	1	6	13	15	0.251
Kingston	2013	1	6	13	45	0.251
Kingston	2013	1	6	14	15	0.251
Kingston	2013	1	6	14	30	0.251
Kingston	2013	1	6	17	0	0.251
Kingston	2013	1	11	15	30	0.251
Kingston	2013	1	11	15	45	0.251
Kingston	2013	1	11	17	15	0.251
Kingston	2013	1	11	18	0	0.251
Kingston	2013	1	11	18	15	0.251
Kingston	2013	1	11	18	30	0.251
Kingston	2013	1	11	20	0	0.251
Kingston	2013	1	12	2	45	0.251
Kingston	2013	1	13	6	30	0.251
Kingston	2013	1	13	6	45	1.004
Kingston	2013	1	13	7	0	0.753
Kingston	2013	1	13	7	15	0.251
Kingston	2013	1	13	7	45	0.753
Kingston	2013	1	13	8	0	0.502
Kingston	2013	1	13	8	15	0.251
Kingston	2013	1	13	8	30	1.757
Kingston	2013	1	13	8	45	1.255
Kingston	2013	1	13	9	0	1.255
Kingston	2013	1	13	9	15	0.753
Kingston	2013	1	13	22	0	0.251
Kingston	2013	1	13	22	30	0.251
Kingston	2013	1	13	23	0	0.251
Kingston	2013	1	14	3	0	0.502
Kingston	2013	1	14	3	15	0.251
Kingston	2013	1	14	4	0	0.251
Kingston	2013	1	20	4	45	0.251
Kingston	2013	1	20	5	0	0.251
Kingston	2013	1	20	5	30	0.251
Kingston	2013	1	20	5	45	0.251
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Kingston	2013	1	29	22	42	0.254
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Kingston	2013	1	29	23	22	0.254
Kingston	2013	1	29	23	28	0.254
Kingston	2013	1	29	23	43	0.254
Kingston	2013	1	30	9	15	0.251
Kingston	2013	1	30	12	0	0.502
Kingston	2013	1	30	12	15	0.753
Kingston	2013	1	30	12	30	0.502
Kingston	2013	1	30	13	0	0.251
Kingston	2013	1	30	22	45	0.251
Kingston	2013	1	30	23	0	0.753
Kingston	2013	1	30	23	15	0.502
Kingston	2013	1	30	23	30	0.502
Kingston	2013	1	30	23	45	0.753
Kingston	2013	1	31	0	0	1.004
Kingston	2013	1	31	0	15	0.276
Kingston	2013	1	31	0	30	0.9789
Kingston	2013	1	31	0	45	1.757
Kingston	2013	1	31	1	0	1.255
Kingston	2013	1	31	1	15	1.004
Kingston	2013	1	31	1	30	0.502
Kingston	2013	1	31	1	45	0.502
Kingston	2013	1	31	2	0	0.753
Kingston	2013	1	31	2	15	0.502
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Kingston	2013	1	31	4	0	0.502
Kingston	2013	1	31	4	15	0.502
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Kingston	2013	2	15	2	45	0.251
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Kingston	2013	2	27	5	0	0.753
Kingston	2013	2	27	5	15	1.004
Kingston	2013	2	27	5	30	0.251
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Kingston	2013	2	27	8	0	0.251
Kingston	2013	2	27	8	15	0.251
Kingston	2013	2	27	8	30	0.251
Kingston	2013	2	27	9	0	0.251
Kingston	2013	2	27	9	45	0.251
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Kingston	2013	2	27	19	45	0.251
Kingston	2013	2	27	20	30	0.251
Kingston	2013	2	27	22	15	0.251
Kingston	2013	2	28	4	30	0.251
Kingston	2013	2	28	8	30	0.251
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Kingston	2013	6	22	16	15	0.753
Kingston	2013	6	22	16	30	1.757
Kingston	2013	6	22	16	45	1.255
Kingston	2013	6	22	17	0	1.004
Kingston	2013	6	22	22	45	0.251
Kingston	2013	6	22	23	0	0.251
Kingston	2013	6	25	10	30	0.251
Kingston	2013	6	25	12	30	0.251
Kingston	2013	6	28	5	0	0.251
Kingston	2013	6	28	6	0	0.251
Kingston	2013	6	28	6	30	0.251
Kingston	2013	6	28	7	30	0.251
Kingston	2013	6	28	8	30	0.251
Kingston	2013	6	28	10	0	0.251
Kingston	2013	6	28	10	30	0.251
Kingston	2013	6	28	10	45	0.753
Kingston	2013	6	28	11	0	0.251
Kingston	2013	6	28	12	15	0.251

Kingston	2013	6	28	12	30	0.251
Kingston	2013	6	28	13	0	0.251
Kingston	2013	6	28	14	30	0.251
Kingston	2013	6	28	17	15	0.251
Kingston	2013	6	28	17	30	0.251
Kingston	2013	6	29	0	15	1.28
Kingston	2013	7	4	10	0	1.004
Kingston	2013	7	4	10	15	0.251
Kingston	2013	7	5	5	15	0.251
Kingston	2013	7	5	6	0	0.251
Kingston	2013	7	5	6	15	0.502
Kingston	2013	7	5	6	30	0.502
Kingston	2013	7	5	6	45	0.251
Kingston	2013	7	5	7	45	0.251
Kingston	2013	7	7	6	45	0.251
Kingston	2013	7	7	10	30	0.251
Kingston	2013	7	8	19	15	0.502
Kingston	2013	7	8	19	30	0.502
Kingston	2013	7	9	1	15	0.251
Kingston	2013	7	9	18	15	1.255
Kingston	2013	7	9	18	30	0.502
Kingston	2013	7	9	19	0	0.251
Kingston	2013	7	10	8	45	0.251
Kingston	2013	7	10	9	0	0.502
Kingston	2013	7	10	9	30	0.502
Kingston	2013	7	10	9	45	0.502
Kingston	2013	7	11	14	0	0.251
Kingston	2013	7	11	14	45	0.251
Kingston	2013	7	11	18	15	0.251
Kingston	2013	7	19	18	0	0.251
Kingston	2013	7	19	20	0	1.255
Kingston	2013	7	19	20	15	3.012
Kingston	2013	7	19	20	30	2.51
Kingston	2013	7	19	20	45	0.502
Kingston	2013	7	19	21	0	0.753
Kingston	2013	7	19	21	15	0.502
Kingston	2013	7	19	21	30	0.502
Kingston	2013	7	20	4	30	0.502
Kingston	2013	7	20	4	45	0.753
Kingston	2013	7	20	5	15	0.502
Kingston	2013	7	20	5	30	0.502
Kingston	2013	7	20	11	30	0.251
Kingston	2013	8	9	9	45	0.251
Kingston	2013	8	9	10	0	0.251
Kingston	2013	8	9	10	15	0.251
Kingston	2013	8	9	9	45	0.254
Kingston	2013	8	9	10	0	0.254
Kingston	2013	8	9	10	15	0.254
Kingston	2013	8	14	5	15	0.254
Kingston	2013	8	14	5	30	0.762
Kingston	2013	8	14	5	45	0.254
Kingston	2013	8	22	13	45	2.8448
Kingston	2013	8	22	14	0	1.2192
Kingston	2013	8	22	14	15	1.016
Kingston	2013	8	22	14	30	0.254
Kingston	2013	8	22	14	45	0.254
Kingston	2013	8	22	15	0	0.508
Kingston	2013	8	22	15	15	0.254
Kingston	2013	8	22	16	45	0.508
Kingston	2013	8	25	23	30	0.508
Kingston	2013	8	26	1	0	0.254
Kingston	2013	8	26	10	0	0.254
Kingston	2013	8	26	16	15	0.254

Kingston	2013	8	26	16	30	0.254
Kingston	2013	8	26	16	45	0.254
Kingston	2013	8	26	17	0	0.508
Kingston	2013	8	26	17	15	0.762
Kingston	2013	8	26	17	30	0.508
Kingston	2013	8	26	17	45	4.826
Kingston	2013	8	26	18	0	5.588
Kingston	2013	8	26	18	15	0.508
Kingston	2013	8	26	18	30	0.254
Kingston	2013	8	26	18	45	0.254
Kingston	2013	8	26	19	0	0.254
Kingston	2013	8	26	20	30	0.254
Kingston	2013	8	26	21	30	0.254
Kingston	2013	8	26	21	45	0.254
Kingston	2013	8	28	4	45	0.254
Kingston	2013	8	31	3	15	0.762
Kingston	2013	8	31	3	30	0.254
Kingston	2013	8	31	3	45	0.254
Kingston	2013	8	31	4	45	0.254
Kingston	2013	8	31	5	0	0.762
Kingston	2013	8	31	5	15	1.524
Kingston	2013	8	31	5	30	1.016
Kingston	2013	8	31	5	45	0.254
Kingston	2013	8	31	14	45	0.254
Kingston	2013	9	1	23	0	0.254
Kingston	2013	9	1	23	15	0.762
Kingston	2013	9	1	23	30	0.762
Kingston	2013	9	1	23	45	3.81
Kingston	2013	9	2	0	0	0.9398
Kingston	2013	9	2	0	15	1.0922
Kingston	2013	9	2	0	45	1.778
Kingston	2013	9	2	1	0	1.016
Kingston	2013	9	2	1	15	0.254
Kingston	2013	9	7	17	15	0.254
Kingston	2013	9	7	18	45	0.0508
Kingston	2013	9	7	19	0	0.2032
Kingston	2013	9	7	20	45	0.254
Kingston	2013	9	10	5	15	0.508
Kingston	2013	9	10	6	0	0.762
Kingston	2013	9	10	6	15	0.508
Kingston	2013	9	10	6	30	0.508
Kingston	2013	9	10	6	45	10.1092
Kingston	2013	9	10	7	0	1.3208
Kingston	2013	9	10	7	15	0.254
Kingston	2013	9	10	7	30	0.254
Kingston	2013	9	10	7	45	0.254
Kingston	2013	9	12	1	30	0.254
Kingston	2013	9	12	2	0	0.254
Kingston	2013	9	12	2	15	0.508
Kingston	2013	9	12	2	45	0.762
Kingston	2013	9	12	3	45	0.254
Kingston	2013	9	12	7	0	0.254
Kingston	2013	9	12	7	30	1.778
Kingston	2013	9	12	7	45	1.016
Kingston	2013	9	12	8	0	0.254
Kingston	2013	9	15	19	45	2.794
Kingston	2013	9	15	20	0	0.762
Kingston	2013	9	15	20	15	0.254
Kingston	2013	9	15	20	30	0.254
Kingston	2013	9	15	20	45	0.254
Kingston	2013	9	15	21	0	0.254
Kingston	2013	9	15	21	15	0.254
Kingston	2013	9	15	21	45	0.508

Kingston	2013	9	15	22	0	0.508
Kingston	2013	9	15	22	15	0.508
Kingston	2013	9	15	22	30	0.254
Kingston	2013	9	15	22	45	0.254
Kingston	2013	9	15	23	15	0.254
Kingston	2013	9	15	23	30	0.254
Kingston	2013	9	16	0	45	0.254
Kingston	2013	9	16	1	0	0.254
Kingston	2013	9	16	1	15	0.254
Kingston	2013	9	16	1	30	0.254
Kingston	2013	9	16	2	15	0.254
Kingston	2013	9	16	9	45	0.254
Kingston	2013	9	21	4	0	1.524
Kingston	2013	9	21	4	15	0.254
Kingston	2013	9	21	7	45	0.254
Kingston	2013	9	21	8	15	3.1496
Kingston	2013	9	21	8	30	1.1684
Kingston	2013	9	21	10	0	0.254
Kingston	2013	9	21	10	15	1.27
Kingston	2013	9	21	10	30	2.286
Kingston	2013	9	21	10	45	0.508
Kingston	2013	9	21	11	45	0.508
Kingston	2013	9	21	12	0	0.762
Kingston	2013	9	21	12	15	0.254
Kingston	2013	9	21	12	30	1.524
Kingston	2013	9	21	13	15	0.254
Kingston	2013	9	21	13	30	1.016
Kingston	2013	9	21	14	0	0.254
Kingston	2013	9	21	14	15	0.508
Kingston	2013	9	21	14	30	0.762
Kingston	2013	9	21	14	45	1.016
Kingston	2013	9	21	15	0	1.016
Kingston	2013	9	21	15	15	2.286
Kingston	2013	9	21	15	30	1.524
Kingston	2013	9	21	15	45	0.762
Kingston	2013	9	21	16	0	1.016
Kingston	2013	9	21	16	15	1.016
Kingston	2013	9	21	16	30	1.524
Kingston	2013	9	21	16	45	1.016
Kingston	2013	9	21	17	0	0.254
Kingston	2013	9	21	17	15	1.016
Kingston	2013	9	21	17	30	0.762
Kingston	2013	9	21	17	45	0.254
Kingston	2013	9	21	18	0	0.762
Kingston	2013	9	21	18	15	0.762
Kingston	2013	9	21	18	30	0.508
Kingston	2013	9	21	18	45	0.508
Kingston	2013	9	21	19	0	0.508
Kingston	2013	9	21	19	15	0.508
Kingston	2013	9	21	19	30	0.508
Kingston	2013	9	21	20	0	0.254
Kingston	2013	9	21	20	30	0.254
Kingston	2013	9	21	20	45	0.254
Kingston	2013	9	21	21	0	0.254
Kingston	2013	9	21	21	30	0.508
Kingston	2013	9	21	21	45	1.27
Kingston	2013	9	21	22	0	0.254
Kingston	2013	9	21	22	15	0.762
Kingston	2013	9	21	22	30	0.254
Kingston	2013	9	21	23	15	0.254
Kingston	2013	9	22	0	0	0.254
Kingston	2013	9	22	0	30	0.254

