DRAFT REPORT

Black Creek

Geomorphic and Erosion Hazard Limit Assessment

March 2011

Ref: 01-11-02

PARISH geomorphic

1.0 Introduction

In response to the proposed expansion of the Acton Wastewater Treatment Plant (WWTP), a Geomorphic and Erosion Hazard Limit Assessment was undertaken. The subject property is located adjacent to a section of Black Creek within the Town of Acton, south of Third Line. The purpose of this assessment is to establish the hazard limits from a geomorphic perspective in order to establish any risk to the proposed expansion due to erosion and satisfy regulatory requirements. In order to achieve this objective, the following work plan was undertaken:

- Collect and review any pertinent background information, such as topographic mapping, historic aerial photographs, and any previous reports that would pertain to the channel.
- Using available mapping, confirm channel reach boundaries.
- Where possible, complete channel migration analyses in order to determine 100-year erosion rates and identify the sensitivity of the reach(es).
- Based on mapping and air photos, delineate the meander belt width on a reach basis in vicinity of the subject development.
- Complete field reconnaissance to confirm existing geomorphic conditions, document any evidence of active erosion and confirm appropriateness of the desktop results.
- Preparation and discussion of possible mitigation measures in the event that the proposed expansion is within the meander belt and/or at risk from channel migration.

2.0 Desktop Assessment

2.1 Background Review – Black Creek Subwatershed Study (Subwatershed 10)

The Black Creek subwatershed is approximately 79.28 sq. km in area and is a major tributary of Silver Creek (**Figure 1**). The majority of land use within the subwatershed is agricultural, with areas of wetland and tracts of forest cover. Acton and Georgetown represent the two main zones of urbanization within the catchment. Within the study area, Black Creek Flows through till moraine, a sandy to silty till which is hummocky in nature. Underlying bedrock within the area is dominated by the Amabel/Lockport formation, a grey to medium blue-grey dolostone. This study area has been identified as the Black Creek at Acton Wetland Complex (CVC, 2009). This complex covers an area of 78.4 ha and straddles the Niagara Escarpment and horseshoe moraines to the northwest end. The wetland complex is largely a floodplain wetland. This wetland environment has been noted as providing habitat for brook trout and the provincially rare redside dace as well as habitat for many regionally rare plant species.

