



GEOMORPHIC SOLUTIONS

UXBRIDGE DOWNTOWN FLOOD REDUCTION CLASS ENVIRONMENT ASSESSMENT STUDY

EXISTING ENVIRONMENTAL CONDITIONS REPORT



Uxbridge Brook Watershed

Prepared for the Town of Uxbridge
and the Region of Durham

Our Project No. 10257.450
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1.0 INTRODUCTION

Uxbridge Brook, with a drainage area of 178 km², originates in the Oak Ridges Moraine and flows north to Pefferlaw Brook, eventually outletting to Lake Simcoe (LSRCA, 1997). The majority of the stream length is located in the Regional Municipality of Durham and the Town of Uxbridge. The catchment area upstream of the Town is approximately 20 km² (Cumming-Cockburn & Associates Limited, 1983). This subwatershed, particularly in the headwater region, is recognized by both Lake Simcoe Region Conservation Authority (LSRCA) and the Ontario Ministry of Natural Resources (MNR) as supporting significant cold and warm water fisheries.

The Regional storm floodline encompasses a major portion of the downtown area of the Town of Uxbridge. Therefore, under existing conditions there is a significant risk of damage to private property and infrastructure due to flooding caused by the Regional storm event. In 1929, the downtown area experienced flooding and significant property damage due to a high rainfall event. In 1965, the failure of the Brookdale Dam located upstream of the downtown Uxbridge area resulted in significant flooding (Cumming-Cockburn and Associates Limited, 1983). Notably, an approximately 191 m portion of Uxbridge Brook is currently piped in the downtown area, which flows underneath commercial properties and Brock Street West. It is understood that the culvert was sized to convey the 100-year storm event. Constriction of flow at the culvert during the Regional event therefore presents a considerable flood hazard to the downtown area.

In support of the Class Environmental Assessment (Class EA), an investigation and evaluation of existing geomorphic, aquatic and terrestrial conditions was completed to inform the development of alternative solutions to reduce the risk of flooding in the downtown area. To provide context for the study, reaches upstream and downstream from the piped portion of the watercourse were also investigated. The study area encompassed Uxbridge Brook from south of Centennial Drive to the Canadian National (CN) railway north of the downtown area (**Figure 1**). The study included a review of all pertinent background information associated with the fluvial geomorphology and aquatic and terrestrial habitat within the study area. Available detailed topographic and geologic maps, historic aerial photographs, pertinent previous reports and available data specific to this assessment were examined. A field investigation, including rapid geomorphic assessments and aquatic habitat and terrestrial resource assessments were also completed in the late summer of 2010 to support the Class EA.



Figure 1: The Uxbridge Brook study area in the Township of Uxbridge (Region of Durham, 2008).

2.0 FLUVIAL GEOMORPHOLOGY ASSESSMENT

2.1 Reach Delineation and Stream Corridor Characterization

Reach delineation was completed utilizing a series of historical aerial photographs, topographic and surficial geology maps, and reports. Reach delineation is typically based on changes in channel planform and active geomorphological processes, which are directly related to local surficial geology, gradient, hydrology, land use, and riparian vegetation (Montgomery *et al.*, 1997; Richards *et al.*, 1997). Each reach is therefore expected to adjust in a generally uniform manner along its full length to changes in hydrology and sediment supply, as well as other modifying factors. Four reaches were delineated within the study area and were subsequently verified in the field (**Appendix A**). The gradient, channel sinuosity, and length of each reach were determined using a 2008 orthophotograph provided by the Region of Durham and are included in **Table 1**.

Table 1: Reach gradient, sinuosity and length.

Reach	Gradient (%)	Sinuosity	Length (m)
UX1	0.69%	1.13	288
UX2	0.80%	1.02	459
UX3	N/A – piped channel section		
UX4	0.26%	1.03	175

2.2 Historical Assessment

A historical mapping examination was conducted using black and white aerial photographs for the years 1959 (1:28,500), 1971 (1:15,840) and 1978 (1:10,000) from the University of Waterloo Map Library to examine historic channel adjustments and assess the channel's dynamic equilibrium. A digital colour image from 2008 obtained from the Region of Durham was also examined to provide context. Historical Aerials are provided in **Appendix B**.