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period 2 years

;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	1.263
Kingston	2008	07	01	01	10	1.263
Kingston	2008	07	01	01	20	1.263
Kingston	2008	07	01	01	30	1.263
Kingston	2008	07	01	01	40	1.263
Kingston	2008	07	01	01	50	1.263
Kingston	2008	07	01	02	00	1.474
Kingston	2008	07	01	02	10	1.474
Kingston	2008	07	01	02	20	1.474
Kingston	2008	07	01	02	30	1.474
Kingston	2008	07	01	02	40	1.474
Kingston	2008	07	01	02	50	1.474
Kingston	2008	07	01	03	00	1.403
Kingston	2008	07	01	03	10	1.403
Kingston	2008	07	01	03	20	1.403
Kingston	2008	07	01	03	30	1.403
Kingston	2008	07	01	03	40	1.403
Kingston	2008	07	01	03	50	1.403
Kingston	2008	07	01	04	00	1.053
Kingston	2008	07	01	04	10	1.053
Kingston	2008	07	01	04	20	1.053
Kingston	2008	07	01	04	30	1.053
Kingston	2008	07	01	04	40	1.053
Kingston	2008	07	01	04	50	1.053
Kingston	2008	07	01	05	00	0.982
Kingston	2008	07	01	05	10	0.982
Kingston	2008	07	01	05	20	0.982
Kingston	2008	07	01	05	30	0.982
Kingston	2008	07	01	05	40	0.982
Kingston	2008	07	01	05	50	0.982
Kingston	2008	07	01	06	00	0.561
Kingston	2008	07	01	06	10	0.561
Kingston	2008	07	01	06	20	0.561
Kingston	2008	07	01	06	30	0.561
Kingston	2008	07	01	06	40	0.561
Kingston	2008	07	01	06	50	0.561
Kingston	2008	07	01	07	00	0.211
Kingston	2008	07	01	07	10	0.211
Kingston	2008	07	01	07	20	0.211
Kingston	2008	07	01	07	30	0.211
Kingston	2008	07	01	07	40	0.211
Kingston	2008	07	01	07	50	0.211
Kingston	2008	07	01	08	00	0.070
Kingston	2008	07	01	08	10	0.070
Kingston	2008	07	01	08	20	0.070
Kingston	2008	07	01	08	30	0.070
Kingston	2008	07	01	08	40	0.070
Kingston	2008	07	01	08	50	0.070

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period						5years
;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	1.716
Kingston	2008	07	01	01	10	1.716
Kingston	2008	07	01	01	20	1.716
Kingston	2008	07	01	01	30	1.716
Kingston	2008	07	01	01	40	1.716
Kingston	2008	07	01	01	50	1.716
Kingston	2008	07	01	02	00	2.002
Kingston	2008	07	01	02	10	2.002
Kingston	2008	07	01	02	20	2.002
Kingston	2008	07	01	02	30	2.002
Kingston	2008	07	01	02	40	2.002
Kingston	2008	07	01	02	50	2.002
Kingston	2008	07	01	03	00	1.907
Kingston	2008	07	01	03	10	1.907
Kingston	2008	07	01	03	20	1.907
Kingston	2008	07	01	03	30	1.907
Kingston	2008	07	01	03	40	1.907
Kingston	2008	07	01	03	50	1.907
Kingston	2008	07	01	04	00	1.430
Kingston	2008	07	01	04	10	1.430
Kingston	2008	07	01	04	20	1.430
Kingston	2008	07	01	04	30	1.430
Kingston	2008	07	01	04	40	1.430
Kingston	2008	07	01	04	50	1.430
Kingston	2008	07	01	05	00	1.335
Kingston	2008	07	01	05	10	1.335
Kingston	2008	07	01	05	20	1.335
Kingston	2008	07	01	05	30	1.335
Kingston	2008	07	01	05	40	1.335
Kingston	2008	07	01	05	50	1.335
Kingston	2008	07	01	06	00	0.763
Kingston	2008	07	01	06	10	0.763
Kingston	2008	07	01	06	20	0.763
Kingston	2008	07	01	06	30	0.763
Kingston	2008	07	01	06	40	0.763
Kingston	2008	07	01	06	50	0.763
Kingston	2008	07	01	07	00	0.286
Kingston	2008	07	01	07	10	0.286
Kingston	2008	07	01	07	20	0.286
Kingston	2008	07	01	07	30	0.286
Kingston	2008	07	01	07	40	0.286
Kingston	2008	07	01	07	50	0.286
Kingston	2008	07	01	08	00	0.095
Kingston	2008	07	01	08	10	0.095
Kingston	2008	07	01	08	20	0.095
Kingston	2008	07	01	08	30	0.095
Kingston	2008	07	01	08	40	0.095
Kingston	2008	07	01	08	50	0.095

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period 10 years

;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.016
Kingston	2008	07	01	01	10	2.016
Kingston	2008	07	01	01	20	2.016
Kingston	2008	07	01	01	30	2.016
Kingston	2008	07	01	01	40	2.016
Kingston	2008	07	01	01	50	2.016
Kingston	2008	07	01	02	00	2.352
Kingston	2008	07	01	02	10	2.352
Kingston	2008	07	01	02	20	2.352
Kingston	2008	07	01	02	30	2.352
Kingston	2008	07	01	02	40	2.352
Kingston	2008	07	01	02	50	2.352
Kingston	2008	07	01	03	00	2.240
Kingston	2008	07	01	03	10	2.240
Kingston	2008	07	01	03	20	2.240
Kingston	2008	07	01	03	30	2.240
Kingston	2008	07	01	03	40	2.240
Kingston	2008	07	01	03	50	2.240
Kingston	2008	07	01	04	00	1.680
Kingston	2008	07	01	04	10	1.680
Kingston	2008	07	01	04	20	1.680
Kingston	2008	07	01	04	30	1.680
Kingston	2008	07	01	04	40	1.680
Kingston	2008	07	01	04	50	1.680
Kingston	2008	07	01	05	00	1.568
Kingston	2008	07	01	05	10	1.568
Kingston	2008	07	01	05	20	1.568
Kingston	2008	07	01	05	30	1.568
Kingston	2008	07	01	05	40	1.568
Kingston	2008	07	01	05	50	1.568
Kingston	2008	07	01	06	00	0.896
Kingston	2008	07	01	06	10	0.896
Kingston	2008	07	01	06	20	0.896
Kingston	2008	07	01	06	30	0.896
Kingston	2008	07	01	06	40	0.896
Kingston	2008	07	01	06	50	0.896
Kingston	2008	07	01	07	00	0.336
Kingston	2008	07	01	07	10	0.336
Kingston	2008	07	01	07	20	0.336
Kingston	2008	07	01	07	30	0.336
Kingston	2008	07	01	07	40	0.336
Kingston	2008	07	01	07	50	0.336
Kingston	2008	07	01	08	00	0.112
Kingston	2008	07	01	08	10	0.112
Kingston	2008	07	01	08	20	0.112
Kingston	2008	07	01	08	30	0.112
Kingston	2008	07	01	08	40	0.112
Kingston	2008	07	01	08	50	0.112

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period 25 years

;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.394
Kingston	2008	07	01	01	10	2.394
Kingston	2008	07	01	01	20	2.394
Kingston	2008	07	01	01	30	2.394
Kingston	2008	07	01	01	40	2.394
Kingston	2008	07	01	01	50	2.394
Kingston	2008	07	01	02	00	2.793
Kingston	2008	07	01	02	10	2.793
Kingston	2008	07	01	02	20	2.793
Kingston	2008	07	01	02	30	2.793
Kingston	2008	07	01	02	40	2.793
Kingston	2008	07	01	02	50	2.793
Kingston	2008	07	01	03	00	2.660
Kingston	2008	07	01	03	10	2.660
Kingston	2008	07	01	03	20	2.660
Kingston	2008	07	01	03	30	2.660
Kingston	2008	07	01	03	40	2.660
Kingston	2008	07	01	03	50	2.660
Kingston	2008	07	01	04	00	1.995
Kingston	2008	07	01	04	10	1.995
Kingston	2008	07	01	04	20	1.995
Kingston	2008	07	01	04	30	1.995
Kingston	2008	07	01	04	40	1.995
Kingston	2008	07	01	04	50	1.995
Kingston	2008	07	01	05	00	1.862
Kingston	2008	07	01	05	10	1.862
Kingston	2008	07	01	05	20	1.862
Kingston	2008	07	01	05	30	1.862
Kingston	2008	07	01	05	40	1.862
Kingston	2008	07	01	05	50	1.862
Kingston	2008	07	01	06	00	1.064
Kingston	2008	07	01	06	10	1.064
Kingston	2008	07	01	06	20	1.064
Kingston	2008	07	01	06	30	1.064
Kingston	2008	07	01	06	40	1.064
Kingston	2008	07	01	06	50	1.064
Kingston	2008	07	01	07	00	0.399
Kingston	2008	07	01	07	10	0.399
Kingston	2008	07	01	07	20	0.399
Kingston	2008	07	01	07	30	0.399
Kingston	2008	07	01	07	40	0.399
Kingston	2008	07	01	07	50	0.399
Kingston	2008	07	01	08	00	0.133
Kingston	2008	07	01	08	10	0.133
Kingston	2008	07	01	08	20	0.133
Kingston	2008	07	01	08	30	0.133
Kingston	2008	07	01	08	40	0.133
Kingston	2008	07	01	08	50	0.133

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period						50 years
;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.673
Kingston	2008	07	01	01	10	2.673
Kingston	2008	07	01	01	20	2.673
Kingston	2008	07	01	01	30	2.673
Kingston	2008	07	01	01	40	2.673
Kingston	2008	07	01	01	50	2.673
Kingston	2008	07	01	02	00	3.119
Kingston	2008	07	01	02	10	3.119
Kingston	2008	07	01	02	20	3.119
Kingston	2008	07	01	02	30	3.119
Kingston	2008	07	01	02	40	3.119
Kingston	2008	07	01	02	50	3.119
Kingston	2008	07	01	03	00	2.970
Kingston	2008	07	01	03	10	2.970
Kingston	2008	07	01	03	20	2.970
Kingston	2008	07	01	03	30	2.970
Kingston	2008	07	01	03	40	2.970
Kingston	2008	07	01	03	50	2.970
Kingston	2008	07	01	04	00	2.228
Kingston	2008	07	01	04	10	2.228
Kingston	2008	07	01	04	20	2.228
Kingston	2008	07	01	04	30	2.228
Kingston	2008	07	01	04	40	2.228
Kingston	2008	07	01	04	50	2.228
Kingston	2008	07	01	05	00	2.079
Kingston	2008	07	01	05	10	2.079
Kingston	2008	07	01	05	20	2.079
Kingston	2008	07	01	05	30	2.079
Kingston	2008	07	01	05	40	2.079
Kingston	2008	07	01	05	50	2.079
Kingston	2008	07	01	06	00	1.188
Kingston	2008	07	01	06	10	1.188
Kingston	2008	07	01	06	20	1.188
Kingston	2008	07	01	06	30	1.188
Kingston	2008	07	01	06	40	1.188
Kingston	2008	07	01	06	50	1.188
Kingston	2008	07	01	07	00	0.446
Kingston	2008	07	01	07	10	0.446
Kingston	2008	07	01	07	20	0.446
Kingston	2008	07	01	07	30	0.446
Kingston	2008	07	01	07	40	0.446
Kingston	2008	07	01	07	50	0.446
Kingston	2008	07	01	08	00	0.149
Kingston	2008	07	01	08	10	0.149
Kingston	2008	07	01	08	20	0.149
Kingston	2008	07	01	08	30	0.149
Kingston	2008	07	01	08	40	0.149
Kingston	2008	07	01	08	50	0.149