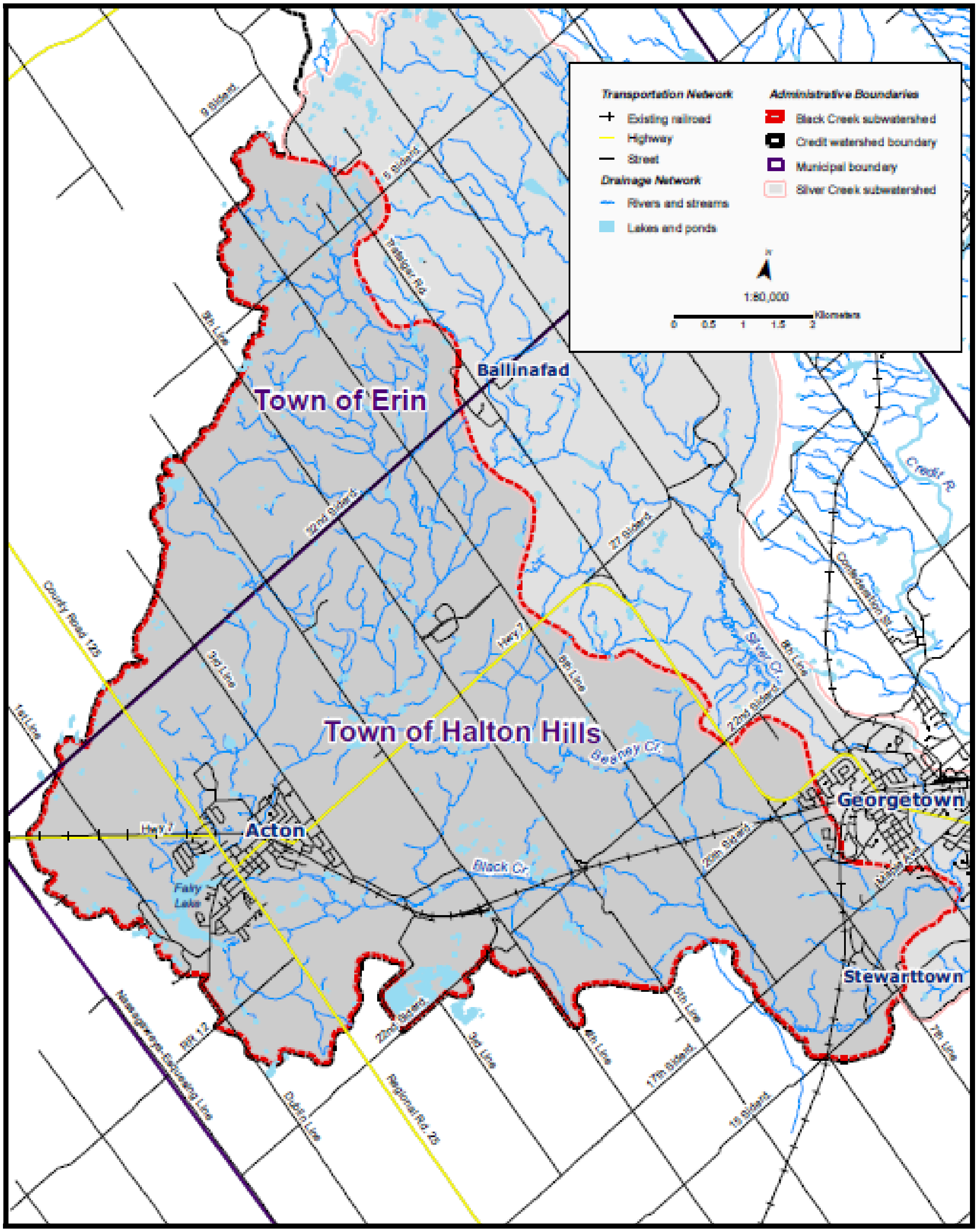

Figure 1. Black Creek subwatershed (image courtesy of CVC, 2009).

2.2 Reach Delineation

The characteristics of the flow or channel materials can change along a creek or stream. In order to account for these changes, channels are separated into reaches – normally several hundred meters to several kilometers in length. A reach displays similarity with respect to its physical characteristics, such as channel form, function, and valley setting. Delineation of a reach considers sinuosity, gradient, hydrology, local geology, degree of valley confinement, and vegetative control using methods outlined in PARISH Geomorphic Ltd. (2001). Based primarily upon land-use, sinuosity, and topography, a total of three reaches were identified for Black Creek within the vicinity of the Acton WWTP (**Figure 2**). Reaches BC-R3, BC-R2, and BC-R1 measure 720, 480, and 460 meters, respectively. As illustrated in **Figure 2**, the broad floodplain conditions surrounding Black Creek within the study area contain a channel that displays multiple channels and standing water conditions typical of a wetland/marsh area. For the purposes of mapping, the main channel (preferrential flow route) has been identified.

Figure 2. General study area (Acton WWTP highlighted).

3.0 Existing Conditions

In order to confirm the findings of the desktop assessment as well as document existing geomorphic conditions, a field investigation of the delineated reaches for Black Creek was completed on March 1, 2011. During the site visit, the entirety of all three reaches was walked and Rapid Assessments (Rapid Geomorphic Assessment and Rapid Stream Assessment Technique) were completed. A Rapid Geomorphic Assessment documents observed indicators of channel instability (MOE, 1999). Observations are quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening and planimetric adjustment. The index produces values that indicate whether the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40) or adjusting (score >0.40).