In 1959, the surrounding land use was dominated by urban development that extended from the Elgin Mill Pond to the CN railway. Agricultural fields surrounded the Town of Uxbridge. Riparian vegetation upstream and downstream from the Town largely consisted of forest with major localized gaps in the downstream channel reaches. Between 1959 and 1978, there was a notable increase in residential development, particularly northwest of the Town, and a moderate decrease in overall forest cover. By 2008, residential development had expanded significantly to the north, east and west, while the headwater region of Uxbridge Brook to the south, remained largely natural.

In 1959, the watercourse flowed through an open area upstream, between the confluence south of Centennial Drive and Brock Street West (Reach UX4), and appeared to be artificially straightened. Despite the increase in residential houses along the east bank and the development of a park on the west bank, there appeared to be no change in channel planform between 1959 and 2008 within Reach UX4.

In 1959, the portion of watercourse between Brock Street West and Main Street North (Reaches UX2 and UX3) flowed through a fragmented forest and channel sinuosity was low. There was no discernable change in channel planform between 1959 and 1978. The majority of commercial development in the downtown area east of the intersection of Brock Street West and Toronto Street North occurred between 1971 and 1978 and it is likely that the piped portion of Uxbridge Brook was extended north during this period in order to facilitate development.

Forest cover was dense in the 1959 imagery for the portion of watercourse between Main Street North and the CN railway (UX1). Where the channel could be delineated sinuosity appeared to be moderate. A portion of the forest vegetation north of watercourse was removed between 1959 and 1971 likely to facilitate construction a treatment plant. It was not possible to determine adjustments in channel planform as it was largely obscured by vegetation for the period examined. However, the removal of vegetation and urban and residential development upstream and within the downtown area of the Town, likely resulted in increased surface runoff to Uxbridge Brook.

2.3 Watershed Characteristics

The planimetric form of a watercourse is fundamentally a product of the channel flow regime and the availability and type of sediments (i.e. surficial geology) within the channel corridor. The 'dynamic equilibrium' of these inputs governs channel planform. These factors are influenced on smaller systems by physiography, riparian vegetation and land use.

The dominant physiographic feature in the headwater region of Uxbridge Brook is located in the Oak Ridges Moraine, located south of the Town of Uxbridge. The watercourse then flows through organic deposits (peat, muck and marl, 1-7 m thick) and river deposits (gravel, sand, silt and clay (Sharpe et al., 1997).

Three aquifers (lower, intermediate, and upper) are located in the subwatershed and are a regionally significant groundwater resource (LSRCA, 1997). The upper aquifer (259 m a.s.l.) is generally unconfined and consists of sand and gravel up to 25 m thick. The aquifer flows in a northerly direction and discharges towards Uxbridge Brook. The intermediate aquifer (244 to 259 m a.s.l.) consists of medium sand with locally cemented gravel and is approximately 27 m thick. However, in some locations it may be intermittent or combined with the lower aquifer. Recharge occurs from the upper aquifer along the moraine and discharge occurs from the intermediate aquifer to the upper aquifer. The lower aquifer (198 to 216 m a.s.l.) consists of sand and gravel deposits up to 20 m thick. This aquifer, along with the upper and intermediate aquifers, receives recharge from the headwater areas of the Beaver River to the east and Pefferlaw Brook to the west (LSRCA, 1997).

Precipitation from climate normals (1971-2000) recorded at the Stouffville WPCP station southeast of the intersection of Main Street and Ninth Line in the Town of Stouffville (23 km southwest of the study site) averaged 63 mm per month in winter (November to February inclusive) and 88 mm in summer (July and August; Environment Canada, 2011). The increase in precipitation in summer months is likely related to convective storm events caused by daytime heating, which produce high intensity flows. However, the overall highest instream flows likely occur during the spring freshet.

2.4 Existing Fluvial Geomorphic Conditions

Field data and observations were collected on August 19, 2010 to identify active geomorphic processes, assess channel stability and to characterize existing geomorphic conditions using rapid assessment techniques. A photographic record is provided in **Appendix C**. Two rapid visual assessment methods were conducted on the reaches as part of the geomorphic analysis, a Rapid Geomorphic Assessment (RGA) and a Rapid Stream Assessment Technique (RSAT). The RGA documents observed indicators of channel instability (MOE, 2003) by quantifying observations using an index that identifies channel sensitivity. Sensitivity is based on evidence of aggradation, degradation, channel widening and planimetric form 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 *in adjustment* (score >0.41).

