J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS

MEMO

Date:	November 27, 2023
To:	Mr. Mike Walker Development Review Officer Town of Carleton Place
From:	Ivan Dzeparoski, P. Eng
CC:	Mark Buchanan, P. Eng J.L. Richards & Associates Ltd.
Subject:	Sanitary Sewer Hydraulic Capacity Assessment
JLR No.:	28063-001

1.0 INTRODUCTION

J.L. Richards & Associates Limited (JLR) was retained by the Town of Carleton Place (Town) to complete a sanitary sewer hydraulic capacity analysis in the southeast quadrant of the town, for the area west of McNeely Avenue and north of Highway 7 in support of the future land development potential. It is understood that the proponent is using the new City of Ottawa design guideline values to show that the existing sewer crossing of McNeely at the Independent grocery store has sufficient capacity.

JLR has previously completed HGL and capacity analysis of the sewer network in the area. In 2018 JLR updated a trunk sanitary sewer model originally built by JLR in 2014. A PCSWMM model of the network in the McNeely Avenue / Highway 7 was set up to assess the capacity and surcharge conditions of the sewer reaches to the Highway 7 Pump Station. JLR will use this model as part of the proposed study.

In 2022 a PCSWMMM model of the trunk network was developed by Stantec as part of the Carleton Place Water and Wastewater Master Plan. However, the 2022 Master Plan model was limited to the trunk network and did not include the network upstream of the Highway 7 pump station. Therefore the 2022 Master Plan model was not used for analysis.

This Technical Memorandum describes the modeling methodology used to update the 2018 JLR PCSWMM wastewater model and scope of the project to provide the answers to the following concerns Town has:

- Updates of the sanitary sewer flows to reflect the City of Ottawa latest design guidelines and the latest development information to assess if the sewer crossing at McNeely/independent can support development of all the areas shown in the ‘Current Condition’s Drainage Areas’.

- Assess the sensitivity of using different design values (previously used by the Town) on the sewer capacity for the McNeely sewer crossing at the Independent grocery store.

- Compare the resulting hydraulic grade level to the sewer obvert elevation and ground elevation, particularly from MH 100a to MH 301, that cross McNeely Avenue.

2.0 WASTEWATER MODELLING METHODOLOGY

The PCSWMM software was used for the hydraulic assessment of the sewer system in 2018. This Hydrologic/Hydraulic modelling software provides a Graphical User Interface (GUI) and Geographical Information System (GIS) supported by the Environmental Protection Agency Storm Water Management Model (EPA SWMM) engine, which solves 1D simulations with the dynamic Saint-Venant equations.

2.1 Modelling Parameters and Peak Flow Calculation

The capacity of the sanitary sewer system was analyzed based on the peak flow routing using the Dynamic Wave Routing option in PCSWMM. This form of routing allows for analysis of pressurized flows in the pipes (i.e., when the flow exceeds the full normal flow value), and it accounts for pipe and maintenance hole (MH) storage, backwater and entrance/exit losses in the system.

For sensitivity analysis mentioned in Section 1.0, the sanitary peak flow calculations were carried out using design criteria traditionally used as an industry standard for sanitary sewer design, which were previously applied by JLR in the 2018 hydraulic assessment and set out in the City of Ottawa Sewer Design Guidelines, (October 2012) (OSDG) until they were updated by the City of Ottawa's Technical Bulletin ISTB-2018-01.

Key design parameters have been summarized in **Table 1** below:

Table 1: Design Parameters

Design Parameter	OSDG Current Design Value	Traditional Design Value
Residential average flow	280 L/cap/day	350 L/cap/day
Residential peaking factor	Harmon Formula x 0.8	Harmon Formula x 0.8
Institutional / Commercial average flow	28,000 L/gross ha/day	28,000 L/gross ha/day
Industrial average flow	35,000 L/gross ha/day	35,000 L/gross ha/day
ICI peaking factor	1.5 if ICI contribution >20%, 1.0 otherwise	2.7
Total Infiltration	0.33 L/s/ha	0.28 L/s/ha
Minimum velocity	0.6 m/s	0.6 m/s
Maximum velocity	3.0 m/s	3.0 m/s
Manning Roughness Coefficient (for smooth wall pipes)	0.013	0.013
Minimum allowable slopes	Varies based on the pipe diameter	Varies based on the pipe diameter
Population Density	Single Family: 3.4 p/unit Townhouses: 2.7 p/unit Apartment: 1.8 p/unit	Single Family: 3.4 p/unit Townhouses: 2.7 p/unit Apartment: 1.8 p/unit

Based on the values presented in the above table, the key differences in design parameters are residential average flow, ICI peaking factor and total infiltration value. The traditional values used previously are higher, except the total infiltration parameter and as such it is expected that they will generate higher values for peak sanitary flows.