An RSAT (Rapid Stream Assessment Technique) provides a broader view of the system by also considering the ecological functioning of the stream (Galli, 1996). Observations include instream habitat, water quality, riparian conditions, and biological indicators. Additionally, the RSAT approach includes semi-quantitative measures of bankfull channel dimensions, type of substrate, vegetative cover, and channel disturbance. RSAT scores rank the channel as maintaining a low (<20), moderate (20-35) or high (>35) degree of stream health. **Table 1** provides a summary of the resulting RGA and RSAT scores for each reach. A photographic record of existing conditions observed during the site visit is provided in **Appendix A**.

BC-R1

Reach BC-R1 flows through a valley setting vegetated by deciduous forest. Beaver activity was observed, with two dams located near the downstream end of the reach, each creating a considerable degree of backwater. Bankfull widths and depths ranged from 4.0-6.0 m and 0.6-1.3 m, respectively. Observed bank materials included silt and very fine to medium sands. Pool substrate was composed of organics and silt to fine sands, while riffles displayed material ranging from gravel to small cobble intermixed with coarse to very coarse sands. The RGA produced a score of 0.35, indicating that Reach BC-R1 was in a stressed or transitional state. Widening emerged as the dominant geomorphic process through indicators such as fallen/leaning trees, occurrence of large organic debris, exposed tree roots, basal scour on inside meanders and steep bank angles.

BC-R2

This reach was situated within a broad floodplain, with vegetation consisting of dense grasses and scrub. Bankfull widths ranged between 3.5-5.0 m, with depths between 1.0 and 1.5 m. A beaver dam was again observed at mid-reach, although wood debris was less common than in the upstream reach. Flow contributions were observed through tributaries observed mid-reach. Bank materials consisted of organics, silt and sands. The channel bed lacked well-defined riffle-pool morphology and substrate was consistent

throughout, dominated by fine materials. Channel disturbances included beaver dams, debris jams and the outlet of the treatment plant. RGA results scored the reach as being in a stressed or transitional state (score of 0.39), with widening and degradation emerging as primary and secondary processes. Indicators of widening included steep bank angles, basal scour at inside meanders and exposed tree roots, among others. Degradation was observed through elevated tree roots above the channel bed, bank height increases, and the absence of depositional features.

BC-R3

Reach BC-R3 primarily extends through a marsh area with a broad, open flood plain, and points of valley wall contact. Fallen trees, woody debris and beaver activity were prevalent throughout the reach, with a mid-reach beaver dam causing a considerable backwater zone of approximately 75.0 meters. Many of these features were associated with localized zones of scour and deposition. Bank material was comprised of silts and very fine sands, while bed substrate ranged from organic material and silt to very fine sands in pools and silt to gravel within the riffles. Bankfull dimensions were fairly consistent with widths ranging from 2.5 to 4.5 m and depths of 0.7 to 1.1 m. The RGA produced a score of 0.29, indicating a stressed or transitional state, which was primarily attributed to widening and aggradation. Widening was observed through fallen/leaning trees, occurrence of large organic debris and steep bank angles. Indicators of aggradation included siltation in pools, poor longitudinal sorting of bed materials, and a soft, unconsolidated channel bed.

Table 1. Summary of rapid assessment results for Black Creek.

Reach	RGA	RSAT	Dominant Geomorphic Process
BC-R1	0.35 Transitional	32.0	**Widening**
BC-R2	0.39 Transitional	28.5	**Widening/Degradation**
BC-R3	0.29 Transitional	34.5	Widening/Aggradation

4.0 Meander Belt Width Delineation

Streams and rivers are dynamic features that change their configuration and position within a floodplain by means of meander evolution, development, and migration processes. When meanders change shape and position, the associated erosion and deposition that enable these changes to occur can cause loss or damage to private property and infrastructure. For this reason, when development or other activities are contemplated near a watercourse, it is desirable to designate a corridor that is intended to contain all of the natural meander and migration tendencies of the channel. Outside of this corridor, it is

assumed that private property and structures will be safe from the erosion potential of the watercourse. The space that a meandering watercourse occupies on its floodplain, within which all associated natural channel processes occur, is commonly referred to as the meander belt.

