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Halifax Regional Municipality
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Attention: Helen Langille, M.Eng., P.Eng., ENV SP, Program Engineer, Engineering & Building Standards
CC: Shannon O'Connell, P.Eng., M.ASc., Senior Program Engineer, Engineering & Building Standards

RE: Sackville Rivers Floodplain Model Updates – Structure Investigation and Survey and Updated Mapping
DesignPoint Project #: 19-174

Introduction

The Sackville River system has had longstanding flooding issues dating back as far as the 1940s. Over the past four decades, several flood studies have been conducted, most recently a floodplain analysis completed by CBCL Limited (CBCL) in 2017 and a mitigation planning study completed by DesignPoint Engineering and Surveying Limited (DesignPoint) in 2020.

Figure 1: Bedford Place Mall, July 21, 2023

As a recent example of this flooding, on July 21 and 22, 2023 the Sackville River watershed area received an extreme rainfall event, in some areas exceeding 240 mm in less than 6 hours. As predicted by the previously mentioned studies, there was significant and severe flooding along the Sackville and Little Sackville Rivers.

DesignPoint was retained by Halifax Regional Municipality (HRM) to update the PCSWMM model used in the 2017 CBCL study and the 2020 DesignPoint study. This includes integrating new LiDAR data collected in 2019 into the analysis, as well as updating the Lucasville Road Bridge and Beaver Bank Cross Road Bridge, as these structures have been replaced/upsized from the 2017 model. The project's primary objectives are to provide HRM with an updated Sackville Rivers floodplain model and update the floodplain map "Map #9" from the 2017 CBCL study. "Map #9" in the 2017 CBCL study incorporates both future development and climate change considerations. Climate change impacts are accounted for using the Western University IDF-CC Tool – Upper Bound Result. Provided tables and maps are based on the vertical datum CGVD2013, as this is the current standard currently used in regulation, design, and construction.

Methodology

Topographic surveys were completed for the structures to be updated in the PCSWMM model, specifically the Lucasville Road Bridge and the Beaver Bank Cross Road Bridge. In the 2017 PCSWMM model, the geometry, inlet and outlet inverts, crossing length, entrance and exit loss coefficients, and Mannings friction coefficient were updated for each structure based on the topographic survey to reflect the current crossing conditions. The Lucasville Road bridge spans approximately 20.8 m with a rise of approximately 4.0 m and has a naturalized channel bottom. The Beaver Bank Cross Road bridge spans approximately 6.5 m and has a chamfered top, with a maximum rise of approximately 2.7 m. The Beaver Bank Cross Road Bridge has tapered wingwalls at the inlet and outlet, and a naturalized channel bottom.

The width of the Lucasville Road bridge was adjusted in the PCSWMM model to reflect the fact that the street/bridge crossing is skewed relative to the watercourse. With the structure skewed, there is less cross-sectional area available in the direction of flow compared to the full structure width/area, and therefore the model had to be updated accordingly. For the Lucasville Road crossing, there is a skew angle of approximately 39°, which resulted in a hydraulic structure width of 16.1 m.

The bridge overflows across street surfaces for each structure were also examined, comparing them to the 2019 LiDAR surface and topographic survey data. During this analysis, a significant change in overflow conditions was observed for both structures. As a result, the overflow parameters in the PCSWMM model were updated, specifically the overflow elevation and cross section (transect object in PCSWMM) used for the overflow crossing.

Additionally, new LiDAR data was acquired for the project area from the provincial LiDAR database, provided by the Government of Nova Scotia. The most recent provincial LiDAR available at the time of this analysis was collected in 2019. The 2019 LiDAR data was then used to create an updated existing grade surface which was utilized in this analysis.

The PCSWMM model was run with the Lucasville Road Bridge and Beaver Bank Cross Road Bridge crossings updated as per the completed topographic surveys. Peak water levels for the Sackville and Little Sackville Rivers based on the updated model results were then projected to the updated existing grade surface created using 2019 LiDAR data. The resulting horizontal floodplain limits formed the basis of the updated "Map #9", which shows approximate floodplain limits for the 1 in 20-year and 1 in 100-year rainfall events.

Results

Sackville River

As part of the assessment, the floodplain limits based on the updated PCSWMM model were compared with the flood lines depicted on the original "Map #9" in the 2017 CBCL study. The most significant differences in flood lines were observed adjacent to the updated structures, as expected, due to the change in hydraulic conditions at these crossings. At the Lucasville Road Bridge crossing, a decrease in headwater elevation was observed. The updated model results also showed an increase in water levels downstream of the crossing. In the 1 in 20-year scenario, water levels almost immediately downstream of the crossing were observed to have increased when compared to the 2017 model results. For the 1 in 100-year scenario, a decrease in tailwater elevation and subsequent downstream water levels was noted. Downstream of the crossing, decreased water levels were observed for a distance of approximately 5.2 km, at the end of which water elevations increased to levels slightly higher than those resulting from the 2017 model. Overall, there is less flooding upstream of the crossing, and a minor increase or decrease in downstream flood elevations depending on the scenario and location. The downstream changes are noted but are not significant.

As the Lucasville Road Bridge is just downstream of Webber Lake, the updated bridge crossing also affected peak water levels in Webber Lake. The updated model results showed water levels in Webber Lake to decrease by approximately 85 cm and 20 cm for the 1 in 20-year and 1 in 100-year scenarios, respectively. Upstream of Webber Lake, water levels in McCabe Lake were minimally affected by the model updates, with reductions of approximately 2 cm and 5 cm for the 1 in 20 Year and 1 in 100 Year scenarios, respectively.

As previously noted, changes in the Lucasville Road Bridge crossing resulted in slightly higher flood levels at certain points downstream of the crossing, depending on the scenario. For both the 1 in 20-year and 1 in 100-year scenarios, the increased water levels continued downstream and were observed to the outlet at the Bedford Basin.