The RSAT offers a slightly different approach by using an index to quantify overall stream health and includes the consideration of biological indicators (Galli, 1996). Observations concerning channel stability, channel scouring/sediment deposition, physical instream habitat, water quality, and riparian habitat conditions are used in an index to produce values that indicate whether the channel is in *poor* (<13), *fair* (13-24), *good* (25-34), or *excellent* (35-42) condition.

Additional observations including bankfull channel dimensions, substrate and bank materials, estimated bank angle, terrestrial and aquatic vegetation cover, and channel disturbances were also noted. General characteristics of each reach and the results of the RGAs and RSATs are shown in **Tables 1** and **2**, respectively.

Reach UX1 extended approximately 300 m upstream from the decommissioned CN railway to the treatment plant on Main Street North, as shown in **Appendix A**. The surrounding land use consisted of residential homes, a public park and forest. The upstream channel was partially confined whereas the downstream channel, closer to Main Street North, was confined. The extent of riparian vegetation was continuous and consisted of trees and grasses. The channel sinuosity and gradient were low. Bankfull widths and depths ranged from 7 to 12 m and 0.5 to 1 m, respectively. Garbage and woody debris jams were frequent and occurred on average approximately every 15 m to 25 m. Erosion and bank undercutting occurred along the outer bends of the channel, exposing tree and grass roots. A valley wall contact and evidence of seepage, iron staining and exposed till were also noted downstream of the stormwater outfall outletting from the treatment plant mid-reach. The base and sides of the stormwater outfall were protected by concrete slabs and gabions, which were outflanked.

Runs were the dominant morphological feature within the channel and the substrate consisted of clay to gravel. Where observed, riffle substrate consisted of coarse sand to gravel with occasional cobbles and concrete rubble. Pool substrate consisted of clay to sand. Based on the results of the rapid assessments, Reach UX1 had an RGA score of 0.38, indicating the channel was in transition/stress. The dominant systematic adjustment was evidence of aggradation, mainly due to siltation in the pools, sediment accumulation in the riffles (embedded) and the presence of medial bars. The RSAT result of 22 indicated that the reach was in fair condition, and the limiting feature was physical instream habitat.

Reach UX2 extended approximately 400 m from the treatment plant on Main Street North to the parking lot near Brock Street West and Main Street North, as shown in **Appendix A**. The surrounding land use consisted of largely residential homes and urban space. The channel was confined and flowed through a number of watercourse crossings at roads. Channel entrenchment (~12 m) may be associated with fill material placed in the floodplain during past

urban infrastructure expansion. However, this was not confirmed through the historical aerial photo assessment. Channel sinuosity was low and gradient was low to moderate. The extent of the riparian vegetation was fragmentary due to urbanization in which residential and industrial properties were manicured to the channel edge. Where forested, the riparian vegetated consisted of trees and grasses. The bankfull width and depth ranged from 7 to 8 m and 0.5 to 1.0 m, respectively. Exposed pipes, garbage debris and woody debris jams were common in the channel banks and bed. A stormwater outfall, perpendicular to the culvert at Dominion and Toronto Street North, was protected by concrete rubble. The culvert at the downstream end of the reach break was protected by rip rap.

Runs were dominant morphological feature within the reach with pool features present. Pools consisted of fine sands, silt and clay, and riffles and consisted of gravel to cobbles. Rooted submergent vegetation was also noted. Based on the results of the rapid assessments, Reach UX2 had an RGA score of 0.33, indicating the channel was in transition/stress. The dominant systematic adjustment was evidence of widening due to basal scour, exposed tree roots, leaning and fallen trees and occurrences of large woody organic debris. The RSAT result of 23 indicated that the reach was in fair condition, and the limiting feature was riparian habitat conditions.

