

Appendix C
SWM Facility Rating Curves

Lower Morrison Creek West SWM Facility Rating Curve for Flood Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
25-year	6176	15.9
100-year	7411	21.2
Overflow	7782	100

Lower Morrison Creek East SWM Facility Rating Curve for Flood Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
25-year	9894	12.4
100-year	12222	15.9
Overflow	12833	100

Wedgewood Creek West SWM Facility Rating Curve for Flood Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
25-year	6310	4.2
100-year	6993	5.7
Overflow	7343	100

Wedgewood Creek East SWM Facility Rating Curve for Flood Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
25-year	21518	20.2
100-year	24746	26.7
Overflow	25983	100

Lower Morrison Creek West SWM Facility Rating Curve for Erosion Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
Extended Detention	6587	1.027

Lower Morrison Creek East SWM Facility Rating Curve for Erosion Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
Extended Detention	9312	0.340

Wedgewood Creek West SWM Facility Rating Curve for Erosion Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
Extended Detention	5458	0.211

Wedgewood Creek East SWM Facility Rating Curve for Erosion Control		
Stage	Storage (m ³)	Discharge (m ³ /s)
Permanent Pool	0	0
Extended Detention	17214	0.884

Appendix D

Revised Subcatchment Imperviousness Estimation Methodology and Subcatchment Parameterization

Table 2 Impervious Coverages for Residential Zones and Municipal Rights-of-Way (%)

Zone Classification	Type	Imperviousness
Residential Low (RL1)	ROW	60.1
	Lot	44.5
Residential Low (RL1-0)	ROW	64.0
	Lot	34.0
Residential Low (RL2)	ROW	NA ¹
	Lot	55.0
Residential Low (RL2-0)	ROW	64.1
	Lot	39.1
Residential Low (RL3)	ROW	70.8
	Lot	47.4
Residential Low (RL3-0)	ROW	58.8
	Lot	43.2
Residential Low (RL4)	ROW	NA ²
	Lot	NA ²
Residential Low (RL4-0)	ROW	58.4
	Lot	40.4
Residential Low (RL5)	ROW	70.8
	Lot	58.3
Residential Low (RL5-0)	ROW	70.5
	Lot	49.1
Residential Low (RL6)	ROW	63.6
	Lot	62.9
Residential Low (RL7)	ROW	65.1
	Lot	62.5
Residential Low (RL7-0)	ROW	59.0
	Lot	58.3
Residential Low (RL8)	ROW	76.1
	Lot	58.9
Residential Low (RL8-0)	ROW	73.4
	Lot	49.4
Residential Low (RL9)	ROW	76.4
	Lot	61.5
Residential Low (RL10)	ROW	NA ¹
	Lot	46.7
Residential Low (RL10-0)	ROW	NA ¹
	Lot	47.0
Residential Low (RL11)	ROW	79.0
	Lot	51.4
Residential Medium (RM1)	ROW	80.5
	Lot	61.5
Residential Medium (RM2)	ROW	NA ²
	Lot	NA ²
Residential Medium (RM3)	ROW	NA ²
	Lot	NA ²
Residential Medium (RM4)	ROW	63.9
	Lot	80.4
Residential High	ROW	60.4
	Lot	68.3
Residential Uptown Core	ROW	NA ²
	Lot	NA ²

Notes: ¹ No road right-of-ways are associated with the residential zones based on the zoning information and property parcel data provided by the Town

² The residential zone or right-of way is not found within the study area based on the zoning information and property parcel data provided by the Town

Table 3 Impervious Coverages for Non-Residential Zones (%)

Class	Imperviousness
Neighbourhood Commercial	82.9
Community Commercial	85.2
Core Commercial	89.3
Central Business District	100.0
Cemetery	8.7
Community Use	30.1
Office Employment	84.0
Business Employment	93.4
Industrial	77.8
Institutional	75.1
Business Commercial	87.9
Existing Development	62.7
Greenbelt	5.0
Midtown Transitional Commercial	92.2
Midtown Transitional Employment	82.8
Main Street 1	100.0
Main Street 2	95.0
Urban Centre	90.0
Urban Core	95.0
Natural Area	5.0
Park	10.0
Private Open Space	5.0
Parkway Belt Public Use	25.0
Parkway Belt Complementary Use	10.0
Utility	26.6

FIGURE 1: MONITORING LOCATIONS



- Legend**
- Cemeteries
 - Parks
 - Monitoring Location

1: 5,000



Notes

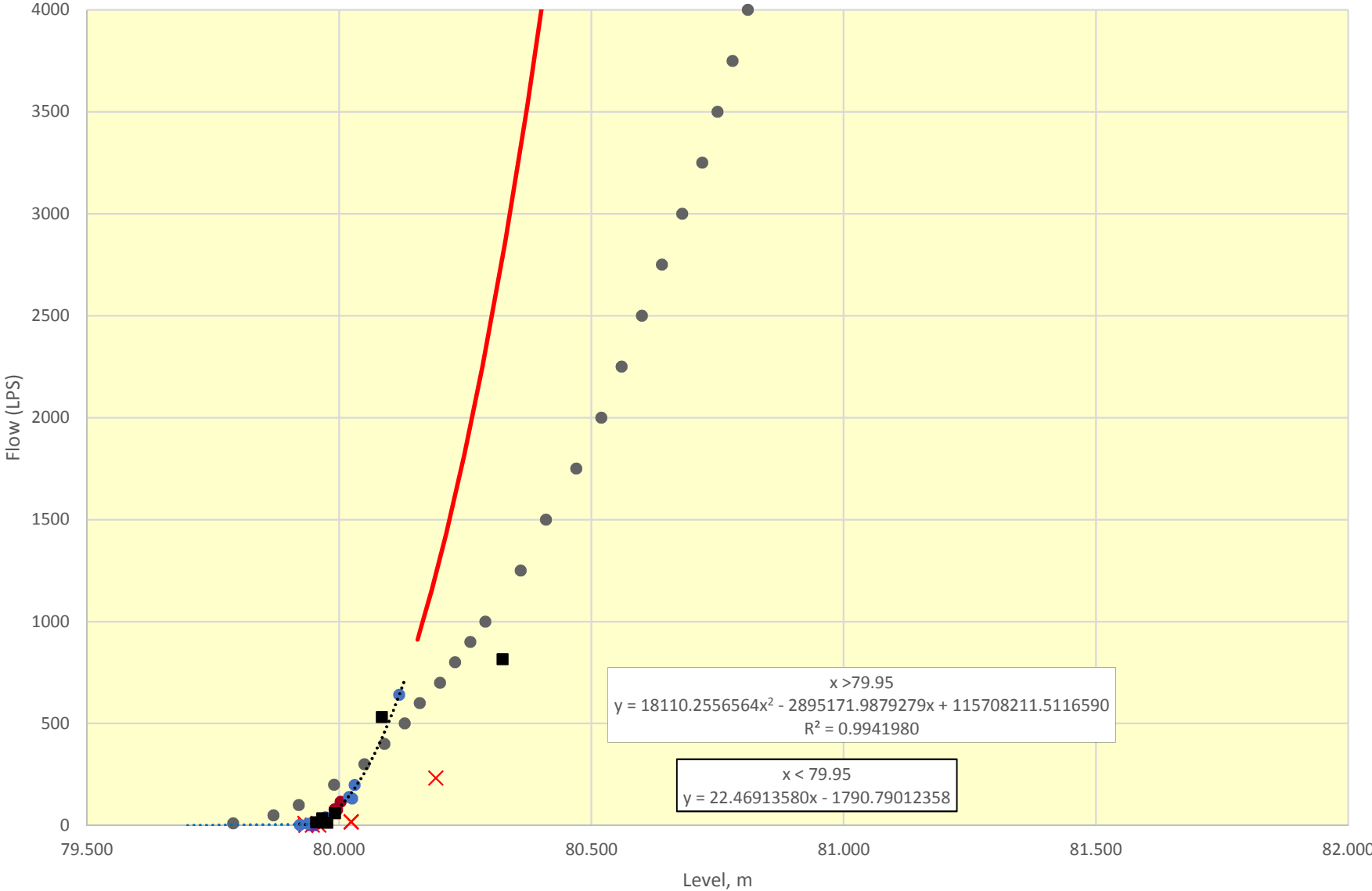
304.8 0 152.40 304.8 Meters

Disclaimer: THIS IS NOT A LEGAL PLAN OF SURVEY.

NAD_1983_UTM_Zone_17N

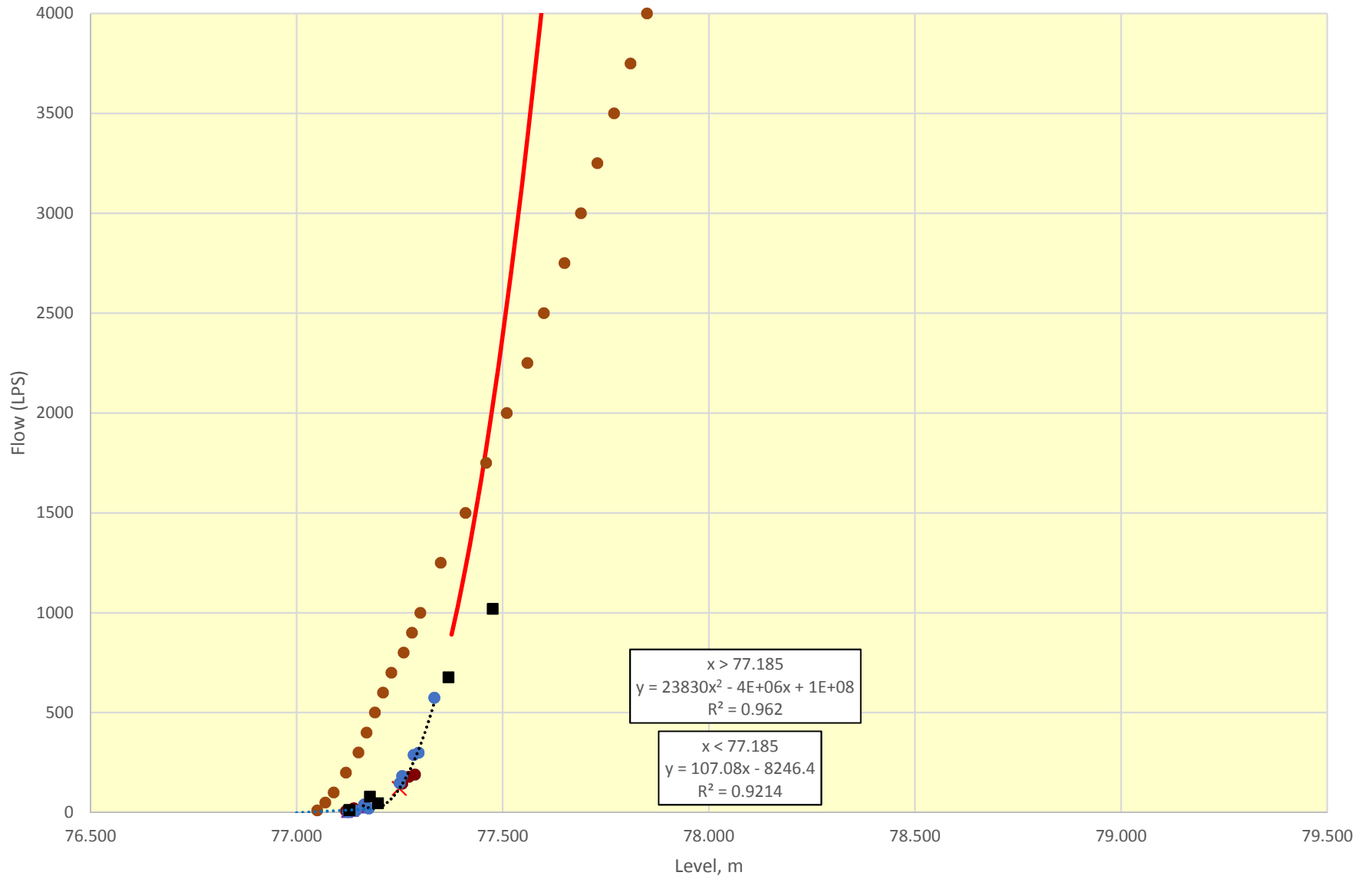
May 22, 2015

Lower Morrison Rating Curve - Morrison Road



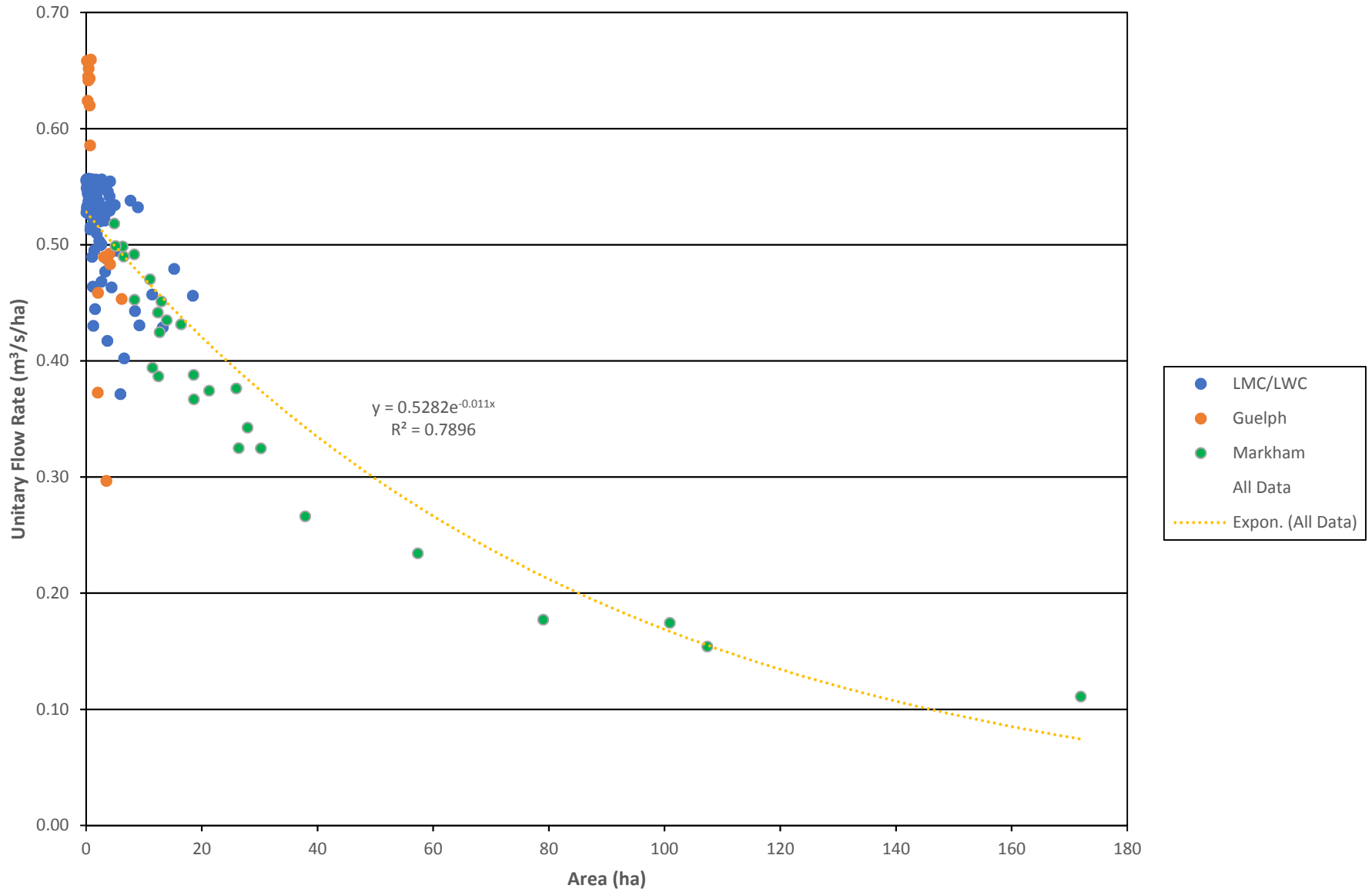
- ✕ Outliers
- 2014
- ▲ 2015
- 2016
- 2017
- Morrison HEC-RAS Results
- Extrapolated Observed Flow

Lower Wedgewood Rating Curve - Lakeshore Road

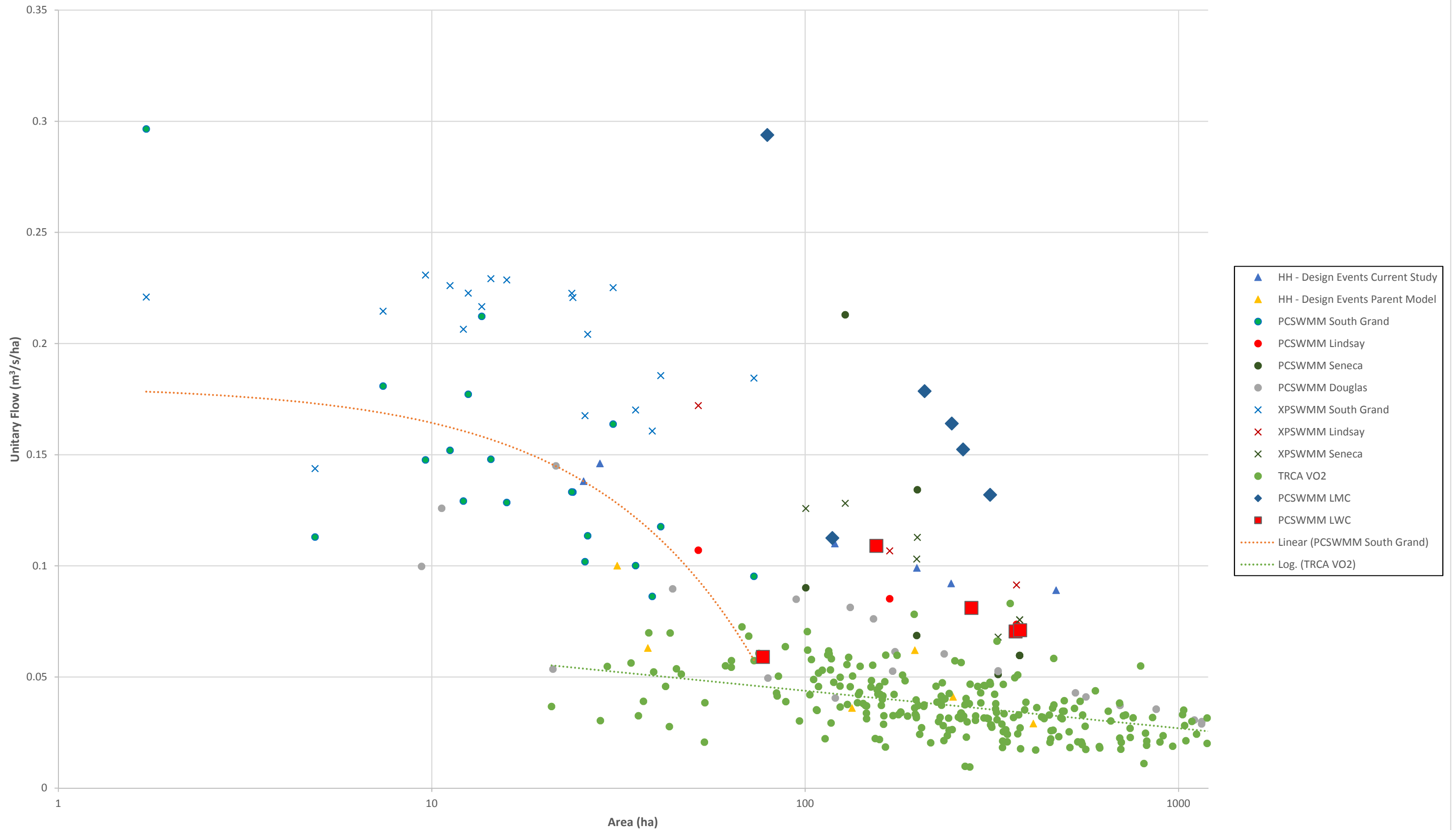


× Outliers ● 2014 ▲ 2015 ● 2016 ■ 2017 ● Wedgewood HEC-RAS Results — Extrapolated Observed Flow

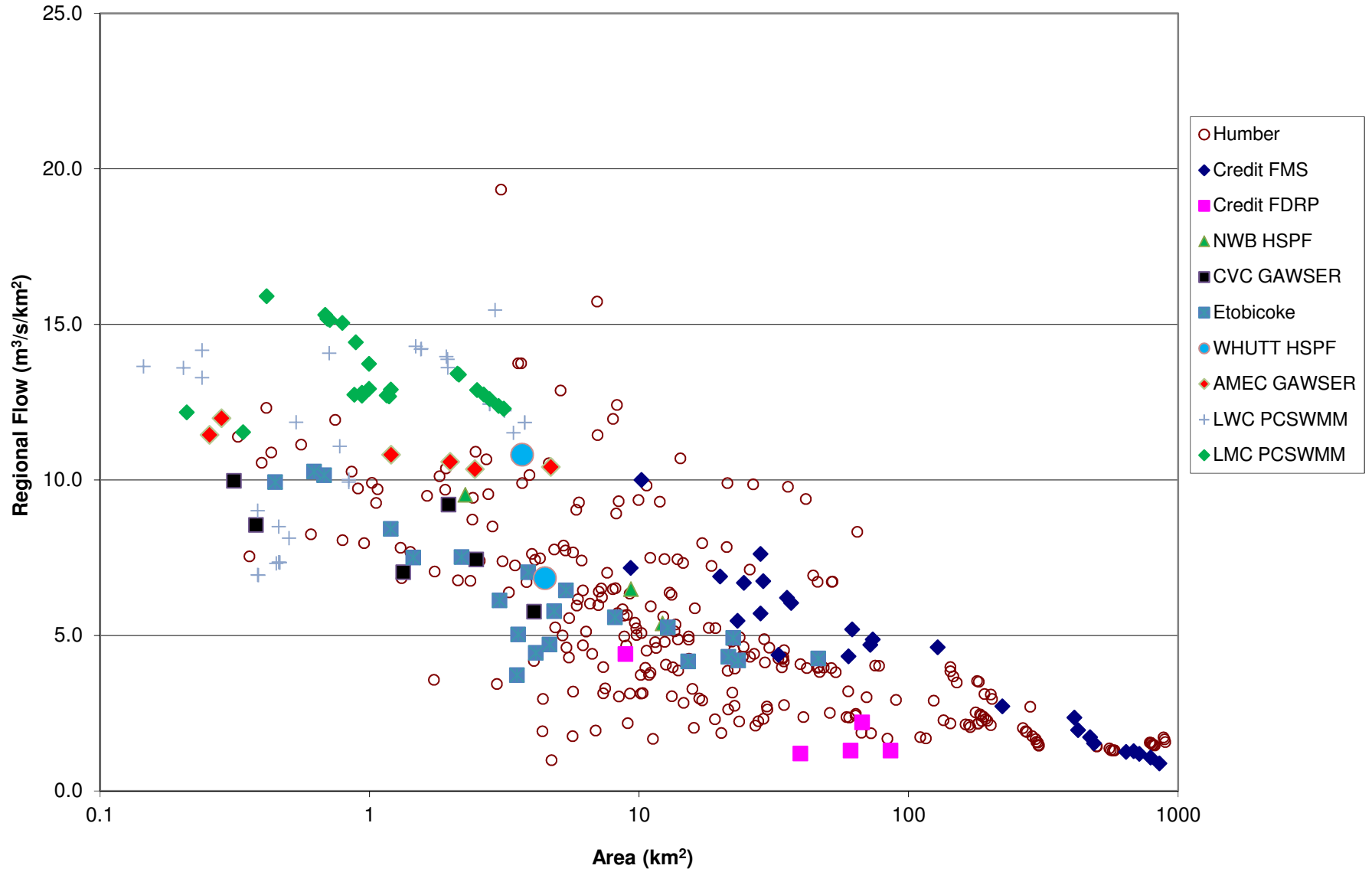
100 Year Storm Event Unitary Flow Rate Comparison of High Impervious PCSWMM Subcatchments (Imperv. > 70%)



100 Year Unitary Flow Comparison



Comparison of Normalized Regional Storm Flows



Appendix E
Hydraulic Structure Inventory

	Potential Channel/Structural Improvements			MTO Criteria										MNR Criteria								
	Reach ID	Road Classification	Location	Potential Channel/Structural Improvements		Existing					Proposed					Existing				Proposed		
				Existing Structure (Span x Rise)	Potential Upgraded Structure (Span x Rise)	Largest Storm Conveyed (Without Overtopping)	Design Storm (for MTO Criteria)	Clearance (m)	FB (m)	Pass MTO Criteria (Y/N)	Largest Storm Conveyed (Without Overtopping)	Clearance (m)	FB (m)	Pass MTO Criteria (Y/N)	Overtopping Depth (m)	Velocity	Depth x Velocity	Pass MNR Criteria (Y/N)	Overtopping Depth (m)	Velocity	Depth x Velocity	Pass MNR Criteria (Y/N)
Morrison Creek	Reach 1 DS	Urban Arterial	Lakeshore	7.9 x 3.2 CONSPAN Arch	14.6 x 3.35 CONSPAN Arch	100	100	0.13	1.51	N	100.00	0.16	1.54	N	N/A	N/A	N/A	Y	N/A	N/A	N/A	Y
	Reach 1 DS	Urban Arterial	Morrison Rd	3.7 x 2.05 Box	N/A	2	50	-1.00	-0.30	N	2.00	N/A	N/A	N	0.36	0.87	0.31	Y	0.35	0.93	0.33	Y
	Reach 1	Urban Arterial	Linbrook Rd	7.3 x 1.5 CONSPAN Arch	N/A	25	100	-0.39	-0.15	N	100.00	0.40	0.64	N	0.15	0.50	0.08	Y	N/A	N/A	N/A	Y
	Reach 1	Urban Arterial	Chartwell Rd	Twin 3 x 2.1 Box	7.32 x 2.13 CONSPAN Arch	100	100	0.13	0.55	N	100.00	0.08	0.50	N	N/A	N/A	N/A	Y	N/A	N/A	N/A	Y
	Reach 1	Urban Arterial	Cornwall Rd	Twin 3.25 x 1.2 Box	N/A	50	100	-1.31	0.02	N	50.00	-1.31	0.02	N	0.02	0.46	0.01	Y	0.02	0.46	0.01	Y
	Reach 1	Urban Arterial	East Longo's Parking Lot	3.5 x 1.3 Box	N/A	10	50	-1.30	-0.06	N	10.00	N/A	N/A	N	0.06	0.41	0.02	Y	0.06	0.57	0.03	Y
	Reach 1	Urban Arterial	Under CNR	1.8 x 1.5 Box	N/A	2	50	-1.20	-0.15	N	2.00	N/A	N/A	N	0.15	0.86	0.13	Y	0.15	0.91	0.14	Y
	Reach 1	Urban Arterial	Hwy 403	5.97 x 1.5 Box	6.4 x 1.8 Box	100	50	0.30	1.52	Y	100.00	N/A	N/A	Y	N/A	N/A	N/A	Y	N/A	N/A	N/A	Y
	Reach 1 US	Urban Arterial	Chartwell Rd	3 x 1.6 Box	6.4 x 1.5 Box	2	50	-0.58	-0.40	N	10.00	-0.42	-0.24	N	0.40	0.44	0.18	Y	0.35	0.81	0.28	Y
	Reach 1 US	Urban Arterial	Maple Ave	3 x 1.2 Box	N/A	2	50	-0.80	-0.01	N	2.00	N/A	N/A	N	0.01	0.54	0.01	Y	0.01	0.58	0.01	Y
	Reach 1 US	Urban Arterial	Cornwall Rd	8 x 1.75 Box	N/A	50	100	-0.58	0.06	N	50.00	N/A	N/A	N	0.06	0.46	0.03	Y	0.06	0.46	0.03	Y
	Reach 1 US	Urban Arterial	DS of CNR Crossing	Twin 1.8 m diameter CSP	N/A	5	50	-2.38	-0.02	N	5.00	N/A	N/A	N	0.02	0.72	0.01	Y	0.02	0.79	0.02	Y
	Reach 1 US	Urban Arterial	CNR Crossing	3.3 x 1.5 Box	N/A	N/A	50	-2.30	-0.02	N	N/A	N/A	N/A	N	0.02	0.44	0.01	Y	0.02	0.55	0.01	Y