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period						100 years
;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.952
Kingston	2008	07	01	01	10	2.952
Kingston	2008	07	01	01	20	2.952
Kingston	2008	07	01	01	30	2.952
Kingston	2008	07	01	01	40	2.952
Kingston	2008	07	01	01	50	2.952
Kingston	2008	07	01	02	00	3.444
Kingston	2008	07	01	02	10	3.444
Kingston	2008	07	01	02	20	3.444
Kingston	2008	07	01	02	30	3.444
Kingston	2008	07	01	02	40	3.444
Kingston	2008	07	01	02	50	3.444
Kingston	2008	07	01	03	00	3.280
Kingston	2008	07	01	03	10	3.280
Kingston	2008	07	01	03	20	3.280
Kingston	2008	07	01	03	30	3.280
Kingston	2008	07	01	03	40	3.280
Kingston	2008	07	01	03	50	3.280
Kingston	2008	07	01	04	00	2.460
Kingston	2008	07	01	04	10	2.460
Kingston	2008	07	01	04	20	2.460
Kingston	2008	07	01	04	30	2.460
Kingston	2008	07	01	04	40	2.460
Kingston	2008	07	01	04	50	2.460
Kingston	2008	07	01	05	00	2.296
Kingston	2008	07	01	05	10	2.296
Kingston	2008	07	01	05	20	2.296
Kingston	2008	07	01	05	30	2.296
Kingston	2008	07	01	05	40	2.296
Kingston	2008	07	01	05	50	2.296
Kingston	2008	07	01	06	00	1.312
Kingston	2008	07	01	06	10	1.312
Kingston	2008	07	01	06	20	1.312
Kingston	2008	07	01	06	30	1.312
Kingston	2008	07	01	06	40	1.312
Kingston	2008	07	01	06	50	1.312
Kingston	2008	07	01	07	00	0.492
Kingston	2008	07	01	07	10	0.492
Kingston	2008	07	01	07	20	0.492
Kingston	2008	07	01	07	30	0.492
Kingston	2008	07	01	07	40	0.492
Kingston	2008	07	01	07	50	0.492
Kingston	2008	07	01	08	00	0.164
Kingston	2008	07	01	08	10	0.164
Kingston	2008	07	01	08	20	0.164
Kingston	2008	07	01	08	30	0.164
Kingston	2008	07	01	08	40	0.164
Kingston	2008	07	01	08	50	0.164

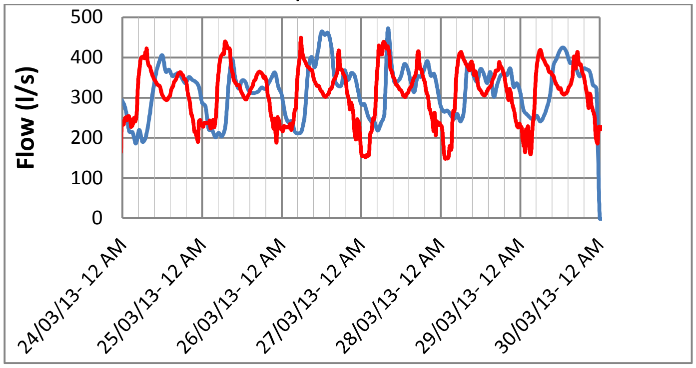
APPENDIX C

Dry-Weather Calibration Observations

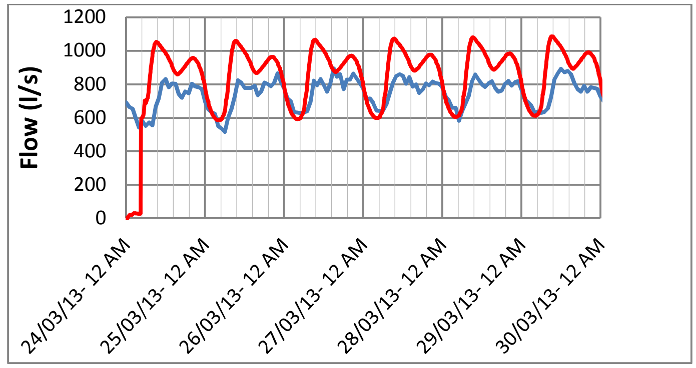
Table C1: March 24-30, 2013 Event – Dry-Weather Calibration (no rainfall recorded)

- Actual   - Computed (2013 – results after wet-weather calibration)

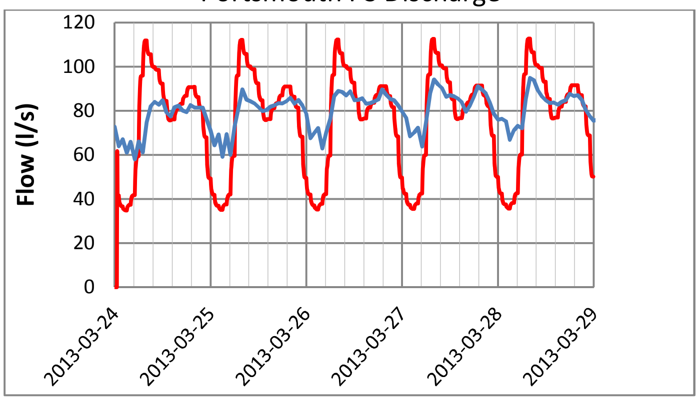
Cataraqui WWTP Inflow



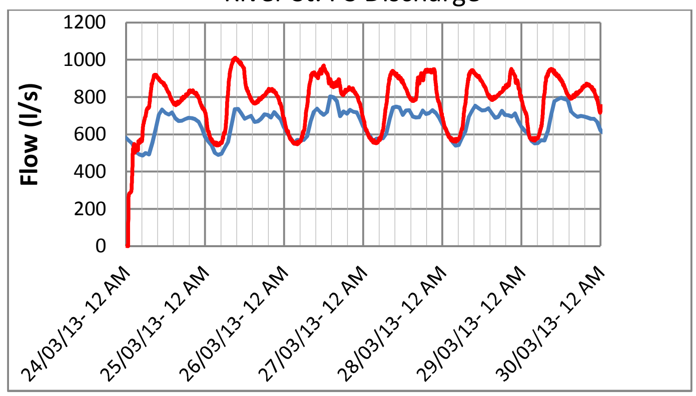
Ravensview WWTP Inflow



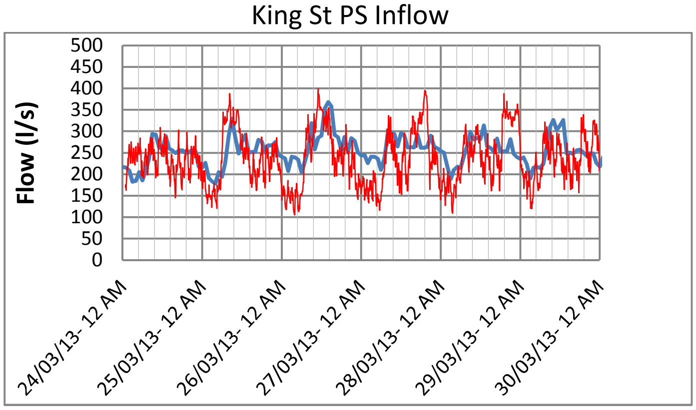
Portsmouth PS Discharge



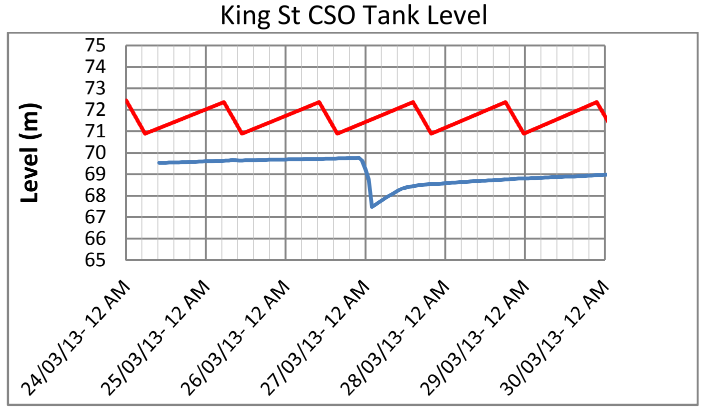
River St. PS Discharge



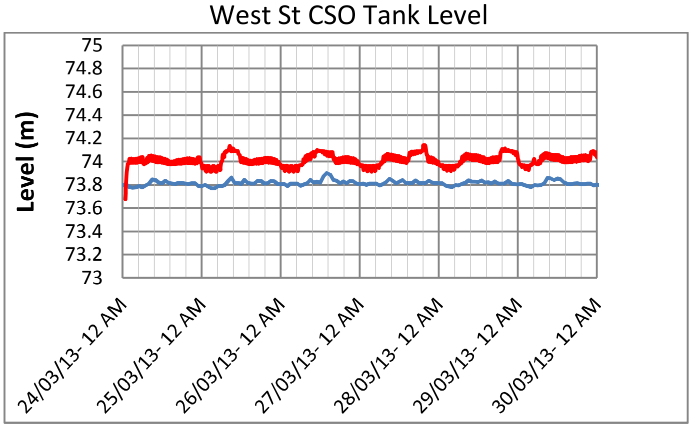
King St PS Inflow



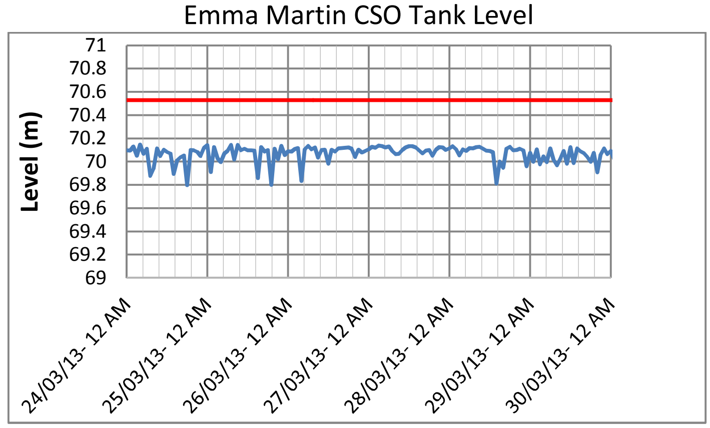
King St CSO Tank Level

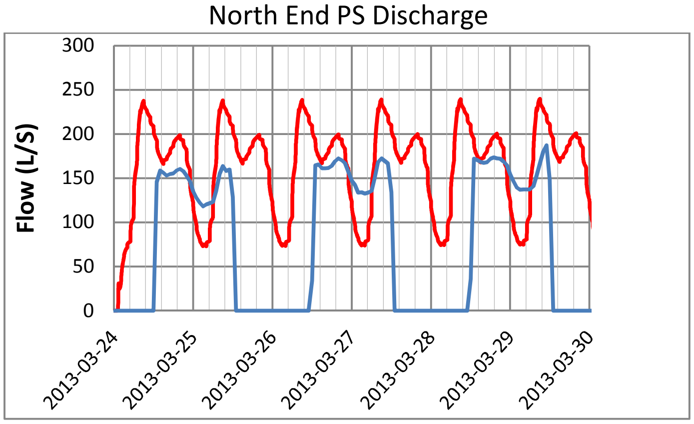


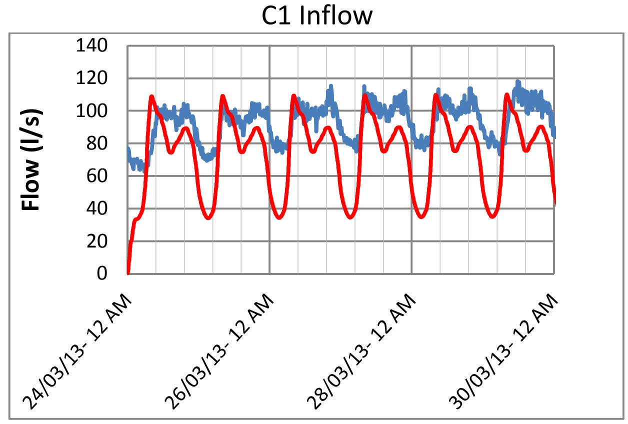
West St CSO Tank Level

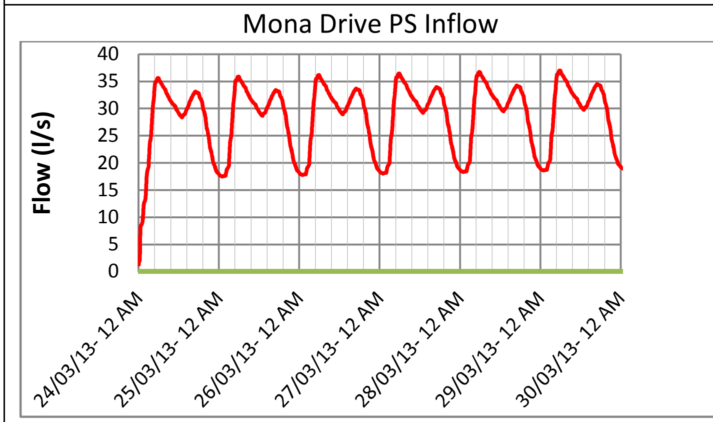


Emma Martin CSO Tank Level




North End PS Discharge
Flow (L/S)
300
250
200
150
100
50
0
2013-03-24
2013-03-25
2013-03-26
2013-03-27
2013-03-28
2013-03-29
2013-03-30