Reach UX3 extended approximately 191 m from the parking lot on Brock Street West and Main Street North to Centennial Drive, as shown in **Appendix A**. As the entire reach was piped, rapid geomorphic assessments were not completed. Overall, the culvert appeared to be smaller than the average bankfull width for the upstream and downstream reaches. However, no significant erosion was observed in the vicinity of the culvert footprint. The hydrologic and structural functions of the culvert are provided under a separate report.

Reach UX4 extended to approximately 175 m south from Centennial Drive. The surrounding land use was parkland (left bank, downstream direction) and residential (right bank). The channel was confined on the left bank, partially confined on the right bank, moderately entrenched. The riparian vegetation consisted of trees and grasses, was fragmentary, and was approximately less than one channel width. Channel sinuosity was low and gradient was moderate. Bankfull width and depth ranged from 6.5 to 8 m and 0.75 to 1.5 m, respectively. Bank material ranged from clay to sand with organics. Erosion was observed along the banks causing the exposure of tree and grass roots. A suspended armour layer was also noted. Minor bank armoring (concrete rubble) was present adjacent to private property in some sections of the reach. Riffles were dominant and consisted of gravels to cobbles, with small boulders occasional and concrete rubble. Pools were deep (~0.65 m) with substrate consisting of silt and clay. Based on the results of the rapid assessments, Reach UX4 had an RGA score of 0.25, indicating the channel was in transition/stress. The dominant systematic adjustment was evidence of widening due to exposed tree roots, leaning and fallen trees and occurrences of large woody organic debris. The RSAT result of 26 indicated that the reach was in good condition, and the limiting feature was riparian habitat conditions.

Table 2: General reach characteristics.

Reach	Bankfull Width (m)	Bankfull Depth (m)	Substrate		Riparian Vegetation	Notes
			Pool	Riffle		
UX1	7 – 12	0.5 – 1.0	sand, silt and clay	coarse gravel and sand, few cobbles	mainly mature deciduous trees and grasses	low sinuosity and gradient; moderate entrenchment; high turbidity; garbage and woody debris jams; undercut outer banks; exposed roots; iron staining; and outflanked gabions at stormwater outfalls.
UX2	7 – 8	0.5 – 1.0	sand, silt and clay	gravel and cobbles	mainly established to mature deciduous trees and grasses	low sinuosity in residential areas; fragmented riparian buffer zone; 12 m entrenchment; garbage and woody debris; valley wall contacts; evidence of seepage into channel; and concrete slabs & rubble revetments;
UX3	Piped – RGA / RSAT not completed					
UX4	6.5 – 8	0.8 – 1.5	sand, silt and clay	gravel and cobbles; boulders and concrete rubble	mainly established deciduous trees and grasses	low sinuosity and gradient; reach within park and residential area; moderately entrenched; 5 – 30% eroded; riffle – pool spacing was 20 m; rooted submergent vegetation; iron staining; and concrete rip-rap for bank stabilization.

Table 3: Results of the rapid geomorphic assessments.

Reach	Rapid Geomorphic Assessment (RGA)			Rapid Stream Assessment Technique (RSAT)		
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)
UX1	0.38	In Transition / Stress	Evidence of Aggradation	22	Fair	Physical Instream Habitat
UX2	0.33	In Transition / Stress	Evidence of Widening	23	Fair	Riparian Habitat Conditions
UX3	Piped channel section – RGA / RSAT not completed					
UX4	0.25	In Transition / Stress	Evidence of Widening	26	Good	Riparian Habitat Conditions

3.0 AQUATIC HABITAT AND TERRESTRIAL RESOURCE ASSESSMENT

3.1 Background Review

The fisheries and aquatic habitat assessments were completed to document and define the extent and quality of all existing aquatic habitat within the study area (**Figure 1**). The overall assessment considered all sources of background information and field data collected as part of this study. The watercourses were divided into reaches for field assessment concurrently with the geomorphic component of this study.

Approximately 65% to 75% of the watershed is buffered with riparian vegetation 30 m wide on either side of the watercourse (LSRCA, 2009). However, land use is dominated by commercial and residential development. Wetland habitat was not documented in the study area but was observed upstream and downstream in natural areas (LSRCA, 1997).