	Potential Channel/Structural Improvements			MTO Criteria										MNR Criteria								
	Reach ID	Road Classification	Location	Potential Channel/Structural Improvements		Existing					Proposed					MNR Criteria				MNR Criteria		
				Existing Structure	Largest Structure Possible	Largest Storm Conveyed (Without Overtopping)	Design Storm	Clearance (m)	FB (m)	Pass MTO Criteria (Y/N)	Largest Storm Conveyed (Without Overtopping)	Clearance (m)	FB (m)	Pass MTO Criteria (Y/N)	Overtopping Depth (m)	Velocity	Depth x Velocity	Pass MNR Criteria (Y/N)	Overtopping Depth (m)	Velocity	Depth x Velocity	Pass MNR Criteria (Y/N)
Wedgewood Creek	Reach 1 DS	Urban Arterial	Lakeshore	3.8 x 1.9 CONSPAN Arch	14.6 x 3.05 CONSPAN Arch	2	50	-1.58	-0.54	N	25.00	-1.19	-0.15	N	0.54	1.00	0.54	N	0.27	1.32	0.36	Y
	Reach 1 DS	Urban Arterial	Warren Dr. Park	4.2 x 1.5 CONSPAN Arch	7.3 x 1.52 CONSPAN Arch	N/A	50	-0.53	-0.44	N	N/A	-0.47	-0.38	N	0.44	0.80	0.35	Y	0.38	0.83	0.32	Y
	Reach 1 DS	Urban Arterial	Wedgewood Dr	5.5 x 1.5 CONSPAN Arch	7.3 x 1.52 CONSPAN Arch	N/A	50	-0.37	-0.49	N	2.00	-0.32	-0.44	N	0.49	0.78	0.38	Y	0.44	0.80	0.35	Y
	Reach 1 DS	Urban Arterial	Devon Rd	Twin 4.3 x 2 CONSPAN Arch	N/A	50	100	-0.71	-0.01	N	100.00	-0.71	-0.01	N	0.01	0.22	0.00	Y	0.01	0.22	0.00	Y
	Reach 4	Urban Arterial	Drummond Rd	1.7 x 1.15 CONSPAN Arch	N/A	N/A	50	-2.07	-0.32	N	N/A	-2.07	-0.32	N	0.32	0.69	0.22	Y	0.32	0.69	0.22	Y
	Reach 2	Urban Arterial	Cumnock Crescent	0.6 m diameter CSP	N/A	N/A	50	-1.76	-0.31	N	N/A	-1.76	-0.31	N	0.31	0.62	0.19	Y	0.31	0.62	0.19	Y
	Reach 2	Urban Arterial	Morrison Rd	1.2 m diameter CSP	N/A	5	50	-0.77	-0.13	N	5.00	-0.77	-0.13	N	0.13	0.41	0.05	Y	0.13	0.41	0.05	Y
	Reach 3	Urban Arterial	Morrison Rd Conc. Bridge	5.7 x 1.5 Box	6.4 x 1.9 Box	100	50	0.06	1.04	N	100.00	0.06	1.04	N	N/A	N/A	N/A	Y	N/A	N/A	N/A	Y
	Reach 3	Urban Arterial	Cornwall Road	5.7 x 1.5 Box	N/A	100	50	0.00	0.45	N	100.00	0.00	0.45	N	N/A	N/A	N/A	Y	N/A	N/A	N/A	Y
	Reach 1 US	Urban Arterial	Duncan Rd	2.45 x 1.8 CONSPAN Arch	N/A	N/A	50	-1.67	-0.57	N	N/A	-1.67	-0.57	N	0.57	0.99	0.56	N	0.57	1.02	0.58	N
	Reach 1 US	Urban Arterial	Rd. N of Pond (Cornwall Rd)	Twin 1.75 x 1.2 Box	7.3 x 1.52 CONSPAN Arch	N/A	50	-1.08	-0.58	N	5.00	-0.92	-0.42	N	0.58	0.95	0.55	N	0.46	0.98	0.45	N
	Reach 1 US	Urban Arterial	CN Railway	3.1 x 2 Box	N/A	2	50	-2.48	-1.04	N	2.00	-2.48	-1.04	N	1.04	1.17	1.22	N	1.04	1.17	1.22	N
	Reach 1 US	Urban Arterial	CN Railway 1993 Culv	3.1 x 2 Box	N/A	2	50	-1.40	-0.43	N	2.00	-1.40	-0.43	N	0.43	1.25	0.54	N	0.43	1.25	0.54	N
	Reach 1 US	Urban Arterial	Royal Windsor Dr	1.9 x 1.1 Box	N/A	N/A	50	-1.04	-0.94	N	N/A	-1.04	-0.94	N	0.94	1.25	1.18	N	0.94	1.25	1.18	N

Appendix F
Detailed Hydraulic Results

Appendix G
Erosion Threshold Assessment for
Midtown Area

Erosion Threshold Analysis DRAFT
Lower Morrison and Lower Wedgewood Creeks
Town of Oakville



Submitted to:

Wood Environment & Infrastructure Solutions Inc.
3450 Harvester Road, Suite 100
Burlington, ON L7N 3W5

January 22, 2019



Erosion Threshold Analysis

Lower Morrison and Lower Wedgewood Creeks

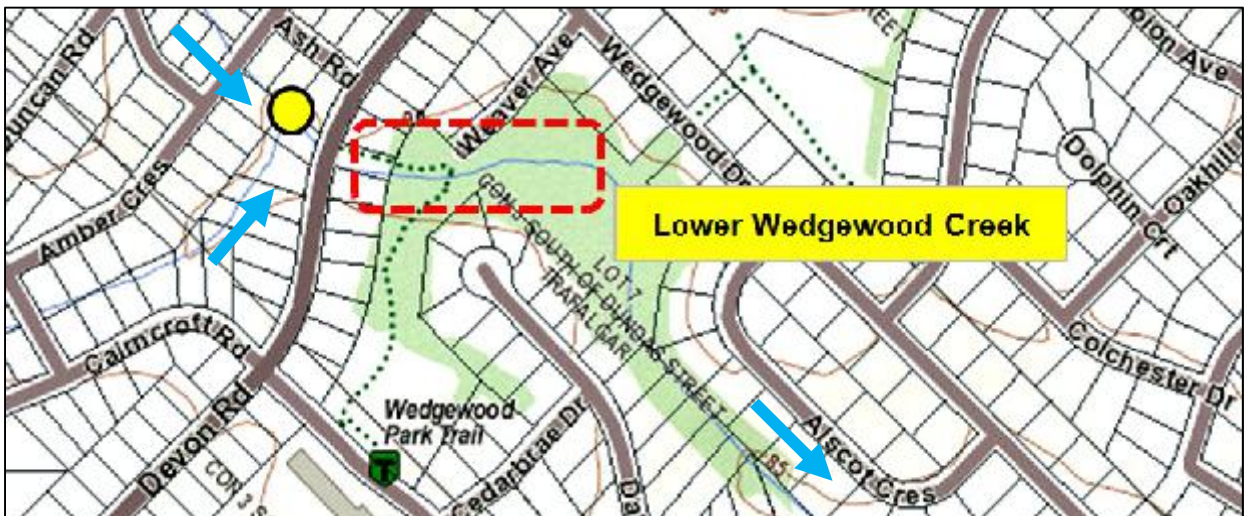
Town of Oakville

Erosion threshold analysis has been undertaken for Lower Morrison and Lower Wedgewood Creeks as support for midtown Oakville stormwater and flood mitigation studies. The selected locations for threshold analysis are based on existing catchment modelling nodes and were predetermined in discussion between Conservation Halton, Wood Environment & Infrastructure, and Town of Oakville staff. Study site locations are shown in **Figures 1 and 2**.

Figure 1: Lower Morrison Creek study reaches



Figure 2: Lower Wedgewood Creek study reach



Analysis has been done based on field review of channel sensitivity and detailed cross-section surveys of the selected locations. Field measurements were used for erosion threshold modelling and results have been summarized for consideration in stormwater management scenarios.

Study Area Summary

The respective drainage area and stream order for each study reach is:

Lower Morrison Creek upstream reach, 70ha, 1st order

Lower Morrison Creek downstream reach, 180ha, 2nd order

Lower Wedgewood Creek, 260ha, 2nd order

The study reaches fall within the Iroquois Plain physiographic region, with each catchment consisting of a diverse mix of urban land uses including low density residential, commercial, industrial, rail corridor, and highway corridor. Each specific study site exists within a mix of residential and linear park land uses. Riparian areas are defined by moderate to high density groundcover and lowland shrub thicket to mature forest canopy. The upstream reach of Lower Morrison Creek flows through a heterogeneous mix of sediment types biased to smaller gravel, sand and cohesive clay-silt. The downstream reach of Lower Morrison Creek and the reach of Lower Wedgewood Creek have made shallow incision contact with underlying sedimentary bedrock and these sites are biased to gravel and cobble mixes of weathered shale and limestone. These reaches have characteristically wider and shallower bankfull channel definition than the lower width to depth ratio of the upper reach of Lower Morrison Creek. The wide shallow conditions and bed pavement result in relatively good channel stability in the downstream reach of Lower Morrison and in Lower Wedgewood Creek. By comparison the upstream reach of Lower Morrison Creek is experiencing combined incision and widening through the finer sediments and displays lower stability under existing conditions.

Erosion Threshold Analysis

Erosion threshold analysis proceeded as a detailed confirmation exercise of the observed channel stability conditions. Modelling analysis was undertaken using the five representative cross-section surveys made over approximately 50m of channel length per location. Backwater influences caused by organic debris were avoided. Channel forming flow lines, fallen and matted vegetation lines where visible, and well defined sediment stain lines were used as field indicators to identify cross-section width under a variety of conditions. Channel geometry was measured laterally at each cross-section

and the longitudinal profile was shot and subsequently compared to topographic mapping. Channel bed substrates were measured through random-step Wolman pebble counts and recorded using the Wentworth sediment distribution scale. Geomorphic open channel flow models were created for each cross-section location. Each model required input of channel bed substrate data, cross-section dimensions, gradient, and bank geometry. Model calculation was done for a range of hydraulic geometry, flow condition, and sediment transport parameters. Erosion indicators and thresholds were reviewed from each model. **Table 1** presents the threshold criteria used for this analysis based on small watercourse channel typology which displays some influence of vegetation control.

Table 1: Critical stability threshold criteria

	low flow morphology		
	riffle	run	pool / glide
semi-alluvial firm to dense till channels	D ₈₄ pavement	D ₈₄ pavement or vegetation control*	D ₁₀₀ pavement or vegetation control*
alluvial cohesionless channels	D ₅₀ pavement	D ₅₀ pavement or vegetation control*	D ₈₄ pavement or vegetation control*

*vegetation control criteria varies depending on vegetation type and density
note: step-pool and cascade-step-pool channels require case by case study

The second row criteria are applied conservatively for this study case, based on soil and sediment conditions, and channel type. Conservative vegetation control criteria are identified as 40N m^{-2} for shear stress and 1.2m s^{-1} for channel velocity. Higher thresholds for vegetation control are common, approximately 80N m^{-2} and 1.8m s^{-1} , and viable under very high levels of vegetative encroachment. Channel run and pool sections that have partial vegetation control but are not judged to be fully protected are deemed to have thresholds of approximately $0.4\text{-}0.7\text{m s}^{-1}$ for velocities acting on pure sand to graded sediments, with shear stress values approximately $10\text{-}15\text{N m}^{-1}$ being acceptable when large volumes of sub coarse sand sized sediment forms both the channel pavement and subpavement (individual sand particle size values would be too low to be practical). More cohesive gradations of silt-clay or gradations that include some gravel with sand are deemed to have thresholds of approximately 30N m^{-2} and 0.8m s^{-1} respectively for shear stress and velocity (ranges summarized in Fischenich 2001). Several references vary on specific erosion threshold levels for sediment sizing, mixes of sizes, vegetative influence, entrenchment risk, and duration of flow effects, but notwithstanding the multiplicity of methods, the noted targets have proven practical over several similar studies and modelling efforts.

Subsequent checks were done to determine if a critical stability threshold discharge is reached under lower flow rates and stages than the channel forming or bankfull flow. Typically, the bankfull or active channel flow might not be dynamically stable, but a sub-bankfull rate is stable based on an integration of the testing criteria described above. The threshold is a target discharge representing a reach based average point at which channel instability is deemed to begin with rising flow stage and rising discharge, and conversely when instability stops with falling flow stage and falling discharge. This discharge then becomes the comparative flow regime target for detailed analysis of SWM hydrology.

The specific iterations in cross-section models were made to achieve velocity and tractive force levels below or improved towards the conservative range for vegetation control of channel banks, at velocity levels for D50 bed stability with at least a 1.0 ratio of critical velocity to boundary velocity, and at stable tractive force levels for D50 bed material within 5mm +/- . Stream power values were reviewed to confirm stable ranges under 400 watts m⁻¹ (Sear et. al. 2003).

Detailed results of stable conditions modelling are appended after the existing conditions bankfull flow modelling. A summary model of the erosion threshold results is included after the stability test cross-section models. This model shows key variables between the respective bankfull and stability conditions. The summary model includes the breakdown of three conditions of dynamic stability, cautionary dynamic stability, and potential instability. The adjustments necessary to achieve stability reflect bump ups from cautionary dynamic stability to full dynamic stability and from unstable to cautionary dynamic stability or full dynamic stability, with an averaged final condition judged to be a realistic stable regime in the watercourse.

The modelling exercise confirmed that the downstream reach of Lower Morrison Creek is deemed stable under existing bankfull flows while each of the upstream reach of Lower Morrison and the reach of Lower Wedgewood required adjustment to achieve stability. **Table 2** shows the determined bankfull or channel forming flow and the dynamic stability flow adjustment, specifically for Lower Morrison downstream and Lower Wedgewood.

Table 2: Cross-section results summary

	bankfull Q cms	stability Q cms
Lower Morrison Creek upstream	0.89	0.24
Lower Morrison Creek downstream	1.41	1.41
Lower Wedgewood Creek	1.70	1.47

The upstream reach of Lower Morrison required stage adjustments of 12 to 16cm to enhance particle size based stability. Specifically, the dynamic stability target of velocity equal to 0.8m s^{-1} , as described above for cohesive clay-silt dominant gradations that include some larger particles, was used as the primary check. Given the relative small size of the channel, the reductions in stage result in a significant percent change in flow rate with the stability flow being 27% of bankfull.

The stage adjustments made for two sections on Lower Wedgewood Creek were 6cm and 7cm. These changes improved the particle based stability at section 4 and the vegetation control stability at section 5. The adjusted stability flow rate is 86% of the bankfull rate, representing only a moderate difference.

Conclusions

Erosion threshold analysis has been undertaken for Lower Morrison and Lower Wedgewood Creeks as support for parallel studies of stormwater and flood mitigation in the midtown Oakville area. Field measurements used for erosion threshold modelling have produced results for consideration in stormwater management scenarios.

The methods and results presented in this report do not address future potential erosion caused by unforeseen circumstances (e.g. SWM pond failure, culvert failures, major debris jam scour, beaver dam construction/breaching, or combinations thereof, etc.). The results presented here are also contingent on long term preservation and maintenance of natural vegetation conditions within the respective corridors. The results are also contingent on maintenance of upstream drainage characteristics that do not adversely modify future flow regime.

Prepared by,

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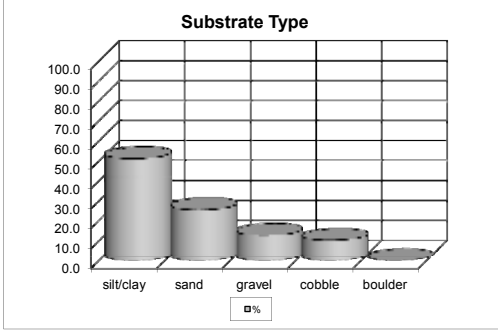
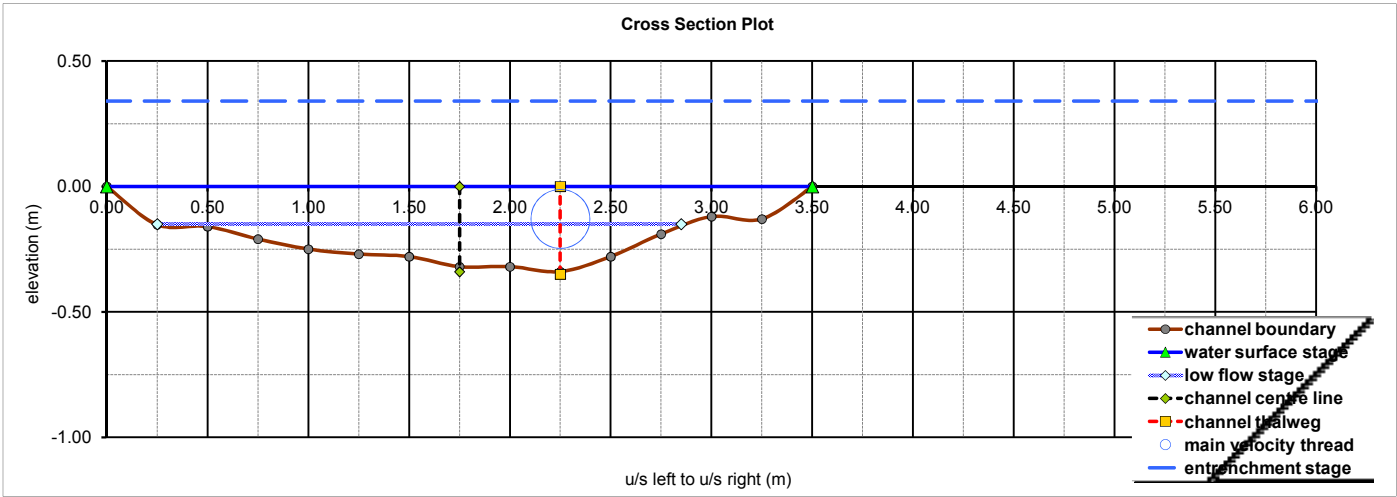
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**Lower Morrison Creek
Upstream Reach**

Bankfull Conditions



Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 1 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.76
step	R (m) 0.21
riffle	TW (m) 3.50
run	WP (m) 3.62
glide	max d (m) 0.34
pool	mean d (m) 0.22
thalweg out of phase	E _s (Limerinos) (m) [+]

Hydraulic Roughness	Hydraulic Ratios
rr R/D ₈₄ 8.35	ER max d 4.29
ff V mean/V* 7.69	r _c / TW
ff D ₈₄ 8.17	TW / L _{f,w} 1.35
ff mean 7.93	TW/max d 10.3
ROUGH BED	TW/mean d 16.2

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.001	0.04	YES	YES	YES	YES
V _c (m s ⁻¹)	0.076	D ₅₀ 0.003	0.09	YES	YES	YES	YES
D ₈₄	0.733	D ₈₄ 23.38		NO	NO	NO	NO

Section Data		ER stations L / R	-5.00	10.00	TW ck
ER _e (m)	0.34	WS stations L / R	0.00	3.50	3.50
WS _e (m)	0.000	Lf stations L / R	0.25	2.85	
L _{f,e} (m)	-0.150	E _s sta. (Limerinos) L / R			
W _{fp} (m)	15.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.35	2.25	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0140				

Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}	T _*	737.9	492.0	1.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)				
B3	0.0018	0.0019	salutation	YES	YES	NO
C3	0.0002	0.0003	rolling	YES	YES	YES
C4	0.0062	0.0067	∅	NO	NO	NO

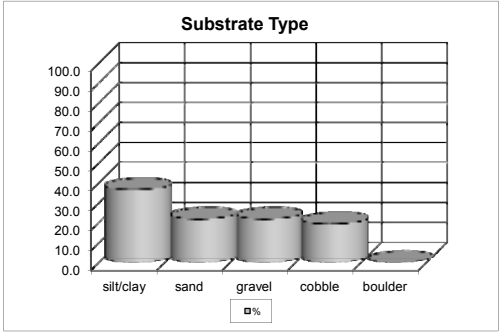
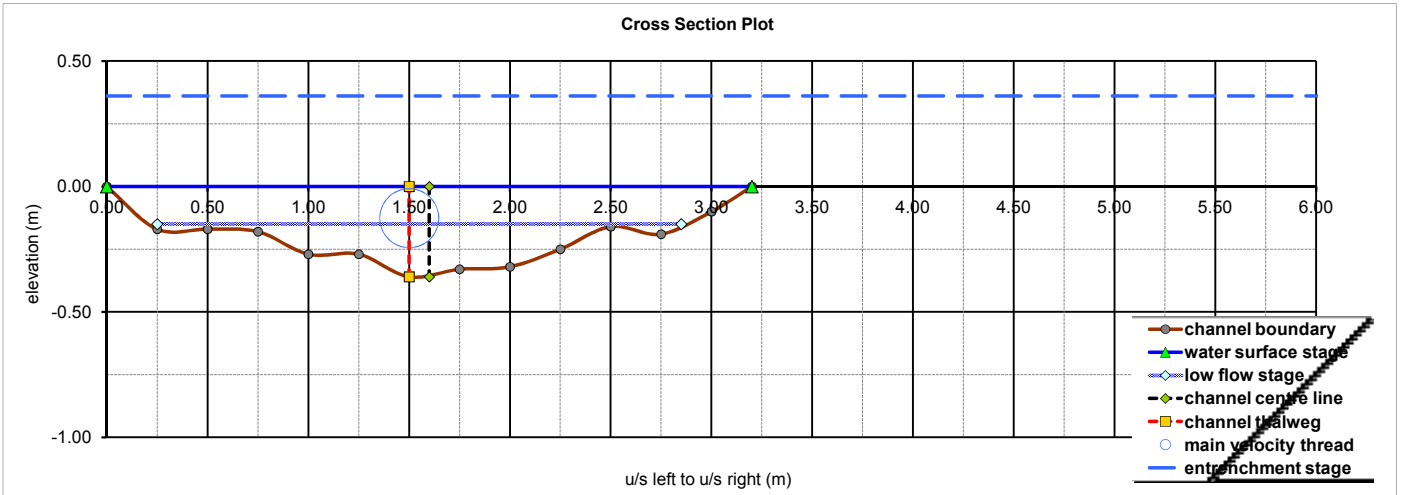
Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.02	0.04	0.06	25.00	160.00
Stability Design Targets (mm)					24.25	155.20
τ _{cr} (N m ⁻²)					24.25	155.20
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	0.894	Q (cms)	Q (cms)
V (m s ⁻¹)	1.18	V (m s ⁻¹)	V (m s ⁻¹)
n	0.035	n	n
Fr	0.81	Fr	Fr
D _c rectangular (m)	0.19	D _c rectangular (m)	D _c rectangular (m)
D _c trapezoidal (m)	0.31	D _c trapezoidal (m)	D _c trapezoidal (m)
D _c triangular (m)	0.45	D _c triangular (m)	D _c triangular (m)
D _c parabolic (m)	0.30	D _c parabolic (m)	D _c parabolic (m)
D _c mean (m)	0.31	D _c mean (m)	D _c mean (m)
flow type	SUBCRITICAL	flow type	flow type
Ω (watts m ⁻¹)	122.64	Ω (watts m ⁻¹)	Ω (watts m ⁻¹)
ω _a (watts m ⁻²)	33.88	ω _a (watts m ⁻²)	ω _a (watts m ⁻²)
ω _s /TW (watts m ⁻¹)	9.68	ω _s /TW (watts m ⁻¹)	ω _s /TW (watts m ⁻¹)
Re*	0.1	Re*	Re*
Re	216599	Re	Re
turbulence	LOW	turbulence	turbulence

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	2.92	H _b (m)		
τ _{calc} (N m ⁻²)	28.63	B _{f,d} (m)		
τ _{crit} (gr-co) (mm)	29.52	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.04	H _b /B _{f,d}		
D ₈₄ V _c (vcs +) (m s ⁻¹)	0.78	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
51.3	25.6	12.8	10.3	0.0

Project: Erosion Threshold Analysis
Block 60 East MESP
Lower Morrison Creek - upstream Section 2 - - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.69
step	R (m) 0.21
riffle	TW (m) 3.20
run	WP (m) 3.35
glide	max d (m) 0.36
pool	mean d (m) 0.22
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.003	0.09	YES	YES	YES	YES
V _c (m s ⁻¹)	0.084	D ₅₀ 0.071	2.07	NO	NO	YES	YES
		D ₈₄ 1.353	39.44	NO	NO	NO	NO

Section Data		ER stations L / R	-5.00	10.00	TW ck
ER _e (m)	0.36	WS stations L / R	0.00	3.20	3.20
WS _e (m)	0.000	Lf stations L / R	0.25	2.85	
Lf _e (m)	-0.150	E _s sta. (Limerinos) L / R			
W _{fp} (m)	15.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.36	1.50	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0170				