C1 Inflow
Flow (l/s)
140
120
100
80
60
40
20
0
24/03/13- 12 AM
26/03/13- 12 AM
28/03/13- 12 AM
30/03/13- 12 AM


Mona Drive PS Inflow
Flow (l/s)
40
35
30
25
20
15
10
5
0
24/03/13- 12 AM
25/03/13- 12 AM
26/03/13- 12 AM
27/03/13- 12 AM
28/03/13- 12 AM
29/03/13- 12 AM
30/03/13- 12 AM

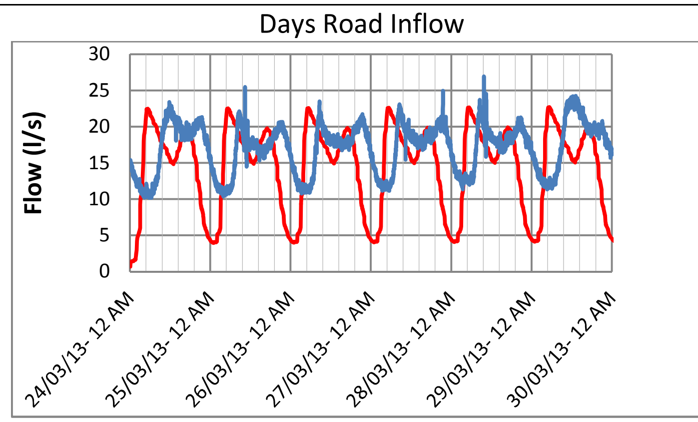

Days Road Inflow
Flow (l/s)
30
25
20
15
10
5
0
24/03/13- 12 AM
25/03/13- 12 AM
26/03/13- 12 AM
27/03/13- 12 AM
28/03/13- 12 AM
29/03/13- 12 AM
30/03/13- 12 AM

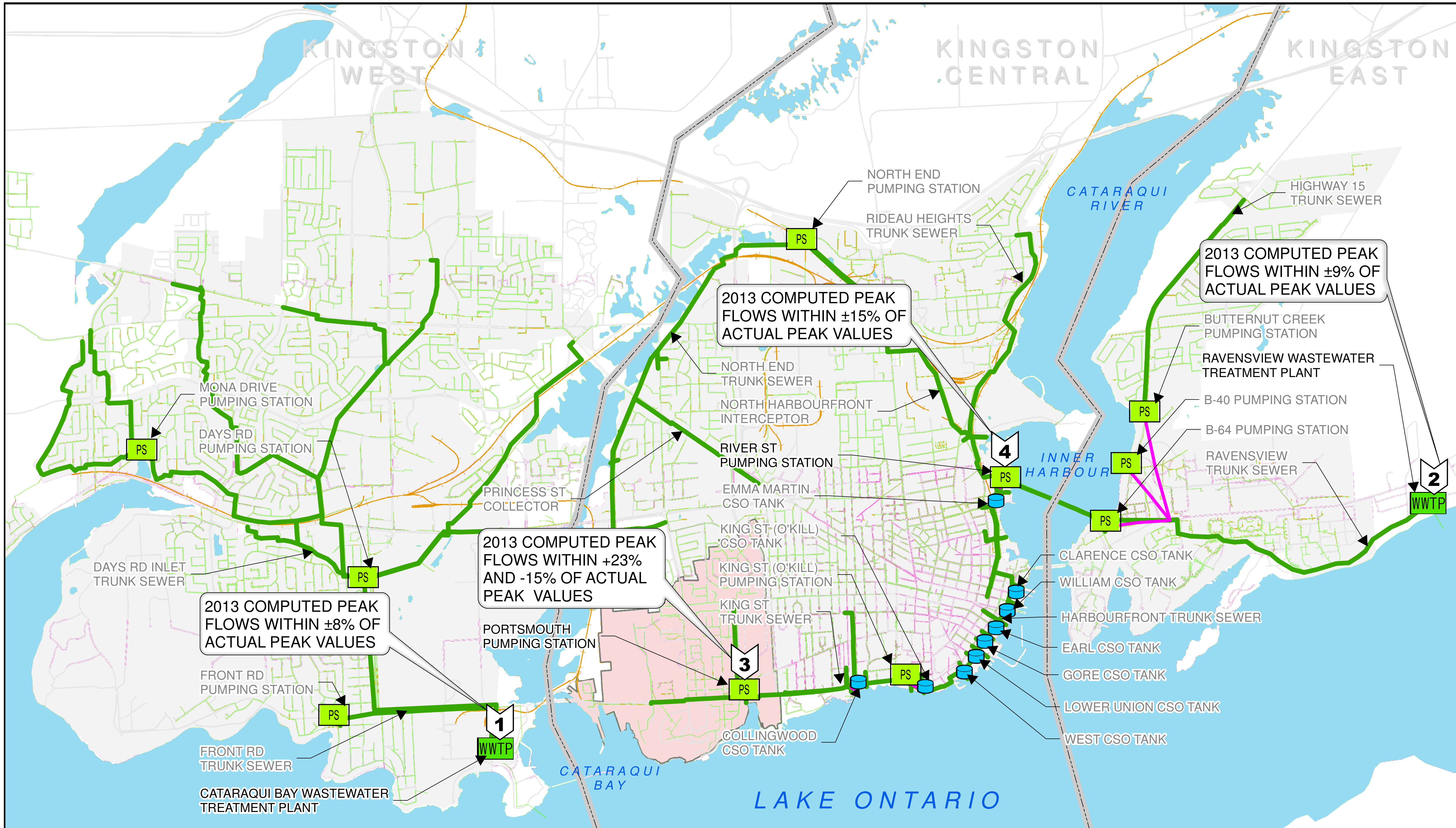
Table C2: Model Parameter Inputs for Dry-Weater Flows						
Junction Node ID	2008 DWF Model Parameter (Original)	2013 DWF Model Parameter (Update)		Junction Node ID	2008 DWF Model Parameter (Original)	2013 DWF Model Parameter (Update)
31068011	2.550	3.110		33738020	0.020	0.020
31111010	1.530	1.540		33740020	0.080	0.080
31325010	2.720	2.790		33827020	0.210	0.210
31327030	1.100	1.130		33828020	0.040	0.040
31445081	2.790	3.070		33829010	0.030	0.030
32149161	0.570	0.570		33861020	0.080	0.080
32173010	0.290	0.290		33863010	0.180	0.190
32173030	0.420	0.420		33865020	0.070	0.070
32173051	0.260	0.260		34003020	0.080	0.080
32173071	0.420	0.420		34008020	0.050	0.050
33005010	0.810	0.820		34021010	0.140	0.140
33022031	0.480	0.530		34021040	0.130	0.130
33022040	0.900	0.910		34022020	0.480	0.480
33024020	0.680	0.680		34023030	0.120	0.130
33026030	3.200	3.200		34024040	0.150	0.160
33026041	0.240	0.240		34026050	0.280	0.280
33089010	2.760	3.170		34153010	0.170	0.170
33104010	0.140	0.140		34154040	0.050	0.050
33104030	0.120	0.120		34156020	0.060	0.060
33117010	0.190	0.190		34158030	0.060	0.060
33125010	0.050	0.050		34166020	1.270	2.080
33135030	1.750	1.750		345010	2.070	2.070
33204010	0.200	0.200		345020	4.260	4.360
33206020	0.050	0.050		345111	1.710	1.760
33212011	0.050	0.050		345121	2.030	2.030
33240010	0.330	0.340		345171	2.430	2.430
33242020	0.410	0.410		345181	0.980	1.000
33243010	2.020	2.020		346251	6.860	6.860
33275020	0.070	0.070		35511011	14.960	27.350
33276010	0.090	0.090		356010	5.170	5.170
33308030	0.050	0.050		356020	0.580	0.580
33309030	0.090	0.090		356031	4.970	4.970
33383041	0.160	0.160		356071	1.980	1.980
33399010	0.580	0.580		33492030	0.060	0.060
33461010	1.140	1.140		33700010	0.140	0.140
33462030	0.460	0.460		514090	3.900	5.310
33463020	0.070	0.070		517010	3.890	4.670
33464020	0.050	0.050		526010	4.110	4.130
33471010	1.730	1.730		526021	1.990	2.080
33472030	0.040	0.040		540010	0.900	0.910
33492020	0.400	0.420		540030	0.030	0.030

Table C2: Model Parameter Inputs for Dry-Weater Flows (Continued)						
Junction Node ID	2008 DWF Model Parameter (Original)	2013 DWF Model Parameter (Update)		Junction Node ID	2008 DWF Model Parameter (Original)	2013 DWF Model Parameter (Update)
61030	21.170	21.350		3151030	6.970	6.990
65010	2.470	2.500		3208020	0.534	0.630
68010	0.930	1.050		3209020	0.040	0.040
763030	4.260	4.400		3210010	2.347	2.380
764020	1.550	1.580		3214010	0.049	0.049
765010	1.500	1.500		329010	5.960	5.960
765110	0.280	0.470		34050	0.106	0.120
769031	25.120	25.300		37010	0.055	0.055
770011	0.080	0.080		39130	2.676	2.690
771031	0.300	0.300		3942010	3.459	3.459
837010	4.390	4.440		3943110	6.456	6.610
837031	4.270	4.320		40030	0.753	0.770
842040	4.220	5.060		4010	0.423	0.430
842070	1.000	1.310		41020	0.104	0.104
842110	0.560	0.560		42020	0.341	0.341
9164020	0.030	0.030		4602010	1.181	1.190
9559010	1.930	2.990		4803002	0.258	0.258
9954021	2.190	2.200		48040	0.159	0.159
9965010	0.770	0.800		49010	22.773	22.870
1010	0.562	0.562		50010	0.180	0.180
11110010	6.299	6.299		5002110	7.306	7.306
11110021	2.018	2.018		509020	1.551	1.560
11245011	9.878	9.950		509031	0.050	0.050
11282010	4.874	4.874		509091	0.083	0.083
12035020	0.676	0.676		51020	0.020	0.020
13266071	21.105	21.120		52010	0.077	0.077
13266081	2.275	2.275		5259010	7.131	7.170
13266091	1.782	1.800		53010	0.018	0.018
1760020	29.285	29.285		5302030	3.707	3.780
1762010	5.606	5.630		54020	3.328	3.410
1762030	5.962	6.750		5402040	0.003	0.003
2284040	0.790	0.790		54040	0.246	0.260
2284060	0.759	0.780		5404010	0.073	0.073
2284131	0.355	0.370		5404050	0.099	0.099
2284141	1.584	1.584		54050	2.853	3.060
2285010	1.147	1.147		5405020	0.055	0.055
2285030	2.146	2.146		5406010	0.021	0.021
231010	1.528	1.540		6020	0.248	0.248
231030	0.028	0.028		6051031	0.316	0.316
233011	5.520	6.140		6052020	0.186	0.200
3151010	1.062	1.062		6053010	0.120	0.120

