APPENDIX H

FLUVIAL GEOMORPHOLOGY TECHNICAL REPORT

Technical Report: Fluvial Geomorphology

PARISH geomorphic

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Subject: **Lakeview Waterfront Connection EA – Technical Report: Fluvial Geomorphology**

Memorandum

1. Introduction

project description provided by SENES

Project Study Area

The LWC study area contains two creeks, Applewood and Serson (**Figure 1**). These creeks have small, urbanized drainage basins extending to south of the Queen Elizabeth Way and form part of CVC's Lake Ontario East Shoreline Subwatershed. The lower reaches of the creeks flow south easterly between Lakeshore Road and Lake Ontario. As part of the LWC project, both creeks will be modified in some capacity (to be determined) at the downstream end to integrate the creeks into the waterfront design while maintaining their natural integrity. In order to successfully develop this plan for Serson Creek, all baseflows and the majority of storm flow events will need to be re-routed down the existing high flow channel. Storm flows exceeding the 2-year event will spill over a berm and flow through the culvert under the G.E. Booth WWTF and down the existing high flow channel. Flows for Applewood Creek will continue to be conveyed through the existing channel. These plans require a technical assessment to describe current characteristics and function of the creeks.

Figure 1: Map showing creeks within the LWC study area.

Objectives

The aim of the Fluvial Geomorphic Assessment is to characterize the existing function of the channels within the study area, thereby developing an understanding which will inform the evaluation of the LWC design alternatives. The assessment will also provide the information necessary for the natural channel designs within the proposed waterfront area. The fluvial geomorphic assessment includes the following components:

1. Review of relevant background information
2. Delineation of channel reaches within the study area
3. Field reconnaissance of the watercourses within the subject property
4. Determination of erosion thresholds (critical discharges) for each creek.

2. Baseline Environmental Conditions

Serson and Applewood Creek are located in an urbanized watershed with large areas of impervious surfaces, meaning that the creeks respond more rapidly than normal to rainfall events (CVC &TRCA, 2012). The area downstream of Lakeshore Road is generally considered to be a depositional zone due to a combination of backwater effects from Lake Ontario and shallow channel gradients. Sediment accumulations that are deposited may be removed under erosive flow conditions when lake levels are low (CVC & TRCA, 2012). As these are both urbanized stream systems they have a low sediment supply from the surrounding land surface. The existing supply is sourced primarily from the channel bed and banks and a few tributary inputs. Applewood Creek has a coarse substrate of gravels and cobbles that are moved under high flows, but delivery to Lake Ontario is rather low as they are reworked and re-deposited amongst existing bar forms throughout. Accompanied by the backwatering effect of the Lake that occurs

100-150m upstream of the current outlet, the reduction in flow velocity creates a depositional environment within the channel and on the floodplain along the east side of this 150m section. Serson Creek is comprised of mainly finer material (silts, sands and fine gravel), which are mobilized regularly. But the existing channel configuration upstream of the WWTF and low gradient have created a depositional area upstream for over 200m, noted by siltation on the bed.

Background Information

Serson Creek

Serson Creek drains a small watershed draining 270ha (CVC & TRCA, 2012). Baseflows from Serson Creek currently travel through a wooded, open channel north of the G.E. Booth Waste Water Treatment Facility (WWTF), before being diverted underneath the plant through a culvert to Lake Ontario. During storm events, flood flows are split between the culvert and a straight, flood conveyance channel located between the G.E. Booth WWTF and the OPG Lands. The current flow splitting conditions impairs ecological functions within the westerly flood conveyance channel, prevents fish migration from the lake to the watershed, and impairs the ability to establish a functioning coastal wetland at its mouth (CVC & TRCA, 2012). Field walks undertaken in 2011, confirmed interaction between Serson Creek and the shoreline to be minimal (Aquafor Beech, 2011a).

An erosion assessment has already been undertaken for the flood conveyance channel of Serson Creek to the west of the G.E. Booth WWTF (AECOM, 2008). The historic assessment noted that Serson Creek has been modified since at least 1954 (the earliest aerial photographs available). Since this time, the channel has been realigned, with the culvert beneath the WWTF and flood conveyance channel being constructed between 1964 and 1970. Field survey of the flood conveyance channel was undertaken and a detailed description of the channel is contained in the original report (AECOM, 2008). Much of the channel is protected on the banks and bed with cobble riprap, of which the majority appears stable. Based on field observations, an erosion rate of 0.05m/yr was estimated and it was concluded that regular monitoring, combined with localized bank restoration if necessary, was an appropriate method of managing future erosion risk along this channel (AECOM, 2008).

Upstream of the flood conveyance channel, a flood berm was constructed in 2009 while, at the same time, the former rail line and bridge / culvert located at the head of the flood conveyance channel was removed. Based on erosion monitoring between 2008 and 2010, it has been concluded that no downstream geomorphic impacts have resulted from the works and that the restored section is functioning as a riparian floodplain area (AECOM, 2010).

Rapid Geomorphological Assessment (RGA) and Rapid Stream Assessment Technique (RSAT) surveys were undertaken along the main channel of Serson Creek in 2011 as part of the Lake Ontario Integrated Shoreline Strategy (LOISS) (Aquafor Beech, 2011a). Three reaches were defined, including two within the Project Study Area - the culverted section under the WWTF (Reach 1) and the open section between Lakeshore Road and the culvert (Reach 2) (Aquafor Beech, 2011b). Field survey of Reach 2 was also undertaken in 2011 to support a scour assessment at Lakeshore Road. The findings of both surveys indicate that aggradation is the dominant geomorphological process along this realigned section, with low scour risk at the crossing. However, there is also evidence that meanders are beginning to develop where the channel is actively adjusting and bank slumping is occurring. Although the channel currently remains in poor condition in terms of stream health, there is evidently a good opportunity to rehabilitate the creek as part of the Lakeview Waterfront Connection initiative.

Applewood Creek

Applewood Creek has a moderately larger drainage area than Serson Creek at 411ha (CVC & TRCA, 2012) and is less modified, maintaining a natural open channel throughout the lower reaches of the watershed. During field walks undertaken in 2011 the channel was observed to be wider at its downstream extent, with lower velocities and backwater conditions for a distance of 150m upstream of Lake Ontario (Aquafor Beech, 2011a).

A geomorphological assessment has already been undertaken for the downstream 472m of Applewood Creek in the vicinity of the G.E. Booth WWTF (Parish Geomorphic, 2005). The creek was noted as flowing within a well-defined valley with an irregular meander pattern as the meanders are partially confined by the valley wall adjacent to the WWTF. Average migration rates were calculated, based on historical aerial photography, to be 0.12m/yr with an average downstream migration of 16m/yr (Parish Geomorphic, 2005). These are moderate rates and reflect meander development. RGA and RSAT surveys were also undertaken and indicated that the channel was adjusting through widening and aggradation. Urban debris was noted to be causing debris jams in the creek.

As for Serson Creek, field surveys were also undertaken at Applewood Creek to inform a scour assessment at Lakeshore Road (Parish Geomorphic, 2011). It was noted that the watercourse upstream of Lakeshore Road is heavily modified with bed protection, aggraded material and some sections of exposed bedrock. The banks are lined with armourstone with gabion protection towards the toe and top of bank. Downstream of Lakeshore Road, however, the channel banks consist of exposed bedrock. This is due to deepening of the channel during the installation of the sanitary trunk sewer at the site in the 1960s. Further RGA and RSAT surveys were undertaken further downstream in the Project Study Area as part of the more recent LOISS study (Aquafor Beech, 2011a). The results indicate that, although the lower 150m of the creek is backwatered, the channel is actively adjusting further upstream. Comparing the 2005 and 2011 survey results, it appears that the downstream section has deteriorated and become more unstable over recent years. Urban debris was noted as an ongoing issue causing debris jams within the creek throughout the sections surveyed (Aquafor Beech, 2011b). It is evident that Applewood Creek is in active adjustment downstream of Lakeshore Road and geomorphological processes will need to be carefully addressed within any restoration plans for the creek.