Ecological Land Classification (ELC) information was provided by LSRCA for review (**Appendix A**). Downstream of Reach UX1, north of the CN railway, the ecological communities adjacent to Uxbridge Brook consisted of areas of deciduous forest (FOD), cultural meadow (CUM), cultural woodland (CUW), cultural thicket (CUT) and mixed swamp (SWM). The majority of Reach UX1 consisted of mainly coniferous forest (FOC) and was characterized as having greater than 75% coniferous canopy cover. Only one other ELC community was delineated along the main branch of Uxbridge Brook, south of Reach UX4, and consisted of cultural woodland (CUW) and open water (OAO, Elgin Mill Pond). The tributary of Uxbridge Brook, south of the study area, contained a thicket swamp (SWT) community.

Approximately 187 species utilize the Uxbridge Brook subwatershed for their life stages (LSRCA, 1997). Forty-three species of flora and fauna were considered to be rare or endangered in the entire watershed. Based on a search of the Natural Heritage Information Centre (NHIC; accessed August 2010) database no Species at Risk (SAR), Environmentally Sensitive Areas (ESA) or Provincially Significant Wetlands (PSW) were documented in the study area. This was confirmed by mapping provided by LSRCA.

According to the Uxbridge Brook Watershed Plan, 18 species of fish were documented in the subwatershed and were comprised of a mix of cold and warmwater species including Brook Trout (*Salvenius fontinalis*) and Sculpin (*Cottidae* spp.), which are both coldwater thermal indicators (LSRCA, 1997). Other species included Largemouth Bass (*Micropterus salmoides*), Brown Trout (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*). Benthic invertebrate composition provides information about the quality of water in the watershed. According to the Watershed Report Card (2009) the water quality in the Uxbridge Brook subwatershed was 'excellent'. However, the aquatic habitat of the Uxbridge Brook subwatershed was given an Index of Biotic Integrity (IBI) of 'fair'.

Issues associated with development in the watershed include soil erosion and sediment related activities, urban runoff from stormwater and runoff from existing uncontrolled urban areas that do not have stormwater quality control (LSRCA, 1997). Phosphorus concentrations in the Uxbridge Brook are above the provincial water quality objective (<0.03 mg/L) and varied from 0.03 to 0.10 mg/L over a five year monitoring period (LSRCA, 2009).

Based on information provided by LSRCA, the area south of the study area is highly vulnerable to groundwater contamination (**Appendix A**). This is dependent on elements such as soil type,

water table elevation, contaminant concentration and the confined or unconfined nature of the aquifer.

Design considerations and management strategies should be directed towards aquatic and terrestrial habitat issues and concerns. Aquatic issues include the lack of vegetated buffers, reduced refuge for fish, overland flow into watercourses, bank erosion/stabilization, destruction of habitat and confined channels. Terrestrial issues include loss of forest species diversity and density and destruction of natural corridors (LSRCA, 1997).

3.2 Existing Aquatic Habitat and Terrestrial Resources

Available background information was reviewed and compiled and watercourse mapping for the study area was overlaid on an orthophotograph. A field investigation was undertaken on August 19, 2010 along the main branch of Uxbridge Brook from approximately 175 m south of Centennial Drive to the railway (**Appendix A**) to identify and assess the existing aquatic and riparian habitat conditions. Although four reaches were delineated based on terrestrial and aquatic habitat, land use and the existing road network, only three reaches were assessed as one reach was piped (Reach UX3). Each reach was assessed to document the aquatic habitat characteristics and georeference key features or points of interest such as barriers, groundwater upwellings, and valley wall contacts. Observations also included flow regime, channel type, riparian cover, instream cover, substrate composition, bankfull channel dimensions, woody debris distribution, water quality and groundwater indicators, thermal regime indicators and observations of use by fish.

Reach UX1 was a typical forest channel dominated by run habitat with deep pools and a few riffles. Pool depths were generally greater than 0.6 m with the majority deeper than 1 m. Pool substrate was composed of sand and exposed till was documented in one pool. Riffle substrate consisted of sand and gravel. This reach was composed of approximately 10% riffles, 70% runs and 20% pools. In-stream cover included frequent occurrences of large woody debris, deep pools, undercut banks (greater than 0.5 m) and overhanging vegetation. The channel had a low to moderate gradient and was in a partially to completely confined valley. Two valley wall contacts were observed at the downstream limit of the reach. A pedestrian bridge, historically a CN railway and at an elevation approximately 10 m above the channel bed, was located near the downstream limit of the reach. Nutrient input from an active perched storm sewer outlet was observed at the upstream limit of Reach UX1. Bank materials include organic matter, clay and silt. Aquatic vegetation in the channel included filamentous and non-filamentous algae. Fish were observed throughout the reach.