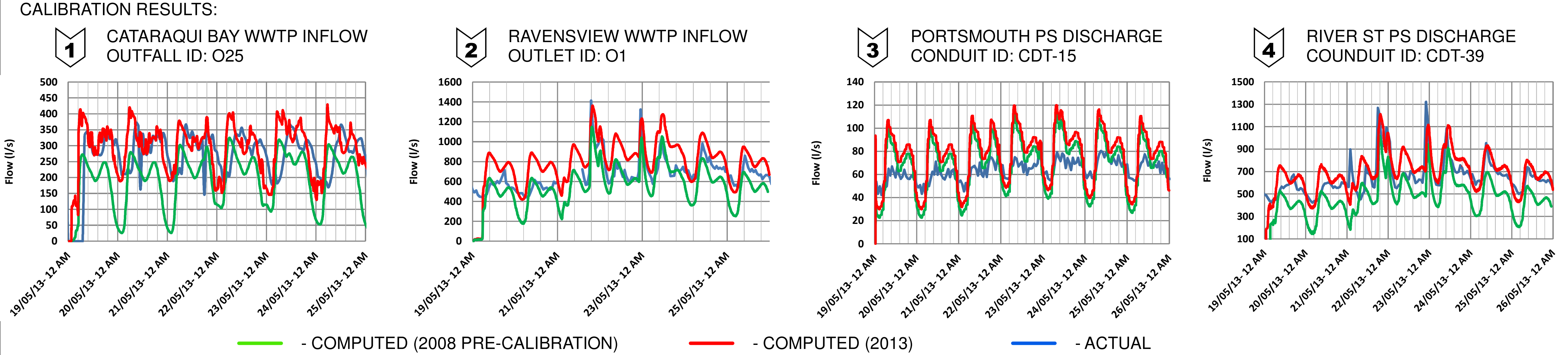
Table C2: Model Parameter Inputs for Dry-Weater Flows (Continued)						
Junction Node ID	2008 DWF Model Parameter (Original)	2013 DWF Model Parameter (Update)		Junction Node ID	2008 DWF Model Parameter (Original)	2013 DWF Model Parameter (Update)
614051	2.743	2.770		8569081	6.384	6.410
6151050	0.605	0.650		8569131	0.226	0.226
6251040	1.435	1.480		8902020	5.698	5.710
630010	0.295	0.295		9101010	0.145	0.145
630020	1.505	1.505		9222010	8.385	8.385
630070	0.068	0.110		9227020	11.481	11.510
631020	0.910	0.930		9227081	6.767	7.230
632010	1.033	1.033		9228041	0.659	0.690
632060	0.178	0.190		9432010	1.976	2.030
633010	1.666	1.666		9502020	1.546	1.590
633060	0.718	1.890		9624010	5.556	6.160
633120	0.308	0.340		9628010	1.263	1.380
6351020	0.804	0.804		9653010	1.373	1.560
636020	1.077	1.600		9654020	0.122	0.140
637060	0.301	0.301		9655010	0.055	0.055
637062	1.313	5.370		9655020	0.118	0.118
6451050	0.785	0.785		9716010	7.196	7.240
6551030	1.234	1.250		9729010	2.595	2.595
6752020	1.301	1.301		9901010	0.423	0.450
6950060	0.434	0.450		9902010	0.152	0.170
7054110	0.263	0.263		9903010	0.110	0.110
7101110	1.822	1.822				
7102110	0.881	0.881				
7104010	1.257	1.300				
7105010	0.056	0.056				
7105020	0.313	0.313				
7109010	0.236	0.350				
7455020	2.700	2.740				
7954110	1.840	1.880				
823020	11.536	11.536				
825030	2.087	2.087				
825080	3.542	3.542				
825090	1.861	1.861				
828040	2.981	3.170				
8554030	0.046	0.046				
8554041	0.805	0.830				
8554081	5.003	5.110				
8565010	0.902	0.910				
8565020	1.297	1.750				
8569041	0.983	0.990				

APPENDIX D

Wet-Weather Calibration Observations



CALIBRATION RESULTS:



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P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- CSO TANK
- EXISTING SANITARY SEWER
- EXISTING COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- CATCHMENT AREA
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utilities Kingston, July 2013, City of Kingston.

Scale: 0 500 1,000 2,000 Metres
1:50,000

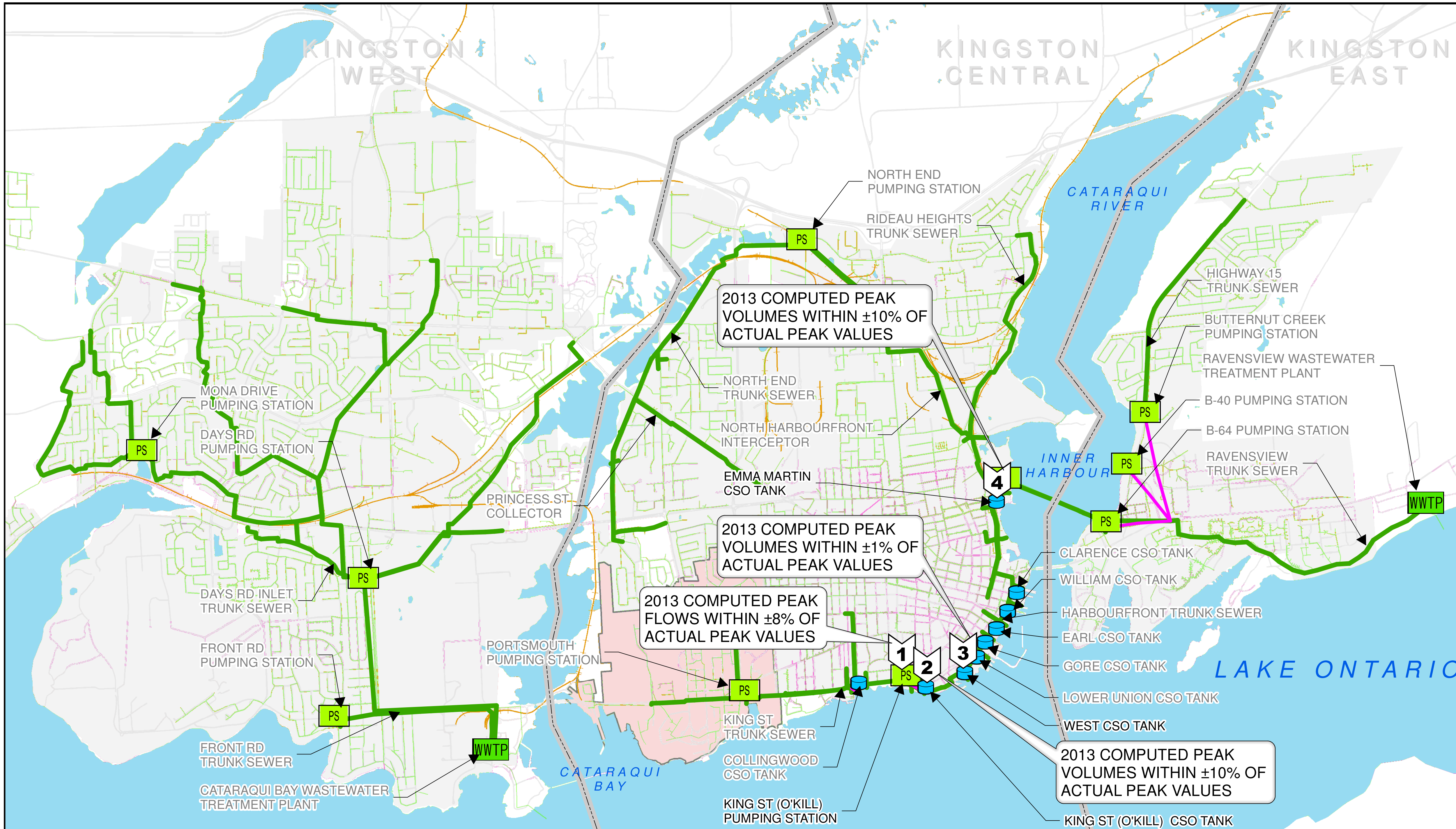
N E S W

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

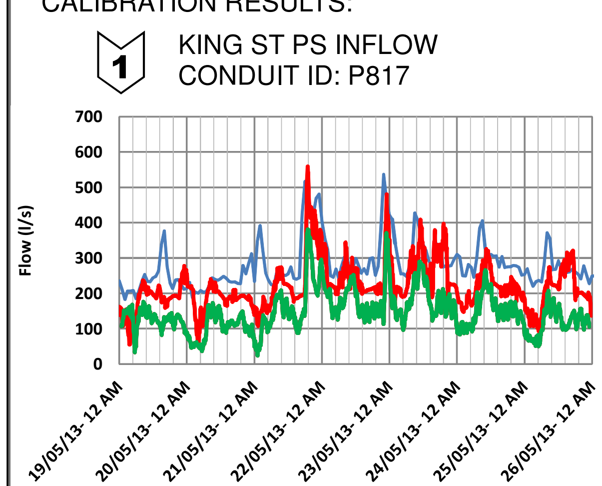
City of Kingston, Ontario

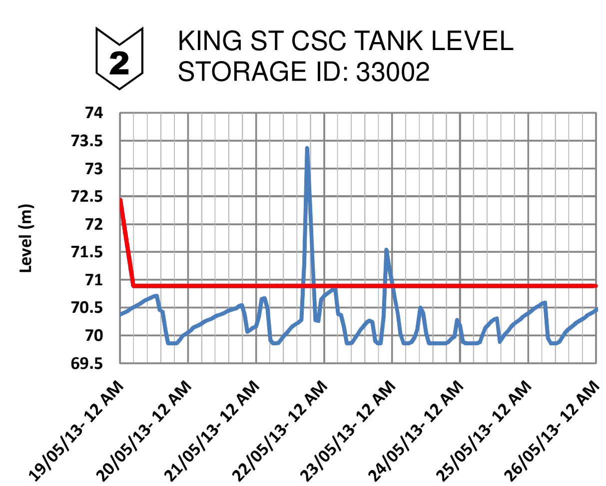
Title: MAY WET-WEATHER EVENT: CALIBRATION SUMMARY MAP 1

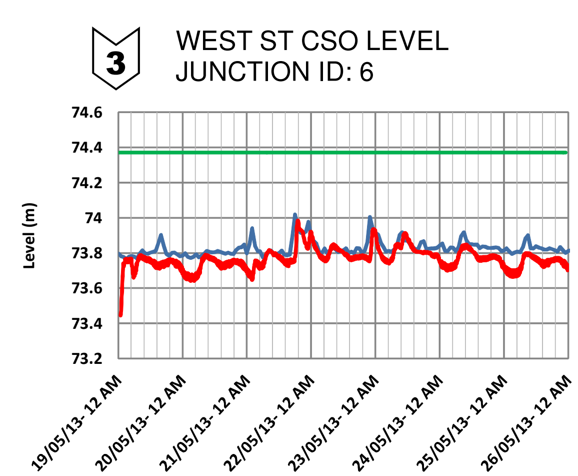
Project No.: 131-18048-00		Date: MARCH, 2014
Drawn By: MF	Checked By: MM	Drawing No.: 4-1

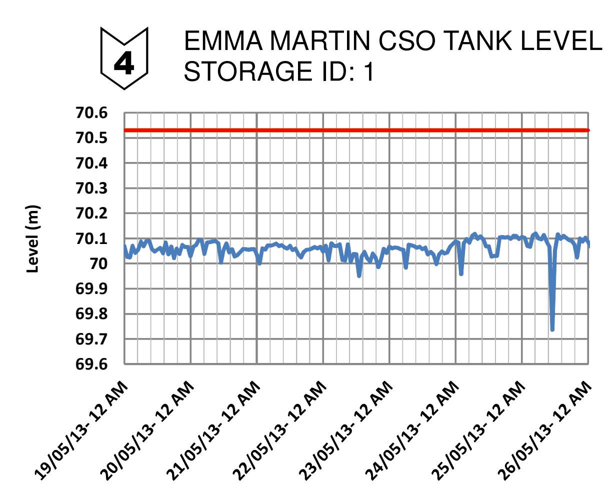


CALIBRATION RESULTS:









- COMPUTED (2008 PRE-CALIBRATION) - COMPUTED (2013) - ACTUAL

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KINGSTON, ONTARIO,
K7L 4X7

Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- CSO TANK
- EXISTING SANITARY SEWER
- EXISTING COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- CATCHMENT AREA
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utilities Kingston, July 2013, City of Kingston.