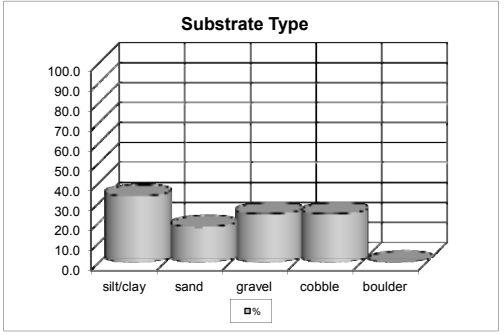
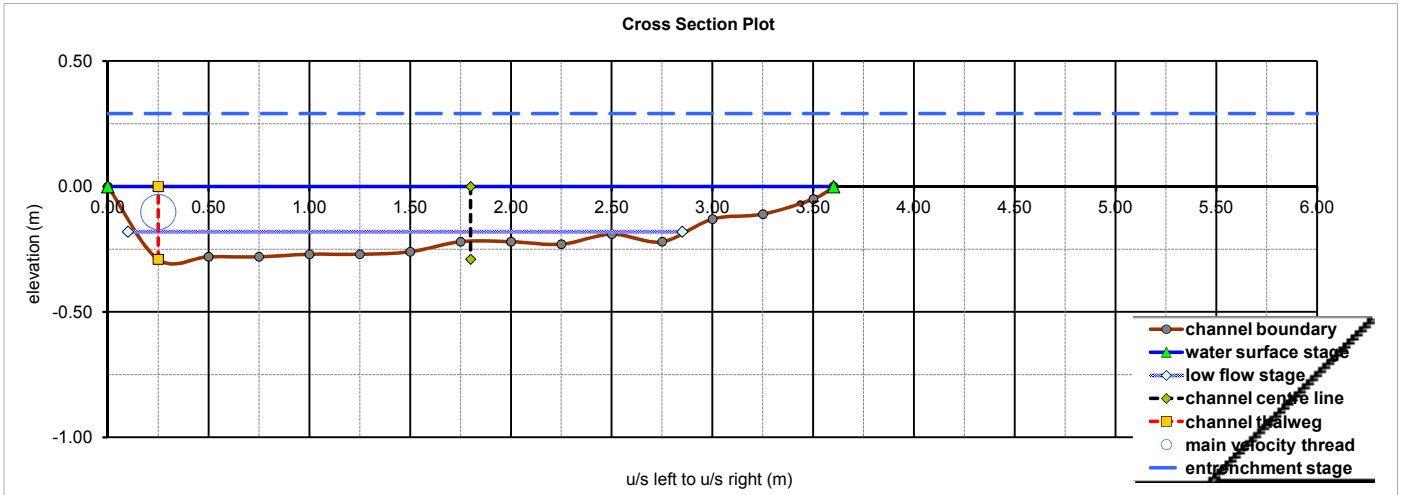
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}	T _*	589.2	70.7	0.4
type	(kg sec ⁻¹)	(kg sec ⁻¹)				
B3	0.0018	0.0017	saltnation	YES	YES	NO
C3	0.0002	0.0001	rolling	YES	YES	NO
C4	0.0062	0.0055	∅	NO	NO	YES

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.03	0.06	0.50	85.00	190.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				82.45	184.30	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Flow Regime
Q (cms)	0.891	Q (cms)	Q (cms)
V (m s ⁻¹)	1.29	V (m s ⁻¹)	V (m s ⁻¹)
n	0.035	n	n
Fr	0.89	Fr	Fr
D _c rectangular (m)	0.20	D _c rectangular (m)	D _c rectangular (m)
D _c trapezoidal (m)	0.32	D _c trapezoidal (m)	D _c trapezoidal (m)
D _c triangular (m)	0.45	D _c triangular (m)	D _c triangular (m)
D _c parabolic (m)	0.30	D _c parabolic (m)	D _c parabolic (m)
D _c mean (m)	0.32	D _c mean (m)	D _c mean (m)
flow type	SUBCRITICAL	flow type	flow type
Ω (watts m ⁻¹)	148.50	Ω (watts m ⁻¹)	Ω (watts m ⁻¹)
ω _a (watts m ⁻²)	44.30	ω _a (watts m ⁻²)	ω _a (watts m ⁻²)
ω _w /TW (watts m ⁻¹)	13.84	ω _w /TW (watts m ⁻¹)	ω _w /TW (watts m ⁻¹)
Re*	0.7	Re*	Re*
Re	233235	Re	Re
turbulence	LOW	turbulence	turbulence

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	3.50	H _b (m)		
τ _{calc} (N m ⁻²)	34.29	Bf _d (m)		
τ _{crit} (gr-co) (mm)	35.35	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.11	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.43	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 3 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.75
step	R (m) 0.20
riffle	TW (m) 3.60
run	WP (m) 3.78
glide	max d (m) 0.29
pool	mean d (m) 0.21
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.003	0.09	YES	YES	YES	YES
V _c (m s ⁻¹)	0.077	D ₅₀ 0.126	3.98	NO	NO	NO	YES
		D ₈₄ 1.641	51.80	NO	NO	NO	NO

Section Data		ER stations L / R	-5.00	10.00	TW ck
ER _e (m)	0.29	WS stations L / R	0.00	3.60	3.60
WS _e (m)	0.000	Lf stations L / R	0.10	2.85	
Lf _e (m)	-0.180	E _s sta. (Limerinos) L / R			
W _{fp} (m)	15.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.29	0.25	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0150				

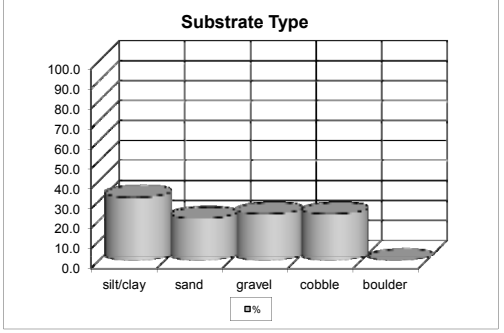
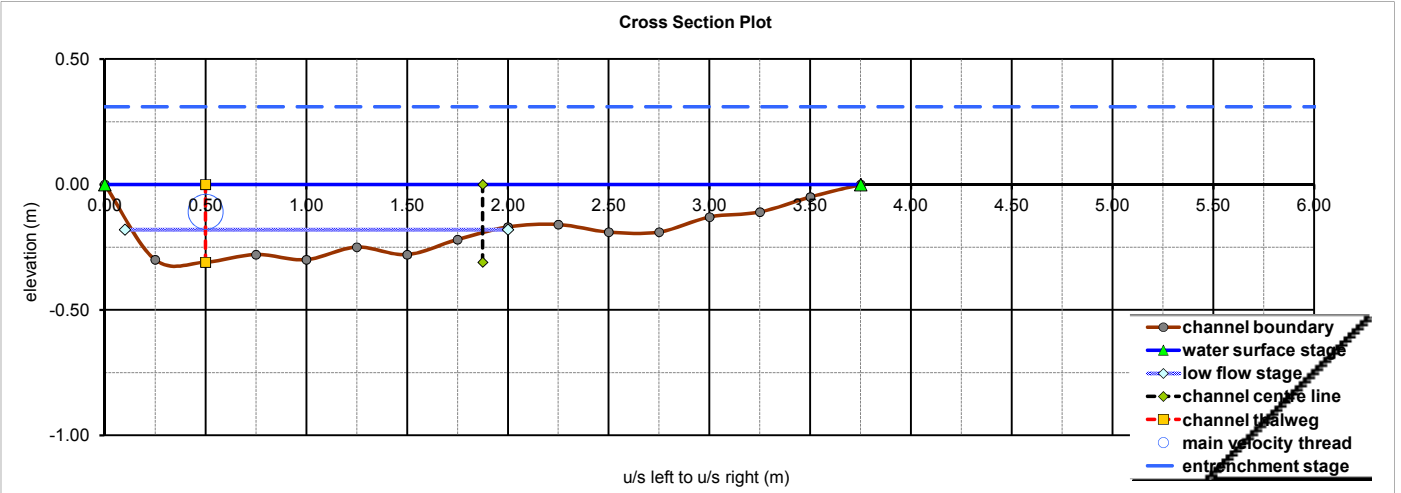
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄	
Rosgen	Q _{sb}	Q _{sb}		T _*	502.3	30.1	0.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)					
B3	0.0018	0.0016	salutation	YES	YES	NO	
C3	0.0002	0.0001	rolling	YES	YES	NO	
C4	0.0062	0.0050	∅	NO	NO	YES	

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.03	0.06	1.00	125.00	170.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				121.25	164.90	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	0.891	Q (cms)	Q (cms)
V (m s ⁻¹)	1.19	V (m s ⁻¹)	V (m s ⁻¹)
n	0.035	n	n
Fr	0.83	Fr	Fr
D _c rectangular (m)	0.19	D _c rectangular (m)	D _c rectangular (m)
D _c trapezoidal (m)	0.31	D _c trapezoidal (m)	D _c trapezoidal (m)
D _c triangular (m)	0.45	D _c triangular (m)	D _c triangular (m)
D _c parabolic (m)	0.30	D _c parabolic (m)	D _c parabolic (m)
D _c mean (m)	0.31	D _c mean (m)	D _c mean (m)
flow type	SUBCRITICAL	flow type	flow type
Ω (watts m ⁻¹)	130.96	Ω (watts m ⁻¹)	Ω (watts m ⁻¹)
ω _a (watts m ⁻²)	34.67	ω _a (watts m ⁻²)	ω _a (watts m ⁻²)
ω _s /TW (watts m ⁻¹)	9.63	ω _s /TW (watts m ⁻¹)	ω _s /TW (watts m ⁻¹)
Re*	1.5	Re*	Re*
Re	206895	Re	Re
turbulence	LOW	turbulence	turbulence

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	2.98	H _b (m)		
τ _{calc} (N m ⁻²)	29.24	Bf _d (m)		
τ D _{crit} (gr-co) (mm)	30.14	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.16	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.73	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 4 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.74
step	R (m) 0.19
riffle	TW (m) 3.75
run	WP (m) 3.93
glide	max d (m) 0.31
pool	mean d (m) 0.20
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)		P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀	0.003	0.09	YES	YES	YES	YES
V _c (m s ⁻¹)	0.080	D ₅₀	0.196	6.00	NO	NO	NO	YES
		D ₈₄	1.431	43.77	NO	NO	NO	NO

Section Data		ER stations L / R		WS stations L / R		Lf stations L / R		E _s sta. (Limerinos) L / R		E _s sta. (Strickler) L / R		T _e (m) T _{o/s} (m)	
ER _e (m)	0.31	-5.00	10.00										
WS _e (m)	0.000	0.00	3.75										
Lf _e (m)	-0.180	0.10	2.00										
W _{fp} (m)	15.00												
r _c (m)													
Z													
E _s (m m ⁻¹)	0.0170												

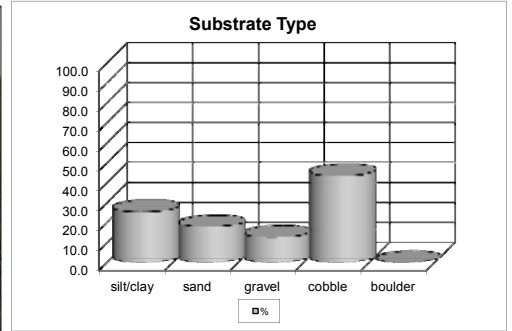
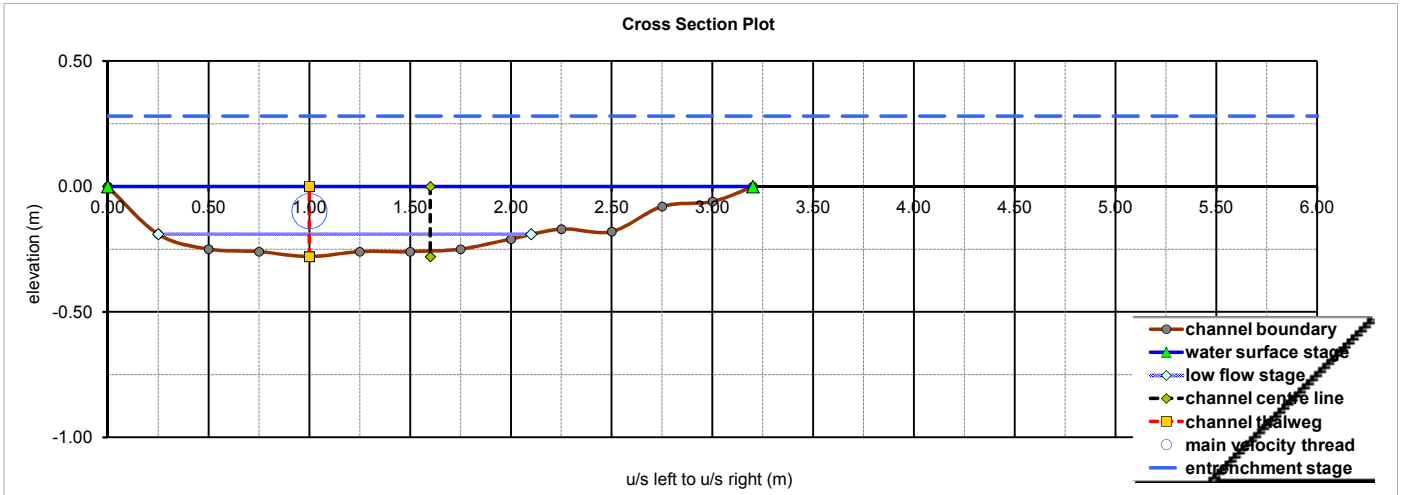
Bedload Transport Data		Strickler Q		Limerinos Q		Rosgen		D ₃₀		D ₅₀		D ₈₄	
rr R/D ₈₄	1.97	Q _{sb}	Q _{sb}	T _*	534.8	16.0	0.3	YES	YES	NO			
ff V mean/V*	5.90	(kg sec ⁻¹)	(kg sec ⁻¹)	rolling	YES	YES	NO	YES	YES	NO			
ff D ₈₄	4.62	B3	0.0018	0.0017	rolling	YES	YES	NO	NO	NO			
ff mean	5.26	C3	0.0002	0.0001	rolling	YES	YES	NO	NO	NO			
ROUGH BED		C4	0.0062	0.0053	∅	NO	NO	YES	NO	YES			

Substrate Gradation		D ₁₅		D ₅₀		D ₈₄		D ₁₀₀	
Existing Conditions (mm)		0.03	0.06	2.00	95.00	160.00			
Stability Design Targets (mm)									
τ _{cr} (N m ⁻²)				92.15	155.20				
high turbulence - angular (mm)									
high turbulence - rounded (mm)									
low turbulence - angular (mm)									
low turbulence - rounded (mm)									

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	3.18	H _b (m)			
τ _{calc} (N m ⁻²)	31.13	Bf _d (m)			
τ D _{crit} (gr-co) (mm)	32.09	RDp (m)			
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.22	H _b /Bf _d			
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.51	RDp/H _b			
		RDn (%)			
		BA (°)			
		BFP (%)			

Flow Regime		Flow Regime	
Strickler method	Q (cms) 0.890	Limerinos method	Q (cms)
V (m s ⁻¹)	1.21	V (m s ⁻¹)	
n	0.035	n	
Fr	0.87	Fr	
D _c rectangular (m)	0.18	D _c rectangular (m)	
D _c trapezoidal (m)	0.31	D _c trapezoidal (m)	
D _c triangular (m)	0.45	D _c triangular (m)	
D _c parabolic (m)	0.30	D _c parabolic (m)	
D _c mean (m)	0.31	D _c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m ⁻¹)	148.25	Ω (watts m ⁻¹)	
ω _a (watts m ⁻²)	37.68	ω _a (watts m ⁻²)	
ω _g /TW (watts m ⁻¹)	10.05	ω _g /TW (watts m ⁻¹)	
Re*	3.0	Re*	
Re	198413	Re	
turbulence	LOW	turbulence	

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 5 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.61
step	R (m) 0.18
riffle	TW (m) 3.20
run	WP (m) 3.31
glide	max d (m) 0.28
pool	mean d (m) 0.19
thalweg out of phase	E _s (Limerinos) (m) [+]

Hydraulic Roughness	Hydraulic Ratios
rr R/D ₈₄ 1.48	ER max d 4.69
ff V mean/V* 5.53	r _c / TW
ff D ₈₄ 3.88	TW / Lf _w 1.73
ff mean 4.71	TW/max d 11.4
ROUGH BED	TW/mean d 16.8

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.032	0.81	NO	YES	YES	YES
V _c (m s ⁻¹)	0.096	D ₅₀ 0.803	20.38	NO	NO	NO	NO
		D ₈₄ 1.641	41.64	NO	NO	NO	NO

Section Data		ER stations L / R	-5.00	10.00	TW ck
ER _e (m)	0.28	WS stations L / R	0.00	3.20	3.20
WS _e (m)	0.000	Lf stations L / R	0.25	2.10	
Lf _e (m)	-0.190	E _s sta. (Limerinos) L / R			
W _{fp} (m)	15.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.28	1.00	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0250				

Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}	T _*	186.6	1.6	0.4
type	(kg sec ⁻¹)	(kg sec ⁻¹)				
B3	0.0018	0.0016	salton	YES	NO	NO
C3	0.0002	0.0001	rolling	YES	YES	NO
C4	0.0062	0.0049	∅	NO	NO	YES

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.05	0.25	30.00	125.00	190.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				29.10	121.25	184.30
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	0.890	Q (cms)	Q (cms)
V (m s ⁻¹)	1.46	V (m s ⁻¹)	V (m s ⁻¹)
n	0.035	n	n
Fr	1.06	Fr	Fr
D _c rectangular (m)	0.20	D _c rectangular (m)	D _c rectangular (m)
D _c trapezoidal (m)	0.32	D _c trapezoidal (m)	D _c trapezoidal (m)
D _c triangular (m)	0.45	D _c triangular (m)	D _c triangular (m)
D _c parabolic (m)	0.30	D _c parabolic (m)	D _c parabolic (m)
D _c mean (m)	0.32	D _c mean (m)	D _c mean (m)
flow type	SUPERCritical	flow type	flow type
Ω (watts m ⁻¹)	218.07	Ω (watts m ⁻¹)	Ω (watts m ⁻¹)
ω _a (watts m ⁻²)	65.91	ω _a (watts m ⁻²)	ω _a (watts m ⁻²)
ω _s /TW (watts m ⁻¹)	20.60	ω _s /TW (watts m ⁻¹)	ω _s /TW (watts m ⁻¹)
Re*	44.5	Re*	Re*
Re	235991	Re	Re
turbulence	HIGH	turbulence	turbulence

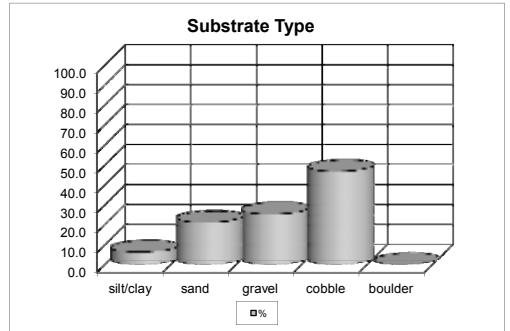
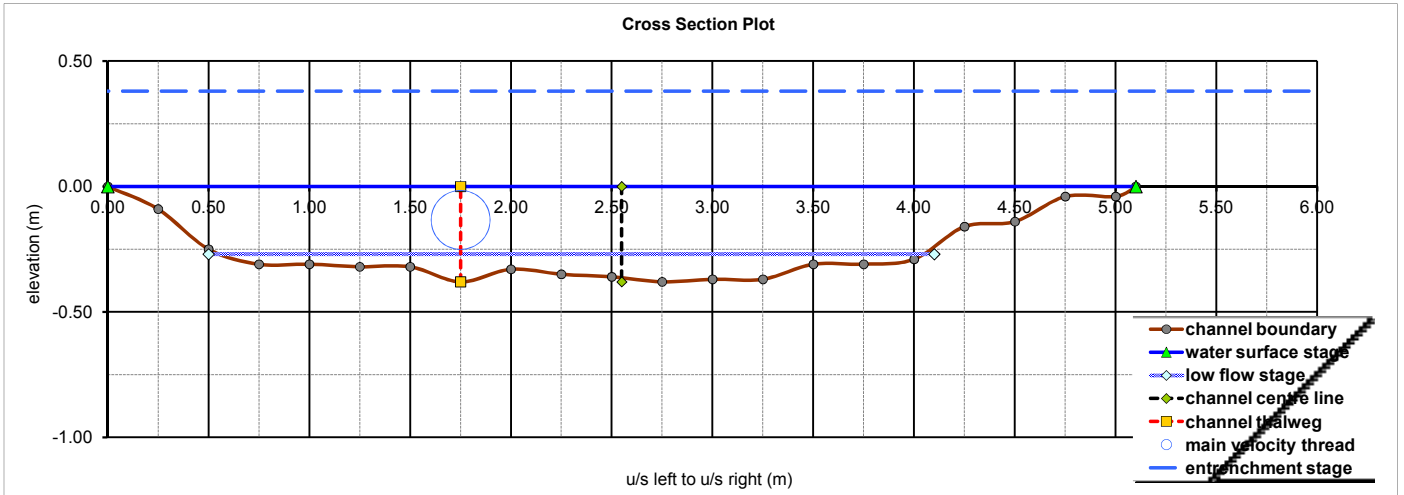
Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	4.62	H _b (m)		
τ _{calc} (N m ⁻²)	45.25	Bf _d (m)		
τ D _{crit} (gr-co) (mm)	46.64	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.85	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.73	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

**Lower Morrison Creek
Downstream Reach**

Bankfull Conditions



Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - downstream Section 1 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.35
step	R (m) 0.26
riffle	TW (m) 5.10
run	WP (m) 5.25
glide	max d (m) 0.38
pool	mean d (m) 0.27
thalweg out of phase	E _s (Limerinos) (m) [+]
Hydraulic Roughness	E _s (Strickler) (m) [+]
rr R/D ₈₄ 2.06	Hydraulic Ratios
ff V mean/V* 6.14	ER max d 2.55
ff D ₈₄ 4.70	r _c / TW
ff mean 5.42	TW / Lf _w 1.42
ROUGH BED	TW/max d 13.4
	TW/mean d 19.2

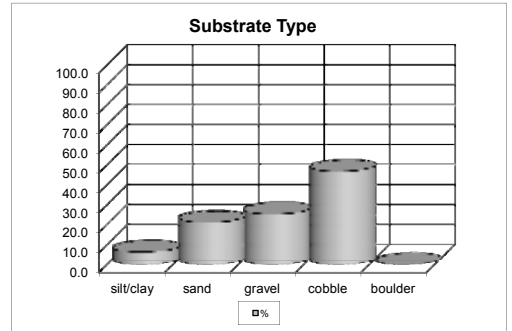
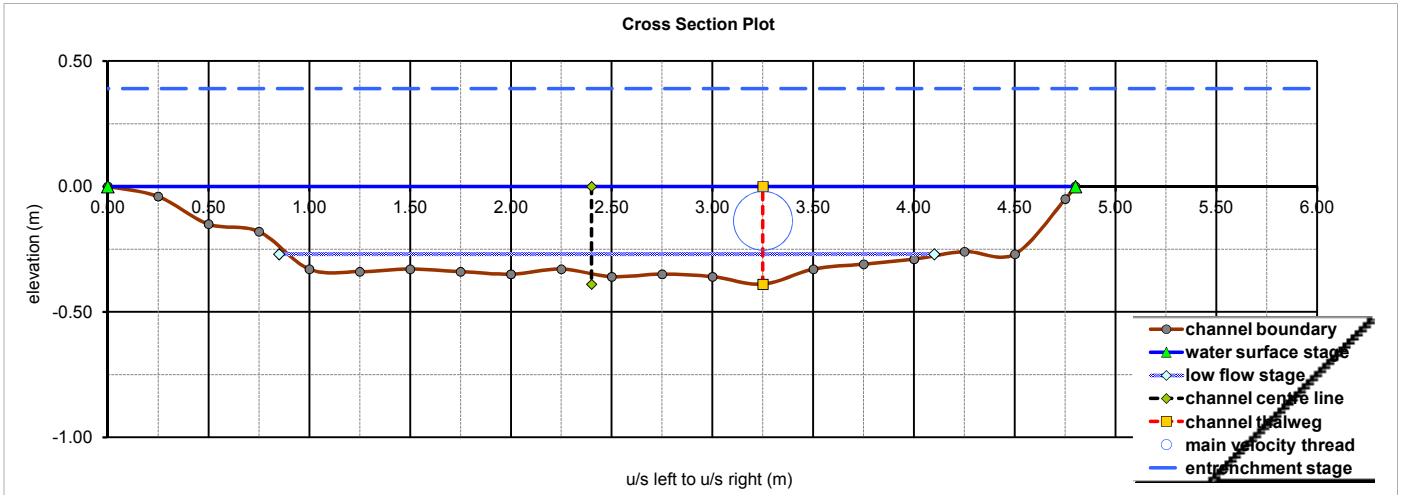
Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.385	14.43	NO	NO	NO	NO
V _c (m s ⁻¹)	0.065	D ₅₀ 1.089	40.80	NO	NO	NO	NO
		D ₈₄ 1.641	61.52	NO	NO	NO	NO

Section Data		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
ER _e (m)	0.38	0.20	7.00	55.00	125.00	170.00
WS _e (m)	0.000	Stability Design Targets (mm)				
Lf _e (m)	-0.270	τ _{cr} (N m ⁻²)				
W _{fp} (m)	13.00	high turbulence - angular (mm)				
r _c (m)		high turbulence - rounded (mm)				
z		low turbulence - angular (mm)				
E _s (m m ⁻¹)	0.0082	low turbulence - rounded (mm)				

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	2.12	H _b (m)		Bf _d (m)	
τ _{calc} (N m ⁻²)	20.73	RDp (m)		H _r /Bf _d	
τ D _{crit} (gr-co) (mm)	21.37	RDp/H _b		RDn (%)	
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.15	BA (°)		BFP (%)	
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.73				

Bedload Transport Data		Flow Regime		
Strickler Q	Limerinos Q	Strickler method		Flow Regime
Rosgen	Q _{sb}	Q (cms)	Q (cms)	Ω (watts m ⁻¹)
type	(kg sec ⁻¹)	V (m s ⁻¹)	V (m s ⁻¹)	ω _a (watts m ⁻²)
B3	0.0021	n	n	ω _a /TW (watts m ⁻¹)
C3	0.0006	Fr	Fr	
C4	0.0077	D _c rectangular (m)	D _c rectangular (m)	
		D _c trapezoidal (m)	D _c trapezoidal (m)	
		D _c triangular (m)	D _c triangular (m)	
		D _c parabolic (m)	D _c parabolic (m)	
		D _c mean (m)	D _c mean (m)	
		flow type	flow type	
		Ω (watts m ⁻¹)	Ω (watts m ⁻¹)	
		ω _a (watts m ⁻²)	ω _a (watts m ⁻²)	
		ω _a /TW (watts m ⁻¹)	ω _a /TW (watts m ⁻¹)	
		Re*	Re*	
		Re	Re	
		turbulence	turbulence	