The terrestrial habitat of Reach UX1 consisted of a deciduous dominated forest with a wide riparian zone greater than 30 m. Dominated by Manitoba Maple (*Acer negundo*) and Eastern White Cedar (*Thuja occidentalis*) clusters of other species include Silver Maple (*Acer saccharinum*), Green Ash (*Fraxinus pennsylvanica*), American Beech (*Fagus grandifolia*), and Common Buckthorn (*Rhamnus cathartica*). The canopy age class was mature (>30 years), with 75 to 85% canopy cover over the channel.

Reach UX2 was an entrenched, straightened ravine channel between watercourse crossings, residential properties, and along road embankments. The toe of the slope was located at the edge of the channel banks. The habitat was dominated by runs with few pools and riffles. Pools were approximately 0.6 m to 1 m deep and were composed of sand substrate. One riffle was documented with coarse materials including cobbles and small boulders. Substrate became coarser in the downstream direction. The reach was composed of approximately 10%

riffles, 70% runs and 20% pools. In-stream cover included boulders at the downstream limit of the reach, undercut banks (up to 0.50 m deep), overhanging vegetation, few deep pools and a high frequency of large woody debris. Iron staining and seepage from the channel banks were also documented in the reach. The channel was fragmented by three watercourse crossings and manicured to the edge of the watercourse in the residential neighbourhoods. Aquatic vegetation included filamentous and non-filamentous algae. Fish observed at the time of the survey included darter species (*Etheostoma spp.*).

Reach UX2 contained ravine terrestrial habitat with a narrow riparian zone. The channel was tree-lined and dominated by deciduous species of Silver Maple, Manitoba Maple, American Basswood (*Tilia americana*), Weeping Willow (*Salix babylonica*), Balsam Poplar (*Populus balsamifera*), Crabapple (*Malus pumila*), American Beech, Eastern White Cedar, White Willow (*Salix alba*), White Ash (*Fraxinus americana*) and Common Buckthorn. The age class was established to mature (>5 years) and provided 70 to 75% canopy cover over the ravine.

Reach UX3 consisted of a piped channel under commercial properties and Brock Street West. Therefore, aquatic and terrestrial assessments could not be completed. The inlet and outlet of the culvert was documented to be in good condition (i.e. no erosion or scour that may impact aquatic habitat).

Reach UX4 was located within a forest at the upstream limit and in between residential properties and a recreational park for the majority of the channel length. Majority of the riparian zone was approximately 2 - 3 m wide. The habitat was dominated by riffles with few pools and some runs. Pools were shallower in comparison to upstream reaches. Riffle materials included sand to boulders. In-stream cover included a moderate frequency of large woody debris, boulder refugia and few pools. Bank stabilization features include concrete slabs and rip rap stabilization.

Tree species found within this reach include Eastern White Cedar, Manitoba Maple, White Ash, and Silver Maple. The lawns of residential properties and the recreational park were manicured to the edge of the channel in many sections along the reach.

4.0 CONCLUSION

Fluvial geomorphology and habitat conditions were determined through a review of background materials including historical aerial photographs, topographic and geology maps, and reports in support of the Municipal Class EA to reduce the flooding risk in the downtown area of the Town of Uxbridge. To verify the background review and provide an update to existing conditions, field investigations of geomorphic and aquatic and terrestrial resources were completed.

Land use within the study area was largely residential and commercial, with several private properties adjacent to the channel in Reaches UX2 and UX4. Historical aerial photos indicated that the degree of urbanization has increased steadily within the watershed. While, riparian vegetation has increased steadily throughout the period of record reviewed, no discernible changes in channel planform characteristics were observed. Based on the field investigations, there were no significant concerns throughout the study area with respect to active channel erosion and stability. Downstream of the study area (Reach UX1), the channel contained minor evidence of aggradation, while the adjoining Reach UX2 and the reach upstream of the piped channel section (Reach UX4) contained evidence of channel widening. Within Reach UX2, the channel was confined with limited to no floodplain area and flowed through a number of watercourse crossings. However, no significant erosion or scour was observed upstream or downstream of the crossings, including the piped channel section (Reach UX3).