In support of the Provincial Policy Statement, the Toronto and Region Conservation Authority (TRCA) has produced a detailed document which outlines Belt Width Delineation Procedures (PARISH Geomorphic Ltd., 2004) for confined and unconfined systems. This document provides a process-based methodology for determining the meander belt width for watercourses within the jurisdiction of the TRCA based on background information, historic data (including aerial photography), degree of valley confinement and channel planform. Based on available mapping and digital aerial photography, a preliminary belt width was delineated for Black Creek in vicinity of the subject property on a reach basis. Due to the nature of wetland setting, the dimension of the meander belt width was largely driven by the dimension of the active floodplain in order to capture the multiple flow patterns associated with this section of Black Creek. This resulted in a preliminary belt width of 90 m for Reachs BC-R2 and BC-R3, and a preliminary belt width of 60 m for Reach BC-R1 which displayed a much more defined channel and flow pattern (**Figure 3**).

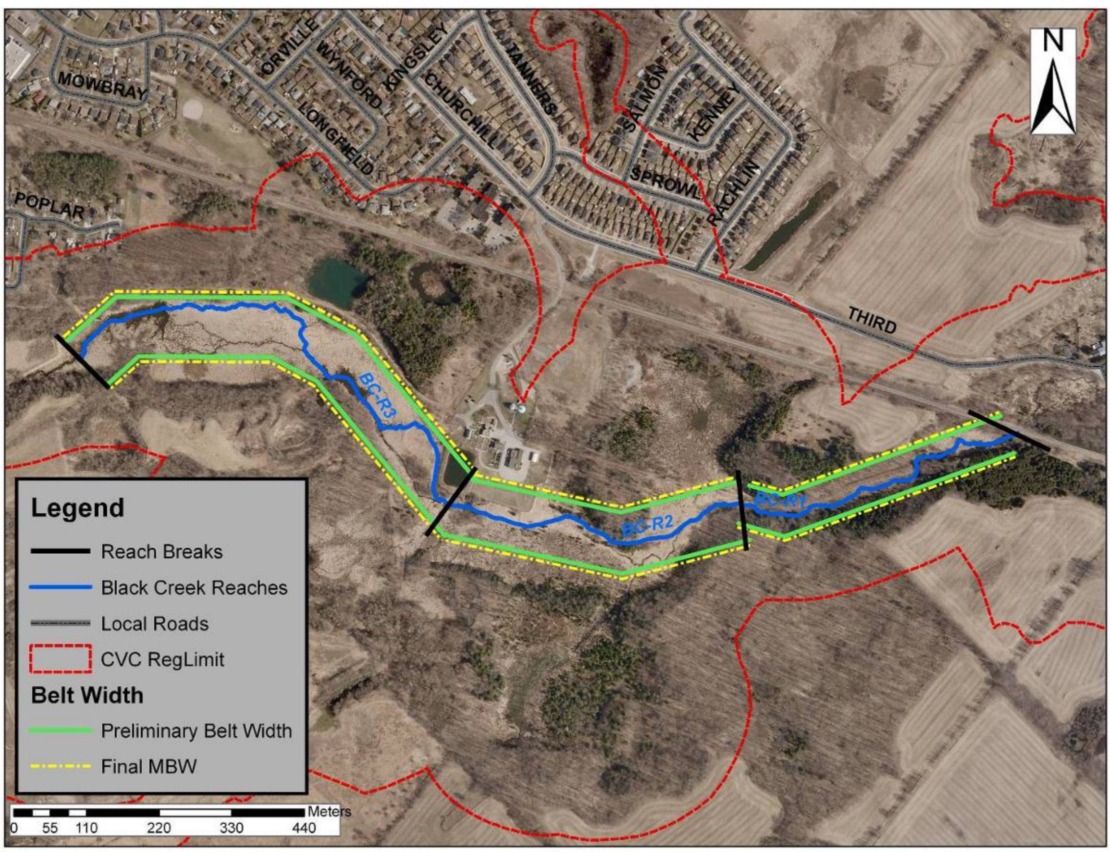

Figure 3. Geomorphic hazard limit delineation for expansion of the Acton WWTP.