Little Sackville River

The changes made to the Beaver Bank Cross Road Bridge were more substantial than those for the Lucasville Road Bridge. Notably, significant modifications were made to the crossing inverts, conduit slope, geometry, and loss coefficients (Manning's roughness, entrance and exit loss coefficients) as per the topographic survey results. When running the updated PCSWMM model, a decrease in headwater elevation was noted of approximately 54 cm for the 1 in 20-year scenario, and 3 cm for the 1 in 100-year scenario. The updated model results also showed a decrease in water levels downstream of the crossing. On average, water levels downstream of the Beaver Bank Cross Road Bridge were approximately 1 cm lower for the 1 in 20-year scenario and 13 cm lower for the 1 in 100-year scenario. Consequently, there is reduced flooding both upstream and downstream of the crossing due to changes in hydraulic conditions.

Similar to the Lucasville Road crossing, the downstream change is noted but is not significant. Additionally, the reduction in flood levels upstream of the crossing was not shown to impact water levels for any upstream in-line storage (Little Lake, Feely Lake, or the Barrett Pond), and the upstream change in flood levels was only observed from Beaver Bank Cross Road to the Millwood Drive crossing.

Generally, reduced flood levels were observed along the Little Sackville River from the downstream end of the Millwood Drive Crossing to approximately 1.7 km upstream of the confluence of the Sackville River and the Little Sackville River.

Flood Elevations

It is acknowledged that horizontal floodplain limits are wholly dependant on the existing grade surface that the flood levels are projected to. Consequently, any alterations to the existing grade – such as regrading a property adjacent to the watercourse – will likely impact these floodplain limits. To address this, a table has also been prepared that details the flood elevation at critical points along the Sackville Rivers based on results of the updated PCSWMM model. See the following:

Table 1: Flood Elevations at Key Points (vertical datum CGVD2013)

	Location	Water Level (20 Year)	Water Level (100 Year)
Sackville River Upstream of Confluence	McCabe Lake	76.81 m	77.47 m
	Webber Lake	74.73 m	76.02 m
	U/S of Lucasville Road Bridge	74.08 m	75.55 m
Little Sackville River Upstream of Confluence	Little Lake	75.25 m	75.38 m
	Feely Lake	68.71 m	68.77 m
	Barrett Pond	62.28 m	62.33 m
	U/S Millwood Drive Crossing	54.84 m	54.97 m
	U/S Beaver Bank Cross Road Crossing	52.28 m	53.00 m
	U/S Beaver Bank Road Crossing	50.65 m	50.78 m
	U/S Sackville Drive Crossing	40.09 m	40.26 m
	U/S Sackville Cross Road Crossing	28.96 m	29.22 m
Sackville River Downstream of Confluence	Sackville River/ Little Sackville River Confluence	13.79 m	14.32 m
	U/S Rifle Range Lane Crossing	9.23 m	9.96 m
	U/S Highway 102 Crossing	9.14 m	9.87 m
	U/S River Lane Crossing	8.61 m	9.20 m
	U/S Sunnyside Mall A	8.42 m	9.03 m
	U/S Sunnyside Mall B	8.32 m	8.95 m
	U/S Bedford Highway Crossing	6.88 m	7.44 m
	U/S Railway Crossing	3.70 m	4.40 m

When planning regulations are prepared using the flood lines, we recommend HRM also require that buildings be constructed above the listed flood elevations. It is also possible to allow buildings to be built inside the horizontal flood lines provided that they are built above the listed flood elevations and a hydraulic study is completed to demonstrate there are no adverse flooding effects upstream or downstream of the infill area.

Comparison Maps

Flood line comparison maps have also been prepared, which compare floodplain extents from the 2017 CBCL study to the updated model for both the 1 in 20 year and 1 in 100 year rainfall events as per Map 9. The floodplain extents labeled as “CBCL 2017” were derived from the results of the provided model and projected onto the 2015 LiDAR surface. For this reason, these extents may not precisely correspond to the lines depicted in the original Map 9 (CBCL 2017).

It is noted that despite increased flood elevations for the Sackville River downstream of the Lucasville Road bridge, the updated floodplain extents are still observed to be narrower than the floodplain extents based on the 2017 CBCL model projected to 2015 LiDAR. When the 2017 model results are projected onto the 2019 LiDAR surface, the floodplain extents are narrower than the updated model results, which aligns with expectations. Based on this, it is expected that the updated floodplain extents being narrower than the 2017 floodplain extents is due to the increase in level of detail with the 2019 LiDAR.

Closing

In summary, the provided PCSWMM model was updated, and model results were then used to create an updated "Map #9" as per the 2017 CBCL study. Updates to the PCSWMM model consisted of updates to the Lucasville Road and Beaver Bank Cross Road crossings, including updates to the conduit crossing and bridge overflows. A table has been enclosed expanding on Table 1 of this document and includes flood elevations from both the 2017 CBCL PCSWMM model and the updated PCSWMM model.

Furthermore, supplementary documents have been provided for review. These include flood line comparison maps, which compare floodplain extents from the 2017 CBCL study to the updated model for both the 1 in 20 year and 1 in 100 year rainfall events as per Map 9. A profile comparison of flood levels in key areas has also been enclosed for informational purposes.

Thank you,
DesignPoint Engineering & Surveying Ltd.

Glenn Woodford, P.Eng.
Senior Civil Engineer & Principal

Enclosures:

a. Flood Line Delineation Map, Map 9
b. Flood Line Comparison Map – 1 in 20 Year
c. Flood Line Comparison Map – 1 in 100 Year
d. Profile Comparison of Flood Levels
e. Flood Elevations at Key Points – Comparison Table