Rapid Assessments and Detailed Survey

Rapid assessments and detailed surveys were done on each of the creeks in September, 2012. Two established reconnaissance techniques were used, the Rapid Geomorphic Assessment (RGA) and the Rapid Stream Assessment Technique (RSAT). The results confirm that Applewood Creek is in active adjustment with aggradation and widening as the main modes of adjustment (**Table 1**). Debris jams were common throughout the reach consisting of woody/urban materials. The jams resulted in localized backwatering, upstream aggradation and downstream scour pools. Large lateral bars consisting of sands or small gravel and pebbles were seen at the downstream end in the lake backwater zone. Point and lateral bars were found throughout the Applewood and showed evidence of recent formation/reworking. Clay bedrock was exposed along the bed and lower banks throughout the downstream end. The clay was soft and resulted in small local pools where it had been easily eroded in bends along the bank. In the upstream, shale bedrock was exposed in the bed and the entire bank in some sections. Shale fragments were a significant portion of the bed substrate in the upstream portion. Planform adjustments were identified as cut-off channels and high flow chutes.

The upstream reach of Serson Creek (SC-1) was classified as Transitional based on significant evidence of aggradation. This included siltation in pools, accretion on point bars, poor longitudinal sorting, and overbank deposition. The channel was confined on both banks throughout the reach resulting in consistent channel dimensions. Urban debris was prevalent, including bricks and large pieces of concrete. Substrate consisted of fine to coarse sands with some pebbles and small cobbles. The RSAT results indicated Reach SC-1 is in Moderate condition. The lowest scores were for in-stream habitat, water quality, and biological indicators. These scores can be attributed to the large amount of urban debris and lack of geomorphic features. Reach SC-2 which is the constructed flood conveyance channel, is classified as In Regime. The flood conveyance channel is heavily overgrown because it lacks regular discharge allowing vegetation to establish within the boundaries. It is mostly dry with only a small amount of water from overland runoff coming in off the banks. The channel is confined by large berms and exhibits very little natural characteristics. The conveyance channel received a RSAT score of Low, as the channel lacks any opportunities to develop characteristics of a natural channel which would support aquatic ecology.

Table 1: RGA results

Reach	Factor Value				Stability Index	Condition
	Aggradation	Degradation	Widening	Planimetric Adjustment		
AC-1	**0.71**	0.60	**0.70**	0.43	0.61	In Adjustment
SC-1	**0.71**	0.25	0.50	0.00	0.37	Transitional
SC-2	0.14	0.00	0.30	0.00	0.11	In Regime

Table 2: RSAT results

Reach	Factor Value						Overall Score	Condition
	Channel stability	Scour / deposition	Instream Habitat	Water Quality	Riparian Condition	Biological Indicators		
Max. Score	11	8	8	8	7	8	50	
AC-1	2	3	6	5	3	5	24	Moderate
SC-1	5	5	2	2	4	2	20	Moderate
SC-2	2	2	2	0	3	3	12	Low

Detailed field assessments (e.g., cross-section surveys and bed sediment data) were done in the upstream reaches of both creeks. As part of the detailed field assessment, standard protocols and known field indicators were used to quantify bankfull cross-sectional dimensions (e.g. bankfull depth and width). Five cross sections were completed for each of the two sites, the average bankfull dimensions for these cross sections are found in **Table 3**. As Applewood Creek has a larger drainage area than Serson Creek, its bankfull width was substantially larger as well. Bankfull widths fell between 12.00m and 5.83m in Applewood and between 3.10m and 2.40m in Serson. Bankfull depths were comparable for both creeks at 0.50m. The resultant average cross-sectional areas were 4.23m^2 for Applewood, and 1.35m^2 for Serson.

Table 3: Average bankfull geometry for detailed sites

Reach Name:	AC-1	SC-1
Bankfull Width (m)	8.32	2.72
Average Bankfull Depth (m)	0.50	0.50
Maximum Bankfull Depth (m)	0.74	0.71
Bankfull Width:Depth	16.77	5.60
Cross-sectional Area (m^2)	4.23	1.35
Wetted Perimeter (m)	8.80	3.35
Hydraulic Radius (m)	0.48	0.40
Left Bank Angle (°)	27.78	46.95
Right Bank Angle (°)	27.77	43.58
Left Bank Height (m)	0.63	0.56
Right Bank Height (m)	0.65	0.57

Bankfull channel dimensions form as a response to the prevailing flow regime. Channel gradient and bankfull dimensions can be used to determine bankfull discharge as well as other flow characteristics by applying standard open-channel hydraulics. The average values for the hydraulic calculations for each site are contained in **Table 4**. Bankfull discharge for Applewood was between 5.23m^3/s and 9.10m^3/s with an average of 6.59m^3/s. The bankfull discharge for Serson was between 1.13m^3/s and 1.83m^3/s with an average of 1.40m^3/s. The accompanying average velocities were 1.31m/s (AC-1) and 0.87m/s (SC-1) resulting in average shear stresses of 28.06N/m^2 (AC-1) and 11.83N/m^2 (SC-1).

Table 4: Average bankfull hydraulics for detailed sites.

Reach Name:	AC-1	SC-1
Bankfull Discharge (m^3/s)	6.59	1.40
Average Bankfull Velocity (m/s)	1.31	0.87
Maximum Bankfull Velocity (m/s)	1.85	1.25
Average Shear Velocity [u*] (m/s)	0.17	0.11
Stream Power (W/m)	388.14	41.30
Average Shear Stress (N/m^2)	28.06	11.83
Maximum Shear Stress (N/m^2)	42.25	20.52
Left Bank Shear Stress (N/m^2)	19.46	7.64
Right Bank Shear Stress (N/m^2)	19.74	7.34
Critical Particle Diameter for Analysis (m)	0.03	0.01

Erosion Thresholds
An erosion threshold analysis was undertaken for AC-1 and SC-1 based on measured cross sections and consideration of the median bed substrate size (D_{50}), as well as bank materials. Four cross sections were used for the analysis as one cross section for each reach was discarded due to error. Results of the erosion threshold analyses are presented in **Table 5**. The results indicate that transport occurs quite readily in the two channels due to the small size of the material resulting in a low critical discharge. In AC-1 transport occurs at 1.88m^3/s, 28% of the bankfull flow, while in SC-1 transport occurs at 0.10m^3/s, 8% of the bankfull flow.

Table 5: Bankfull channel characteristics and erosion thresholds.

Parameter	AC-1	SC-1
Bankfull Geometry		
Average Bankfull Width (m)	8.32	7.01
Average Bankfull Depth (m)	0.50	0.45
Bankfull Gradient (%)	0.60	0.30
Bank and Bed Material		
Bed Material D_{50} (mm)	27.27	57.19
Bed Material D_{84} (mm)	70.43	139.19
Bankfull Hydraulics		
Manning's n (estimate)	0.035	0.035
Average Bankfull Velocity (m/s)	1.31	0.87
Average Bankfull Discharge (m^3/s)	6.59	3.33
Thresholds		
Method of analysis	Bed threshold Komar (2001)	Bed threshold Fischenich (2001)
Critical particle size (mm)	28.62	5.45
Critical Discharge (m^3/s)	1.88	0.10
Critical: Bankfull Discharge (%)	28%	8%
No of cross-sections analyzed	4	4

3. Development of Alternatives

Conceptual design alternatives were developed for various configurations of the proposed waterfront area. The alternatives were evaluated to determine which configuration would be best suited to the current characteristics of the creeks and facilitate the implementation of functioning natural channel designs throughout the waterfront area. The Island Beach E alternative (**Figure 2**) was chosen as the preferred. A detailed conceptual design was then developed for both of the creeks to be incorporated into the Alternative selection process.