4.1 Historic Assessment and Erosion Setback

For the purposes of this study, historic aerial coverage of the general study area dating from 1955 and 1978 was compared to recent digital ortho imagery (2009) in order to document changes in land use and channel form over time (**Figure 4**). In 1955, the access road to the WWTP is evident off of Third Line. Residential development can also be observed, largely northwest of Highway 7. This development then expands east towards the WWTP between 1955 and 2009. The greatest observable change within the stream corridor is the modifications to the floodplain and wetland complex. In 1955, a series of ponds are visible just upstream of the general study area. By 2009, only two such ponds are visible. The footprint of the WWTP was established by 1978.

Typically, air photo analysis also supports the quantification of the 100-year erosion rate. From a geomorphic perspective, the 100-year migration rate generally represents the erosion setback to be applied to either side of the meander belt width in order to account for bank erosion and channel migration over time. However, due to the degree of vegetative cover and wetland/multiple flow path nature of Black Creek within the study area, migrations could not be quantified on a reach basis in vicinity of the study site. In lieu of applying the 100-year migration rate, however, an erosion setback that considered both the preliminary meander belt width, the findings of the field investigation and the Provincial Policy Statement 3.1 guidance on toe erosion allowance was applied to either side of the channel. For the Black Creek study area, this resulted in a setback of 8 meters on either side of the channel for Reaches BC-R2 and BC-R3 and a setback of 6 m for BC-R1 (**Table 2**). These setbacks were based on the reported average bankfull channel widths of less than 5 m, as well as the observed evidence of active erosion in the form of channel widening. Given that the majority of this widening appeared to be associated with the numerous woody debris jams and beaver dams, the minimum toe erosion allowance was applied for Reaches BC-R2 and BC-R3. Since Reach BC-R1 scored as the most stable reach within the study area, the setback represents 10% of the meander belt width and was considered appropriate within the context of the PPS (**Table 3**).

Table 2. Belt width and erosion setback dimensions

Reach	Preliminary Belt Width (m)	Erosion Setback (m)	Final Belt Width (m)
BC-R1	60	6	**72**
BC-R2	90	8	**106**
BC-R3	90	8	106

Figure 4. Historic air photo coverage of the general study area.

Table 3. Provincial Policy Statement 3.1 guidance for toe erosion allowance.

Type of material Native Soil Structure	Evidence of active erosion* or where the bankfull flow velocity is greater than competent flow velocity	No evidence of active erosion		
		bankfull width		
		< 5 m	5-30 m	> 30 m
Hard rock (e.g. granite)	0 – 2 m	0 m	0 m	1 m
Soft rock (shale, limestone), cobbles, boulders	2 - 5 m	0 m	1 m	2 m
Clays, clay-silt, gravels	5 – 8 m	1 m	2 m	4 m
Sand, silt	8 – 15 m	1 – 2m	5 m	7 m

4.2 Implications for WWTP Expansion

As illustrated in **Figure 3**, a portion of the Acton WWTP property is located within the meander belt width. As such, following the letter of regulatory policy, this would characterize the Acton WWTP as being situated within hazard lands. However, the evaluation of geomorphic risk to this facility should also be cognizant of the extent of the regulatory limit also identified in Figure 3, and the low-energy wetland environment that typifies Black Creek within the study area. The WWTP property has been in existence since at least 1978. Based on aerial photography analysis, the property does not appear to show evidence of active erosion due to its proximity to Black Creek. The proposed WWTP expansion does not require an expansion of the original development footprint (**Figure 5**); therefore, the risk to this proposed development is no greater than to that of the original plant. With this in mind, the actual risk to the Acton WWTP in the form of channel migration or erosion was deemed minimal.