There were limited significant ecological communities within the study area according to the ecological land classification (ELC) provided by LSRCA, with the exception of the coniferous forest (FOC) within reach UX1 and the cultural woodland (CUW) in Reach UX4. No Species at Risk (SAR), Environmentally Significant Areas (EAS), or Provincially Significant Wetlands (PSW) were noted within the study area. Overall, the Uxbridge Brook subwatershed was assessed as having “excellent” water quality and “fair” aquatic habitat conditions. Riparian cover was generally good throughout the study area, but was fragmented within Reach UX2. Reach UX4, upstream of the piped portion of Uxbridge Brook, contained mainly riffles, with few pools and runs and was evaluated as containing good instream aquatic habitat. The downstream reaches (UX1 and UX2) were dominated by runs, with few relatively shallow pools and riffles. The instream aquatic habitats of these two reaches were evaluated as fair.

Respectfully submitted,

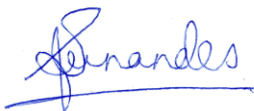
GEOMORPHIC SOLUTIONS



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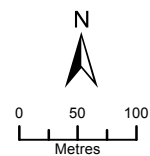
APPENDIX A
EXISTING ENVIRONMENTAL CONDITIONS



- Legend**
- Photo Location
 - ➔ Reach Break and ID
 - 1 m Contour
 - Ecological Land Classification
 - Groundwater Conditions
 - Watercourse

Reach Breaks and IDs, and Photo Locations: Geomorphic Solutions, 2011; Orthomagery, Watercourse, 1 m Contours: Durham Region, 2008; Ecological Land Classification and Groundwater Conditions: LSRCA, 2010.

Uxbridge Flood Reduction EA Existing Environmental Conditions



GEOMORPHIC SOLUTIONS

DRAWN BY: S.S., N.C.

DATE: MARCH 2012

PROJECT: 10257.450

APPENDIX A

APPENDIX B
HISTORICAL AERIAL ASSESSMENT



Year: 1959

Location: Uxbridge, ON.

Easting: N/A
Northing: N/A

Aerial ID: A17188-39a

Scale: 1:28.500

Source: University of Waterloo Map Library



Year: 1971

Location: Uxbridge, ON.

Easting: N/A
Northing: N/A

Aerial ID: 4405-163b

Scale: 1:15,840

Source: University of Waterloo Map Library



Year: 1978

Location: Uxbridge, ON

Easting: N/A
Northing: N/A

Aerial ID: 4408-82b

Scale: 1: 10,000

Source: University of Waterloo Map Library



Year: 2008

Location: Uxbridge, ON.

Easting: 650310.495 m
Northing: 4885930.738 m

Aerial ID: N/A

Scale: N/A

Source: Region of Durham

APPENDIX C
PHOTOGRAPHIC INVENTORY



Photo 1.

Reach UX1

Photo Location 1

Downstream view of wooden footbridge & decommissioned CN railway. Wetted width was 7 m and wetted depth was 0.6 m. Note: minor vegetation encroachment, woody debris jam and garbage debris.



Photo 2.

Reach UX1

Photo Location 2

Photograph of valley wall contact (centre). Valley wall toe was protected by concrete rubble.



Photo 3.

Reach UX1

Iron staining on the channel bank (yellow arrow) was indicative of groundwater discharge.



Photo 4.

Reach UX1

Example of a medial bar and woody debris jam.



Photo 5.

Reach UX1

Photograph of storm sewer outfall from treatment plant. Undermined concrete slab at base and outflanked gabion baskets (centre).



Photo 6.

Reach UX2

Photo Location 3

Outflanked gabion baskets (centre-left), concrete rubble and exposed steel pipe along channel bank. Note proximity of building to channel.



Photo 7.

Reach UX2

Photo Location 4

Upstream view of straight (and typical) channel section. Low to moderate input of woody debris. Bankfull width was 7 m and bankfull height ranged between 0.5 to 0.75 m.



Photo 8.