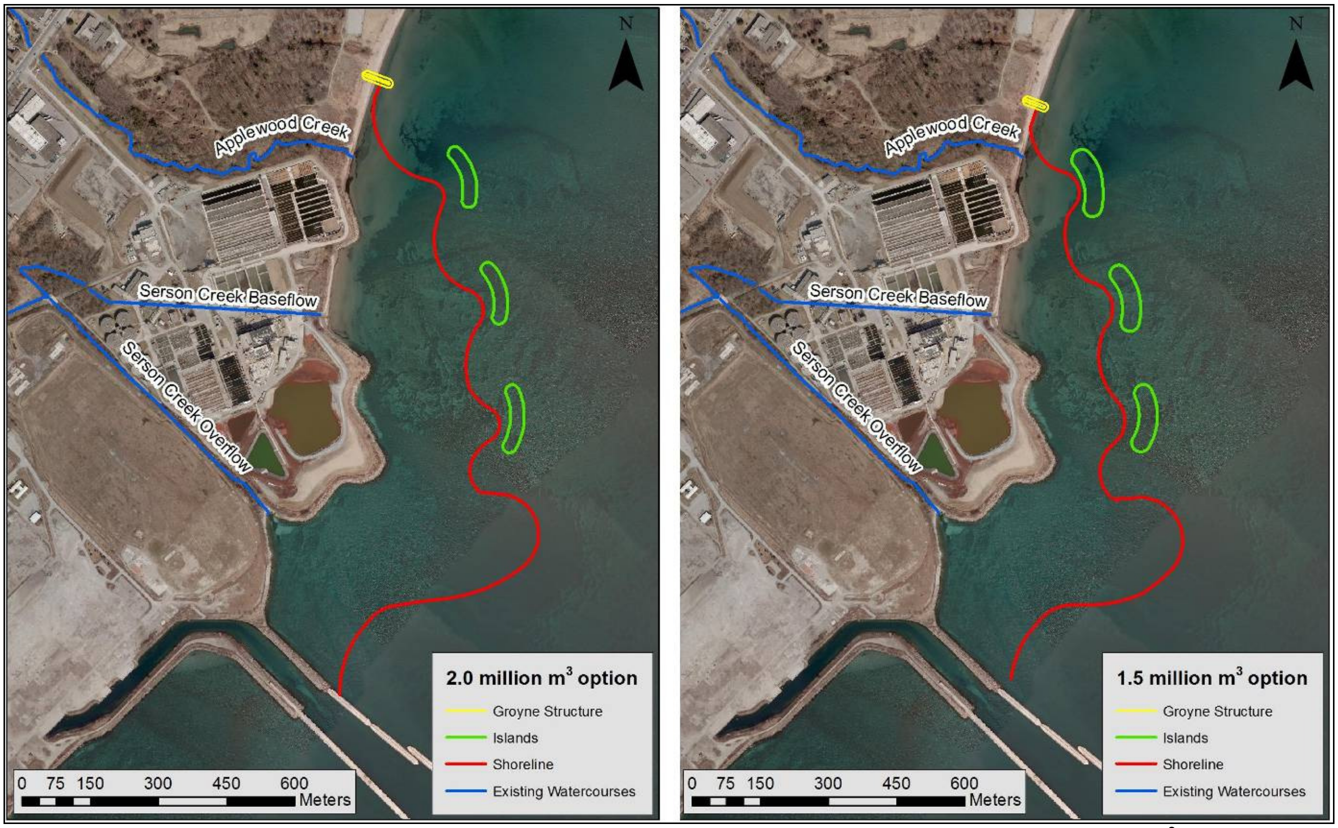

Figure 2: Preferred Alternative with existing watercourses—showing the original 2.0 million m^3 and the revised 1.5 million m^3 options.

Design Constraints and Considerations

The main goal in designing the two channels was to adequately convey the 2-year flood to the Lake and provide additional capacity for the 5-year flood. The primary constraint in satisfying this goal was maintaining gradient through the channel designs. This was problematic because both creeks were relatively low gradient (0.60% and 0.30%) and extending them 200-300m downstream would further reduce the gradient. Another consideration was accounting for variations in the lake surface elevation and ensuring that the creek would function at both high and low levels. A third principle was to ensure that this project does not increase flood risk at the regulatory event for existing and future development.

Planform and Long Profile

The planform configurations were designed to be relatively straight with slight sinuosity to preserve channel gradient throughout the length of the design (**Figure 3**). The smooth, gentle bends were also designed to avoid debris and ice-jams that may potentially occur within backwater zones near the lake.

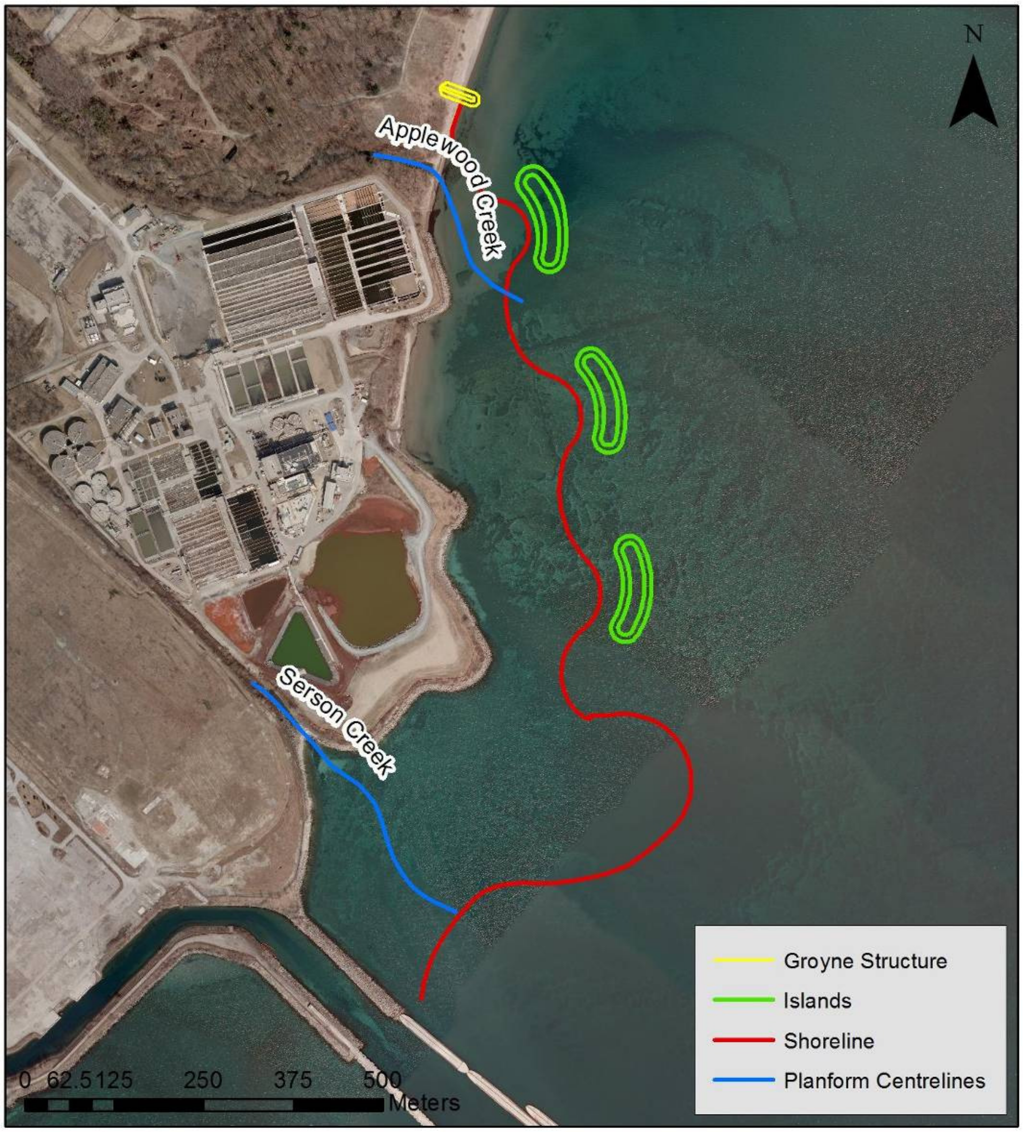

Figure 3: Preferred alternative with design planform centrelines (1.5 million m^3 option).

Lengthening these streams towards Lake Ontario can severely reduce the gradient, therefore a suitable elevation had to be located upstream from the existing outlets that would provide enough slope to ensure flow conveyance. On both creeks this resulted in the bed elevation being raised by approximately 30cm at the existing outlets. The effects of raising the bed elevation upon the regulatory flood are discussed in the following section.