4.3 Erosion Mitigation Measures

While the risk to the WWTP due to erosion was deemed minimal, the results of the field evaluation did identify evidence of active erosion (channel widening). With this in mind, two potential mitigation measures have been developed in order to provide an additional factor of safety against future bank erosion or channel migration. **Figure 6** illustrates a buried stone bank treatment (Option 1) and a buried stone trench treatment (Option 2). Both of these treatments incorporate the use of Class 1 rip rap (D50 of 30 cm). Rip rap is a special application of rock protection. It consists of rocks, broken rocks, angular stones or concrete debris placed together in a set and stable manner to a specified thickness for the protection of slopes and surfaces. It is used in areas where erosion is presently a problem or is an anticipated concern. While the size class associated with Class 1 rip rap may vary slightly

depending on the source of the aggregate materials, the general size range corresponds to 15-45 cm.

Option 1 (buried stone bank treatment) is best suited for the length of property located along the existing settling pond where the difference in grade is sufficient to allow the incorporation of a stone treatment into the bank/berm face. Along the portion of the property identified for the new secondary clarifiers and UV disinfection building, a buried trench approach (Option 2) is likely more appropriate as the property appears to be at sitting close to floodplain elevation. In both cases, the Class 1 riprap should be installed to a depth greater than that of the existing channel invert (by around 0.3 m). The width and location of the treatments were designed in such a way to avoid disturbance of the active channel, while also avoiding encroachment on the property limits. The width of the stone trench treatment will largely be driven by the depth of stone required and an optimal side slope greater than 1:1.