In recent Master Servicing Studies completed by JLR where flow monitoring has been carried out the dry weather flows have been in the range of 250 to 280 L/cap/day. The 280 L/cap/day is still within the range of residential loading criteria set by the MECP in their 2008 Guidelines for Sewage Works and it is within the current Design Criteria for Sanitary Sewers, Storm Sewers and Forcemains for Alterations Authorized under Environmental Compliance Approval (MECP, 2022), which specifies that the average daily residential flows of 225 to 450 L/cap/day shall be used. Given that the lower residential loading value is within design criteria ranges and is representative of measured flows in similar communities, it is reasonable to maintain consistency with the latest City of Ottawa design criteria for this assessment of the existing sewer network. To gauge sensitivity of the values the two sets of criteria will be compared in the assessment.

The peak flows for the model routing were calculated for the current development and future build out scenario at each MH location that represents the outlet point for the particular sewershed area. The calculation of the sanitary peak flows accounted for residential population, commercial and institutional development. The information on development scenarios is received from the Town in the form of design sheet (completed by McIntosh Perry) and associated figures, which can be found in Attachment 1. The following Table 2 and Table 3 summarizes peak flow calculation for the sewershed areas and associated outlet locations (i.e., MHs) along the sanitary sewer network in accordance with the received information:

Table 2: Sanitary Sewer Peak Flow Calculation and Outlet Locations – Current Development

<table>
<tr><th>Sewershed Area ID</th><th>Outlet MH ID</th><th>Land Use</th><th>Area (ha)</th><th>Population</th><th>Current OSDG Peak Flow (L/s)</th><th>Traditional Peak Flow (L/s)</th></tr>
<tr><td>R2a</td><td>102</td><td>Residential</td><td>5.2</td><td>237</td><td>4.40</td><td>4.81</td></tr>
<tr><td>C3</td><td>102c</td><td>Commercial</td><td>3.9</td><td>n/a</td><td>3.18</td><td>4.50</td></tr>
<tr><td>R1a, R1b</td><td rowspan="3">101</td><td>Residential</td><td>9.3</td><td>876</td><td rowspan="3">21.90</td><td rowspan="3">27.72</td></tr>
<tr><td>C1, C2</td><td>Commercial</td><td>11.0</td><td>n/a</td></tr>
<tr><td>C5</td><td>Commercial</td><td>0.7</td><td>n/a</td></tr>
<tr><td>C4</td><td>100a</td><td>Commercial</td><td>2.6</td><td>n/a</td><td>2.12</td><td>3.00</td></tr>
<tr><td>C6</td><td>100c</td><td>Commercial</td><td>5.7</td><td>n/a</td><td>4.65</td><td>6.58</td></tr>
<tr><td></td><td colspan="4">Total PCSWMM Peak Flow (L/s)</td><td>36.26</td><td>46.62</td></tr>
</table>

Table 3: Sanitary Sewer Peak Flow Calculation and Outlet Locations – Build-Out Development