Scale: 0 500 1,000 2,000 Metres
1:50,000

N E S W

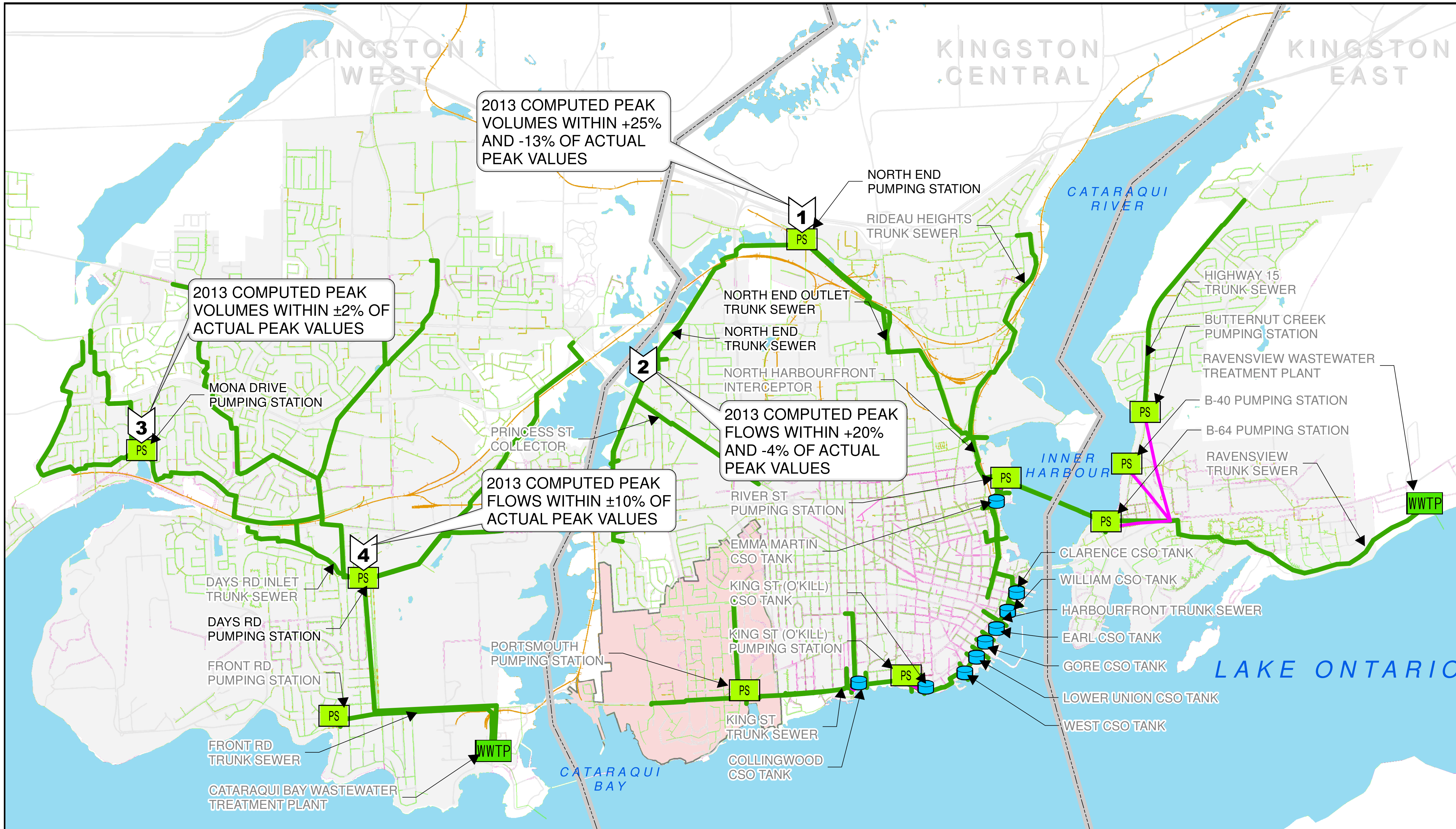
Project:

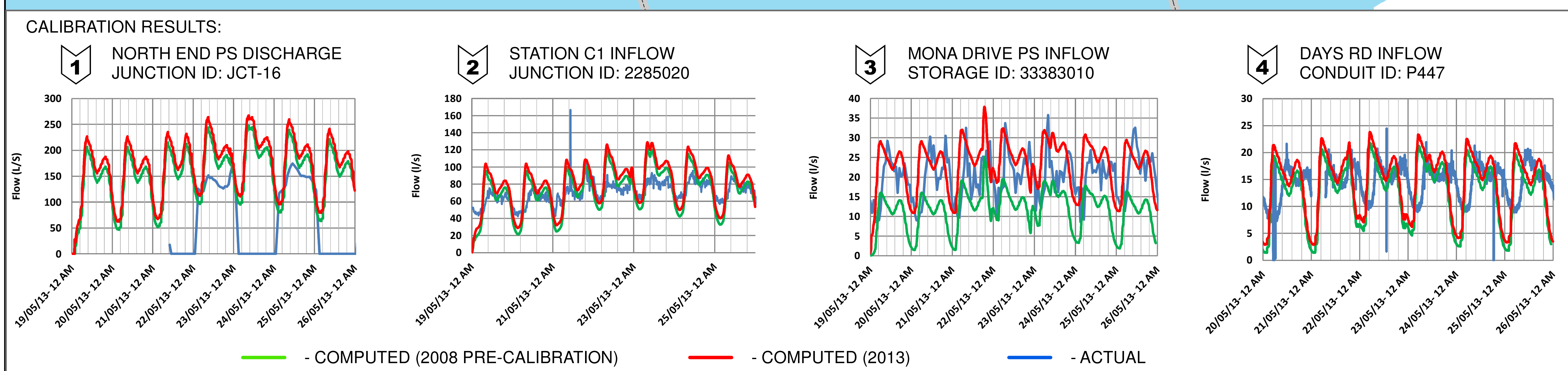
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: MAY WET-WEATHER EVENT: CALIBRATION SUMMARY MAP 2

Project No.:		Date:
131-18048-00		MARCH, 2014
Drawn By: MF	Checked By: MM	Drawing No.: 4-2





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Utilities Kingston

UTILITIES KINGSTON
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KINGSTON, ONTARIO,
K7L 4X7

Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- CSO TANK
- EXISTING SANITARY SEWER
- EXISTING COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- CATCHMENT AREA
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utilties Kingston, July 2013, City of Kingston.

Scale:
0 495 990 1,980 Metres
1:50,000

N E S W

Project:

Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: MAY WET-WEATHER EVENT: CALIBRATION SUMMARY MAP 3

Project No.:		Date:
131-18048-00		MARCH, 2014
Drawn By: MF	Checked By: MM	Drawing No.: 4-3

APPENDIX E

Growth Projection Calibration and Supplementary Reports

Table E1 - Population Calculation

DESIGNED BY: Michael Flowers. EIT
CHECKED BY: Matt Morkem, P.Eng.

Assumptions

Units per Hectare=	37.5 Units/Ha	City of Kingston - Large Scale Developments
Average Persons Per Unit=	2.1	City of Kingston - Residential
2026 Growth Rate =	26%	2% growth/year from 2013

Proposed 2026 Projection

Development	Area (Ha)	Building Type[1]	Total Units	Total Population	Notes
St. Mary's Hospital	5	N/A	49	102	26% of long term development
Williamsville 'A'	24.25	Residential	341	660	Includes U1, V4, V8 & V11 Refer to Appended Williamsville Service Study
		Retail	267	173	
			TOTAL	**833**	
Williamsville ' B'	2.51	Residential	15	28	Includes V10 Refer to Appended Williamsville Service Study
		Retail	16	11	
			TOTAL	**39**	
North Block	5.04	Residential	39	82	26% of long term development Refer to Appended North Block Service Study
		Commercial[2]	6,500 sq. ft.		
Davis Tannery	11.08	Refer to Appended WSP Service Study			
IO Psych Hospital	50.12	Refer to Appended XCG/FoTenn Service Study			
Alcan Property	104.95	N/A	1023	2149	26% of long term development. In accordance with City of Kingston Official Plan
Novellis	74.55	N/A	727	1526	26% of long term development. In accordance with City of Kingston Official Plan

Proposed Full Build-Out Projection

Development	Area (Ha)	Building Type[1]	Total Area/Units	Total Population	Notes
St. Mary's Hospital	5	N/A	188	394	26% of long term development
Williamsville 'A'	24.25	Residential	1606	3100	Includes U1-U23, V1-V9 & V11 Refer to Appended Willaimsville Service Study
		Retail	1361	885	
			TOTAL	**3985**	
Williamsville 'B'	2.51	Residential	68	130	Includes U24, U25 & V10 Refer to Appended Willaimsville Service Study
		Retail	57	37	
			TOTAL	**167**	
North Block	5.04	Residential	150	315	Refer to Appended North Block Service Study
		Commercial[2]	25,000 sq. ft.		
Davis Tannery	11.08	Refer to Appended WSP Service Study			
IO Psych Hospital	50.12	Refer to Appended XCG/FoTenn Service Study			
Alcan Property	104.95	N/A	3936	8265	In accordance with City of Kingston Official Plan
Novellis	74.55	N/A	2796	5871	In accordance with City of Kingston Official Plan

Notes:
1) Building Type provided by City of Kingston
2) Persons per unit from City of Kingston Subdivision Design Guidelines
3) Flow per MOE Design Guidelines (5 $L/d/m^2$)
4) Total persons calculated by multipling Total Number of Units and Persons Per Unit

Table E2 - Sanitary Sewer Calculation Sheet - Flow Projections

DEVELOPMENT AREA DESCRIPTION					FLOW GENERATION[2]					
LOCATION	FROM	TO	Contributing Area No.	Ha	P	P(1000)	q l/cap/d)	M	Peak Flow (l/s)	Additional Flow (l/s)[4]
St. Mary's Hospital - 2026					102	0.10	350	4.00	**1.66**	
St. Mary's Hospital - Build-Out	Site	39130	COKL05	5.00	394	0.39	350	4.00	**6.38**	
Williamsville 'A' - 2026[1]			CHRB02,		833	0.833	350	3.85	**12.99**	
Williamsville 'A' - Build-Out[1]	Site	9222010	COM_CHRB02	24.25	3985	3.985	350	3.33	**53.83**	
Williamsville 'B' - 2026[1]			CHBT03,		39	0.039	350	4.00	**0.63**	
Williamsville 'B' - Build-Out[1]	Site	7101110	COM_CHBT03	2.51	167	0.167	350	4.00	**2.71**	
North Block - 2026[1]			CHRB07, CHRB08, CHRB09, CHRB10,		82	0.0819	350	4.00	**1.33**	**0.04**
North Block - Build-Out[1]	Site	9902010	CHRB11, COM_CHRB11	5.04	315	0.315	350	4.00	**5.10**	**0.13**
Davis Tannery - 2026			CNEO01, CHRB01,		WSP Service Study				**7.20**	
Davis Tannery - Build-Out	Site	7109010	COM_CHRB01	11.88					**27.70**	
IO Psych Hospital - 2026					XCG/FoTenn Service Study				**12.22**	
IO Psych Hospital - Build-Out	Site	49010	CKNG03	50.12					**42.00**	
Alcan Property - 2026	Site				2149	2.15	350	3.56	**31.00**	
Alcan Property - Build-Out		1760020	CNET04	104.95	8265	8.26	350	3.04	**101.66**	
Novellis - 2026					1526	1.53	350	3.67	**22.72**	
Novellis - Build-Out	Site	823020	CPRS06	74.55	5871	5.87	350	3.18	**75.62**	

DESIGN PARAMETER

Manning's n =	0.0130	City of Kingston Guidelines
Average Daily Flow (q)=	350 l/cap/d	City of Kingston Guidelines

Notes:

1) Refer to Table A1 for population information/calculations (Provided by Utilties Kingston)

2) Flow caclulation for development represents additional intensificiation from previous growth projection.