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - downstream Section 2 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.34
step	R (m) 0.27
riffle	TW (m) 4.80
run	WP (m) 4.99
glide	max d (m) 0.39
pool	mean d (m) 0.28
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.385	14.35	NO	NO	NO	NO
V _c (m s ⁻¹)	0.065	D ₅₀ 1.089	40.56	NO	NO	NO	NO
		D ₈₄ 1.641	61.16	NO	NO	NO	NO

Section Data		ER stations L / R	-3.00	10.00	TW ck
ER _e (m)	0.39	WS stations L / R	0.00	4.80	4.80
WS _e (m)	0.000	Lf stations L / R	0.85	4.10	
Lf _e (m)	-0.270	E _s sta. (Limerinos) L / R			
W _{fp} (m)	13.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.39	3.25	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0080				

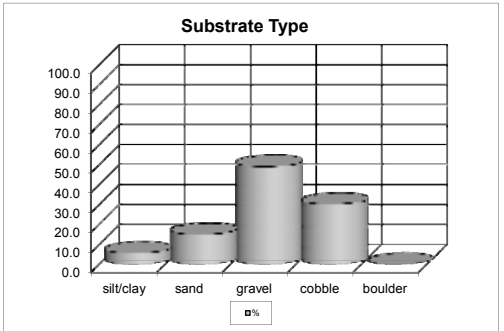
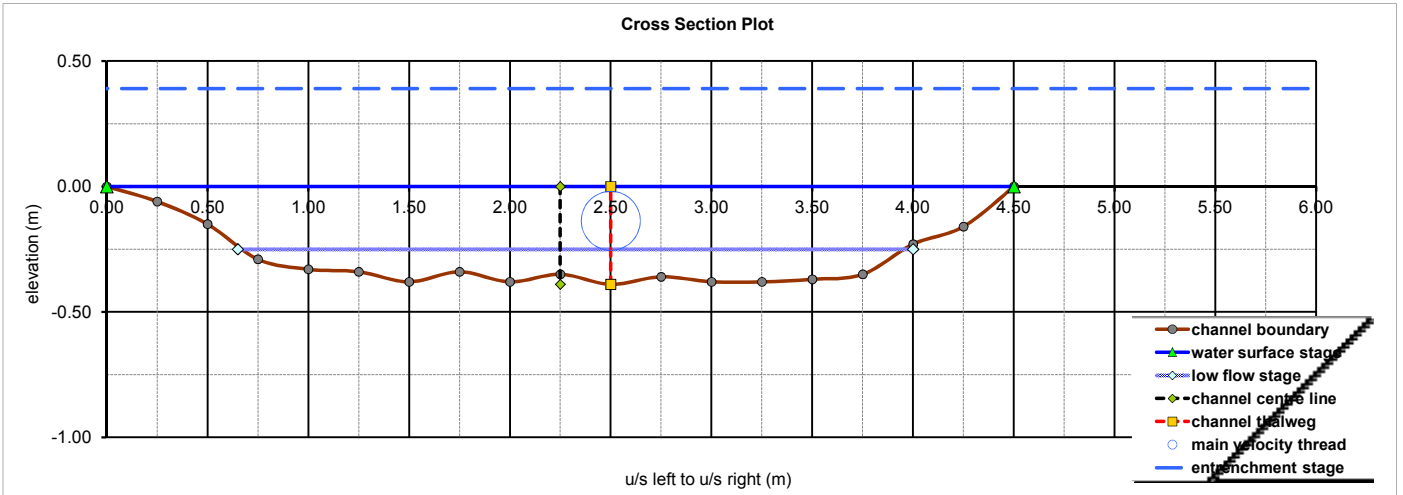
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄	
Rosgen	Q _{sb}	Q _{sb}		T _{*s}	3.1	0.4	0.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)		rolling	YES	NO	NO
B3	0.0021	0.0019		rolling	YES	NO	NO
C3	0.0006	0.0003		∅	NO	YES	YES
C4	0.0076	0.0065					

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.20	7.00	55.00	125.00	170.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				53.35	121.25	164.90
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	1.410	Q (cms)	1.410
V (m s ⁻¹)	1.06	V (m s ⁻¹)	1.06
n	0.035	n	0.035
Fr	0.64	Fr	0.64
D _c rectangular (m)	0.21	D _c rectangular (m)	0.21
D _c trapezoidal (m)	0.37	D _c trapezoidal (m)	0.37
D _c triangular (m)	0.54	D _c triangular (m)	0.54
D _c parabolic (m)	0.35	D _c parabolic (m)	0.35
D _c mean (m)	0.37	D _c mean (m)	0.37
flow type	SUBCRITICAL	flow type	SUBCRITICAL
Ω (watts m ⁻¹)	110.57	Ω (watts m ⁻¹)	110.57
ω _a (watts m ⁻²)	22.16	ω _a (watts m ⁻²)	22.16
ω _s /TW (watts m ⁻¹)	4.62	ω _s /TW (watts m ⁻¹)	4.62
Re*	76.8	Re*	76.8
Re	247941	Re	247941
turbulence	HIGH	turbulence	HIGH

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	2.14	H _b (m)		
τ _{calc} (N m ⁻²)	20.98	Bf _d (m)		
τ _{crit} (gr-co) (mm)	21.62	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.15	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.73	RDp/H _b		
Substrate Type (%)		RDn (%)		
silt/clay	sand	BA (°)		
6.4	21.3	BFP (%)		
	25.5			
	46.8			
	0.0			

Project: Erosion Threshold Analysis
Midtown Oakvillr
Lower Morrison Creek - downstream Section 3 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.31
step	R (m) 0.28
riffle	TW (m) 4.50
run	WP (m) 4.66
glide	max d (m) 0.39
pool	mean d (m) 0.29
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.356	13.10	NO	NO	NO	NO
V _c (m s ⁻¹)	0.066	D ₅₀ 0.803	29.59	NO	NO	NO	NO
		D ₈₄ 1.674	61.65	NO	NO	NO	NO

Section Data		ER stations L / R	-3.00	10.00	TW ck
ER _e (m)	0.39	WS stations L / R	0.00	4.50	4.50
WS _e (m)	0.000	Lf stations L / R	0.65	4.00	
Lf _e (m)	-0.250	E _s sta. (Limerinos) L / R			
W _{fp} (m)	13.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.39	2.50	
z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0078				

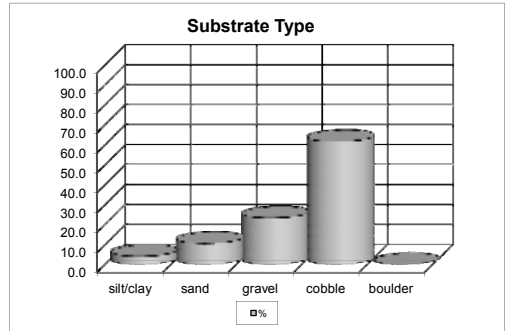
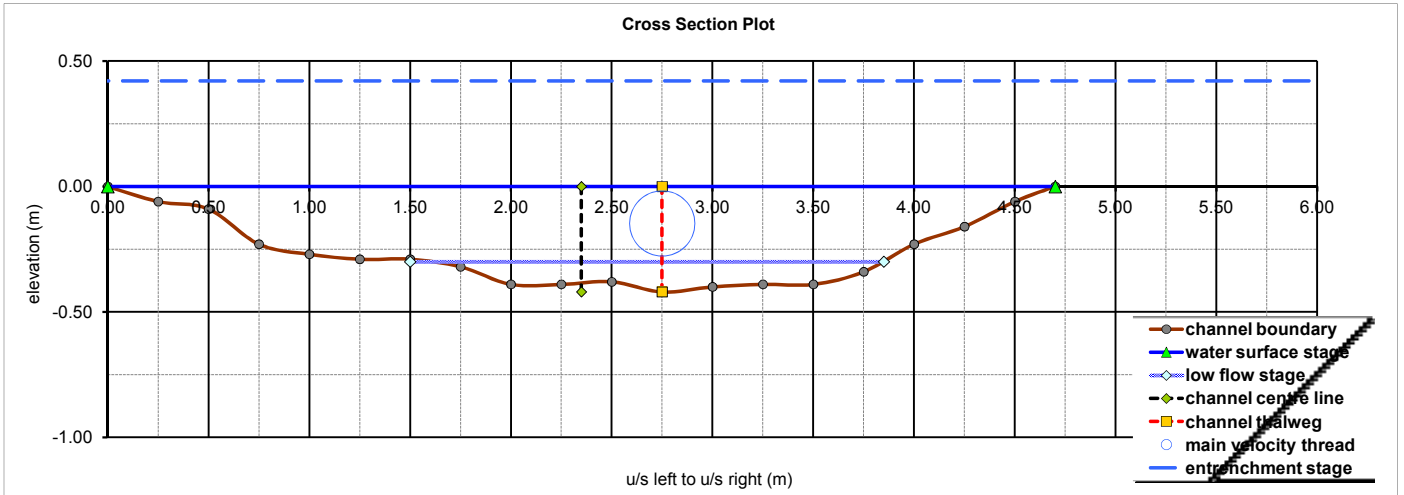
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄	
Rosgen	Q _{sb}	Q _{sb}		T _{*c}	3.7	0.7	0.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)		rolling	YES	NO	NO
B3	0.0021	0.0019		rolling	YES	NO	NO
C3	0.0006	0.0003		∅	NO	YES	YES
C4	0.0076	0.0065					

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.50	6.00	30.00	130.00	170.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				29.10	126.10	164.90
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	1.412	Q (cms)	1.412
V (m s ⁻¹)	1.08	V (m s ⁻¹)	1.08
n	0.035	n	0.035
Fr	0.64	Fr	0.64
D _c rectangular (m)	0.22	D _c rectangular (m)	0.22
D _c trapezoidal (m)	0.37	D _c trapezoidal (m)	0.37
D _c triangular (m)	0.54	D _c triangular (m)	0.54
D _c parabolic (m)	0.35	D _c parabolic (m)	0.35
D _c mean (m)	0.37	D _c mean (m)	0.37
flow type	SUBCRITICAL	flow type	SUBCRITICAL
Ω (watts m ⁻¹)	107.90	Ω (watts m ⁻¹)	107.90
ω _a (watts m ⁻²)	23.13	ω _a (watts m ⁻²)	23.13
ω _g /TW (watts m ⁻¹)	5.14	ω _g /TW (watts m ⁻¹)	5.14
Re*	41.5	Re*	41.5
Re	265463	Re	265463
turbulence	HIGH	turbulence	HIGH

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	2.19	H _b (m)		
τ _{calc} (N m ⁻²)	21.47	Bf _d (m)		
τ _{crit} (gr-co) (mm)	22.13	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.85	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.77	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - downstream Section 4 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.27
step	R (m) 0.26
riffle	TW (m) 4.70
run	WP (m) 4.83
glide	max d (m) 0.42
pool	mean d (m) 0.27
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.733	25.95	NO	NO	NO	NO
V _c (m s ⁻¹)	0.069	D ₅₀ 1.353	47.90	NO	NO	NO	NO
		D ₈₄ 1.997	70.67	NO	NO	NO	NO

Section Data		ER stations L / R	-3.00	10.00	TW ck
ER _e (m)	0.42	WS stations L / R	0.00	4.70	4.70
WS _e (m)	0.000	Lf stations L / R	1.50	3.85	
Lf _e (m)	-0.300	E _s sta. (Limerinos) L / R			
W _{fp} (m)	13.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.42	2.75	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0090				

Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄	
Rosgen	Q _{sb}	Q _{sb}		T _*	1.0	0.3	0.1
type	(kg sec ⁻¹)	(kg sec ⁻¹)					
B3	0.0021	0.0018	saltnation	NO	NO	NO	
C3	0.0006	0.0002	rolling	NO	NO	NO	
C4	0.0077	0.0059	∅	YES	YES	YES	

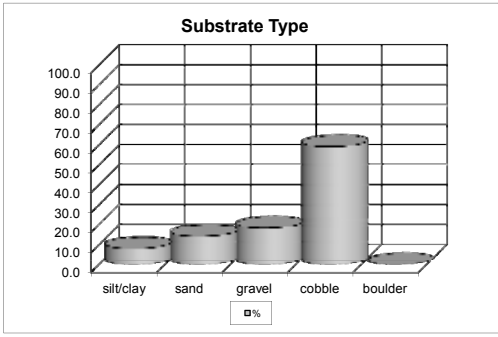
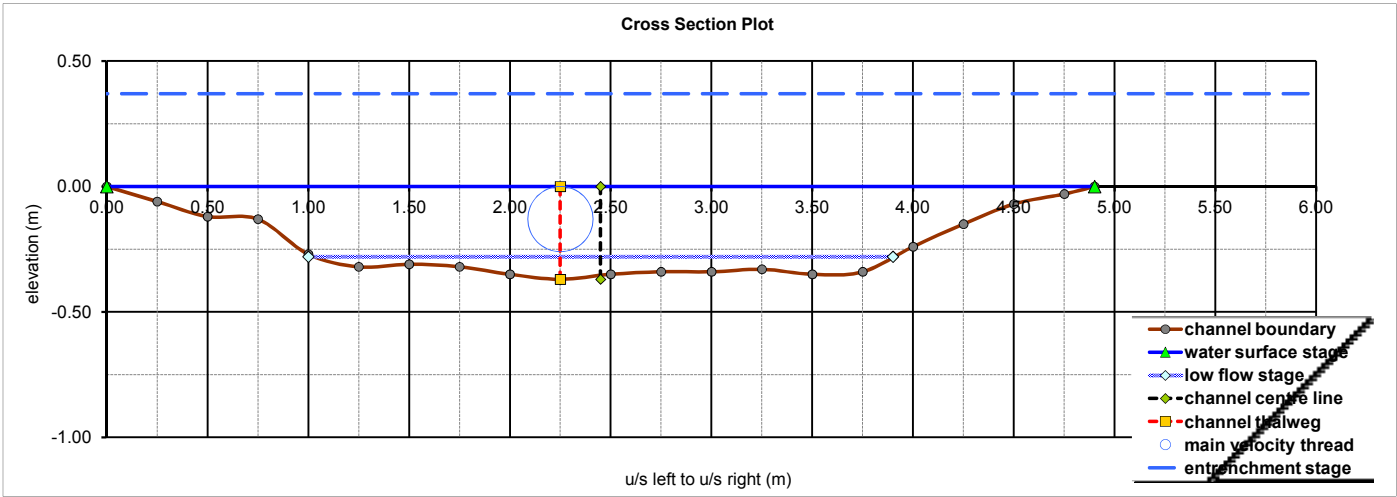
Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		2.00	25.00	85.00	185.00	210.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				82.45	179.45	203.70
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Flow Regime	
Strickler method		Limerinos method	
Q (cms)	1.413	Q (cms)	
V (m s ⁻¹)	1.11	V (m s ⁻¹)	
n	0.035	n	
Fr	0.68	Fr	
D _c rectangular (m)	0.21	D _c rectangular (m)	
D _c trapezoidal (m)	0.37	D _c trapezoidal (m)	
D _c triangular (m)	0.54	D _c triangular (m)	
D _c parabolic (m)	0.35	D _c parabolic (m)	
D _c mean (m)	0.37	D _c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m ⁻¹)	124.61	Ω (watts m ⁻¹)	
ω _a (watts m ⁻²)	25.80	ω _a (watts m ⁻²)	
ω _s /TW (watts m ⁻¹)	5.49	ω _s /TW (watts m ⁻¹)	
Re*	118.4	Re*	
Re	256544	Re	
turbulence	HIGH	turbulence	

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	2.37	H _b (m)		
τ _{calc} (N m ⁻²)	23.25	Bf _d (m)		
τ D _{crit} (gr-co) (mm)	23.97	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.43	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	2.11	RDp/H _b		
Substrate Type (%)		RDn (%)		
silt/clay	sand	BA (°)		
4.3	10.6	BFP (%)		
23.4	61.7			
0.0				

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - downstream Section 5 - existing bankfull flow

B. de Geus 05.11



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.20
step	R (m) 0.24
riffle	TW (m) 4.90
run	WP (m) 5.01
glide	max d (m) 0.37
pool	mean d (m) 0.24
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Hydraulic Roughness	Hydraulic Ratios
rr R/D ₈₄ 1.33	ER max d 2.65
ff V mean/V* 5.36	r _c / TW
ff D ₈₄ 3.58	TW / Lf _w 1.69
ff mean 4.47	TW/max d 13.2
ROUGH BED	TW/mean d 20.1

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.655	20.29	NO	NO	NO	NO
V _c (m s ⁻¹)	0.079	D ₅₀ 1.353	41.90	NO	NO	NO	NO
		D ₈₄ 1.970	60.98	NO	NO	NO	NO

Section Data		ER stations L / R	-3.00	10.00	TW ck
ER _e (m)	0.37	WS stations L / R	0.00	4.90	4.90
WS _e (m)	0.000	Lf stations L / R	1.00	3.90	
Lf _e (m)	-0.280	E _s sta. (Limerinos) L / R			
W _{fp} (m)	13.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.37	2.25	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0130				

Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄	
Rosgen	Q _{sb}	Q _{sb}		T _{*s}	1.6	0.4	0.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)					
B3	0.0021	0.0018	salutation	NO	NO	NO	
C3	0.0006	0.0002	rolling	YES	NO	NO	
C4	0.0076	0.0059	∅	NO	YES	YES	

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.20	20.00	85.00	180.00	230.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)		19.40	82.45	174.60	223.10	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	1.411	Q (cms)	1.411
V (m s ⁻¹)	1.18	V (m s ⁻¹)	1.18
n	0.037	n	0.037
Fr	0.76	Fr	0.76
D _c rectangular (m)	0.21	D _c rectangular (m)	0.21
D _c trapezoidal (m)	0.37	D _c trapezoidal (m)	0.37
D _c triangular (m)	0.54	D _c triangular (m)	0.54
D _c parabolic (m)	0.36	D _c parabolic (m)	0.36
D _c mean (m)	0.37	D _c mean (m)	0.37
flow type	SUBCRITICAL	flow type	SUBCRITICAL
Ω (watts m ⁻¹)	179.72	Ω (watts m ⁻¹)	179.72
ω _a (watts m ⁻²)	35.84	ω _a (watts m ⁻²)	35.84
ω _g /TW (watts m ⁻¹)	7.31	ω _g /TW (watts m ⁻¹)	7.31
Re*	127.0	Re*	127.0
Re	246758	Re	246758
turbulence	HIGH	turbulence	HIGH

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	3.10	H _b (m)		
τ _{calc} (N m ⁻²)	30.38	Bf _d (m)		
τ D _{crit} (gr-co) (mm)	31.32	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.43	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	2.08	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

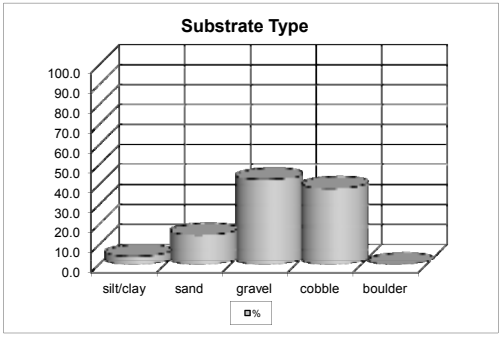
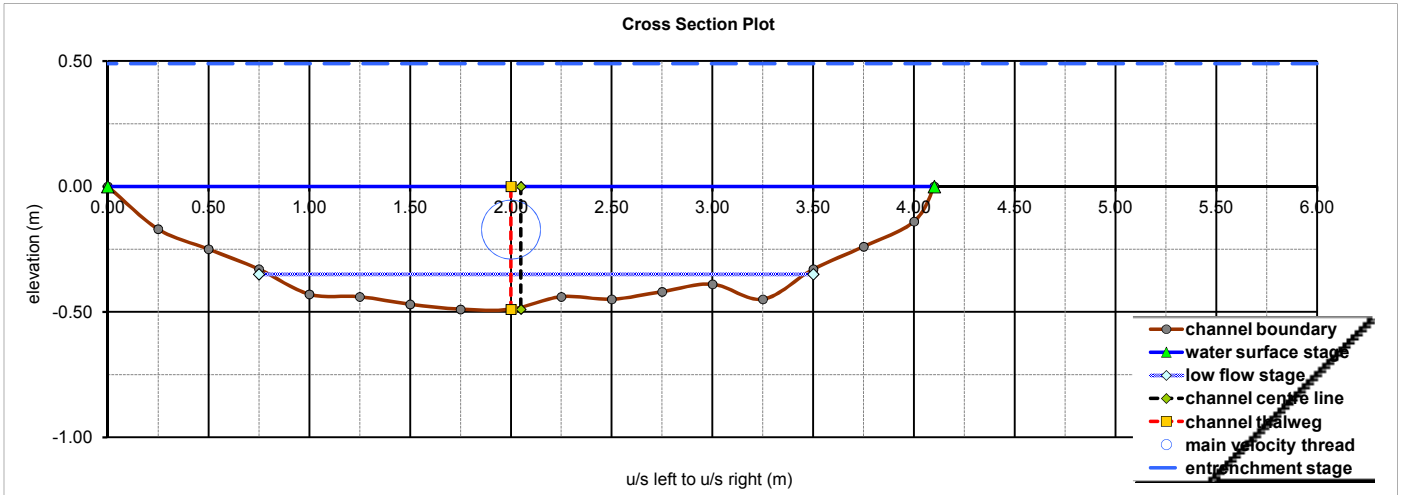
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
8.2	14.3	18.4	59.2	0.0

Lower Wedgewood Creek

Bankfull Conditions



Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek - Section 1 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.47
step	R (m) 0.34
riffle	TW (m) 4.10
run	WP (m) 4.35
glide	max d (m) 0.49
pool	mean d (m) 0.36
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.438	15.51	NO	NO	NO	NO
V _c (m s ⁻¹)	0.069	D ₅₀ 0.984	34.87	NO	NO	NO	NO
		D ₈₄ 1.608	56.96	NO	NO	NO	NO

Section Data		ER stations L / R	-2.00	8.00	TW ck
ER _e (m)	0.49	WS stations L / R	0.00	4.10	4.10
WS _e (m)	0.000	Lf stations L / R	0.75	3.50	
Lf _e (m)	-0.350	E _s sta. (Limerinos) L / R			
W _{fp} (m)	10.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.49	2.00	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0070				

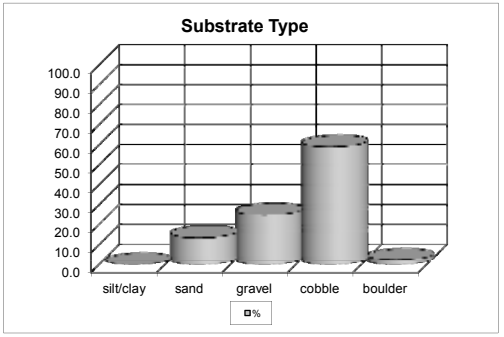
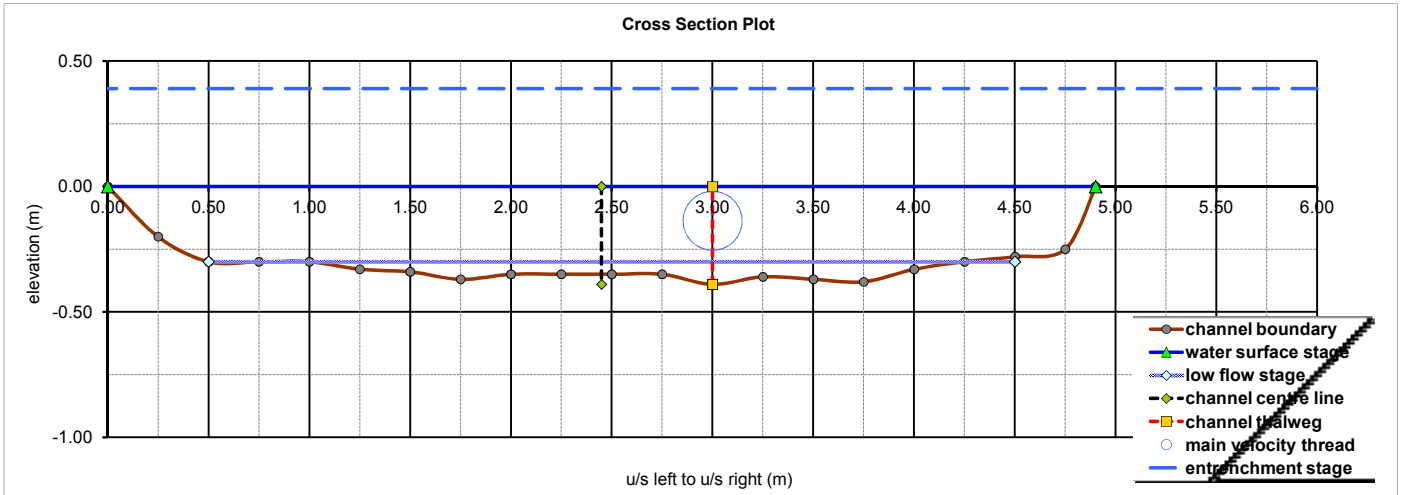
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄	
Rosgen	Q _{sb}	Q _{sb}		T _*	2.7	0.5	0.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)					
B3	0.0022	0.0021	salton	YES	NO	NO	
C3	0.0008	0.0005	rolling	YES	NO	NO	
C4	0.0084	0.0074	∅	NO	YES	YES	

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.50	9.00	45.00	120.00	140.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				43.65	116.40	135.80
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Flow Regime	
Strickler method	Limerinos method	Strickler method	Limerinos method
Q (cms)	1.703	Q (cms)	1.703
V (m s ⁻¹)	1.16	V (m s ⁻¹)	1.16
n	0.035	n	0.035
Fr	0.62	Fr	0.62
D _c rectangular (m)	0.26	D _c rectangular (m)	0.26
D _c trapezoidal (m)	0.40	D _c trapezoidal (m)	0.40
D _c triangular (m)	0.58	D _c triangular (m)	0.58
D _c parabolic (m)	0.36	D _c parabolic (m)	0.36
D _c mean (m)	0.40	D _c mean (m)	0.40
flow type	SUBCRITICAL	flow type	SUBCRITICAL
Ω (watts m ⁻¹)	116.80	Ω (watts m ⁻¹)	116.80
ω _a (watts m ⁻²)	26.85	ω _a (watts m ⁻²)	26.85
ω _g /TW (watts m ⁻¹)	6.55	ω _g /TW (watts m ⁻¹)	6.55
Re*	61.0	Re*	61.0
Re	343390	Re	343390
turbulence	HIGH	turbulence	HIGH

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	2.37	H _b (m)		Bf _d (m)	
τ _{calc} (N m ⁻²)	23.22	RDp (m)		H _r /Bf _d	
τ D _{crit} (gr-co) (mm)	23.93	RDp/H _b		RDn (%)	
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.04	BA (°)		BFP (%)	
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.70				