<table>
<tr><th>Sewershed Area ID</th><th>Outlet MH ID</th><th>Land Use</th><th>Area (ha)</th><th>Population</th><th>Current OSDG Peak Flow (L/s)</th><th>Traditional Peak Flow (L/s)</th></tr>
<tr><td rowspan="3">R2a, R2b, R2c, R2d, R2e, R2f</td><td rowspan="3">102</td><td>Residential</td><td>15.79</td><td>1,472</td><td rowspan="3">21.22</td><td rowspan="3">24.59</td></tr>
<tr><td>Institutional</td><td>0.42</td><td>n/a</td></tr>
<tr><td>Commercial</td><td>0.79</td><td>n/a</td></tr>
<tr><td>C3</td><td>102c</td><td>Commercial</td><td>3.9</td><td>n/a</td><td>3.18</td><td>4.50</td></tr>
<tr><td>R1a, R1b, R3</td><td rowspan="3">101</td><td>Residential</td><td>12.5</td><td>1,372</td><td rowspan="3">24.57</td><td rowspan="3">30.91</td></tr>
<tr><td>C1, C2</td><td>Commercial</td><td>7.8</td><td>n/a</td></tr>
<tr><td>C5</td><td>Commercial</td><td>0.7</td><td>n/a</td></tr>
<tr><td>C4</td><td>100a</td><td>Commercial</td><td>15.4</td><td>n/a</td><td>12.57</td><td>17.79</td></tr>
<tr><td>C6</td><td>100c</td><td>Commercial</td><td>5.7</td><td>n/a</td><td>4.65</td><td>6.58</td></tr>
<tr><td colspan="5">Total Peak Flow</td><td>66.76</td><td>84.37</td></tr>
</table>

As discussed above, the previously applied design parameters generate higher sanitary sewer loading to the system than current OSDG values.

The above calculated peak flows were used as plug-in flows in PCSWMM to perform flow routing and hydraulic analysis of the sanitary sewer network to assess network capacity under both development scenarios. For detailed sanitary sewer peak flow calculations refer to Attachment No. 2.

2.2 Sanitary Sewer Network

The sanitary sewer PCSWMM model from 2018 was developed based on the sanitary sewer network physical characteristics (pipe diameters, pipe lengths, slopes, etc.,) obtained from the available drawings provided by the Town. However, as per Town instructions the PCSWMM information was compared to the sanitary sewer design sheet completed by McIntosh Perry (refer to Attachment No. 1). In a case of any difference (pipe slopes, lengths, diameters) the Town advised to use sanitary sewer design sheet information.

2.3 Sanitary Sewer Outlet

Wastewater flow from residential, commercial and industrial areas is collected and conveyed via trunk sanitary sewers that ultimately discharge into the HWY 7 PS. This pump station was simulated in PCSWMM as an outfall node with a fixed water level of 123.7 m, which represents the high-water level alarm elevation in the wet well and is a conservative elevation for the downstream boundary condition.

3.0 SIMULATION RESULTS

The sewer capacity is evaluated from the results of the simulation based on the two criteria:

- Available theoretical pipe conveyance capacity required to convey calculated peak flow; and
- Flow depth and surcharge conditions in the pipe.

The theoretical sewer pipe conveyance capacity is presented in the form of a ‘Max/Full Flow’ relationship. Max/Full Flow values above 1, or close to 1, indicate that the simulated flow exceeds the theoretical conveyance capacity of the sewer section indicating surcharge operating condition (i.e., HGL above the sewer obvert). Similarly, the surcharge conditions in the pipes were evaluated based on the ‘Max/Full Depth’ relationship, which describes the maximum (peak) fraction of pipe full depth computed during the simulation. In this case, the value equal to 1 indicates the pipe is operating under surcharge conditions.

3.1 Current Development Conditions

The current development conditions and full-build out scenario were simulated for both current OSDG and traditional design parameters. The key simulation results are summarized in the **Table 4** and **Error! Reference source not found.** below for OSDG parameters and for traditionally used parameters. Detailed PCSWMM output table is presented in Attachment No. 3.

Table 4: Summary of the Simulation Results – Current Development Conditions (Current OSDG Parameters)

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
101b-100a	300	0.26	29.00	127.74	0.60	0.58	3.81
100a-100c	300	0.25	32.00	127.65	0.65	0.66	3.97
100c-100d	300	0.19	36.00	127.58	0.86	0.75	3.34
100d-100e	300	0.15	36.00	127.48	0.97	0.72	2.96

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
100e-100f	300	0.23	36.00	127.35	0.78	0.68	3.15
100f-301b	300	0.31	36.00	127.2	0.67	0.60	2.80

McNeely sewer crossing extends from MH structure 101b to MH structure 301b. Simulation results show that this section of sewer has sufficient capacity to maintain free flowing conditions as the ‘Max/Full Flow’ ratio and ‘Max/Full Depth’ ratio are below 1. The most critical sections of the sewer are ‘100c-100d’ and ‘100d-100e’ where the ‘Max/Full Flow’ ratios are 0.86 and 0.97, respectively while Max/Full Depth’ ratios are 0.75 and 0.72 respectively. This is an indication that the system is nearing the conveyance capacity potential and as such represents a limiting factor for the future development of the area.