The profiles were specially designed to deal with the lake level fluctuations by inserting a slope break at the downstream end. This divides the profile into two segments (referred to as upper and lower segments). The bankfull elevation of the *upper segment* is tied into the high lake level elevation of 75.2m a.s.l. This was done to contain the design discharge within the channel during high lake levels when backwatering is prominent, and HEC-RAS modeling was used to look at the capacity of the channel as it ties into this lake level, and effects of increasing lake level upon the design cross-section. This results in slopes of 0.38% (Applewood) and 0.48% (Serson) for the upper segments (**Figure 4 and 5**). The *lower segment* is designed to convey flow to the lake during low lake levels tying in at 73.75m a.s.l. The length of the segments is 35m resulting in slopes of 1.0% (Applewood) and 1.8% (Serson). Total lengths of the entire design including both the upper and lower segments are 315m (Applewood) and 440m (Serson).

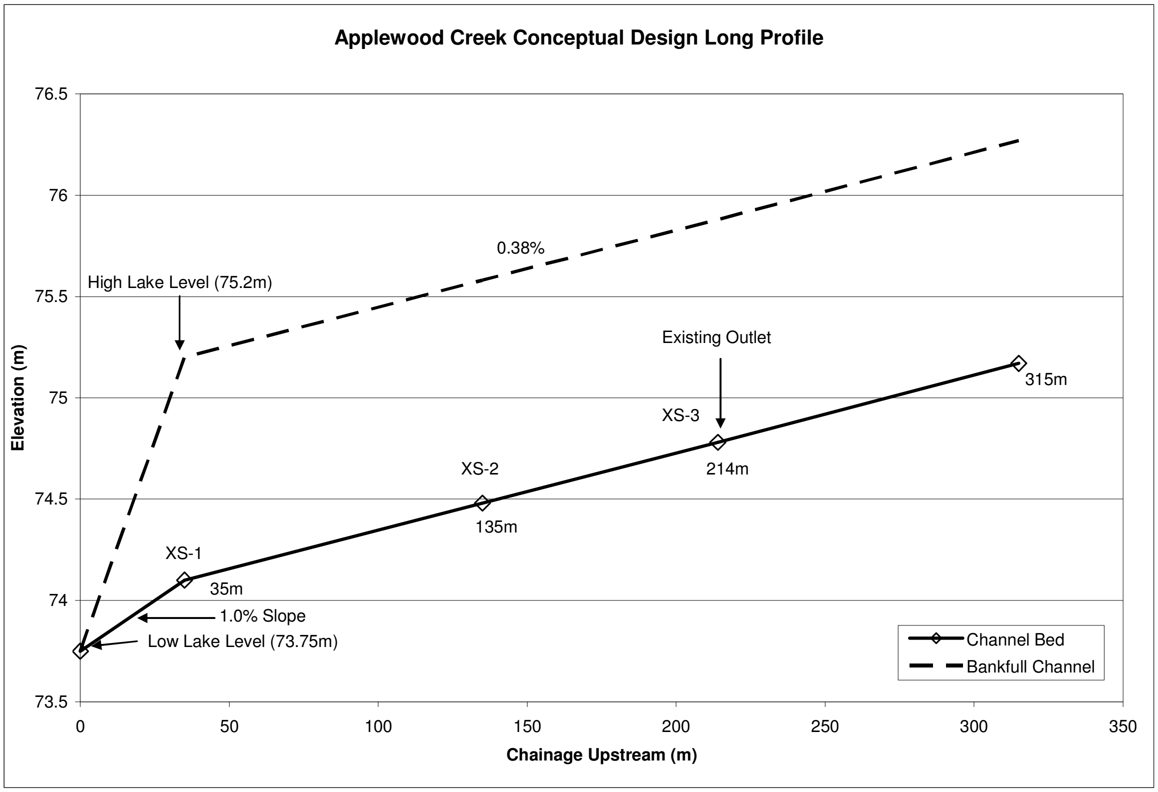

Figure 4: Applewood Creek conceptual design long profile

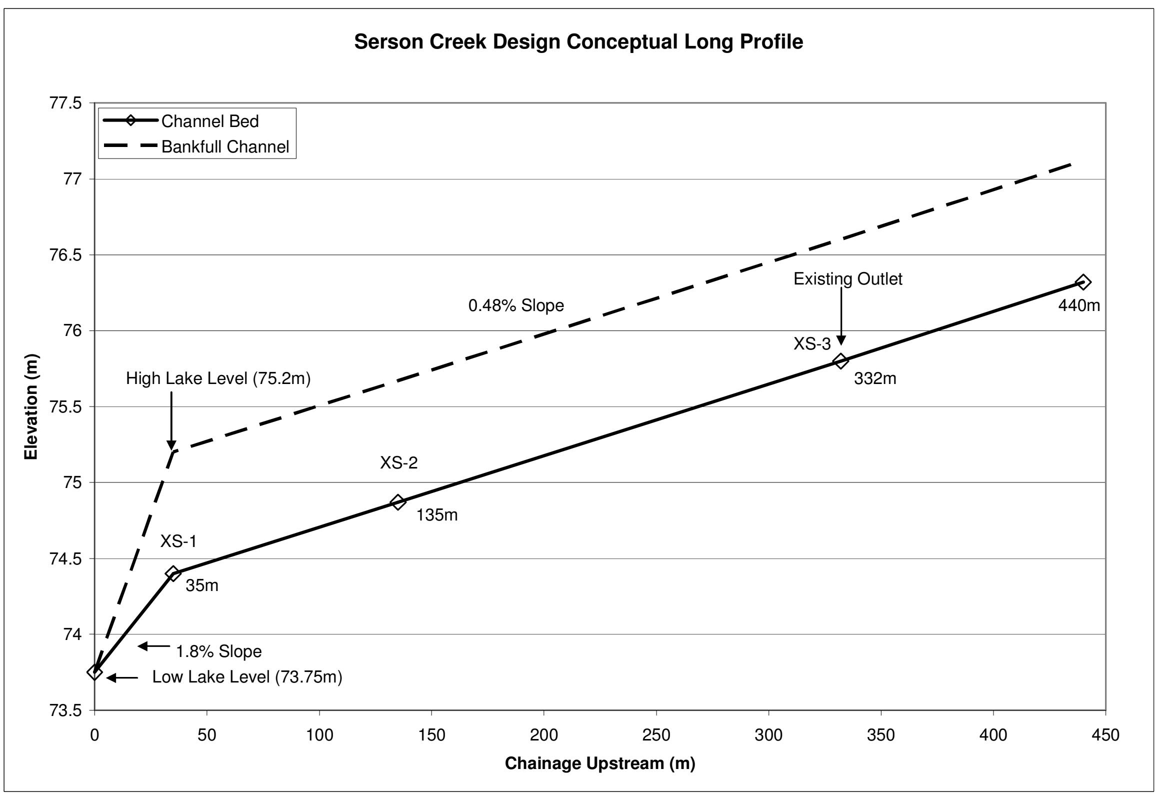

Figure 5: Serson Creek conceptual long profile

Cross Sections

Three conceptual cross sections were designed for each creek using the energy gradient and the 2-year flood discharges from HEC-RAS (**Figure 6 and 7**). The design discharge for Applewood was 9.6m^3/s and for Serson it was 4.10m^3/s. The cross section dimensions were then modeled in HEC-RAS to determine berm elevations which will contain the 5-year flood. This cross section (XS-2) was placed 100m upstream of the bottom of the *upper segment* to be representative of a section within the wetland area of the waterfront design (**Figure 8 and 9**). The other two cross sections, located at the upstream end of the design (XS-1) and the downstream end of the *upper segment* (XS-3), consist of the same dimensions as XS-2. They were placed in different locations to determine the berm elevations throughout the designs. This procedure was used for both creeks.

Downstream of XS-1 in the *lower segment* the channels fan out 20m, and the top of bank and channel bed elevations pinch out at the monthly low lake level (**Figure 10 and 11**). It is expected that in this section, all flows will spill out as the banks taper. This was done to compensate for the steep gradient in this section.