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek - Section 2 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.54
step	R (m) 0.30
riffle	TW (m) 4.90
run	WP (m) 5.15
glide	max d (m) 0.39
pool	mean d (m) 0.31
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.803	27.49	NO	NO	NO	NO
V _c (m s ⁻¹)	0.071	D ₅₀ 1.468	50.24	NO	NO	NO	NO
		D ₈₄ 2.076	71.06	NO	NO	NO	NO

Section Data		ER stations L / R	-2.00	20.00	TW ck
ER _e (m)	0.39	WS stations L / R	0.00	4.90	4.90
WS _e (m)	0.000	Lf stations L / R	0.50	4.50	
Lf _e (m)	-0.300	E _s sta. (Limerinos) L / R			
W _{fp} (m)	22.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.39	3.00	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0085				

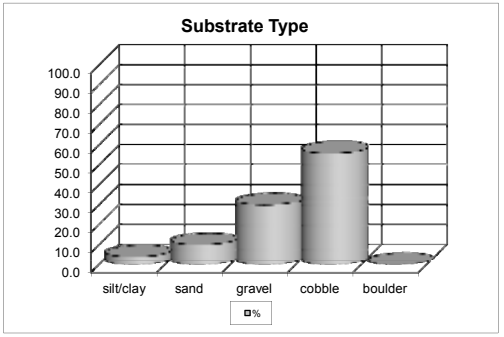
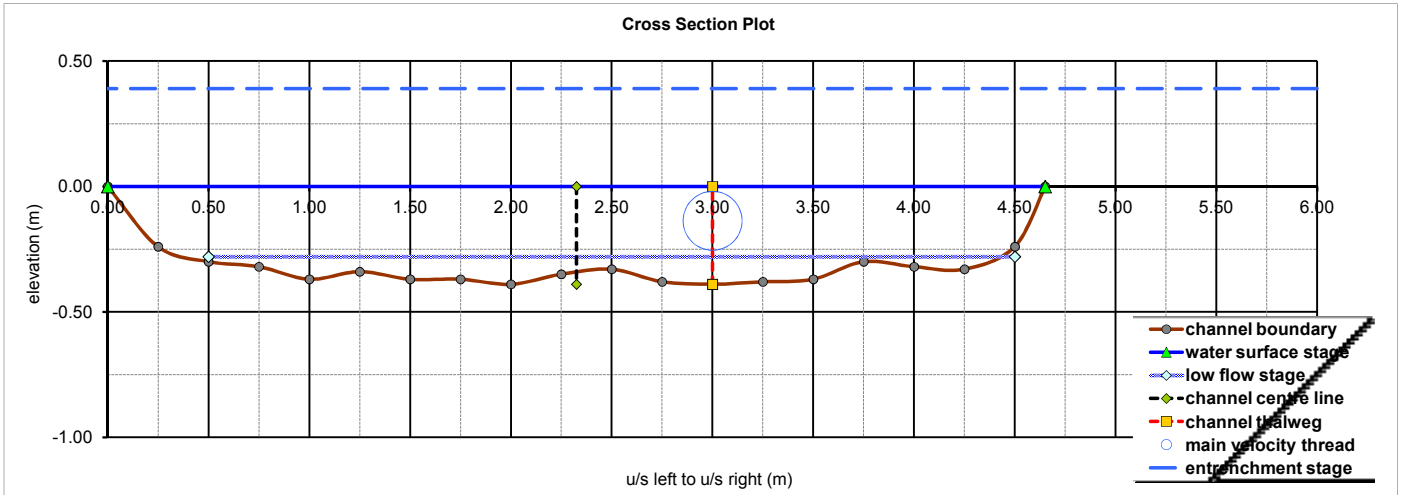
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}				
type	(kg sec ⁻¹)	(kg sec ⁻¹)	T _*	0.9	0.3	0.1
B3	0.0022	0.0019	salutation	NO	NO	NO
C3	0.0008	0.0003	rolling	NO	NO	NO
C4	0.0084	0.0066	∅	YES	YES	YES

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		6.00	30.00	100.00	200.00	270.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)		29.10	97.00	194.00	261.90	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Flow Regime	
Strickler method		Limerinos method	
Q (cms)	1.704	Q (cms)	
V (m s ⁻¹)	1.11	V (m s ⁻¹)	
n	0.037	n	
Fr	0.63	Fr	
D _c rectangular (m)	0.23	D _c rectangular (m)	
D _c trapezoidal (m)	0.40	D _c trapezoidal (m)	
D _c triangular (m)	0.58	D _c triangular (m)	
D _c parabolic (m)	0.37	D _c parabolic (m)	
D _c mean (m)	0.40	D _c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m ⁻¹)	141.97	Ω (watts m ⁻¹)	
ω _a (watts m ⁻²)	27.57	ω _a (watts m ⁻²)	
ω _g /TW (watts m ⁻¹)	5.63	ω _g /TW (watts m ⁻¹)	
Re*	145.8	Re*	
Re	290288	Re	
turbulence	HIGH	turbulence	

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	2.54	H _b (m)			
τ _{calc} (N m ⁻²)	24.87	Bf _d (m)			
τ D _{crit} (gr-co) (mm)	25.64	RDp (m)			
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.55	H _b /Bf _d			
D ₈₄ V _c (vcs +) (m s ⁻¹)	2.19	RDp/H _b			
Substrate Type (%)		RDn (%)			
silt/clay	sand	BA (°)			
0.0	13.6	BFP (%)			
	25.0				
	59.1				
	2.3				

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek - Section 3 - existing bankfull flow



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.51
step	R (m) 0.31
riffle	TW (m) 4.65
run	WP (m) 4.93
glide	max d (m) 0.39
pool	mean d (m) 0.32
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.655	22.15	NO	NO	NO	NO
V _c (m s ⁻¹)	0.072	D ₅₀ 1.228	41.50	NO	NO	NO	NO
		D ₈₄ 1.798	60.76	NO	NO	NO	NO

Section Data		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
ER _e (m)	0.39	ER stations L / R	-2.00	20.00	TW ck	
WS _e (m)	0.000	WS stations L / R	0.00	4.65	4.65	
Lf _e (m)	-0.280	Lf stations L / R	0.50	4.50		
W _{fp} (m)	22.00	E _s sta. (Limerinos) L / R				
r _c (m)		E _s sta. (Strickler) L / R				
Z		T _e (m)	T _{o/s} (m)	-0.39	3.00	
E _s (m m ⁻¹)	0.0085					

Bedload Transport Data		D ₃₀	D ₅₀	D ₈₄
Strickler Q	Limerinos Q			
Rosgen	Q _{sb}	Q _{sb}	T _{*s}	
type	(kg sec ⁻¹)	(kg sec ⁻¹)		
B3	0.0022	0.0020	1.3	0.4
C3	0.0008	0.0004	rolling	YES
C4	0.0084	0.0071	∅	NO

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		3.00	20.00	70.00	150.00	200.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)		19.40	67.90	145.50	194.00	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

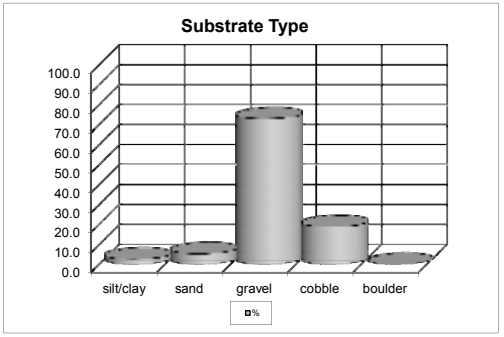
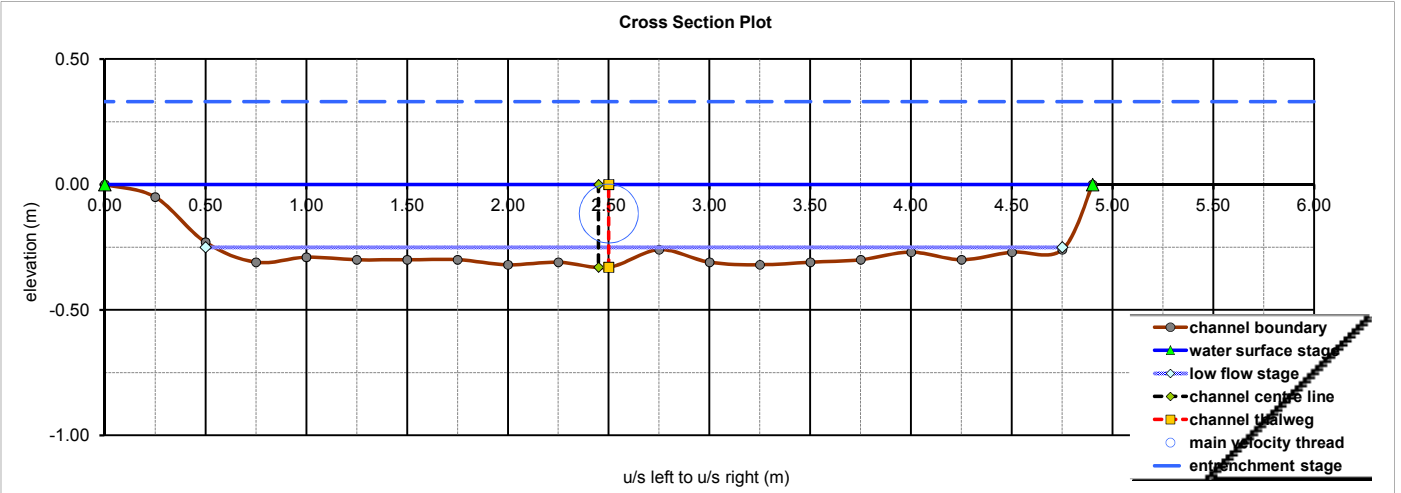
Flow Regime		Flow Regime	
Strickler method	Q (cms)	Limerinos method	Q (cms)
Q (cms)	1.703	Q (cms)	1.13
V (m s ⁻¹)	1.13	V (m s ⁻¹)	n
n	0.037	n	Fr
Fr	0.63	Fr	D _c rectangular (m)
D _c rectangular (m)	0.24	D _c rectangular (m)	D _c trapezoidal (m)
D _c trapezoidal (m)	0.40	D _c trapezoidal (m)	D _c triangular (m)
D _c triangular (m)	0.58	D _c triangular (m)	D _c parabolic (m)
D _c parabolic (m)	0.37	D _c parabolic (m)	D _c mean (m)
D _c mean (m)	0.40	D _c mean (m)	

Erosion Thresholds		Bank Data u/s L		u/s R		
τ _{calc} (kg m ⁻²)	2.60	H _b (m)				
τ _{calc} (N m ⁻²)	25.51	Bf _d (m)				
τ _{Dcrit} (gr-co) (mm)	26.30	RDp (m)				
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.30	H _b /Bf _d				
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.90	RDp/H _b				
		RDn (%)				
		BA (%)				
		BFP (%)				

Flow Regime		Flow Regime	
flow type	SUBCRITICAL	flow type	
Ω (watts m ⁻¹)	141.88	Ω (watts m ⁻¹)	
ω _a (watts m ⁻²)	28.76	ω _a (watts m ⁻²)	
ω _a /TW (watts m ⁻¹)	6.19	ω _a /TW (watts m ⁻¹)	
Re*	102.1	Re*	
Re	302893	Re	
turbulence	HIGH	turbulence	

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek - Section 4 - existing bankfull flow

B. de Geus 05.11



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.32
step	R (m) 0.26
riffle	TW (m) 4.90
run	WP (m) 5.15
glide	max d (m) 0.33
pool	mean d (m) 0.27
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Hydraulic Roughness	Hydraulic Ratios
rr R/D ₈₄ 3.67	ER max d 2.45
ff V mean/V* 6.65	r _c / TW
ff D ₈₄ 6.17	TW / Lf _w 1.15
ff mean 6.41	TW/max d 14.8
ROUGH BED	TW/mean d 18.2

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.604	17.37	NO	NO	NO	NO
V _c (m s ⁻¹)	0.085	D ₅₀ 0.733	21.08	NO	NO	NO	NO
		D ₈₄ 1.228	35.31	NO	NO	NO	NO

Section Data		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
ER _e (m)	0.33	8.00	17.00	25.00	70.00	160.00
WS _e (m)	0.000					
Lf _e (m)	-0.250					
W _{fb} (m)	12.00					
r _c (m)						
Z						
E _s (m m ⁻¹)	0.0140					

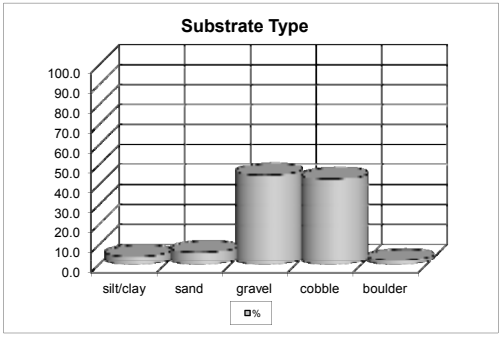
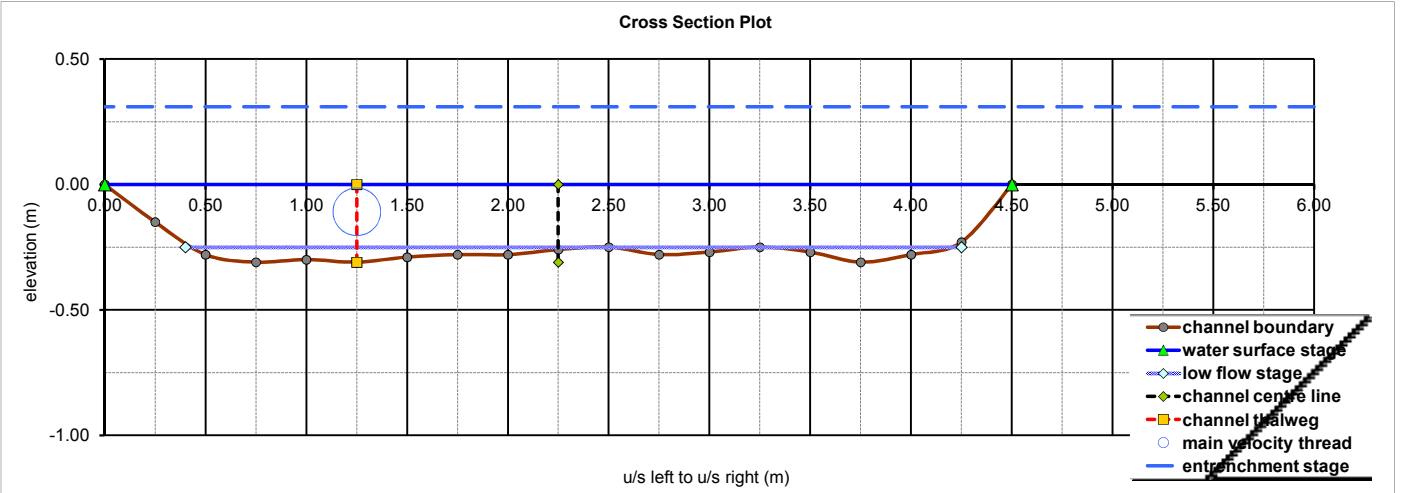
Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		8.00	17.00	25.00	70.00	160.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)		16.49	24.25	67.90	155.20	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	3.59	H _b (m)		Bf _d (m)	
τ _{calc} (N m ⁻²)	35.22	RDp (m)		H _r /Bf _d	
τ D _{crit} (gr-co) (mm)	36.31	RDp/H _b		RDn (%)	
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.78	BA (°)		BFP (%)	
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.30				

Bedload Transport Data		Flow Regime		
Strickler Q	Limerinos Q	Strickler method	Flow Regime	
Rosgen	Q _{sb}	Q (cms)	Limerinos method	
type	Q _{sb} (kg sec ⁻¹)	V (m s ⁻¹)	Q (cms)	
B3	0.0022	n	V (m s ⁻¹)	
C3	0.0008	Fr	n	
C4	0.0084	D _c rectangular (m)	Fr	
		D _c trapezoidal (m)	D _c rectangular (m)	
		D _c triangular (m)	D _c trapezoidal (m)	
		D _c parabolic (m)	D _c triangular (m)	
		D _c mean (m)	D _c parabolic (m)	
		flow type	D _c mean (m)	
		Ω (watts m ⁻¹)	flow type	
		ω _a (watts m ⁻²)	Ω (watts m ⁻¹)	
		ω _w /TW (watts m ⁻¹)	ω _a (watts m ⁻²)	
		Re*	ω _w /TW (watts m ⁻¹)	
		Re	Re*	
		turbulence	Re	
			turbulence	

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek - Section 5 - existing bankfull flow

B. de Geus 05.11



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.15
step	R (m) 0.25
riffle	TW (m) 4.50
run	WP (m) 4.68
glide	max d (m) 0.31
pool	mean d (m) 0.26
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.655	15.03	NO	NO	NO	NO
V _c (m s ⁻¹)	0.106	D ₅₀ 1.089	24.96	NO	NO	NO	NO
		D ₈₄ 1.608	36.88	NO	NO	NO	NO

Section Data		ER stations L / R	-2.00	10.00	TW ck
ER _e (m)	0.31	WS stations L / R	0.00	4.50	4.50
WS _e (m)	0.000	Lf stations L / R	0.40	4.25	
Lf _e (m)	-0.250	E _s sta. (Limerinos) L / R			
W _{fp} (m)	12.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.31	1.25	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0230				

Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄	
Rosgen	Q _{sb}	Q _{sb}		T _*	2.9	1.0	0.5
type	(kg sec ⁻¹)	(kg sec ⁻¹)					
B3	0.0022	0.0021	saltnation	YES	NO	NO	
C3	0.0008	0.0005	rolling	YES	YES	NO	
C4	0.0084	0.0075	∅	NO	NO	YES	

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		4.00	20.00	55.00	120.00	200.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)		19.40	53.35	116.40	194.00	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	1.702	Q (cms)	1.702
V (m s ⁻¹)	1.48	V (m s ⁻¹)	1.48
n	0.040	n	0.040
Fr	0.94	Fr	0.94
D _c rectangular (m)	0.25	D _c rectangular (m)	0.25
D _c trapezoidal (m)	0.41	D _c trapezoidal (m)	0.41
D _c triangular (m)	0.58	D _c triangular (m)	0.58
D _c parabolic (m)	0.39	D _c parabolic (m)	0.39
D _c mean (m)	0.41	D _c mean (m)	0.41
flow type	SUBCRITICAL	flow type	SUBCRITICAL
Ω (watts m ⁻¹)	383.72	Ω (watts m ⁻¹)	383.72
ω _a (watts m ⁻²)	81.98	ω _a (watts m ⁻²)	81.98
ω _g /TW (watts m ⁻¹)	18.22	ω _g /TW (watts m ⁻¹)	18.22
Re*	89.1	Re*	89.1
Re	319036	Re	319036
turbulence	HIGH	turbulence	HIGH

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	5.65	H _b (m)		Bf _d (m)	
τ _{calc} (N m ⁻²)	55.38	RDp (m)		H _r /Bf _d	
τ D _{crit} (gr-co) (mm)	57.09	RDp/H _b		RDn (%)	
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.15	BA (°)		BFP (%)	
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.70				

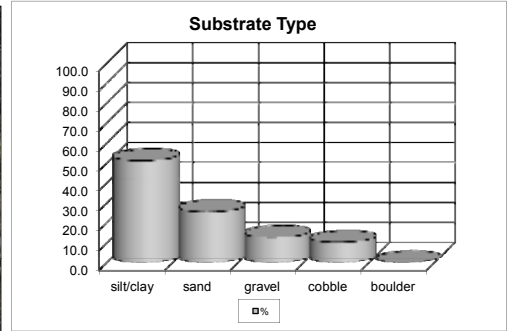
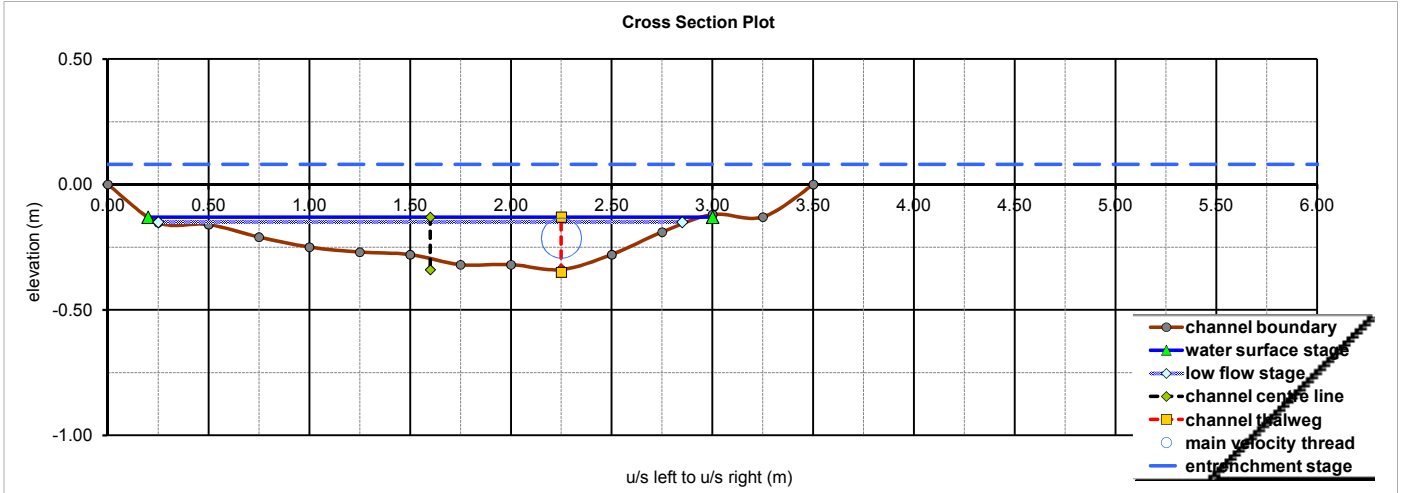
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
4.1	6.1	44.9	42.9	2.0

**Lower Morrison Creek
Upstream Reach**

Stability Conditions



Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 1 - stability test



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.33
step	R (m) 0.12
riffle	TW (m) 2.75
run	WP (m) 2.80
glide	max d (m) 0.21
pool	mean d (m) 0.12
thalweg out of phase	E _s (Limerinos) (m) [+]

Hydraulic Roughness	Hydraulic Ratios
rr R/D ₈₄ 4.74	ER max d 5.45
ff V mean/V* 6.66	r _c / TW
ff D ₈₄ 6.73	TW / L _f 1.06
ff mean 6.69	TW/max d 13.1
ROUGH BED	TW/mean d 22.8

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.001	0.06	YES	YES	YES	YES
V _c (m s ⁻¹)	0.058	D ₅₀ 0.003	0.13	YES	YES	YES	YES
		D ₈₄ 0.733	31.02	NO	NO	NO	NO

Section Data		ER stations L / R	-5.00	10.00	TW ck
ER _e (m)	0.08	WS stations L / R	0.20	3.00	2.80
WS _e (m)	-0.130	Lf stations L / R	0.25	2.85	
L _f _e (m)	-0.150	E _s sta. (Limerinos) L / R			
W _{fp} (m)	15.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.35	2.25	
z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0140				

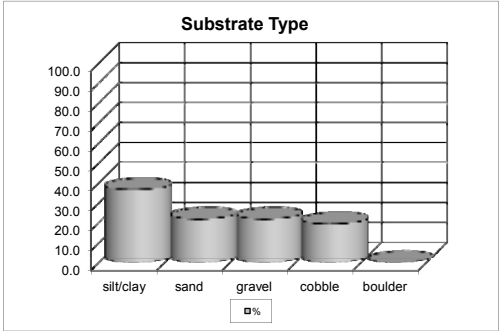
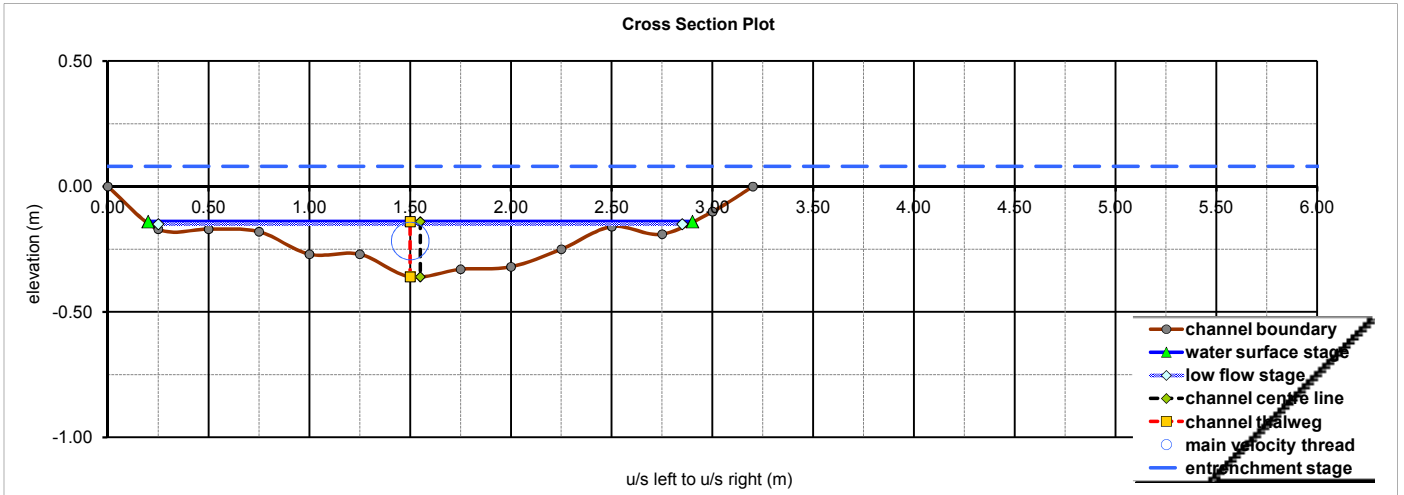
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}	T _*	419.2	279.5	0.7
type	(kg sec ⁻¹)	(kg sec ⁻¹)				
B3	0.0013	0.0013	salutation	YES	YES	NO
C3	0.0000	0.0000	rolling	YES	YES	NO
C4	0.0035	0.0037	∅	NO	NO	YES

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.02	0.04	0.06	25.00	160.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				24.25	155.20	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Flow Regime
Strickler method	Q (cms)	Limerinos method
Q (cms)	0.269	Q (cms)
V (m s ⁻¹)	0.81	V (m s ⁻¹)
n	0.035	n
Fr	0.74	Fr
D _c rectangular (m)	0.10	D _c rectangular (m)
D _c trapezoidal (m)	0.19	D _c trapezoidal (m)
D _c triangular (m)	0.28	D _c triangular (m)
D _c parabolic (m)	0.19	D _c parabolic (m)
D _c mean (m)	0.19	D _c mean (m)
flow type	SUBCRITICAL	flow type
Ω (watts m ⁻¹)	36.91	Ω (watts m ⁻¹)
ω _a (watts m ⁻²)	13.18	ω _a (watts m ⁻²)
ω _w /TW (watts m ⁻¹)	4.79	ω _w /TW (watts m ⁻¹)
Re*	0.1	Re*
Re	84250	Re
turbulence	LOW	turbulence