Based on the simulation results, the most critical pipe section ‘100d-100e’ has residual capacity of approximately 1.1 L/s before the ‘Max/Full Flow’ indicator reaches value of 1. Using the City of Ottawa design values there is capacity in the sewer system for an additional residential development area of 0.6 ha and approximately 80 people (based on an average of 130 ppl/cap/ha) to maintain free flow conditions in the network (‘Max/Full Flow’ of 1 or less).

The simulation results for the traditional design parameters are summarized in the **Table 5** below.

Table 5: Summary of the Simulation Results – Current Development Conditions (Traditional Parameters)

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
101b-100a	300	0.26	37.00	127.79	0.75	0.80	3.76
100a-100c	300	0.25	40.00	127.73	0.83	0.94	3.89
100c-100d	300	0.19	47.00	127.67	1.11	0.99	3.25
100d-100e	300	0.15	47.00	127.54	1.24	0.90	2.90
100e-100f	300	0.23	47.00	127.4	1.00	0.84	3.10
100f-301b	300	0.31	47.00	127.24	0.87	0.70	2.76

Simulation results with the traditional design parameters indicates that the system at McNeely crossing does not have any residual capacity to maintain the free flow conditions under the current development condition scenario. The critical pipes in the system 100c-100d’ and ‘100d-100e’ have ‘Max/Full Flow’ ratios of 1.11 and 1.24, respectively, and ‘Max/Full Depth’ ratios close to 1, which is an indication of surcharged flowing conditions. Despite the surcharged conditions the freeboard in the sewer section is still within 60mm of the free-flow condition and the impact of the more conservative design criteria on the HGL in the system is therefore marginal.

3.2 Build-Out Development Condition

The simulation results for build-out conditions for current OSDG and traditional parameters under the current infrastructure layout shows that the system does not have sufficient capacity to provide a free-flowing condition to support future development. The 300 mm diameter pipes along the McNeely crossing are undersized to accept future sanitary loading. **Table 6** and **Table 7** below, provide summary results for this section of the sewer.

Table 6: Summary of the Simulation Results – Build-Out Condition (Current OSDG Parameters)

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
101b-100a	300	0.26	50.00	128.58	1.00	1.00	2.97
100a-100c	300	0.25	62.00	128.47	1.28	1.00	3.15
100c-100d	300	0.19	67.00	128.31	1.58	1.00	2.61
100d-100e	300	0.15	67.00	128.01	1.78	1.00	2.43
100e-100f	300	0.23	67.00	127.7	1.44	1.00	2.80
100f-301b	300	0.31	67.00	127.36	1.24	0.84	2.64

Table 7: Summary of the Simulation Results – Build-Out Condition (Traditional Parameters)

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
101b-100a	300	0.26	60.00	129.42	1.22	1.00	2.13
100a-100c	300	0.25	78.00	129.27	1.61	1.00	2.35
100c-100d	300	0.19	84.00	129.01	2.00	1.00	1.91
100d-100e	300	0.15	84.00	128.53	2.25	1.00	1.91
100e-100f	300	0.23	84.00	128.03	1.82	1.00	2.47
100f-301b	300	0.31	84.00	127.49	1.57	0.88	2.51

For both scenarios the 'Max/Full Flow' ratio and 'Max/Full Depth' ratio are equal to 1 or above 1, indicating the lack of flow conveyance capacity and surcharge conditions exist in the pipe system. To improve flowing conditions a pipe diameter was increased to a 375 mm. By increasing the pipe size flowing conditions were improved for the simulation with peak flows calculated using the OSDG parameters. As shown in the **Table 8** below the 'Max/Full Flow' ratios are below 1, with critical pipe '100d-100e' having the ratio of 0.98. Flowing depths are also improved with the maximum value for 'Max/Full Depth' ratio of 0.75 for the pipe '100c-100d'.