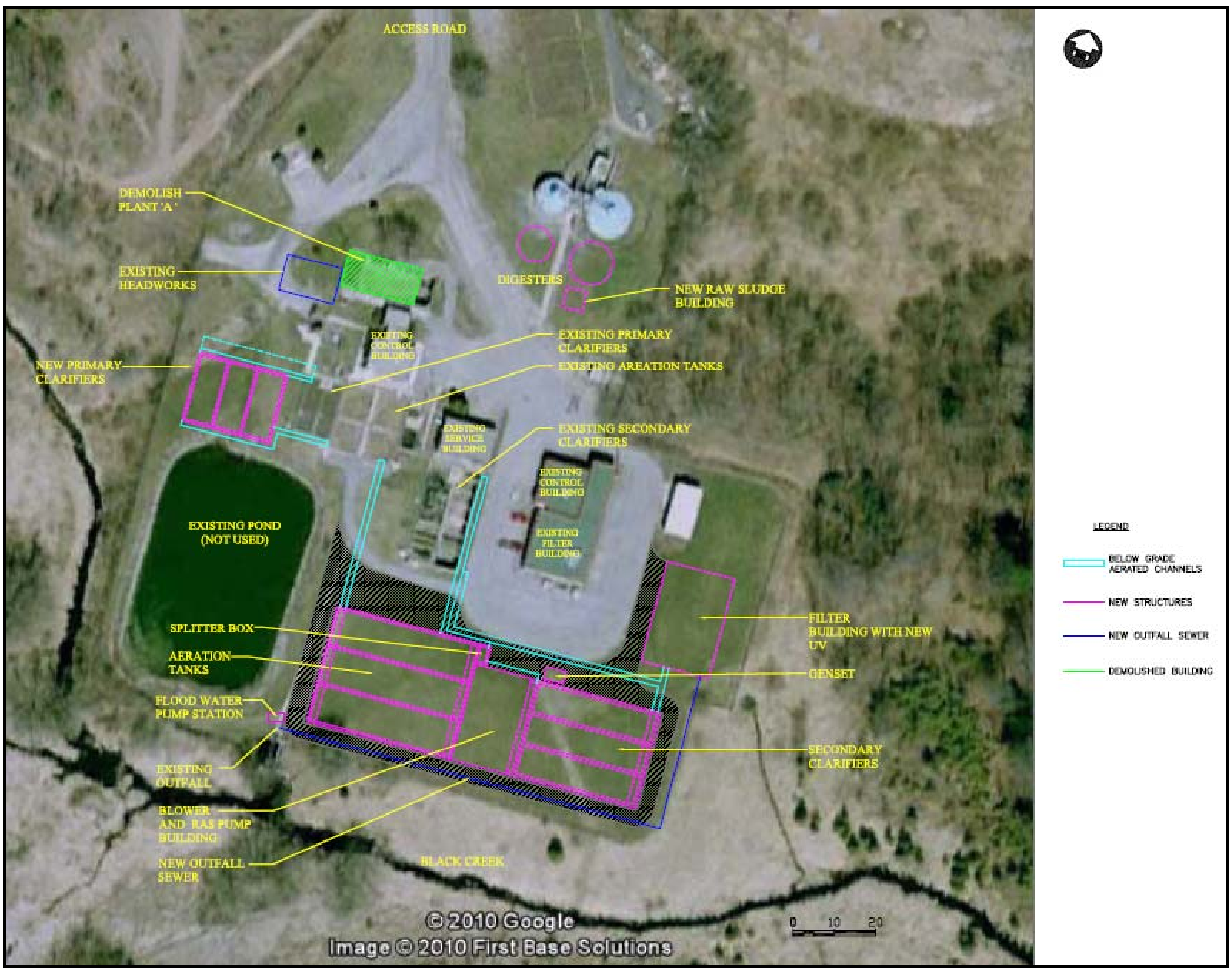

Figure 5. Proposed expansion of Acton WWTP (delineated in pink)

5.0 Summary and Next Steps

In support of a proposed expansion of the Acton WWTP, a Geomorphic and Erosion Hazard Limit Assessment was undertaken. The purpose of this report was to establish the hazard limits from a geomorphic perspective for the subject area. Based on a review of existing mapping, as well as historic and recent aerial photography, preliminary and final belt widths were delineated within the general study area on a reach basis. Final belt width dimensions measured 106 m for BC-R2/3 and 72 m for BC-R1. While a portion of the Acton WWTP property was identified as being within the meander belt width and, as such, technically within hazard lands, a sensitivity analysis based on the desktop evaluation determined that the actual risk to the property was likely minimal.

Given that the findings of the field investigation did indicate evidence of active erosion along the study reaches, however, potential mitigative measures were developed for the property. These measures entail the installation of buried stone treatment along the property limits that provide an additional factor of safety against bank erosion/channel migration. In support of the detailed design stage, some additional analyses would be required in order to ensure appropriate stone sizing and depth of treatment. This would entail the collection of detailed geomorphic field information within the study reach (sections, substrate/bank characterization and long profile). This data would then be processed in order to estimate a range of velocities and shear stresses for the active channel, as well as provide a context for scour potential along the bed. Detailed cross-sectional information would also confirm the required depth of the stone treatment such that it achieves the minimum 0.30 m below the existing channel invert. The results of this work would support or refine the mitigation concepts presented in this report.