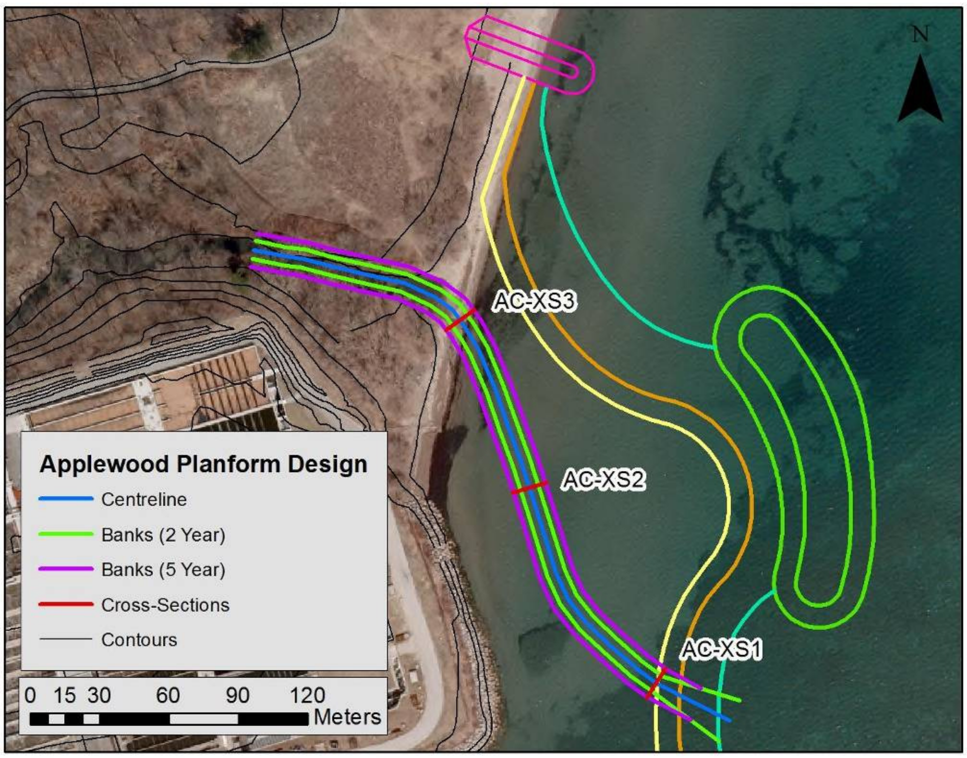

Figure 6: Applewood Creek Planform with design cross-section locations.

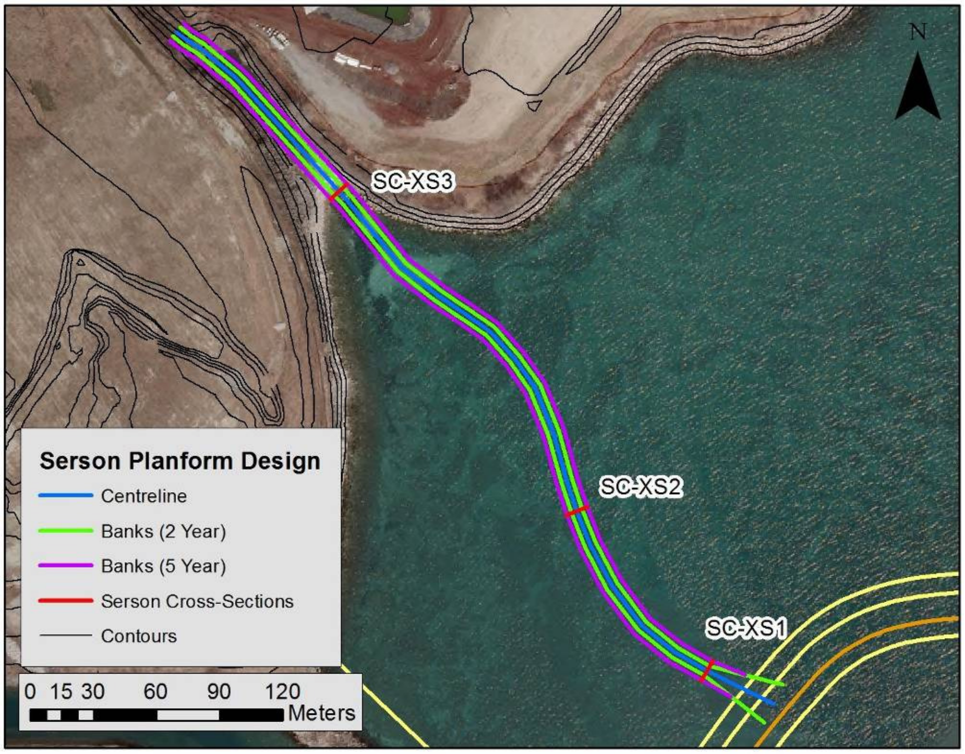

Figure 7: Serson Creek Planform with design cross-section locations.

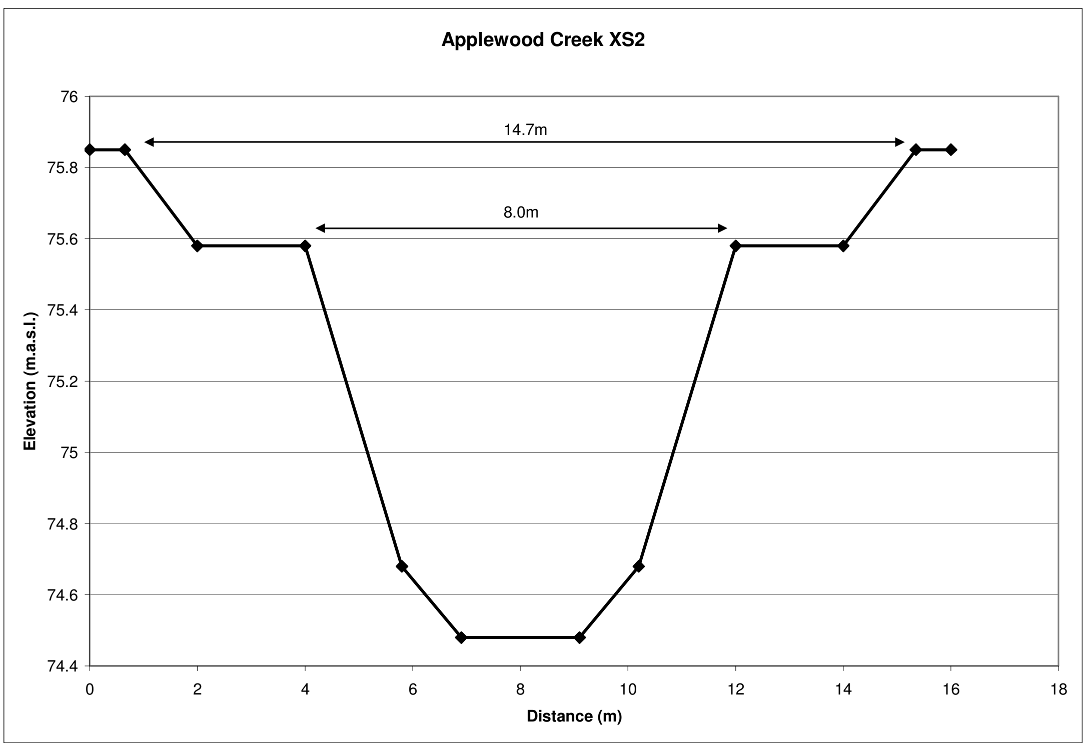

Figure 8: Applewood Creek XS2 (Total section width 16m).