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	1.66	H _b (m)		
τ _{calc} (N m ⁻²)	16.27	B _f _d (m)		
τ D _{crit} (gr-co) (mm)	16.77	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.04	H _b /B _f _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	0.78	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 2 - stability test



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.28
step	R (m) 0.10
riffle	TW (m) 2.68
run	WP (m) 2.76
glide	max d (m) 0.22
pool	mean d (m) 0.10
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Hydraulic Roughness	Hydraulic Ratios
rr R/D ₈₄ 1.18	ER max d 5.59
ff V mean/V* 4.91	r _c / TW
ff D ₈₄ 3.31	TW / L _{f,w} 1.03
ff mean 4.11	TW/max d 12.2
ROUGH BED	TW/mean d 26.0

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.003	0.12	YES	YES	YES	YES
V _c (m s ⁻¹)	0.058	D ₅₀ 0.071	2.97	NO	NO	NO	YES
		D ₈₄ 1.353	56.54	NO	NO	NO	NO

Section Data		ER stations L / R	-5.00	10.00	TW ck
ER _e (m)	0.08	WS stations L / R	0.20	2.90	2.70
WS _e (m)	-0.140	Lf stations L / R	0.25	2.85	
L _{f,e} (m)	-0.150	E _s sta. (Limerinos) L / R			
W _{fp} (m)	15.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.36	1.50	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0170				

Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}	T _*	286.7	34.4	0.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)				
B3	0.0012	0.0010	saltonation	YES	YES	NO
C3	0.0000	0.0000	rolling	YES	YES	NO
C4	0.0032	0.0025	∅	NO	NO	YES

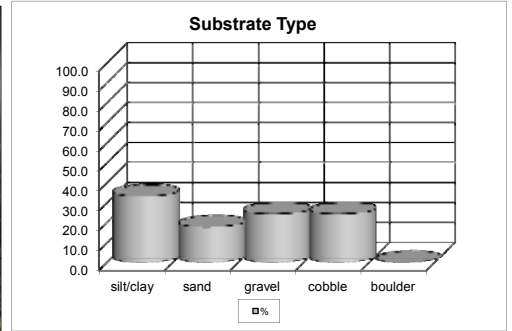
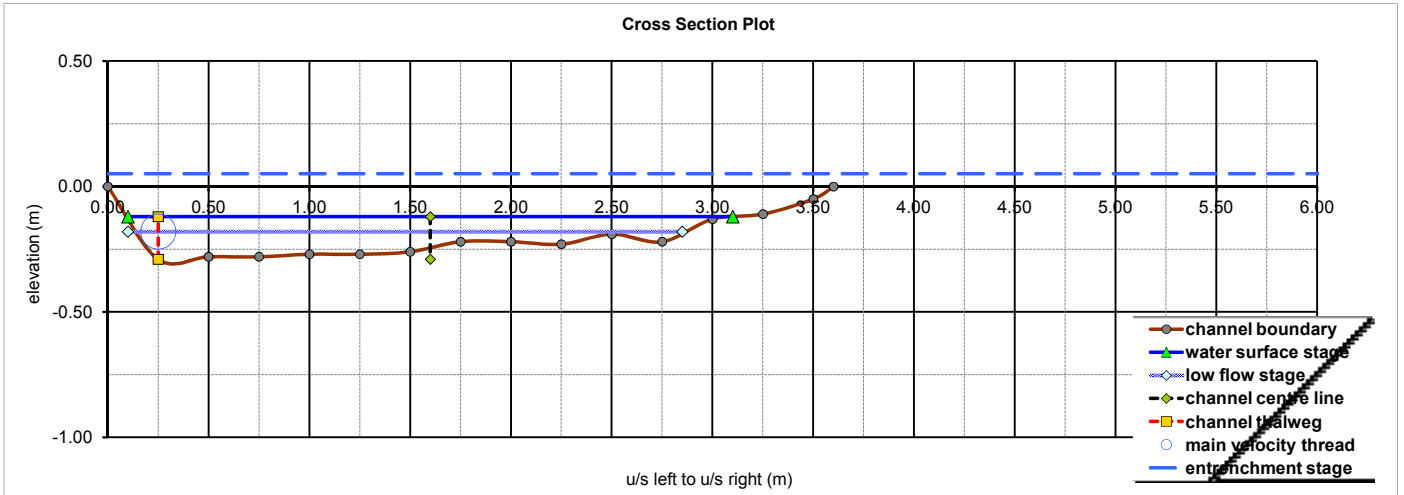
Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.03	0.06	0.50	85.00	190.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				82.45	184.30	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	0.221	Q (cms)	Q (cms)
V (m s ⁻¹)	0.80	V (m s ⁻¹)	V (m s ⁻¹)
n	0.035	n	n
Fr	0.79	Fr	Fr
D _c rectangular (m)	0.09	D _c rectangular (m)	D _c rectangular (m)
D _c trapezoidal (m)	0.17	D _c trapezoidal (m)	D _c trapezoidal (m)
D _c triangular (m)	0.26	D _c triangular (m)	D _c triangular (m)
D _c parabolic (m)	0.18	D _c parabolic (m)	D _c parabolic (m)
D _c mean (m)	0.17	D _c mean (m)	D _c mean (m)

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	1.70	H _b (m)		
τ _{calc} (N m ⁻²)	16.69	B _{f,d} (m)		
τ D _{crit} (gr-co) (mm)	17.20	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.11	H _b /B _{f,d}		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.43	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Flow Regime		Flow Regime
flow type	SUBCRITICAL	flow type
Ω (watts m ⁻¹)	36.75	Ω (watts m ⁻¹)
ω _a (watts m ⁻²)	13.31	ω _a (watts m ⁻²)
ω _g /TW (watts m ⁻¹)	4.96	ω _g /TW (watts m ⁻¹)
Re*	0.8	Re*
Re	70060	Re
turbulence	LOW	turbulence

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 3 - stability test

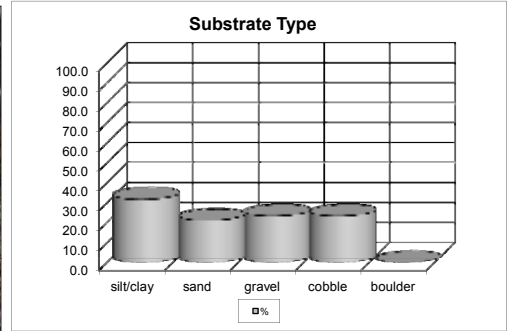
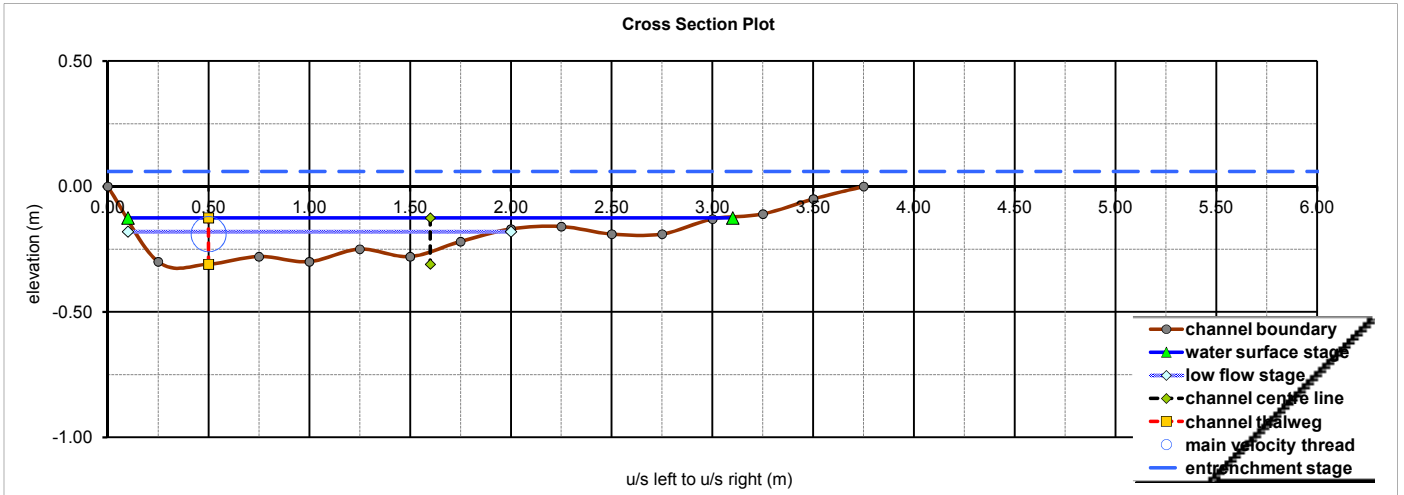


Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.35
step	R (m) 0.11
riffle	TW (m) 3.02
run	WP (m) 3.12
glide	max d (m) 0.17
pool	mean d (m) 0.11
thalweg out of phase	E _s (Limerinos) (m) [+]
Hydraulic Roughness	E _s (Strickler) (m) [+]
rr R/D ₈₄ 0.88	Hydraulic Ratios
ff V mean/V* 4.63	ER max d 4.96
ff D ₈₄ 2.61	r _c / TW
ff mean 3.62	TW / L _{f,w} 1.10
ROUGH BED	TW/max d 17.8
	TW/mean d 26.4

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.003	0.13	YES	YES	YES	YES
V _c (m s ⁻¹)	0.058	D ₅₀ 0.126	5.34	NO	NO	NO	YES
		D ₈₄ 1.641	69.47	NO	NO	NO	NO
Section Data							
ER _e (m)	0.05	ER stations L / R		-5.00	10.00	TW ck	
WS _e (m)	-0.120	WS stations L / R		0.10	3.10	3.00	
L _{f,e} (m)	-0.180	Lf stations L / R		0.10	2.85		
W _{fp} (m)	15.00	E _s sta. (Limerinos) L / R					
r _c (m)		E _s sta. (Strickler) L / R					
Z		T _e (m)	T _{o/s} (m)	-0.29	0.25		
E _s (m m ⁻¹)	0.0150						
Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀	
Existing Conditions (mm)		0.03	0.06	1.00	125.00	170.00	
Stability Design Targets (mm)							
τ _{cr} (N m ⁻²)						121.25	164.90
high turbulence - angular (mm)							
high turbulence - rounded (mm)							
low turbulence - angular (mm)							
low turbulence - rounded (mm)							
Erosion Thresholds				Bank Data u/s L u/s R			
τ _{calc} (kg m ⁻²)	1.66	V _c / V _b		H _b (m)			
τ _{calc} (N m ⁻²)	16.26	Strickler Limerinos		B _{f,d} (m)			
τ D _{crit} (gr-co) (mm)	16.76			RDp (m)			
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.16	0.28		H _b /B _{f,d}			
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.73	3.09		RDp/H _b			
Substrate Type (%)				RDn (%)			
silt/clay	sand	gravel	cobble	boulder	BA (°)		
33.3	17.8	24.4	24.4	0.0	BFP (%)		

Bedload Transport Data						
Strickler Q		Limerinos Q		D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}	T _{*s}	279.4	16.8	0.1
type	(kg sec ⁻¹)	(kg sec ⁻¹)				
B3	0.0013	0.0011	salutation	YES	YES	NO
C3	0.0000	0.0000	rolling	YES	YES	NO
C4	0.0035	0.0025	∅	NO	NO	YES
Flow Regime			Flow Regime			
Strickler method			Limerinos method			
Q (cms)	0.277	Q (cms)				
V (m s ⁻¹)	0.80	V (m s ⁻¹)				
n	0.035	n				
Fr	0.76	Fr				
D _c rectangular (m)	0.10	D _c rectangular (m)				
D _c trapezoidal (m)	0.19	D _c trapezoidal (m)				
D _c triangular (m)	0.28	D _c triangular (m)				
D _c parabolic (m)	0.19	D _c parabolic (m)				
D _c mean (m)	0.19	D _c mean (m)				
flow type	SUBCRITICAL	flow type				
Ω (watts m ⁻¹)	40.66	Ω (watts m ⁻¹)				
ω _a (watts m ⁻²)	13.01	ω _a (watts m ⁻²)				
ω _g /TW (watts m ⁻¹)	4.31	ω _g /TW (watts m ⁻¹)				
Re*	1.6	Re*				
Re	77655	Re				
turbulence	LOW	turbulence				

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 4 - stability test



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.31
step	R (m) 0.10
riffle	TW (m) 2.96
run	WP (m) 3.07
glide	max d (m) 0.19
pool	mean d (m) 0.10
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Hydraulic Roughness	Hydraulic Ratios
rr R/D ₈₄ 1.06	ER max d 5.07
ff V mean/V* 4.80	r _c / TW
ff D ₈₄ 3.08	TW / Lf _w 1.56
ff mean 3.94	TW/max d 16.0
ROUGH BED	TW/mean d 28.2

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.003	0.12	YES	YES	YES	YES
V _c (m s ⁻¹)	0.059	D ₅₀ 0.196	8.16	NO	NO	NO	NO
		D ₈₄ 1.431	59.50	NO	NO	NO	NO

Section Data		ER stations L / R	-5.00	10.00	TW ck
ER _e (m)	0.06	WS stations L / R	0.10	3.10	3.00
WS _e (m)	-0.125	Lf stations L / R	0.10	2.00	
Lf _e (m)	-0.180	E _s sta. (Limerinos) L / R			
W _{fp} (m)	15.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.31	0.50	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0170				

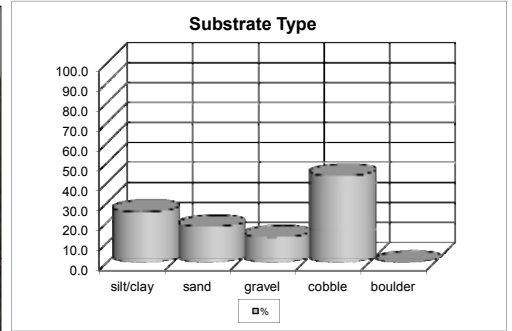
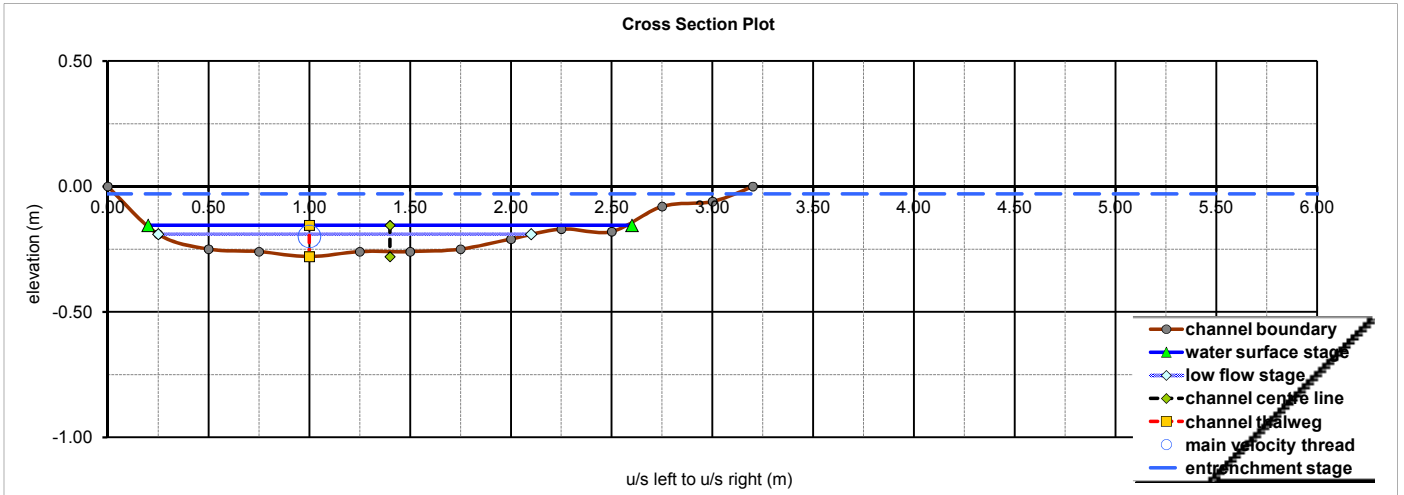
Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}		T _{* 289.3}	8.7	0.2
type	(kg sec ⁻¹)	(kg sec ⁻¹)				
B3	0.0013	0.0011	saltnation	YES	YES	NO
C3	0.0000	0.0000	rolling	YES	YES	NO
C4	0.0034	0.0025	∅	NO	NO	YES

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		0.03	0.06	2.00	95.00	160.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)				92.15	155.20	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Strickler method	Limerinos method
Q (cms)	0.249	Q (cms)	Q (cms)
V (m s ⁻¹)	0.80	V (m s ⁻¹)	V (m s ⁻¹)
n	0.035	n	n
Fr	0.79	Fr	Fr
D _c rectangular (m)	0.09	D _c rectangular (m)	D _c rectangular (m)
D _c trapezoidal (m)	0.18	D _c trapezoidal (m)	D _c trapezoidal (m)
D _c triangular (m)	0.27	D _c triangular (m)	D _c triangular (m)
D _c parabolic (m)	0.19	D _c parabolic (m)	D _c parabolic (m)
D _c mean (m)	0.18	D _c mean (m)	D _c mean (m)
flow type	SUBCRITICAL	flow type	flow type
Ω (watts m ⁻¹)	41.48	Ω (watts m ⁻¹)	Ω (watts m ⁻¹)
ω _a (watts m ⁻²)	13.51	ω _a (watts m ⁻²)	ω _a (watts m ⁻²)
ω _g /TW (watts m ⁻¹)	4.57	ω _g /TW (watts m ⁻¹)	ω _g /TW (watts m ⁻¹)
Re*	3.3	Re*	Re*
Re	71121	Re	Re
turbulence	LOW	turbulence	turbulence

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	1.72	H _b (m)		
τ _{calc} (N m ⁻²)	16.84	Bf _d (m)		
τ D _{crit} (gr-co) (mm)	17.36	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.22	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.51	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - upstream Section 5 - stability test



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.18
step	R (m) 0.08
riffle ●	TW (m) 2.36
run	WP (m) 2.39
glide	max d (m) 0.13
pool	mean d (m) 0.08
thalweg out of phase ●	E _s (Limerinos) (m) [+]
Hydraulic Roughness	E _s (Strickler) (m) [+]
rr R/D ₈₄ 0.62	Hydraulic Ratios
ff V mean/V* 3.98	ER max d 6.36
ff D ₈₄ 1.66	r _c / TW
ff mean 2.82	TW / Lf _w 1.27
ROUGH BED	TW/max d 18.9
	TW/mean d 30.2

Sediment Transport Mode		w _s (m s ⁻¹)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀ 0.032	1.25	NO	NO	YES	YES
V _c (m s ⁻¹)	0.062	D ₅₀ 0.803	31.57	NO	NO	NO	NO
		D ₈₄ 1.641	64.49	NO	NO	NO	NO

Section Data		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
ER _e (m)	-0.03	0.05	0.25	30.00	125.00	190.00
WS _e (m)	-0.155	Stability Design Targets (mm)				
Lf _e (m)	-0.190	τ _{cr} (N m ⁻²)				
W _{fb} (m)	15.00	high turbulence - angular (mm)				
r _c (m)		high turbulence - rounded (mm)				
z		low turbulence - angular (mm)				
E _s (m m ⁻¹)	0.0250	low turbulence - rounded (mm)				

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	1.92	H _b (m)		Bf _d (m)	
τ _{calc} (N m ⁻²)	18.86	RDp (m)		H _r /Bf _d	
τ _{crit} (gr-co) (mm)	19.45	RDp/H _b		RDn (%)	
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.85	BA (°)		BFP (%)	
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.73				

Bedload Transport Data		Flow Regime		
Strickler Q	Limerinos Q	Strickler method		
Rosgen	Q _{sb}	Q _{sb}	D ₃₀	D ₅₀
type	(kg sec ⁻¹)	(kg sec ⁻¹)	T _*	D ₈₄
B3	0.0011	0.0008	saltnation	YES
C3	0.0000	0.0000	rolling	YES
C4	0.0026	0.0016	∅	NO

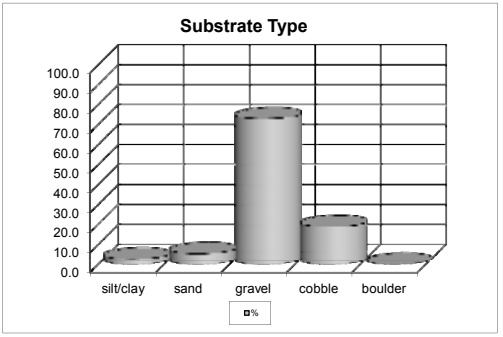
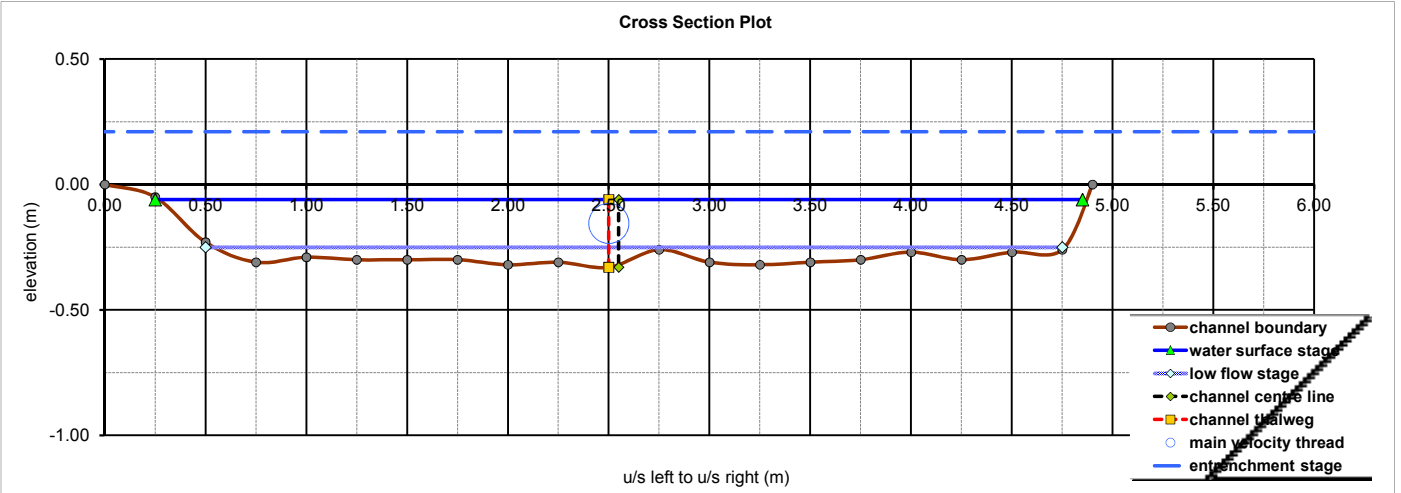
Flow Regime		Flow Regime	
Q (cms)	0.149	Limerinos method	
V (m s ⁻¹)	0.81	Q (cms)	
n	0.035	V (m s ⁻¹)	
Fr	0.93	n	
D _c rectangular (m)	0.08	Fr	
D _c trapezoidal (m)	0.15	D _c rectangular (m)	
D _c triangular (m)	0.22	D _c trapezoidal (m)	
D _c parabolic (m)	0.16	D _c triangular (m)	
D _c mean (m)	0.15	D _c parabolic (m)	
flow type	SUPERCritical	D _c mean (m)	
Ω (watts m ⁻¹)	36.56	flow type	
ω _a (watts m ⁻²)	15.29	Ω (watts m ⁻¹)	
ω _a /TW (watts m ⁻¹)	6.48	ω _a (watts m ⁻²)	
Re*	51.1	ω _a /TW (watts m ⁻¹)	
Re	54754	Re*	
turbulence	HIGH	Re	
		turbulence	

Lower Wedgewood Creek

Stability Conditions



Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek - Section 4 - stability test



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 1.04
step	R (m) 0.22
riffle	TW (m) 4.60
run	WP (m) 4.81
glide	max d (m) 0.27
pool	mean d (m) 0.23
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)		P		wash load		high		low		bedload	
k	0.41	D ₃₀	0.604	18.94	NO	NO	NO	NO	NO	NO	NO	NO	NO
V _c (m s ⁻¹)	0.078	D ₅₀	0.733	22.99	NO	NO	NO	NO	NO	NO	NO	NO	NO
		D ₈₄	1.228	38.51	NO	NO	NO	NO	NO	NO	NO	NO	NO

Section Data		ER stations L / R		WS stations L / R		Lf stations L / R		E _s sta. (Limerinos) L / R		E _s sta. (Strickler) L / R		T _e (m) T _{o/s} (m)	
ER _e (m)	0.21	-2.00	10.00										
WS _e (m)	-0.060	0.25	4.85										
Lf _e (m)	-0.250	0.50	4.75										
W _{fp} (m)	12.00												
r _c (m)													
Z													
E _s (m m ⁻¹)	0.0140												