3) I & I was not included as calculated flows are for dry weather only. I & I is accounted for within the InfoSWMM model

4) Commercial flow rates from MOE 2008 Sewer Desgin Guidelines

PROJECT:

Portsmouth Pumping Station Flow Redirection Environmental Assessment

LOCATION:

City of Kingston - Urban Area
Kingston, ON

Project Number: 131-18048-00

Date: 10-Apr-14

Table E3 - Peak Dry Weather Flow - Model Parameter Update

DEVELOPMENT AREA DESCRIPTION				EXISTING DRY - WEATHER FLOW[1]		ADJUSTED PEAK FLOW[3]				DRY-WEATHER FLOW MODEL PARAMETERS[2]				
LOCATION	FROM	TO	Contributing Area No.	2026 (l/s)	Build-Out (l/s)	Peak Flow 2026 (l/s)	Adjusted 2026 (l/s)	Peak Flow Build-Out (l/s)	Adjusted Build-Out (l/s)	Diurnal Peaking Factor[4]	Existing 2026 (l/s)	Adjusted 2026 (l/s)	Existing Build-Out (l/s)	Adjusted Build-Out (l/s)
				A	B	C	A+C	D	B+D	E		(A+C) / E		(B+D) / E
St. Mary's Hospital	Site	39130	COKL05	4.81	4.81	1.66	**6.47**	6.38	**11.19**	1.78	2.71	**3.64**	2.71	**6.30**
Williamsville 'A'	Site	9222010	CHRB02, COM_CHRB02	14.88	14.88	12.99	**27.87**	53.83	**68.72**	1.78	8.39	**15.70**	8.39	**38.71**
Williamsville 'B'	Site	7101110	CHBT03, COM_CHBT03	2.48	2.48	0.63	**3.12**	2.71	**5.19**	1.36	1.82	**2.29**	1.82	**3.81**
North Block	Site	9902010	CHRB07, CHRB08, CHRB09, CHRB10, CHRB11, COM_CHRB11	0.27	0.36	1.36	**1.64**	5.23	**5.60**	1.36	0.20	**1.20**	0.27	**4.11**
Davis Tannery	Site	7109010	CNEO01, CHRB01, COM_CHRB01	1.13	4.21	7.20	**8.33**	27.70	**31.91**	1.78	0.64	**4.69**	2.37	**17.98**
IO Psych Hospital	Site	49010	CKNG03	41.07	42	12.22	**53.29**	42.00	**83.75**	1.78	23.14	**30.02**	23.52	**47.18**
Alcan Property	Site	1760020	CNET04	51.98	68	31.00	**82.98**	101.66	**169.59**	1.78	29.29	**46.75**	38.27	**95.54**
Novellis	Site	823020	CPRS06	20.48	23	22.72	**43.19**	75.62	**98.37**	1.78	11.54	**24.33**	12.82	**55.42**

DESIGN PARAMETER

Notes:

1) & 2) Existing dry-weather flow and dry-weather flow model paramaters taken from Utilties Kingston InfoSWMM Model. (Provided by Utilites Kingston)

3) Refer to Table A2 for adjusted Peak Flow data information/calculations

4) Diurnal peaking factor taken from Utilities Kingston InfoSWMM Model

By: Michael Flowers, EIT

Checked By: Matt Morkem, P.Eng

PROJECT: **Portsmouth Pumping Station Flow Redirection Environmental Assessment**

LOCATION: **City of Kingston - Urban Area Kingston, ON**

Dwg. Reference: 131-18048-00_DWG5_1.mxd

Project Number: 131-18048-00

Date: 10-Apr-14

APPENDIX F

Design Storm and CSO Analysis Results

TABLE F-1: Design Storm Pumping Station and WWTP Capacity Analysis for Kingston Central – Portsmouth Service Area Routed East vs. West

Station/Outfall[1]	Model ID(s)	Reported Firm*/Peak Instantaneous Capacity (L/s)	Route Direction	2013 Peak Inflow (L/s)							2026 Peak Inflow (L/s)							Build-out Peak Inflow (L/s)						
				DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 yr	DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 yr	DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 yr
Portsmouth Pumping Station	Storage ID: 48010	285***	EAST 1	128	190	231	261	302	332	364	132	193	235	265	305	336	365	152	213	255	285	325	356	387
			EAST 2	128	190	231	261	302	332	364	145	206	247	277	317	348	380	194	255	297	327	367	395	424
			WEST	128	190	231	261	302	332	364	145	206	247	277	317	348	380	194	255	297	327	367	395	424
North End Pumping Station	Storage ID: 1760010	1,050*	EAST 1	240	401	496	560	692	774	854	249	412	506	570	704	786	865	284	447	535	621	775	822	902
			EAST 2	240	401	496	560	692	774	854	300	460	546	639	754	831	902	448	584	708	788	876	942	1,009
			WEST	240	401	496	560	692	774	854	300	460	546	639	754	831	902	448	584	708	788	876	942	1.009
River St Pumping Station	Storage ID: 7114003	1,425*	EAST 1	1,198	1,967	1,997	2,007	2,097	2,196	2,402	1,221	1,954	1,983	1,997	2,007	2,024	2,043	1,311	1,355	1,973	1,979	2,001	1,985	2,003
			EAST 2	1,198	1,967	1,997	2,007	2,097	2,196	2,402	1,302	1,966	1,992	1,996	2,060	2,097	2,049	2,021	1,980	1,995	2,003	1,991	2,022	2,074
			WEST	1,123	1,968	1,996	2,025	2,040	2,058	2,193	1,211	1,960	1,989	1,989	2,019	2,000	2,001	1,450	1,377	1,982	1,980	1,1989	2,010	2,056
King St Pumping Station	Storage ID: 34010	600*	EAST 1	729	881	1,147	1,233	1,268	1,289	1,346	740	775	923	1,038	1,090	1,185	1,274	768	770	786	963	1,069	1,097	1,067
			EAST 2	735	950	1,147	1,233	1,268	1,295	1,346	740	741	1,038	1,049	1,124	1,289	1,300	765	770	805	932	953	1,054	1,110
			WEST	735	930	979	1,170	1,227	1,238	1,270	740	725	759	868	996	990	1,045	550	572	678	702	711	762	797
Cataraqui Bay WWTP	Outfall ID: O25	799**	EAST 1	439	649	815	904	1,033	1,140	1,277	512	760	894	1,014	1,118	1,250	1,377	709	954	1,099	1,196	1,335	1,432	1,571
			EAST 2	439	649	815	904	1,033	1,140	1,277	512	760	894	1,014	1,118	1,250	1,377	709	954	1,099	1,196	1,335	1,432	1,571
			WEST	545	953	1,012	1,143	1,315	1,455	1,624	666	953	1,095	1,265	1,424	1,581	1,744	948	1,164	1,375	1,495	1,672	1,808	1,944
Ravensview WWTP	Outfall ID: O1	2,153**	EAST 1	1,567	2,342	2,403	2,459	2,528	2,599	2,619	1,525	2,300	2,405	2,444	2,541	2,557	2,569	1,603	1,694	2,348	2,464	2,544	2,557	2,568
			EAST 2	1,567	2,342	2,403	2,459	2,528	2,599	2,619	1,549	2,313	2,405	2,444	2,541	2,557	2,569	2,142	2,296	2,423	2,489	2,544	2,557	2,569
			WEST	1,376	2,342	2,403	2,459	2,528	2,599	2,619	1,481	2,276	2,405	2,444	2,541	2,557	2,569	1,664	1,692	2,362	2,456	2,541	2,555	2,569

Flow under firm/peak instantaneous capacity	Flow exceeds firm/peak instantaneous capacity

Notes:

- EAST 1: Represents 2013 existing conditions with current upgrades and no development intensification.
- EAST 2: Represents 2013 existing conditions with currents upgrades and development intensification proposed for 2026 and build-out growth scenarios.
- WEST: Represents current upgrades and the sanitary flow from the Portsmouth PS service area redirected West towards Cataraqui Bay with development intensification proposed for 2026 and build-out growth scenarios.
- * Values shown are firm capacities based on the Kingston Sewer Master Plan.
- ** Values shown are peak process instantaneous flows based on the Kingston Sewer Master Plan
- *** Value from Ministry of Environment Certificate of Approval

TABLE F-2: Design Storm Trunk Sewer Capacity Analysis Results– Portsmouth Service Area Routed East vs. West

Sewer	Conduit ID(s)	Route Direction	**2013 Peak Inflow (L/s)** Trunk Sewer Surcharging							**2026 Peak Inflow (L/s)** Trunk Sewer Surcharging							**Build-out Peak Inflow (L/s)** Trunk Sewer Surcharging						
			DW	1:2yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 yr	DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 yr	DW	1:2 yr	1:5 yr	1:10 yr	1:25 yr	1:50 yr	1:100 yr
North End Outfall Sewer	P188-P208	EAST 1																					
		EAST 2																					18%
		WEST																					18%
North End Trunk Sewer	P93-P145	EAST 1							5%							2%							2%
		EAST 2							5%							5%					2%	5%	10%
		WEST							5%							5%					2%	5%	10%
Princess St Collector	P69-P91	EAST 1					13%	26%	65%				9%	17%	26%	43%				9%	17%	30%	52%
		EAST 2					13%	26%	65%			9%	17%	39%	57%	83%	13%	39%	65%	65%	74%	78%	83%
		WEST					13%	26%	65%			9%	17%	39%	57%	83%	13%	39%	65%	65%	74%	78%	83%
Rideau Heights	P157-P186	EAST 1				3%	23%	29%	32%					13%	24%	26%							
		EAST 2				3%	23%	29%	32%					19%	24%	29%							16%
		WEST				3%	17%	23%	32%					10%	24%	29%							
North Harbourfront Interceptor	P211-P215	EAST 1		29%	29%	100%	100%	100%	100%		29%	29%	29%	100%	100%	100%		14%	29%	29%	29%	29%	71%
		EAST 2		29%	29%	100%	100%	100%	100%		29%	29%	43%	100%	100%	100%	14%	29%	29%	29%	29%	71%	100%
		WEST		14%	29%	86%	100%	100%	100%		14%	29%	29%	100%	100%	100%		14%	29%	29%	29%	29%	29%
King St Trunk	P257-P351	EAST 1		10%	24%	38%	48%	57%	62%					19%	19%	43%							5%
		EAST 2		10%	24%	38%	48%	57%	62%					33%	33%	48%							5%
		WEST					33%	38%	62%														
Harbourfront Trunk	P241-P343	EAST 1		100%	100%	100%	100%	100%	100%		21%	96%	100%	100%	100%	100%		19%	21%	25%	93%	93%	93%
		EAST 2		100%	100%	100%	100%	100%	100%		21%	96%	100%	100%	100%	100%	21%	21%	21%	79%	93%	93%	100%
		WEST		96%	100%	100%	100%	100%	100%		21%	93%	100%	100%	100%	100%		19%	21%	21%	21%	25%	50%
Ravensview Trunk Sewer	P6 – P156	EAST 1					38%	46%	52%					33%	38%	48%				9%	38%	43%	52%
		EAST 2					38%	46%	52%					38%	43%	52%				38%	43%	52%	52%
		WEST					29%	43%	52%					33%	43%	52%				9%	38%	43%	52%

No pipe surcharging	**Pipe surcharging greater than 0.3m above pipe and 2m below ground elevation.***	**Pipe surcharging within 2m of ground elevation***

Notes:

- EAST 1: Represents 2013 existing conditions with current upgrades and no development intensification.
- EAST 2: Represents 2013 existing conditions with currents upgrades and development intensification proposed for 2026 and build-out growth scenarios.
- WEST: Represents current upgrades and Portsmouth PS service area flow redirected West towards Cataraqui Bay WWTP with development intensification proposed for 2026 and build-out growth scenarios.
- *Values indicate percentage of pipes surcharged

APPENDIX G

Cost Estimates

WSP Canada Inc
1224 Gardiners Road, Suite 201,
Kingston, ON, K7P 0G2
Telephone: 613-634-7373
Fax: 613-634-3523

Summary of Cost

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Redirect West			
1.0	Portsmouth Pumping Station Upgrades		$1,875,000
2.0	Portsmouth Forcemain_West		$7,292,500
Estimated Total Redirection Cost			**$9,167,500**

Required Upgrades to Continue East			
1.0	River St PS Upgrades		$3,535,000
2.0	North Harbourfront Interceptor Trunk Sewer Upgrades		$1,025,050
3.0	King Street Trunk Sewer Upgrades		$900,050
4.0	Harbourfront Trunk Sewer Upgrades		$6,420,000
5.0	Ravensview Trunk Sewer Upgrades		$2,400,000
6.0	Harbourfront CSO Tank Upgrades		$4,040,000
7.0	Collingwood CSO Tank Upgrades		$410,000
8.0	Belle Park Local 1200 Overflow CSO Tank Upgrades		$590,000
9.0	Barrack Street CSO Tank Upgrades		$410,000
10.0	Queen Street CSO Tank Upgrades		$410,000
11.0	Belle Park Trunk Overflow CSO Tank Upgrades		$295,000
12.0	Lower Union St CSO Tank Upgrades		$205,000
Estimated Total Upgrade Cost			**$20,640,100**

WSP Canada Inc
1224 Gardiners Road, Suite 201,
Kingston, ON, K7P 0G2
Telephone: 613-634-7373
Fax: 613-634-3523

Portsmouth Pumping Station Upgrades

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate
1	Dewatering and Demolition/Removals	$75,000
2	Wet well upgrades	$135,000
3	Pump System including Controls (VFD's etc)	$500,000
4	Building Upgrades	$100,000
5	Communitor	$100,000
6	Process Piping	$70,000
7	Electrical	$100,000
8	Site Works Piping	$90,000
9	Pumping Station By-Pass	$35,000
10	Restorations	$30,000
11	Testing & Commisioning	$10,000
	Sub-Total	**$1,245,000**
	General Contractor O/H & Profit (10%)	$130,000
	Contigency (25%)	$310,000
	Engineering (15%)	$190,000
	Estimated Total Project Cost	**$1,875,000**