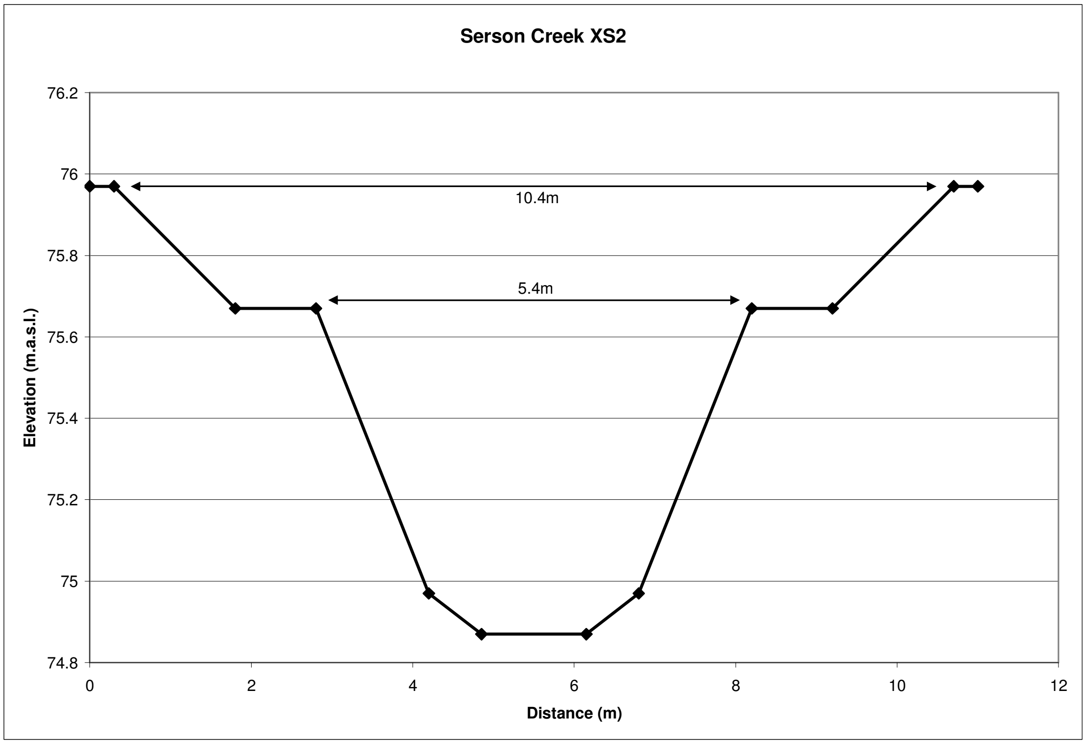

Figure 10: Serson Creek XS2 (total section width 11m).

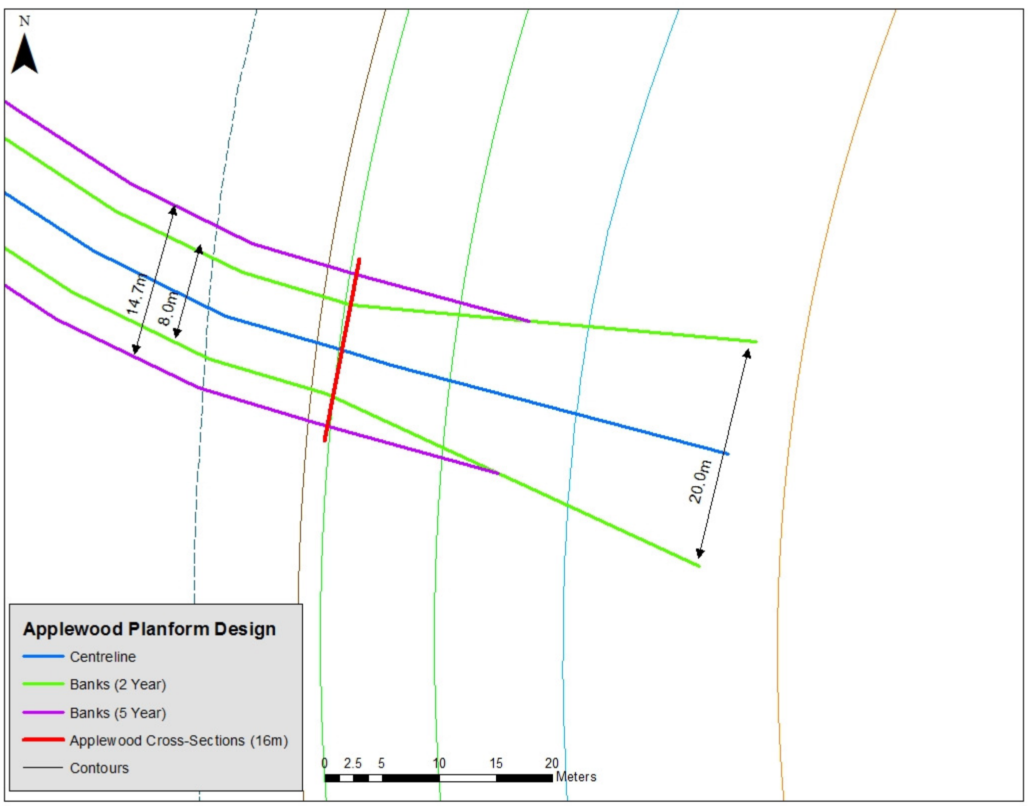

Figure 11: Applewood Creek Planform – Fan Section with top of bank widths.

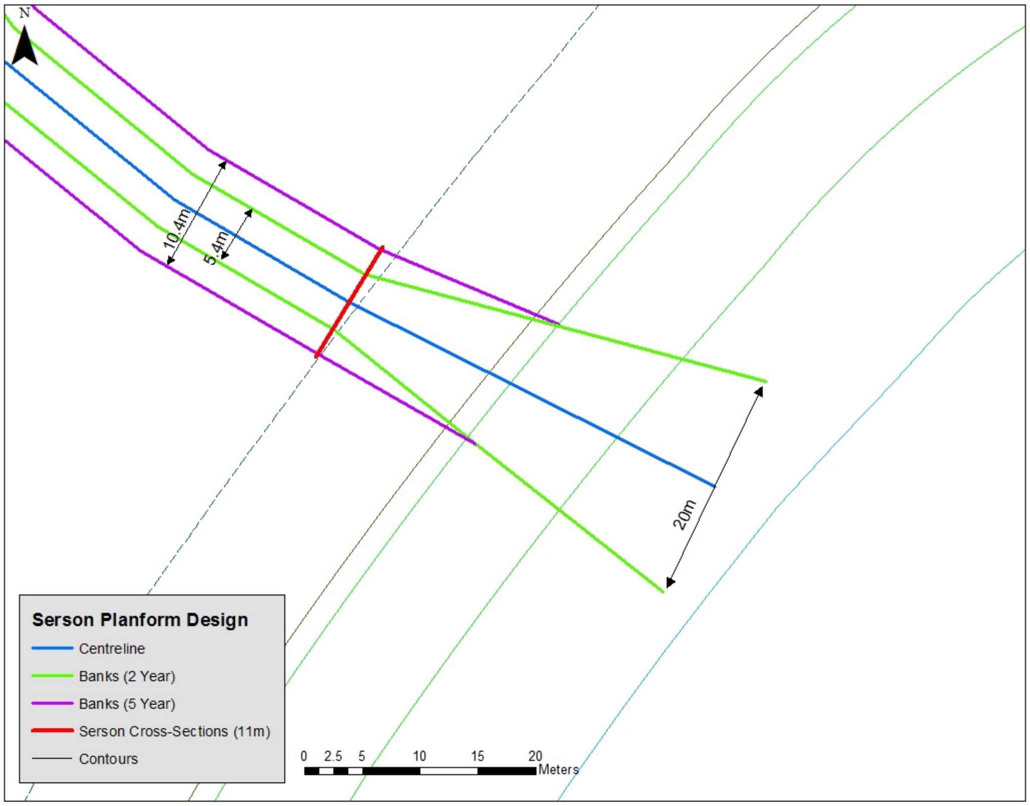

Figure 12: Serson Creek Planform – Fan Section with top of bank widths.

Flood Modeling

Each channel invert was raised by approximately 30cm at the existing outlets, and the design cross-section was constructed from the upstream tie-in down throughout the design length (i.e. there are both changes in profile and cross-section in existing portions of the channel). Such changes require that flood risk be assessed in regards to the regulatory event which is the regional storm, and this was completed using a high lake level of 75.4m a.s.l. Floodlines do not change at the tie-in point or upstream on Serson Creek. The existing profile has a steep drop downstream of the tie-in elevation where the channel elevation falls 0.72m over 35m, and is then relatively flat towards the lake. Therefore, extending the gentler slope upstream of the tie-in through our design has resulted in no adjustment of floodline elevations for the regional flood. Applewood Creek, however, shows a response to the design in the regional flood. At the cross-section where the design ties into the existing channel, this flood elevation increases locally by 0.38m, and is located 693m downstream from Lakeshore Rd (**Figure 13**). Here, the flood width increases by 8.94m, primarily into parklands, and does not affect the WWTF. Assumptions were made regarding the grading of the floodplain and wetlands in the design to reflect the current landscape plan.