Table 8: Summary of the Simulation Results – Build-Out Condition with 375 mm pipe size (Current OSDG Parameters)

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
101b-100a	375	0.26	50.00	127.77	0.56	0.59	3.78
100a-100c	375	0.251	62.00	127.71	0.71	0.69	3.91
100c-100d	375	0.19	67.00	127.64	0.87	0.75	3.28
100d-100e	375	0.151	67.00	127.54	0.98	0.72	2.90
100e-100f	375	0.23	67.00	127.4	0.79	0.70	3.10
100f-301b	375	0.31	67.00	127.26	0.68	0.61	2.74

Pipe size increases improved flow conditions for the sanitary peak flow option calculated using the traditional parameters. However, there are still some pipe sections with flowing conveyance capacity 'Max/Full Flow' ratio above 1. The results for this option are summarized in the **Table 9** below.

Table 9: Summary of the Simulation Results – Build-Out Condition with 375 mm pipe size (Traditional Parameters)

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
101b-100a	375	0.26	60.00	127.84	0.67	0.81	3.71
100a-100c	375	0.25	78.00	127.8	0.89	0.93	3.82
100c-100d	375	0.19	84.00	127.73	1.10	0.97	3.19
100d-100e	375	0.15	84.00	127.61	1.24	0.90	2.83
100e-100f	375	0.23	84.00	127.46	1.00	0.85	3.04
100f-301b	375	0.31	84.00	127.31	0.86	0.71	2.69

Flowing conveyance conditions for this scenario could be additionally improved if the following pipe sections are set to slope of 0.34%: '100c-100d', '100d-100e', '100e-100f' and '100f-301b'. The following **Table 10** provides summary of the improved flowing conditions.

Table 10: Summary of the Simulation Results – Build-Out Condition with 375 mm pipe size with improved slope conditions (Traditional Parameters)

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
101b-100a	375	0.26	60.00	127.8	0.67	0.68	3.75
100a-100c	375	0.25	78.00	127.74	0.89	0.71	3.88

Pipe Name	Diameter (mm)	Slope (%)	Max Flow (L/s)	Max HGL (m)	Max/Full Flow	Max/Full Depth	Freeboard (m)
100c-100d	375	0.34	85.00	127.63	0.82	0.69	3.29
100d-100e	375	0.34	84.00	127.41	0.82	0.69	3.03
100e-100f	375	0.34	84.00	127.19	0.82	0.76	3.31
100f-301b	375	0.34	84.00	127	0.82	0.77	3.00

Increasing the pipe slope of the critical sections would improve the flowing capacity and surcharge pipe conditions along the McNeely crossing sewer system under higher design criteria values. Therefore, to satisfy the build-out condition scenario for the sanitary sewer loading calculated using more conservative traditional design parameters, the sewer section along McNeely crossing should be upsized to a 375 mm pipe diameter and slope along four (4) sections of the pipe should be set at 0.34%.

4.0 DISCUSSION

The latest City of Ottawa design criteria for sanitary loading assessment has values that remain consistent with the MECP guidelines, both from 2008 and the latest Design Criteria for Sanitary Sewers, Storm Sewers and Forcemains for Alterations Authorized under Environmental Compliance Approval (MECP, 2022). It is therefore reasonable to use these loading values to assess the existing sewer network capacity.

Use of the latest City of Ottawa design criteria values shows that there is sufficient sewer capacity in the McNeely crossing to accommodate the proposed current level of development within the McIntosh Perry design sheets.

There is sufficient capacity using the latest City of Ottawa design criteria values for an additional flow of 1.1 L/s which is equivalent to 80 persons across 0.6 ha of residential development, accounting for residential flows and Infiltration.

Beyond development of approximately 80 persons, upgrading the pipe to a 375mm diameter is expected to provide sufficient capacity for the proposed ultimate build-out based on the latest City of Ottawa design criteria values. It is recommended that during the sanitary sewer upgrade the opportunity to refine the pipe grading to gain additional flow capacity is considered.

In addition, the Town should consider updating the master plan PCSWMM model to include the subject development area in the analysis. As part of the model update the Town could consider carrying out a flow monitoring program to determine dry weather flows and wet weather response within the system and use this data to calibrate the model. This will provide the Town an opportunity to have a fully dynamic sanitary sewer model that can be used in the analysis of any future development within the Town boundaries.

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