WSP Canada Inc
1224 Gardiners Road, Suite
201, Kingston, ON, K7P 0G2
Telephone: 613-634-7373
Fax: 613-634-3523

Front Road Watermain and Portsmouth Forcemain Project

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

				Total Engineer's Estimate	
Item No.	**Description**	**Unit Rate**	**Unit**	**Quantity**	**Amount**
1	Removal of Existing Concrete Curb	$40.00	LM	3000	$120,000
2	Removal of Existing Asphalt and Concrete	$6.00	SM	18000	$108,000
3	450mm Forcemain by Trenching	$350.00	LM	3000	$1,050,000
4	450mm Forcemain by HDD	$2,000.00	LM	350	$700,000
5	450mm Valve on Forcemain	$7,500.00	EA	10	$75,000
6	ARV (50mm) & Chamber for Forcemain	$25,000.00	EA	3	$75,000
7	Rock Removal	$100.00	CM	3000	$300,000
8	Common Excavation	$60.00	CM	8000	$480,000
9	Granular "B"	$18.00	T	20000	$360,000
10	Granular "A"	$20.00	T	10000	$200,000
11	HotMix Asphalt - HL8	$140.00	T	4500	$630,000
12	HotMix Asphalt - HL3	$150.00	T	2200	$330,000
13	Concrete Curb & Gutter - All Types	$85.00	LM	2700	$229,500
14	Topsoil & Sod	$10.00	SM	15000	$150,000
15	Sediment Control & Environmental Protection	$100,000.00	LS	1	$100,000
16	Dewatering	$75,000.00	LS	1	$75,000
17	Traffic Control	$150,000.00	LS	1	$150,000
18	Lump Sum for Other Requirements	3%	LS	1	$160,000.00
	SUBTOTAL:				**$5,292,500**
	Contigency			25%	$ 1,330,000.00
	Engineering			10%	$ 670,000.00
	Estimated Total Project Cost				**$7,292,500**

Note: Cost for transient protection are estimated and not based on analysis

WSP Canada Inc
1224 Gardiners Road, Suite 201,
Kingston, ON, K7P 0G2
Telephone: 613-634-7373
Fax: 613-634-3523

River Street Pumping Station Upgrades

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate
1	Dewatering and Demolition/Removals	$100,000
2	Wet well upgrades	$350,000
3	Pump System including Controls (VFD's etc)	$300,000
4	Building Upgrades	$750,000
5	Process Piping	$400,000
6	Electrical	$250,000
7	Restorations	$100,000
8	Testing & Commisioning	$25,000
	Sub-Total	**$2,275,000**
	General Contractor O/H & Profit (15%)	$350,000
	Contigency (30%)	$680,000
	Engineering (15%)	$230,000
	Estimated Total Project Cost	**$3,535,000**

WSP Canada Inc
1224 Gardiners Road, Suite
201, Kingston, ON, K7P 0G2
Telephone: 613-634-7373
Fax: 613-634-3523

North Harbourfront Interceptor Upgrades

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

				Total Engineer's Estimate	
Item No.	**Description**	**Unit Rate**	**Unit**	**Quantity**	**Amount**
1	Removal of Existing Asphalt and Concrete	$6.00	SM	1000	$6,000
2	≤1500mm Sanitary Sewer (Currently 1200mm)	$1,100.00	LM	300	$330,000
3	Precast Manholes	$35,000.00	EA	4	$140,000
4	Common Excavation	$10.00	CM	1250	$12,500
5	Granular "B"	$18.00	T	850	$15,300
6	Granular "A"	$20.00	T	425	$8,500
7	HotMix Asphalt - HL8	$140.00	T	150	$21,000
8	HotMix Asphalt - HL3	$150.00	T	75	$11,250
9	Concrete Curb & Gutter - All Types	$85.00	LM	300	$25,500
10	Topsoil & Sod	$10.00	SM	5000	$50,000
11	Sediment Control & Environmental Protection	$25,000.00	LS	1	$25,000
12	Traffic Control	$10,000.00	LS	1	$10,000
13	Lump Sum for Other Requirements	3%	LS	1	$20,000.00
	SUBTOTAL:				**$675,050**
	Contigency			30%	$ 210,000.00
	Engineering			15%	$ 140,000.00
	Estimated of Total Project Cost				**$1,025,050**

Note: Exact length of required upgrades extimated based on number of pipes surcharged
Upgrade Pipe Size estimated based on existing pipe size and level of surcharging

WSP Canada Inc
1224 Gardiners Road, Suite
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King St Trunk Sewer Upgrades

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

				Total Engineer's Estimate		
Item No.	**Description**	**Unit Rate**	**Unit**	**Quantity**		**Amount**
1	Removal of Existing Asphalt and Concrete	$6.00	SM	1000		$6,000
2	≤1050mm Sanitary Sewer	$1,000.00	LM	225		$225,000
3	Precast Manholes	$25,000.00	EA	4		$100,000
4	Common Excavation	$10.00	CM	1250		$12,500
5	Granular "B"	$18.00	T	850		$15,300
6	Granular "A"	$20.00	T	425		$8,500
7	HotMix Asphalt - HL8	$140.00	T	150		$21,000
8	HotMix Asphalt - HL3	$150.00	T	75		$11,250
9	Concrete Curb & Gutter - All Types	$85.00	LM	300		$25,500
10	Topsoil & Sod	$10.00	SM	5000		$50,000
11	Sediment Control & Environmental Protection	$50,000.00	LS	1		$50,000
12	Traffic Control	$75,000.00	LS	1		$75,000
13	Lump Sum for Other Requirements	3%	LS	1		$20,000.00
	SUBTOTAL:					**$620,050**
	Contigency			30%	$	190,000.00
	Engineering			10%	$	90,000.00
	Estimated of Total Project Cost					**$900,050**

Note: Exact length of required upgrades extimated based on number of pipes surcharged
Upgrade Pipe Size estimated based on existing pipe size and level of surcharging

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Harbourfront Trunk Sewer Upgrades

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate	Unit	Total Engineer's Estimate: Quantity	Total Engineer's Estimate: Amount
1	Removal of Existing Asphalt and Concrete	$6.00	SM	6000	$36,000
2	≤1500mm Sanitary Sewer (Currently 1200mm)	$1,500.00	LM	1600	$2,400,000
3	Precast Manholes	$30,000.00	EA	15	$450,000
4	Common Excavation	$10.00	CM	5000	$50,000
5	Granular "B"	$18.00	T	6000	$108,000
6	Granular "A"	$20.00	T	3000	$60,000
7	HotMix Asphalt - HL8	$140.00	T	2000	$280,000
8	HotMix Asphalt - HL3	$150.00	T	1000	$150,000
9	Concrete Curb & Gutter - All Types	$85.00	LM	1600	$136,000
10	Topsoil & Sod	$10.00	SM	5000	$50,000
11	Sediment Control & Environmental Protection	$100,000.00	LS	1	$100,000
12	Traffic Control	$300,000.00	LS	1	$300,000
13	Lump Sum for Other Requirements	4%	LS	1	$170,000.00
	SUBTOTAL:				**$4,290,000**
	Contigency			30%	$ 1,290,000.00
	Engineering			15%	$ 840,000.00
	Estimated of Total Project Cost				**$6,420,000**

Note: Exact length of required upgrades extimated based on number of pipes surcharged
Upgrade Pipe Size estimated based on existing pipe size and level of surcharging

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Ravensview Trunk Upgrades

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate	Unit	Total Engineer's Estimate – Quantity	Total Engineer's Estimate – Amount
1	Removal of Existing Asphalt and Concrete	$6.00	SM	2000	$12,000
2	≤1650mm Sanitary Sewer (Currently 1350mm)	$1,500.00	LM	700	$1,050,000
3	Precast Manholes	$40,000.00	EA	7	$280,000
4	Common Excavation	$10.00	CM	1500	$15,000
5	Granular "B"	$18.00	T	1500	$27,000
6	Granular "A"	$20.00	T	750	$15,000
7	HotMix Asphalt - HL8	$140.00	T	150	$21,000
8	HotMix Asphalt - HL3	$150.00	T	100	$15,000
9	Concrete Curb & Gutter - All Types	$85.00	LM	0	$0
10	Topsoil & Sod	$10.00	SM	3000	$30,000
11	Sediment Control & Environmental Protection	$50,000.00	LS	1	$50,000
12	Traffic Control	$15,000.00	LS	1	$15,000
13	Lump Sum for Other Requirements	4%	LS	1	$70,000.00
	SUBTOTAL:				**$1,600,000**
	Contigency			30%	$ 480,000.00
	Engineering			15%	$ 320,000.00
	Estimated of Total Project Cost				**$2,400,000**

Note: Exact length of required upgrades extimated based on number of pipes surcharged
Upgrade Pipe Size estimated based on existing pipe size and level of surcharging

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Harbourfront CSO at West St.

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

1	Dewatering and Demolition/Removals	$100,000
2	Tank upgrades (32x32x4m)	$2,500,000
3	Pumping Station By-Pass	$50,000
4	Restorations	$15,000
5	Testing & Commisioning	$25,000
	Sub-Total	**$2,690,000**
	General Contractor O/H & Profit (10%)	$270,000
	Contigency (30%)	$810,000
	Engineering (15%)	$270,000
	Estimated Total Project Cost	**$4,040,000**

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Collingwood CSO

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate
1	Dewatering and Demolition/Removals	$ 15,000.00
2	Tank upgrades	$ 150,000.00
3	Pumping Station By-Pass	$ 50,000.00
4	Restorations	$ 50,000.00
5	Testing & Commisioning	$ 5,000.00
	Sub-Total	**$270,000**
	General Contractor O/H & Profit (10%)	$30,000
	Contigency (30%)	$80,000
	Engineering (15%)	$30,000
	Estimated Total Project Cost	**$410,000**

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Belle Park Local 1200 Overflow CSO

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate
1	Dewatering and Demolition/Removals	$ 40,000.00
2	Tank upgrades	$ 225,000.00
3	Pumping Station By-Pass	$ 60,000.00
4	Restorations	$ 60,000.00
5	Testing & Commisioning	$ 5,000.00
	Sub-Total	**$390,000**
	General Contractor O/H & Profit (10%)	$40,000
	Contigency (30%)	$120,000
	Engineering (15%)	$40,000
	Estimated Total Project Cost	**$590,000**

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Barrack Street CSO

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate
1	Dewatering and Demolition/Removals	$ 15,000.00
2	Tank upgrades	$ 150,000.00
3	Pumping Station By-Pass	$ 50,000.00
4	Restorations	$ 50,000.00
5	Testing & Commisioning	$ 5,000.00
	Sub-Total	**$270,000**
	General Contractor O/H & Profit (10%)	$30,000
	Contigency (30%)	$80,000
	Engineering (15%)	$30,000
	Estimated Total Project Cost	**$410,000**

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Queen Street CSO

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate
1	Dewatering and Demolition/Removals	$ 15,000.00
2	Tank upgrades	$ 150,000.00
3	Pumping Station By-Pass	$ 50,000.00
4	Restorations	$ 50,000.00
5	Testing & Commisioning	$ 5,000.00
	Sub-Total	**$270,000**
	General Contractor O/H & Profit (10%)	$30,000
	Contigency (30%)	$80,000
	Engineering (15%)	$30,000
	Estimated Total Project Cost	**$410,000**

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Belle Park Trunk Overflow

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description	Unit Rate
1	Dewatering and Demolition/Removals	$ 10,000.00
2	Tank upgrades	$ 100,000.00
3	Pumping Station By-Pass	$ 40,000.00
4	Restorations	$ 40,000.00
5	Testing & Commisioning	$ 5,000.00
	Sub-Total	**$195,000**
	General Contractor O/H & Profit (10%)	$20,000
	Contigency (30%)	$60,000
	Engineering (15%)	$20,000
	Estimated Total Project Cost	**$295,000**

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Lower Union St CSO

Protect No: 131-18048
Date Revised: April-22-14
Class "D" Estimate

Item No.	Description		Unit Rate
1	Dewatering and Demolition/Removals	$	5,000.00
2	Tank upgrades	$	75,000.00
3	Pumping Station By-Pass	$	20,000.00
4	Restorations	$	20,000.00
5	Testing & Commisioning	$	5,000.00
	Sub-Total		**$125,000**
	General Contractor O/H & Profit (10%)		$20,000
	Contigency (30%)		$40,000
	Engineering (15%)		$20,000
	Estimated Total Project Cost		**$205,000**