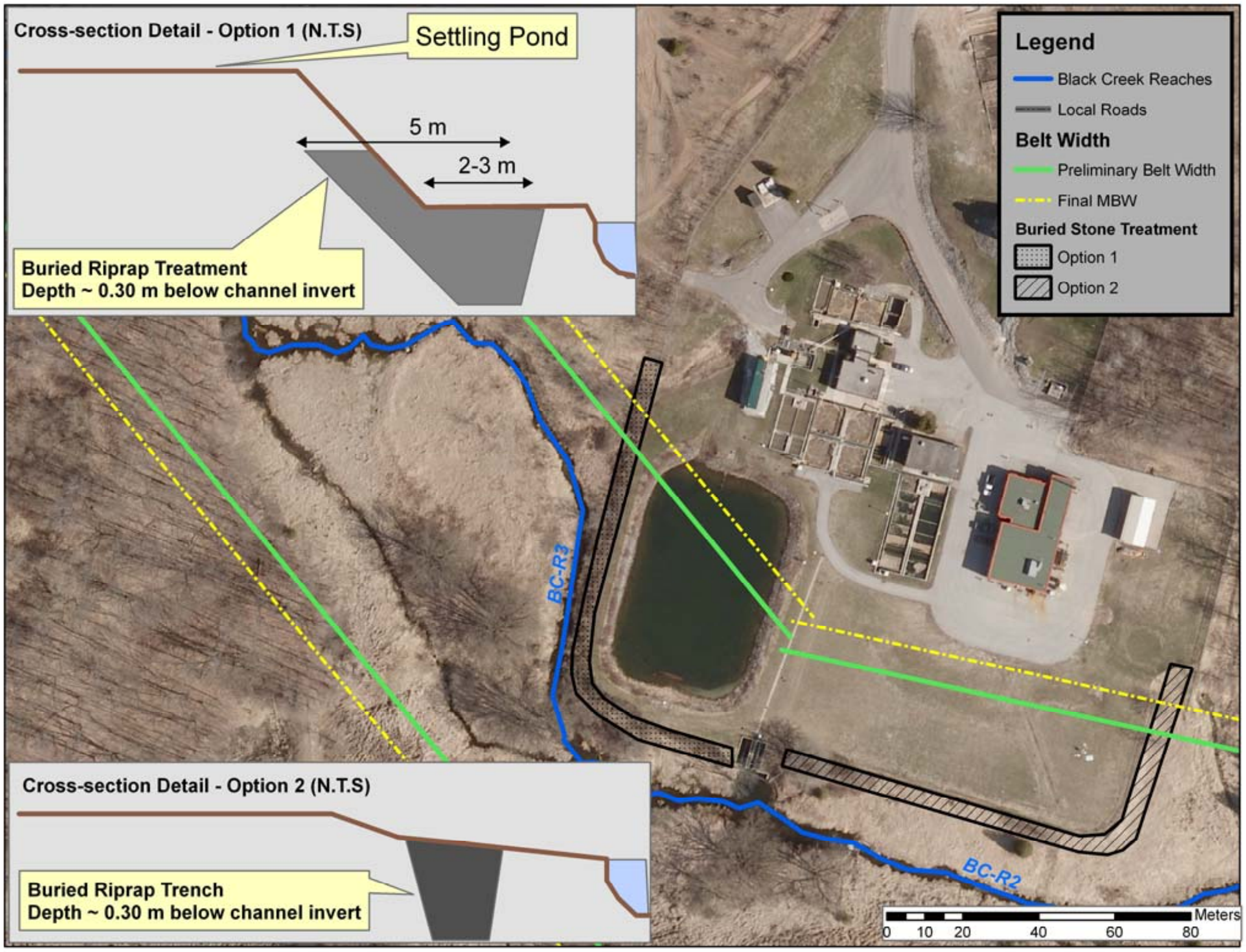

Figure 6. Potential erosion mitigation measures.

References

CVC. 2009. Black Creek Subwatershed Subwatershed Study – Subwatershed 10. Background Report.

Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments. 36pp.

Ministry of Environment. 2003. *Revised Stormwater Management Guidelines Draft Report.*

Ministry of Natural Resources. 2001. *Provincial Policy Statement 3.1*- In: Technical Guide – River and Stream Systems: Flooding Hazard Limit

PARISH Geomorphic Ltd. 2002. *Geomorphological protocols for subwatershed studies.* Submitted to: Regional Municipality of Ottawa-Carleton.

Toronto and Region Conservation Authority. 2008. *Humber River State of the Watershed Report – Aquatic System*.

APPENDIX A – PHOTOS

Photo 1. BC-R3 section of reach within vicinity of the WWTP.

Photo 2. BC-R3 backwatering due to beaver dam at downstream limit.

Photo 3. BC-R3 general lowland riparian conditions.

Photo 4. BC-R2 beaver dam at upstream limit.

Photo 5. BC-R2 at Acton WWTP outlet.

Photo 6. BC-R2 conditions at downstream reach limit.

Photo 7. BC-R1 fallen/leaning trees.

Photo 8. BC-R1 increased confinement and valley wall contact.

Photo 9. BC-R1 railway crossing and culvert at downstream limit