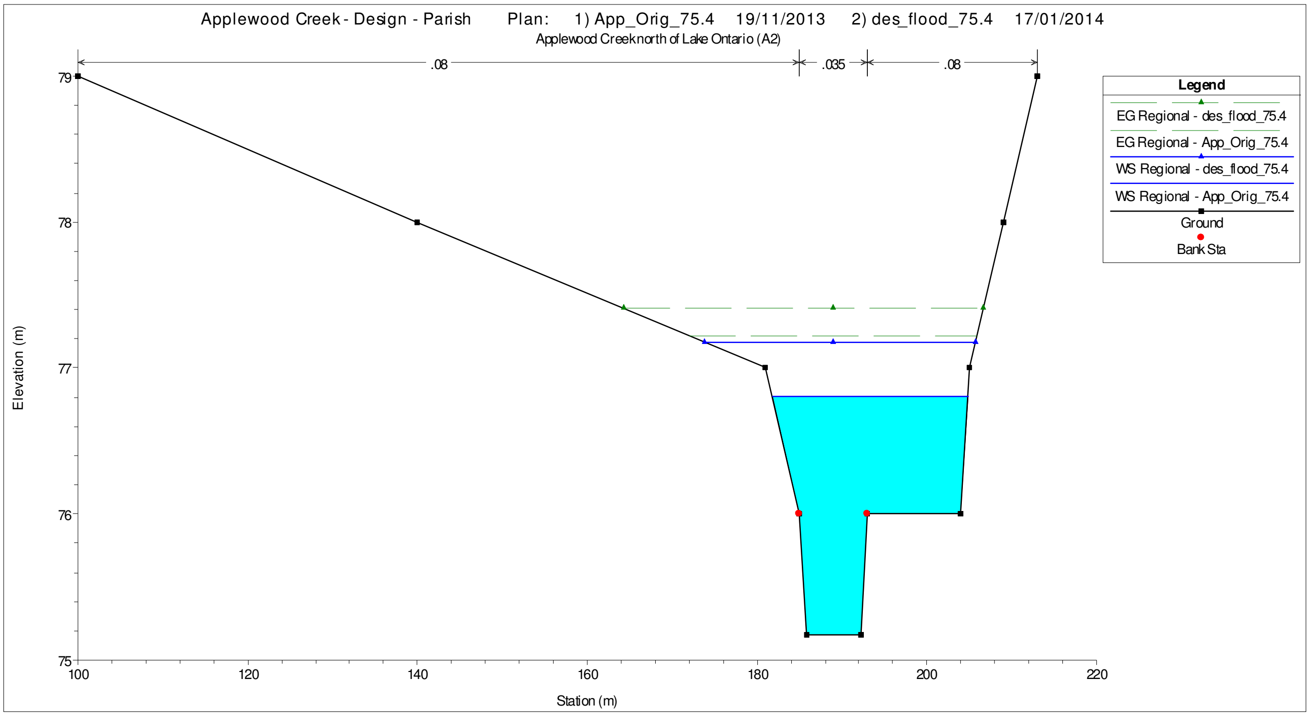

Figure 13: Regional flood changes at tie-in point 693m downstream of Lakeshore Road. View is downstream, with parklands along the left and the WWTF on the right.

The impact on flooding from the design attenuates progressing upstream towards Lakeshore Road, and no changes are evident at a station located 200m downstream of the culvert. At 285m downstream of the culvert, the elevation increase is only 0.02m. The largest adjustment is localized the tie-in, and elsewhere where flood elevations increase, they are of a lesser magnitude and appear to remain confined within natural areas, and do not inundate the WWTF. Therefore, from a risk perspective to existing and future development, the increase in flood elevation and extent is primarily within naturalized areas, and well downstream of Lakeshore Road. Downstream of the existing outlet, in the design, it is expected that wetlands will become inundated.

Serson Creek – Flow re-routing and High-flow in-channel structure

In order to ensure that all flows reach Lake Ontario along the Serson Creek overflow channel, the current planform will need to be re-routed/graded away from the existing outlet. At the upstream end of the overflow channel, a flow diversion currently exists where low flows are directed into a culvert under the G.E. Booth Facility, and high flows (greater than bankfull) can to top the banks where they are diverted down the high flow channel that borders OPG and Region of Peel land.

To re-route the channel down the overflow channel, a small berm will need to be constructed across the current low flow channel with a suitable elevation to direct most flows down the high flow channel, and allow for a portion of high flows to flow through the culvert under the WWTF as well as conveying water from a small tributary downstream of the diversion. The planform will need to be gradually routed into the over flow channel, with a less abrupt meander bend geometry as currently exists (**Figure 14**). This channel construction will require some material to be removed along the north and east portions of the creek, for which banks will need to be regraded (2:1 or 3:1) and stabilized by vegetation or rip rap, or a combination of hard and bio-engineered banks. **Figure 14** provides the extent of the proposed re-routing of Serson Creek, with the proposed creek location, berm, and bank construction. The constructed bank will tie into existing top of bank locations upstream and downstream, but will dip to the same elevation of the berm to allow for overflow.

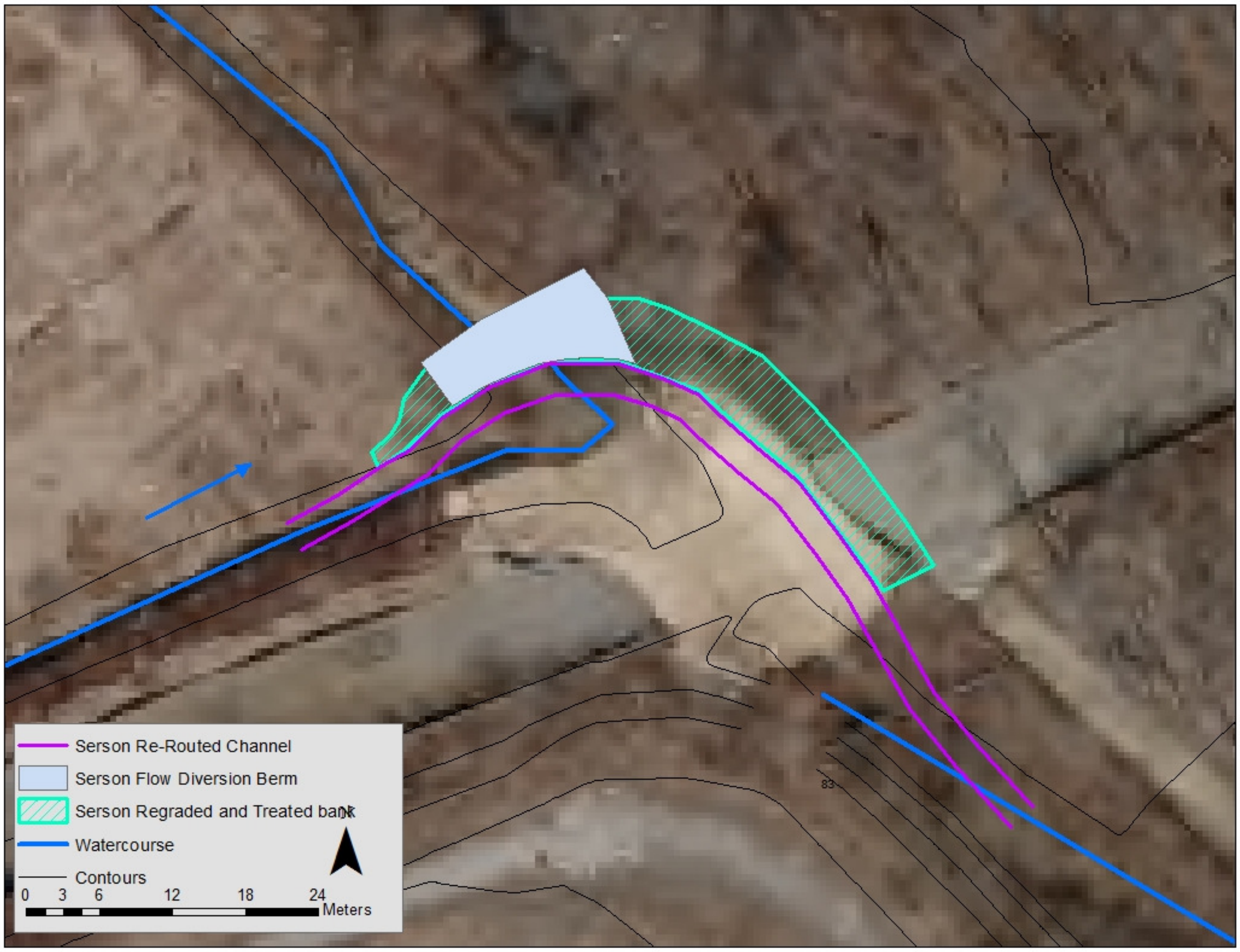

Figure 14: Channel alignment and treatments to re-route Serson Creek flows down the overflow channel.