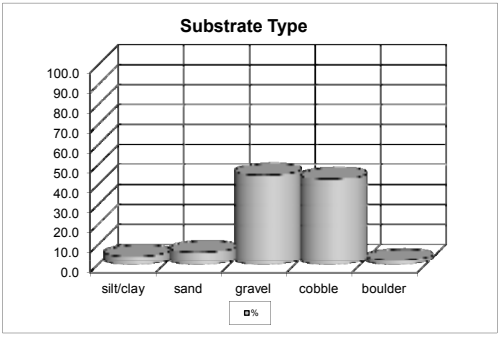
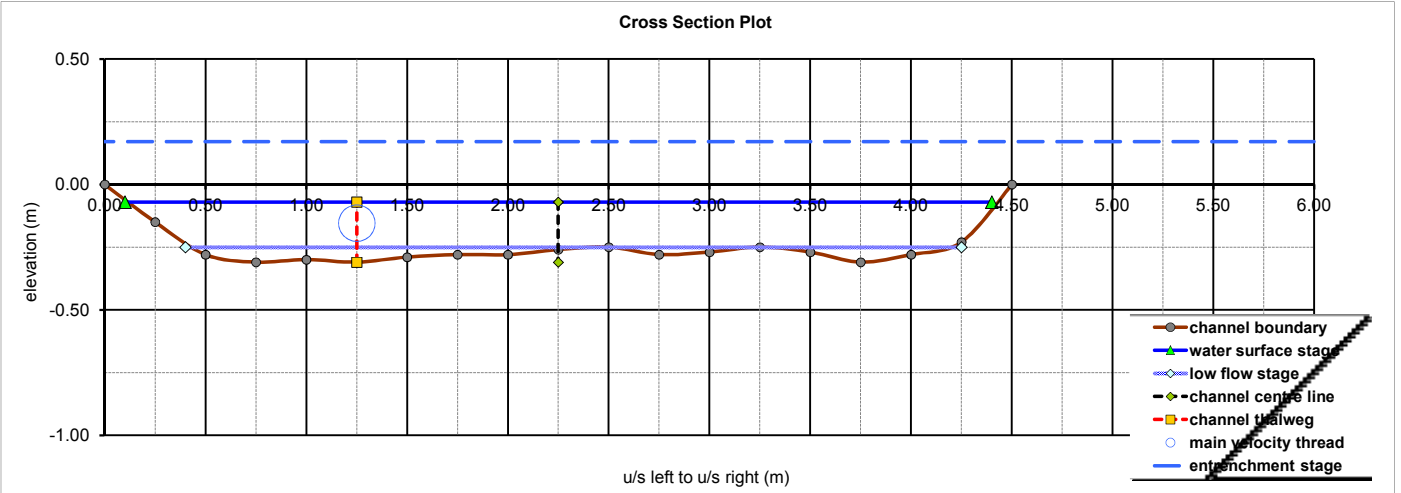
Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		8.00	17.00	25.00	70.00	160.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)		16.49	24.25	67.90	155.20	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Erosion Thresholds		Bank Data u/s L		u/s R	
τ _{calc} (kg m ⁻²)	3.02	H _b (m)			
τ _{calc} (N m ⁻²)	29.62	Bf _d (m)			
τ _{Dcrit} (gr-co) (mm)	30.53	RDp (m)			
D ₅₀ V _c (vcs +) (m s ⁻¹)	0.78	H _r /Bf _d			
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.30	RDp/H _b			
		RDn (%)			
		BA (°)			
		BFP (%)			

Bedload Transport Data		Strickler Q		Limerinos Q		Rosgen		D ₃₀		D ₅₀		D ₈₄	
Q _{sb}	Q _{lb}	Q _{sb}	Q _{lb}	Q _{sb}	Q _{lb}	type	T _*	1.8	1.2	0.4			
B3	0.0020	0.0019				type	salton	NO	NO	NO			
C3	0.0004	0.0003				type	rolling	YES	YES	NO			
C4	0.0071	0.0067				type	∅	NO	NO	YES			

Flow Regime		Strickler method		Flow Regime		Limerinos method	
Q (cms)	1.188	Q (cms)	1.188	Q (cms)	1.188	Q (cms)	1.188
V (m s ⁻¹)	1.14	V (m s ⁻¹)	1.14	V (m s ⁻¹)	1.14	V (m s ⁻¹)	1.14
n	0.037	n	0.037	n	0.037	n	0.037
Fr	0.77	Fr	0.77	Fr	0.77	Fr	0.77
D _c rectangular (m)	0.19	D _c rectangular (m)	0.19	D _c rectangular (m)	0.19	D _c rectangular (m)	0.19
D _c trapezoidal (m)	0.34	D _c trapezoidal (m)	0.34	D _c trapezoidal (m)	0.34	D _c trapezoidal (m)	0.34
D _c triangular (m)	0.50	D _c triangular (m)	0.50	D _c triangular (m)	0.50	D _c triangular (m)	0.50
D _c parabolic (m)	0.34	D _c parabolic (m)	0.34	D _c parabolic (m)	0.34	D _c parabolic (m)	0.34
D _c mean (m)	0.34	D _c mean (m)	0.34	D _c mean (m)	0.34	D _c mean (m)	0.34
flow type	SUBCRITICAL	flow type	SUBCRITICAL	flow type	SUBCRITICAL	flow type	SUBCRITICAL
Ω (watts m ⁻¹)	163.03	Ω (watts m ⁻¹)	163.03	Ω (watts m ⁻¹)	163.03	Ω (watts m ⁻¹)	163.03
ω _a (watts m ⁻²)	33.91	ω _a (watts m ⁻²)	33.91	ω _a (watts m ⁻²)	33.91	ω _a (watts m ⁻²)	33.91
ω _g /TW (watts m ⁻¹)	7.37	ω _g /TW (watts m ⁻¹)	7.37	ω _g /TW (watts m ⁻¹)	7.37	ω _g /TW (watts m ⁻¹)	7.37
Re*	38.4	Re*	38.4	Re*	38.4	Re*	38.4
Re	216794	Re	216794	Re	216794	Re	216794
turbulence	HIGH	turbulence	HIGH	turbulence	HIGH	turbulence	HIGH

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek - Section 5 - stability test



Morphology Type	Hydraulic Geometry
cascade	A (m ²) 0.84
step	R (m) 0.19
riffle	TW (m) 4.31
run	WP (m) 4.44
glide	max d (m) 0.24
pool	mean d (m) 0.20
thalweg out of phase	E _s (Limerinos) (m) [+]
	E _s (Strickler) (m) [+]

Sediment Transport Mode		w _s (m s ⁻¹)		P	wash load	high sus. load	low sus. load	bedload
k	0.41	D ₃₀	0.655	17.11	NO	NO	NO	NO
V _c (m s ⁻¹)	0.093	D ₅₀	1.089	28.42	NO	NO	NO	NO
		D ₈₄	1.608	41.99	NO	NO	NO	NO

Section Data		ER stations L / R	-2.00	10.00	TW ck
ER _e (m)	0.17	WS stations L / R	0.10	4.40	4.30
WS _e (m)	-0.070	Lf stations L / R	0.40	4.25	
Lf _e (m)	-0.250	E _s sta. (Limerinos) L / R			
W _{fp} (m)	12.00	E _s sta. (Strickler) L / R			
r _c (m)		T _e (m)	-0.31	1.25	
Z		T _{o/s} (m)			
E _s (m m ⁻¹)	0.0230				

Bedload Transport Data		Strickler Q	Limerinos Q	D ₃₀	D ₅₀	D ₈₄
Rosgen	Q _{sb}	Q _{sb}				
type	(kg sec ⁻¹)	(kg sec ⁻¹)	T _*	2.2	0.8	0.4
B3	0.0019	0.0018	saltnation	YES	NO	NO
C3	0.0003	0.0002	rolling	YES	NO	NO
C4	0.0066	0.0057	∅	NO	YES	YES

Substrate Gradation		D ₁₅	D ₃₀	D ₅₀	D ₈₄	D ₁₀₀
Existing Conditions (mm)		4.00	20.00	55.00	120.00	200.00
Stability Design Targets (mm)						
τ _{cr} (N m ⁻²)		19.40	53.35	116.40	194.00	
high turbulence - angular (mm)						
high turbulence - rounded (mm)						
low turbulence - angular (mm)						
low turbulence - rounded (mm)						

Flow Regime		Flow Regime	
Strickler method	Q (cms)	Limerinos method	Q (cms)
Q (cms)	1.047	Q (cms)	1.047
V (m s ⁻¹)	1.24	V (m s ⁻¹)	1.24
n	0.040	n	0.040
Fr	0.90	Fr	0.90
D _c rectangular (m)	0.18	D _c rectangular (m)	0.18
D _c trapezoidal (m)	0.33	D _c trapezoidal (m)	0.33
D _c triangular (m)	0.48	D _c triangular (m)	0.48
D _c parabolic (m)	0.33	D _c parabolic (m)	0.33
D _c mean (m)	0.33	D _c mean (m)	0.33
flow type	SUBCRITICAL	flow type	SUBCRITICAL
Ω (watts m ⁻¹)	236.04	Ω (watts m ⁻¹)	236.04
ω _a (watts m ⁻²)	53.15	ω _a (watts m ⁻²)	53.15
ω _g /TW (watts m ⁻¹)	12.34	ω _g /TW (watts m ⁻¹)	12.34
Re*	92.7	Re*	92.7
Re	206829	Re	206829
turbulence	HIGH	turbulence	HIGH

Erosion Thresholds		Bank Data u/s L		u/s R
τ _{calc} (kg m ⁻²)	4.36	H _b (m)		
τ _{calc} (N m ⁻²)	42.72	Bf _d (m)		
τ D _{crit} (gr-co) (mm)	44.04	RDp (m)		
D ₅₀ V _c (vcs +) (m s ⁻¹)	1.15	H _b /Bf _d		
D ₈₄ V _c (vcs +) (m s ⁻¹)	1.70	RDp/H _b		
		RDn (%)		
		BA (°)		
		BFP (%)		

Erosion Threshold Summary Models



GEO - ESUM v.1.3 Erosion Threshold Summary Model



B. de Geus 8.11

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek- upstream reach

Existing	Q m ³ s ⁻¹	V m s ⁻¹	veg control	D ₅₀ particle	D ₈₄ -D ₁₀₀ particle	τ _{calc} N m ⁻²	veg control	D ₅₀ particle*	D ₈₄ -D ₁₀₀ particle*	Ω watts m ⁻¹	Ω threshold
Xsec. 1	0.894	1.18	Y	N	N	29	Y	N	Y	123	Y
Xsec. 2	0.891	1.29	N	N	Y	34	Y	N	Y	149	Y
Xsec. 3	0.891	1.19	Y	N	Y	29	Y	N	Y	131	Y
Xsec. 4	0.890	1.21	N	N	Y	31	Y	N	Y	148	Y
Xsec. 5	0.890	1.46	N	N	Y	45	N	N	Y	218	Y

Dynamic Stability

Xsec. 1	0.289	0.81	Y	D	Y	26	Y	D	Y	37	Y
Xsec. 2	0.221	0.80	Y	D	Y	17	Y	D	Y	37	Y
Xsec. 3	0.277	0.80	Y	D	Y	16	Y	D	Y	41	Y
Xsec. 4	0.249	0.80	Y	D	Y	17	Y	D	Y	41	Y
Xsec. 5	0.149	0.82	Y	Y	Y	19	Y	Y	Y	37	Y

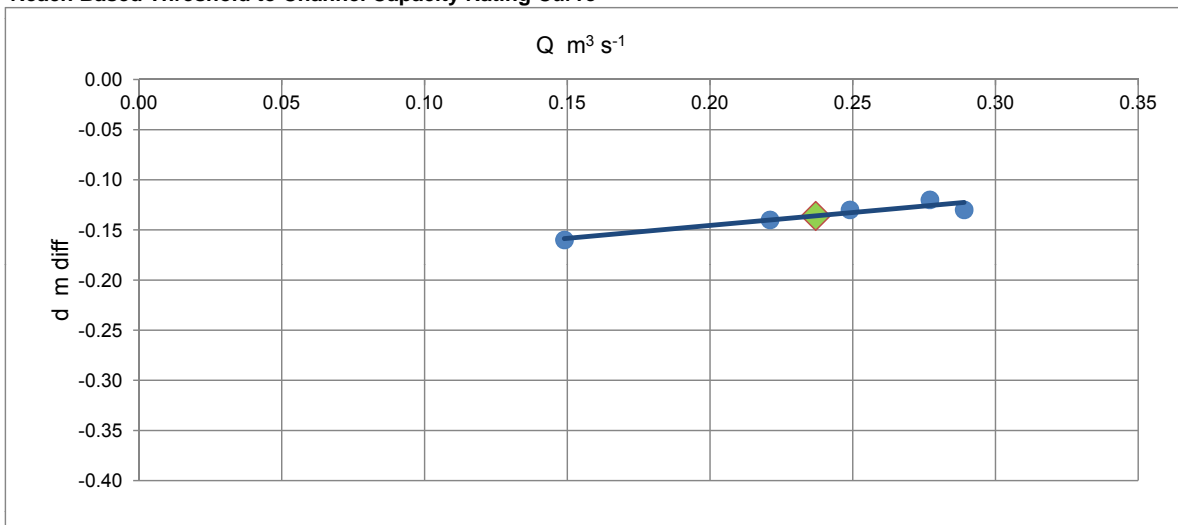
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

Dynamic Stability
 Dynamic Stability = Cautionary
 Unstable

	Q m ³ s ⁻¹ existing	Q m ³ s ⁻¹ stable	Q m ³ s ⁻¹ diff	d m diff
Xsec. 1	0.89	0.29	0.61	-0.13
Xsec. 2	0.89	0.22	0.67	-0.14
Xsec. 3	0.89	0.28	0.61	-0.12
Xsec. 4	0.89	0.25	0.64	-0.13
Xsec. 5	0.89	0.15	0.74	-0.16
mean	0.89	0.24	0.65	-0.14

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model



B. de Geus 8.11

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Morrison Creek - downstream reach

Existing	Q m ³ s ⁻¹	V m s ⁻¹	veg control	D ₅₀ particle	D ₈₄ -D ₁₀₀ particle	τ _{calc} N m ⁻²	veg control	D ₅₀ particle*	D ₈₄ -D ₁₀₀ particle*	Ω watts m ⁻¹	Ω threshold
Xsec. 1	1.414	1.04	Y	Y	Y	21	Y	Y	Y	114	Y
Xsec. 2	1.410	1.06	Y	Y	Y	21	Y	Y	Y	111	Y
Xsec. 3	1.412	1.08	Y	Y	Y	21	Y	Y	Y	107	Y
Xsec. 4	1.413	1.11	Y	Y	Y	23	Y	Y	Y	125	Y
Xsec. 5	1.411	1.18	Y	Y	Y	30	Y	Y	Y	180	Y

Dynamic Stability

Xsec. 1				
Xsec. 2				
Xsec. 3				
Xsec. 4				
Xsec. 5				

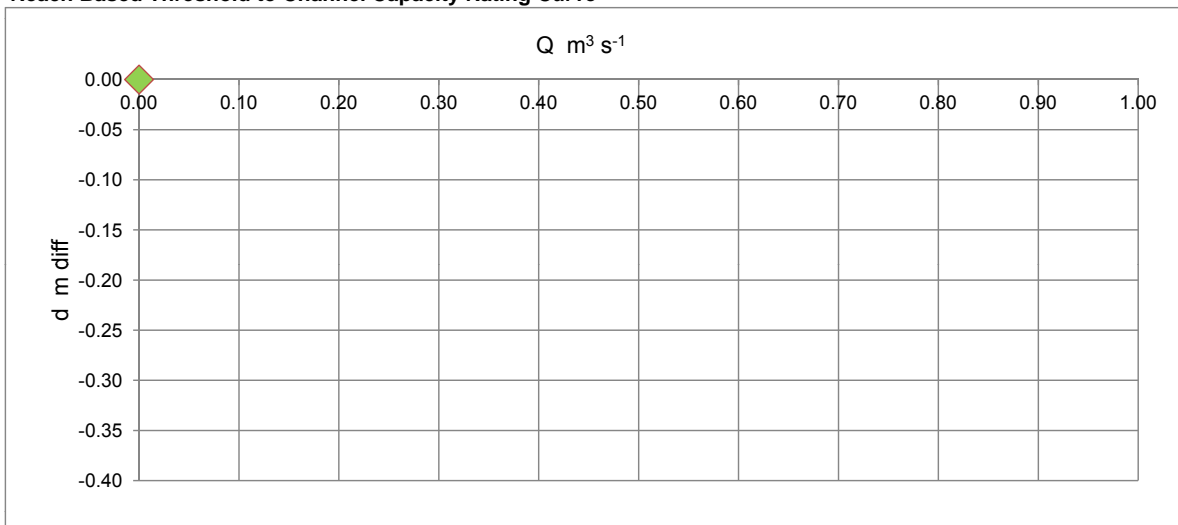
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

Dynamic Stability
Dynamic Stability = Cautionary
Unstable

	Q m ³ s ⁻¹ existing	Q m ³ s ⁻¹ stable	Q m ³ s ⁻¹ diff	d m diff
Xsec. 1	1.41			
Xsec. 2	1.41			
Xsec. 3	1.41			
Xsec. 4	1.41			
Xsec. 5	1.41			
mean	1.41			

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model



B. de Geus 8.11

Project: Erosion Threshold Analysis
Midtown Oakville
Lower Wedgewood Creek

Existing	Q m ³ s ⁻¹	V m s ⁻¹	veg control	D ₅₀ particle	D ₈₄ -D ₁₀₀ particle	τ _{calc} N m ⁻²	veg control	D ₅₀ particle*	D ₈₄ -D ₁₀₀ particle*	Ω watts m ⁻¹	Ω threshold
Xsec. 1	1.703	1.16	Y	Y	Y	23	Y	Y	Y	117	Y
Xsec. 2	1.704	1.11	Y	Y	Y	25	Y	Y	Y	142	Y
Xsec. 3	1.703	1.13	Y	Y	Y	26	Y	Y	Y	141	Y
Xsec. 4	1.700	1.29	N	N	Y	35	Y	N	Y	233	Y
Xsec. 5	1.702	1.48	N	Y	Y	55	N	Y	Y	383	Y

Dynamic Stability

Xsec. 1	1.703	1.16	Y	Y	Y	23	Y	Y	Y	117	Y
Xsec. 2	1.704	1.11	Y	Y	Y	25	Y	Y	Y	142	Y
Xsec. 3	1.703	1.13	Y	Y	Y	26	Y	Y	Y	141	Y
Xsec. 4	1.188	1.14	Y	D	Y	30	Y	D	Y	163	Y
Xsec. 5	1.047	1.24	D	Y	Y	43	D	Y	Y	236	Y

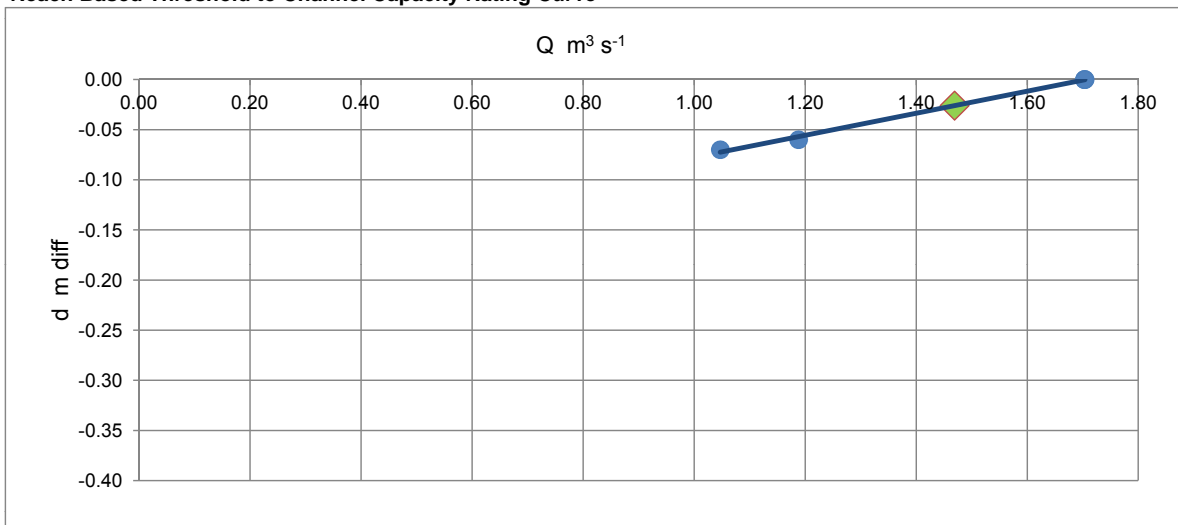
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

Dynamic Stability
 Dynamic Stability = Cautionary
 Unstable

	Q m ³ s ⁻¹ existing	Q m ³ s ⁻¹ stable	Q m ³ s ⁻¹ diff	d m diff
Xsec. 1	1.70	1.70	0.00	0.00
Xsec. 2	1.70	1.70	0.00	0.00
Xsec. 3	1.70	1.70	0.00	0.00
Xsec. 4	1.70	1.19	0.51	-0.06
Xsec. 5	1.70	1.05	0.66	-0.07
mean	1.70	1.47	0.23	-0.03

Reach Based Threshold to Channel Capacity Rating Curve







Appendix H
Invicta Drive Figures and Flood
Mitigation Alternative Assessment
Results

Drawing □ - Morrison Creek (100 Year Floodlines) with Culvert Upgrades

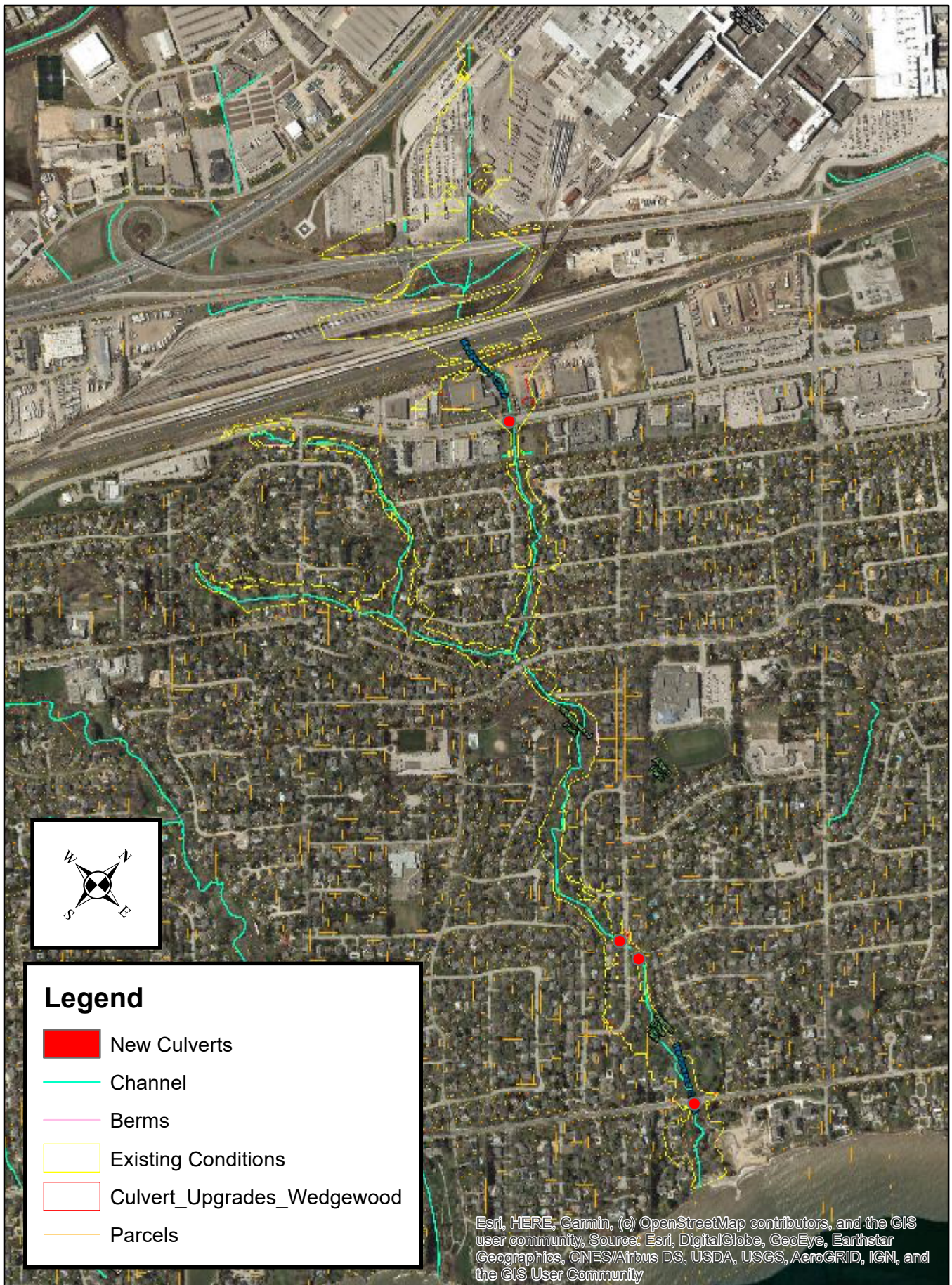


Legend

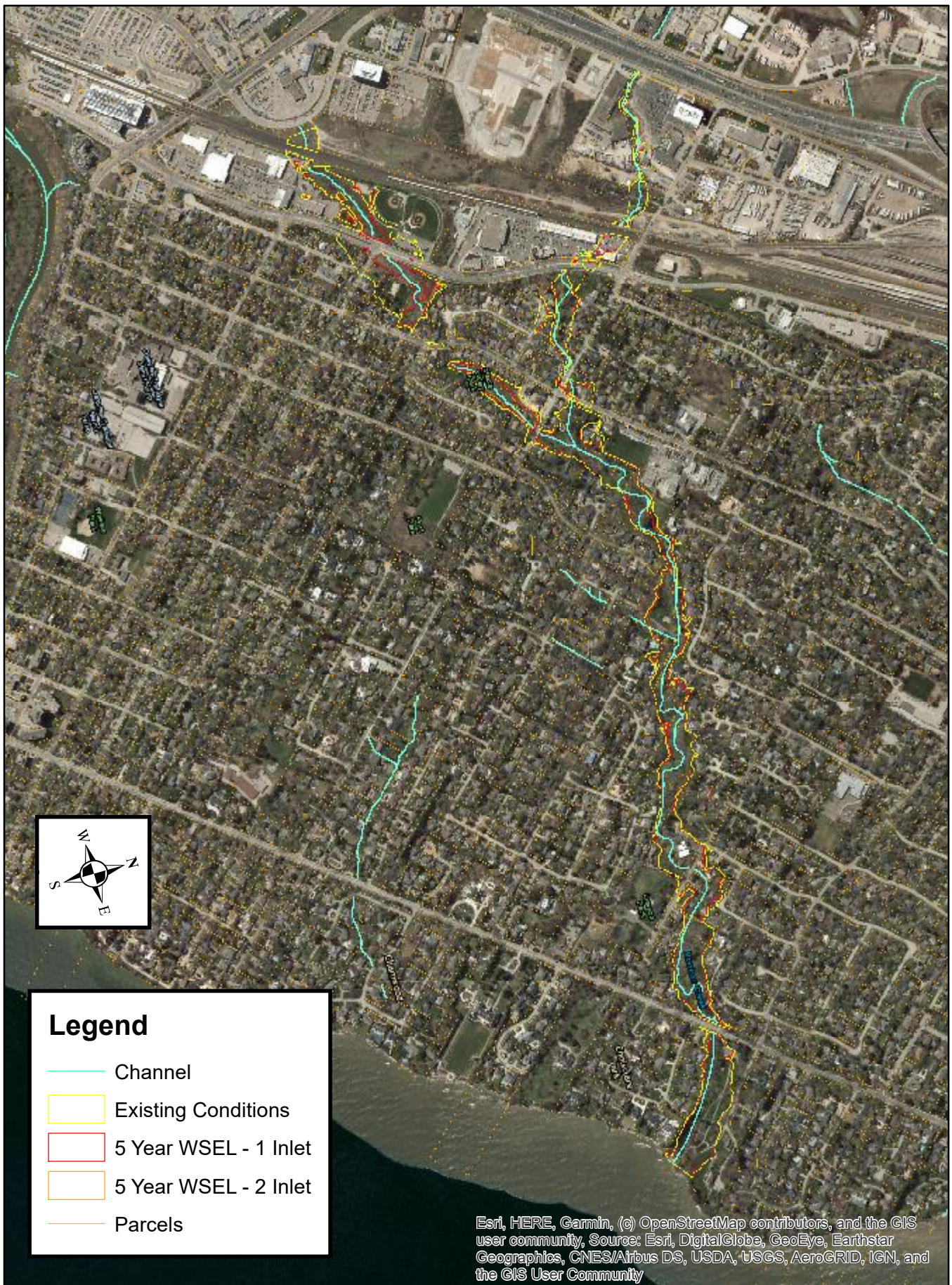
-  New Culverts
-  Channel
-  Existing Conditions
-  Culvert_Upgrades_Morrison
-  Parcels