Reach UX2

Upstream end of CSP culvert at Main Street North.



Photo 9.

Reach UX2

Photo Location 5

Elevated stormwater outfall (500 mm diameter) at Dominion Street West and Toronto Street North. Concrete rubble and boulders at base.



Photo 10.

Reach UX2

Upstream end of CSP culvert at Dominion Street West. Note rooted algae, and cobble and silt substrate. No erosion or scour was observed.



Photo 11.

Reach UX2

Photo Location 6

Upstream view of channel at 38 Main Street North. Erosion along outer bends, and deposition of woody debris was observed. Note the manicured lawn and proximity of property to channel.

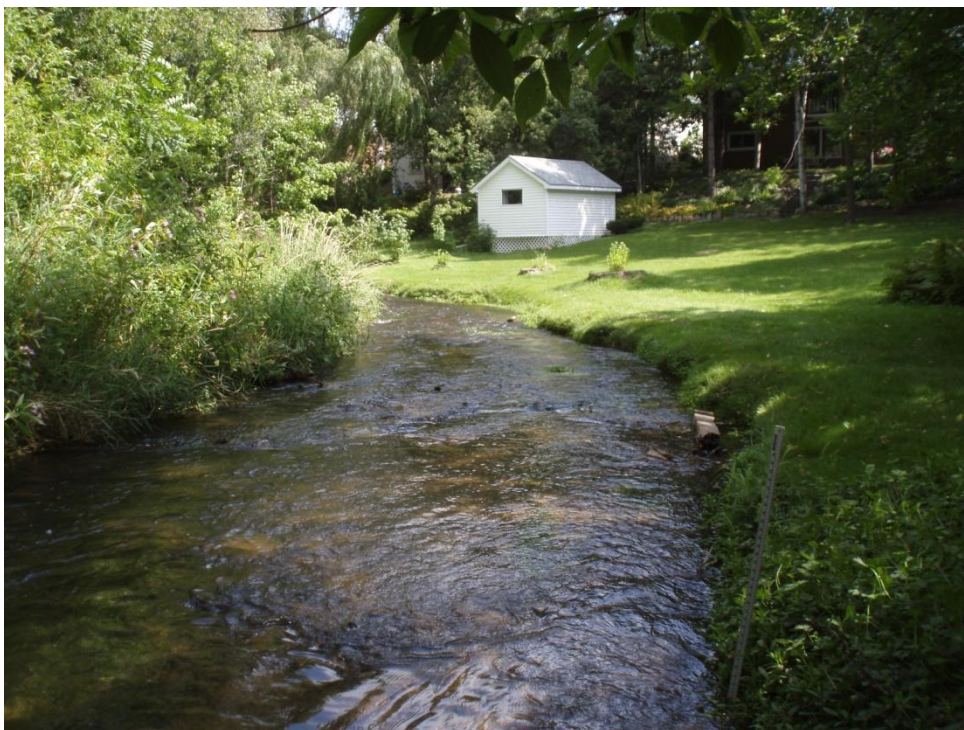


Photo 12.

Reach UX2

Photo Location 7

Downstream view from CSP culvert at parking lot. Defined right bank, poorly defined left bank. Note the manicured lawn and lack of riparian cover (centre).



Photo 13.

Reach UX2

Photo Location 7

Downstream end of CSP culvert at Brock Street West and Main Street North parking lot. Rip rap armouring on right bank.



Photo 14.

Photo Location 8

Reach UX4

Upstream end of CSP culvert at Centennial Drive. Failed pavement was observed behind armour stone blocks. Cobble and gravel substrate within channel.



Photo 15.

Reach UX4

View upstream from the Brock Street East. Note the riffle, and steeper channel gradient observed in the foreground of the photo.



Photo 16.

Photo Location 9

Reach UX4

Concrete rubble protection on right bank. Overbank sand and organic debris deposits. Note the manicured lawns.



Photo 17.

Photo Location 10

Reach UX4

Upstream view of pedestrian bridge with CSP culvert. An approximate 0.6 m deep scour pool was observed downstream of the crossing structure.



Photo 18.

Reach UX4

Suspended armour layer in channel bank (yellow arrow), upstream of photo location 10, is indicative of channel downcutting.



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