Within this high-flow channel (downstream of the diversion), it is desirable to enhance aquatic habitat by adding bed structure. Natural channel designs typically develop a pool-riffle sequence to achieve goals of enhancing habitat, and creating more balance in the system by developing locations of high energy (riffle) and low energy (pool), while maintaining a dynamic stability in the plan and profile channel configurations. The high-flow channel for Serson Creek is straight and laterally confined. A channel corridor like this can become prone to incision and head cutting, but also areas of localized bank scour as the channel tries to meander or widen. To address concerns of aquatic habitat, fish passage, and erosion, straight channels can be designed to include structures across the bed (e.g. weirs, steps) that create heterogeneity in the energy profile along the system, controlling the erosive processes, and effectively maintaining the channel form. The high-flow channel has been designed to convey flows over the 2-year event to Lake Ontario, without flooding adjacent lands (OPG and WWTF). At present, the majority of this channel is close to capacity at the Regional flood event, with the greatest capacity occurring closest to the existing outlet into Lake Ontario. Some cross-sections in the existing CVC model (with the proposed extension into the lake) have very small differences between the Regional water surface elevation and the WWTF (7-20cm), therefore backwatering from additional structure might create flooding in some sections. At 325m, 95m, and 35m upstream of the existing outlet, these differences range from 99cm to 161cm, so some structure additions are possible. The details of these structures and their precise locations cannot be determined until the detailed design phase. The proposed flow reversal at the upstream end will require some regrading, which can possibly add some capacity near the upstream end. At the design stage, the model can be updated to include the profile adjustment, and then additional structures can be included to observe the effects on channel capacity.

4. Comparative Evaluation of Alternatives – Effects Assessment

Discussion of Relevant Evaluation Criteria

The criteria of the *effects of hydraulics and hydrology/sedimentation on sustainability of wetland communities*, and indicators of these effects are more useful during the establishment phase of the preferred alternative rather than during construction. Assuming that a proper erosion and sediment control plan is undertaken, and that the constructed channels remain offline either by diversion or damming and pumping, flow and sediment should continue to be delivered to Lake Ontario without affecting any constructed wetlands. It is during the establishment of the preferred alternative when the criteria and indicators become relevant, and as flow and sediment is delivered via the new creek alignment that changes in each indicator may have an effect on wetland communities. The construction phase can have direct effects on the existing channel morphology and hydrology where any temporary crossings are required (culverts) to allow for construction access. Here culverts will need to be sized appropriately and should not create any barriers to flow or sediment movement.

5. Detailed Assessment of Preferred Alternative

Overview of Preferred Alternative

The preferred alternative detailed in this memo extends Serson and Applewood Creeks into Lake Ontario to outlet at the proposed shoreline. Sinuosity has been created whilst maintaining a gradient to convey flow and sediment through the system. The channel cross-section contains a bankfull channel that conveys the 2-year flood inset within a larger channel that conveys up to the 5-year flood before spilling into adjacent floodplain/wetlands.

Analyses: Methods

To understand the potential impacts of the channel design upon hydrology and sediment movement for each creek, existing HEC-RAS models were updated to include the channel design. Boundary conditions at the lake were input to observe how changes in lake level could affect the capacity of the design channel. This does not model any sediment movement or provide a sufficient understanding of how material is conveyed through the system. Fieldwork completed by PGL in 2012 and 2013 as a part of the LOISS study for CVC was used to gain insight into the sediment regime of each creek (sediment load and grain size distribution). These analyses are based on an upset limit volume for the design alternative of 2.0 million m^3. The proposed channel designs in **Section 3** are based on the reduced footprint with 1.5 million m^3 of fill material. The reduction in area resulted in an adjustment required the previous planform design for Applewood Creek to be altered. The resultant planform in Section 3 maintained the same channel length overall, and tie-in elevations, ensuring that slopes remained the same. Therefore, the analysis provided can be applied to both the 1.5 and 2.0 million m^3 alternatives confidently.

Discussion on each indicator based on the criteria of the effects of hydraulics hydrology/sedimentation on sustainability of wetland communities.

i) Qualitative assessment of ability to manage a full range of flows without adverse impact on wetland communities (high erosion stress, sediment deposits)

Both Serson and Applewood Creeks have been designed to contain flows up to 5 year event. The main channel cross section will convey the 2 year flow while berms placed on either side of the channel will contain the 5 year flow. Flows beyond this capacity will spill onto floodplain and wetland features. Hydraulic conditions within the creeks are likely to be low velocity with little energy to erode the boundaries; therefore, erosional stress on the wetland boundaries is not anticipated to be an issue. Sedimentation in the design channel is likely to naturally occur, but it is expected that the channels will be able to manage sediment over time by flushing it out during higher, less-frequent flows (2-year and higher). The design will maintain flow between Applewood and Serson Creeks and Lake Ontario. As such, there is negligible effect anticipated from flows on the wetland communities.

ii) Influence of lake level fluctuation on channel and wetland connectivity

The creek designs incorporate the anticipated high lake level and the monthly low lake level to produce a profile that will ensure connectivity to the lake under both conditions. Levels at the outlets successfully convey the 5-year flood for each creek at a lake level of 75.4m a.s.l. The design should ensure that the creeks do not become ‘perched’ during flow conditions based on current available data, and they are designed to meet the low lake level of 73.75m a.s.l. The design maintains connectivity at the downstream end and does not account for any potential disconnects upstream. Under low lake levels the backwater effect will be reduced in the channel and the drop in water level may lead to higher velocities flushing out accumulated sediments. Low lake levels are not anticipated to effect connectivity with the wetlands but this is not built into the creek designs so it is not certain.

iii) Potential for sedimentation to affect channel form (including river mouths) and associated vegetation

The potential risk for sedimentation in the creeks is relatively low. In Serson Creek, there is low sediment supply which consists of mainly fine sediments (very fine sand to small cobble) which will be easily transported through the system. For Applewood Creek, sediment load and size is slightly larger (pebble to small boulder; however, transport of sediment mainly consists of redistribution within the channel. Applewood has several large bar features and it is assumed that the new designed section will similarly re-work sediments as bars and riffles but will likely not move large volumes of sediment in the downstream direction. While the movement of the sediment within the channel may result in some accumulation, it is likely this will be temporary and sediment transport processes within the channel are expected to balance naturally

6. Identification of Mitigation Measures

The assessment of the three indicators show that during the establishment phase, the channel will naturally manage sediment over time and flows will be conveyed through to the lake within the design channel and berms of a 5-year capacity. In the design, sedimentation should be negligible. At lower flows, fines will deposit at locations within the design channels, but shall be remobilized during high flow events.

Sedimentation is less of an issue with the steeper design channel of Serson Creek. Applewood Creek, though, may pose a slightly increased risk of deposition. Containment of the flows up to the 5-year event further ensures that the design channels move and store sediment regularly. The relatively low sediment supply to the lake and these design considerations provide a system which can function over time to maintain the conveyance of water and sediment to Lake Ontario.

7. References

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