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

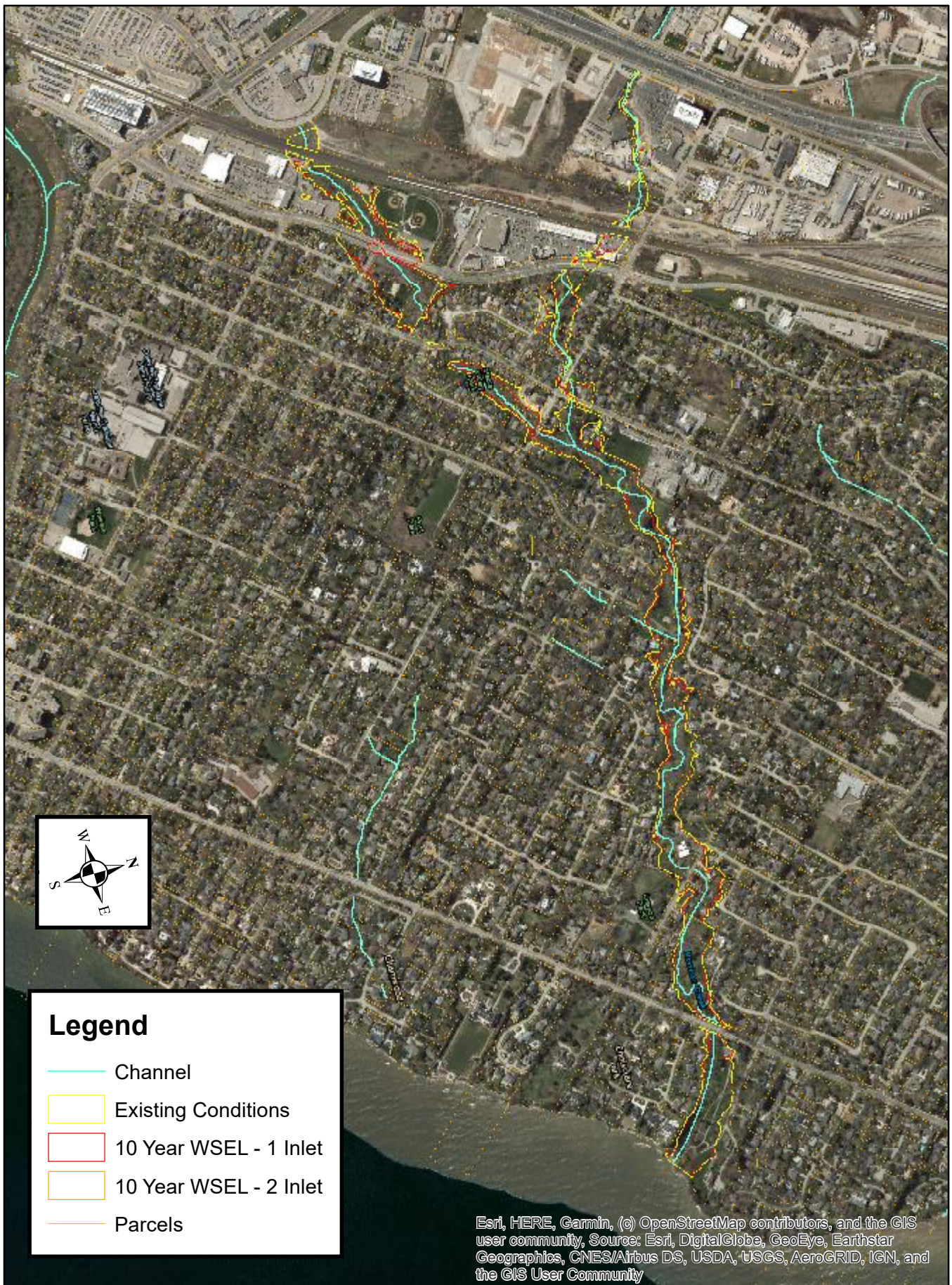
Drawing □ - Wedgewood Creek (100 Year Floodlines) with Culvert Upgrades



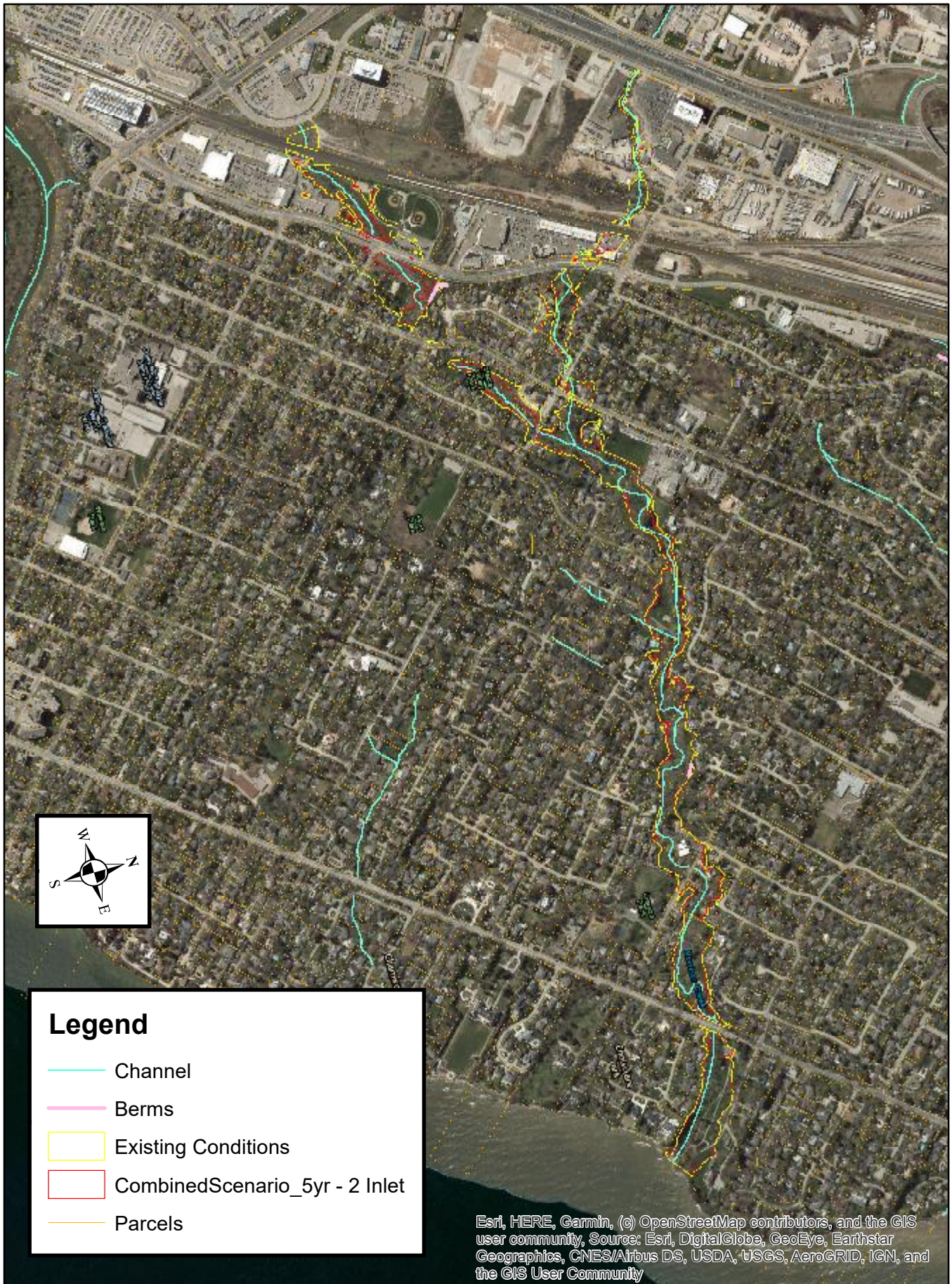
Drawing □ - Morrison Creek (100 Year Floodlines) with 5 Year Inlet WSELs



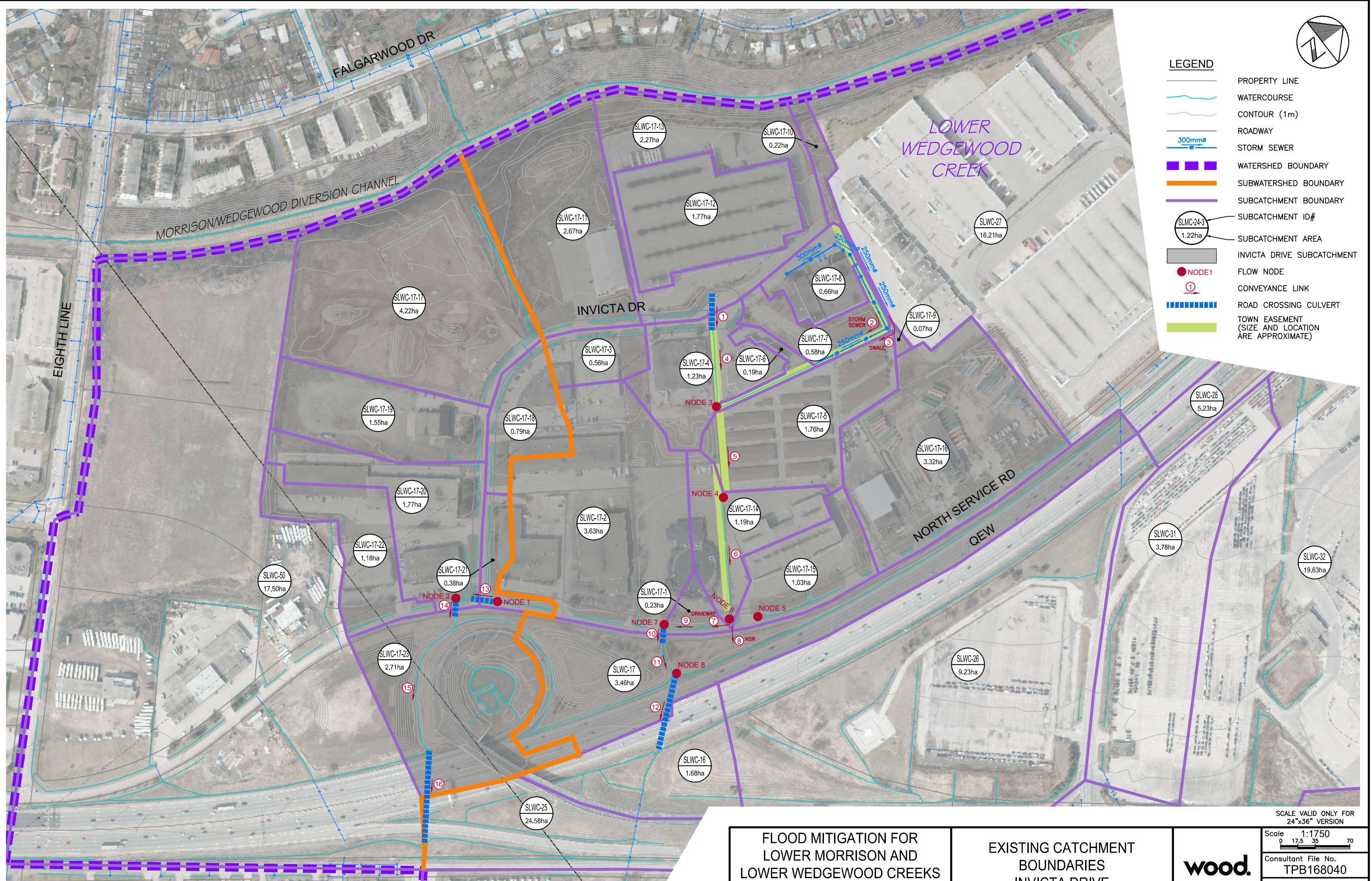
Drawing □ - Morrison Creek (100 Year Floodlines) with 10 Year Inlet WSELs



Drawing 5 - Morrison Creek (100 Year Floodlines) Combined Scenario with Culverts, 5 Year 2-Inlet WSELs, and Localized Berming



Plotted: 2021-05-18 Plotted By: richard.bartolo
 Last Saved: 2021-05-10 Last Saved By: richard.bartolo
 Path: I:\TPB168040 - LowerMorrison - Wedgewood\06_DES-ENG\01_CAD\02_DWGS\05_WR\01_PROJ\2021-05 (InvictaUpd)\Fig_Catchment.dwg



LEGEND

- PROPERTY LINE
- WATERCOURSE
- CONTOUR (1m)
- ROADWAY
- 300mm ϕ STORM SEWER
- WATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- SUBCATCHMENT ID#
SUBCATCHMENT AREA
- INVICTA DRIVE SUBCATCHMENT
- NODE1 FLOW NODE
- CONVEYANCE LINK
- ROAD CROSSING CULVERT
- TOWN EASEMENT (SIZE AND LOCATION ARE APPROXIMATE)

FLOOD MITIGATION FOR
 LOWER MORRISON AND
 LOWER WEDGEWOOD CREEKS
 TOWN OF OAKVILLE

EXISTING CATCHMENT
 BOUNDARIES
 INVICTA DRIVE



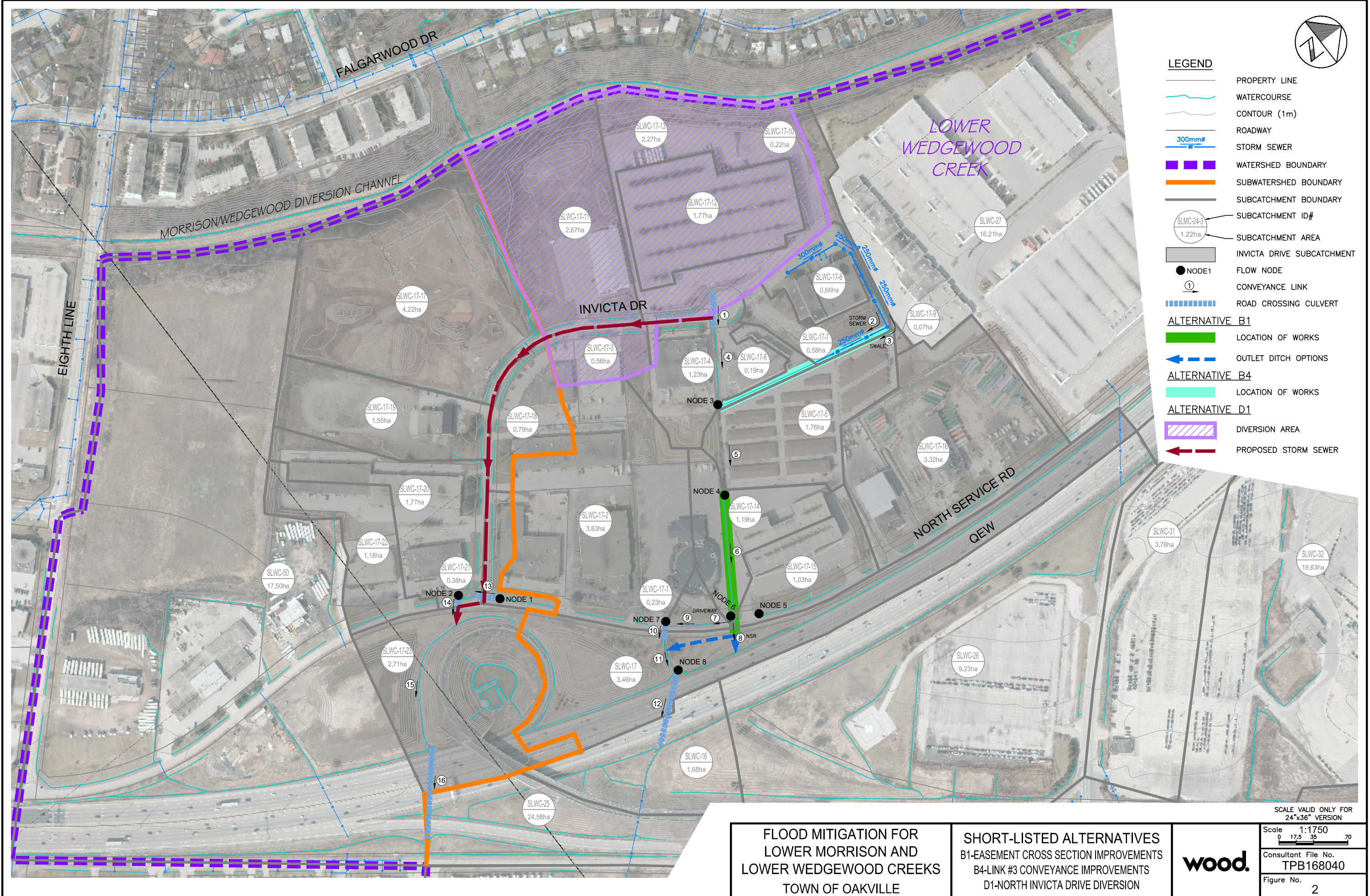
SCALE VALID ONLY FOR
 24"x36" VERSION

Scale 1:1750
 0 17.5 35 70

Consultant File No.
 TPB168040

Figure No.
 1

Plotted: 2021-05-18 Plotted By: richard.bartolo
 Last Saved: 2021-05-10 Last Saved By: richard.bartolo
 Path: I:\TPB168040 - LowerMorrison - Wedgewood\06_DES-ENG\01_CAD\02_DWGS\05_WR\01_PROJ\2021-05 (InvictaUpd)\Fig2-3 AlternativeWorks.dwg



**FLOOD MITIGATION FOR
 LOWER MORRISON AND
 LOWER WEDGEWOOD CREEKS
 TOWN OF OAKVILLE**

SHORT-LISTED ALTERNATIVES
 B1-EASEMENT CROSS SECTION IMPROVEMENTS
 B4-LINK #3 CONVEYANCE IMPROVEMENTS
 D1-NORTH INVICTA DRIVE DIVERSION

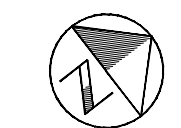
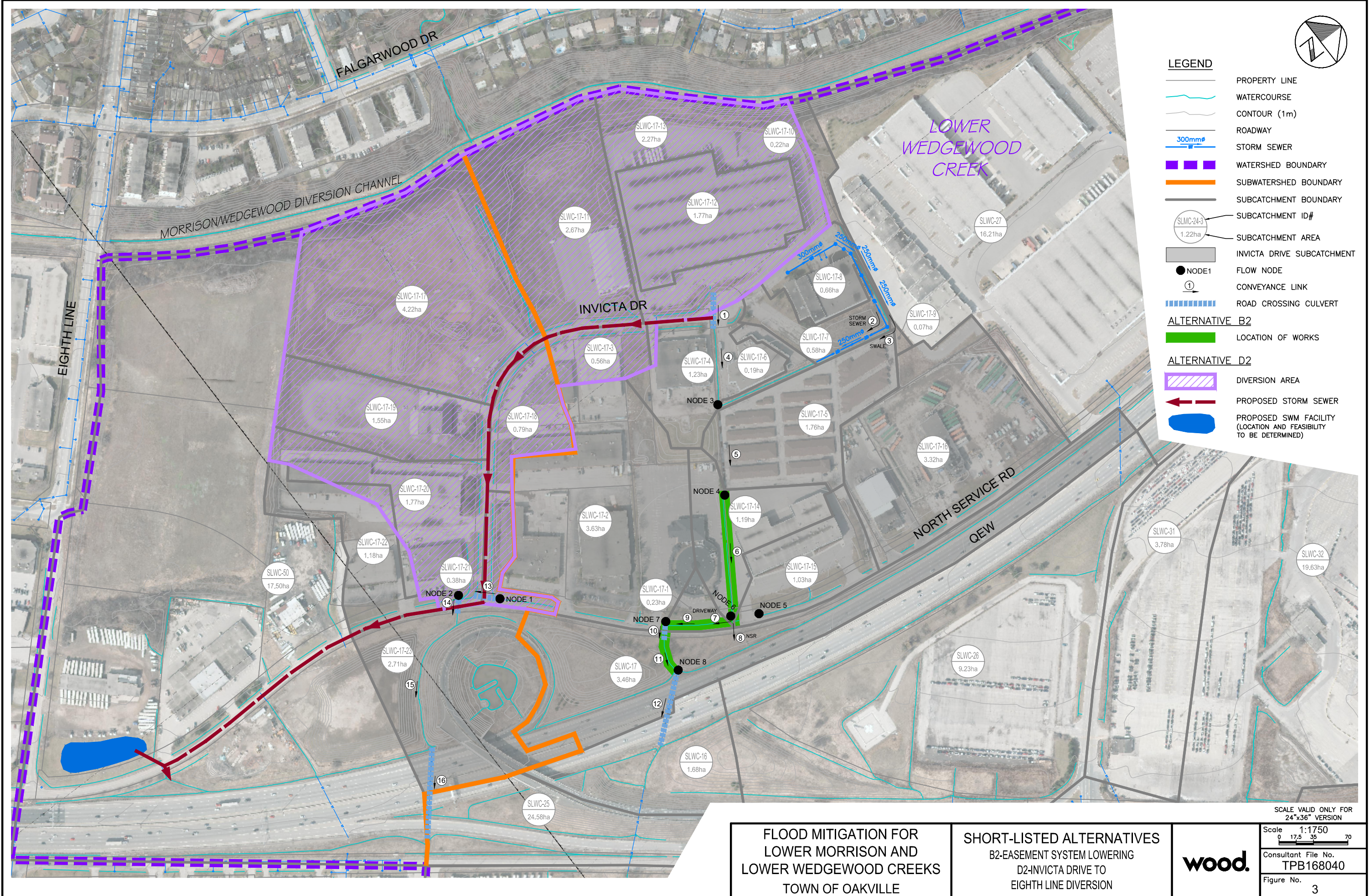


SCALE VALID ONLY FOR 24"x36" VERSION

Scale	1:1750
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Consultant File No.	TPB168040
Figure No.	2

Path: I:\TPB168040 - LowerMorrison - Wedgewood\06_DES-ENG\01_CAD\02_DWGS\05_WF\01_PROJ\2021-05 (InvictaUpd)\Fig2-3 AlternativeWorks.dwg

Plotted By: richard.bartolo
Last Saved By: richard.bartolo
2021-05-18
Last Saved: 2021-05-10



- LEGEND**
- PROPERTY LINE
 - WATERCOURSE
 - CONTOUR (1m)
 - ROADWAY
 - STORM SEWER
 - WATERSHED BOUNDARY
 - SUBWATERSHED BOUNDARY
 - SUBCATCHMENT BOUNDARY
 - SUBCATCHMENT ID#
 - SUBCATCHMENT AREA
 - INVICTA DRIVE SUBCATCHMENT
 - NODE1 FLOW NODE
 - CONVEYANCE LINK
 - ROAD CROSSING CULVERT
 - ALTERNATIVE B2**
 - LOCATION OF WORKS
 - ALTERNATIVE D2**
 - DIVERSION AREA
 - PROPOSED STORM SEWER
 - PROPOSED SWM FACILITY (LOCATION AND FEASIBILITY TO BE DETERMINED)

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD MITIGATION FOR LOWER MORRISON AND LOWER WEDGEWOOD CREEKS TOWN OF OAKVILLE

SHORT-LISTED ALTERNATIVES B2-EASEMENT SYSTEM LOWERING D2-INVICTA DRIVE TO EIGHTH LINE DIVERSION



Scale 1:1750
0 17.5 35 70
Consultant File No. TPB168040
Figure No. 3

Appendix I
Cost Estimates

West Morrison Creek Flow Diversion to Sixteen Mile Creek					
Item	Unit of Measure	Estimated Quantity	Unit Cost (\$)	Total Cost (\$)	With Contingency (%15)
Inlet Structure/ Headwall	each	2	\$ 34,729	\$ 69,458	\$ 79,876
3 m x 2.4 m inlet box culvert (twin)	Length (m)	12	\$ 43,786	\$ 525,432	\$ 604,247
Custom MH Structures (Reduce from 3 m * 2.4 m to 1500 mm sewer)	each	2	\$ 57,881	\$ 115,763	\$ 133,127
1500 mm diameter reinforced concrete pipes (Park to Cornwall Road)	Length (m)	10	\$ 6,008	\$ 60,081	\$ 69,093
1500 mm diameter reinforced concrete pipe	Length (m)	800	\$ 6,008	\$ 4,806,459	\$ 5,527,428
1500 mm diameter reinforced concrete outlet pipe	Length (m)	40	\$ 6,008	\$ 240,323	\$ 276,371
Cast in Place Manhole (for 1500 mm diameter pipe)	each	10	\$ 17,364	\$ 173,644	\$ 199,690
Outlet Drop Structure	each	1	\$ 231,525	\$ 231,525	\$ 266,254
Outlet Headwall	each	1	\$ 22,050	\$ 22,050	\$ 25,358
ESC and Dewatering	LS	1	\$ 57,881	\$ 57,881	\$ 66,563
Revegetation	m2	675	\$ 174	\$ 117,210	\$ 134,791
Mobilization and Demobilization	LS	1	\$ 11,576	\$ 11,576	\$ 13,313
Notes: 1 - Costing does not include utilities or removal of municipal infrastructure			Sub Total	\$ 6,431,401	\$ 7,396,111

LWMC

Location	Height (m)	Length (m)	Volume (m ³)
Bohemia Crescent	0.5	63.7	96
Botany Hill	0.5	26.7	40
Wedgewood Drive	0.5	65	98
Cynthia Lane	0.5	66	99
		221	332

Morrison Creek - West of Bohemia Crescent					
Item	Unit of Measure	Estimated Quantity	Unit Cost (\$)	Total Cost (\$)	With Contingency (\$)
Fill	Volume (m ³)	96	\$ 46	\$ 4,445	\$ 5,112.07
Landscaping	Area (m ²)	255	\$ 23	\$ 5,904	\$ 6,789.47
Site Access/Removals/Replacements	Each	1	\$ 23,153	\$ 23,153	\$ 26,625.38
Mobilization and Demobilization	Each	1	\$ 11,025	\$ 11,025	\$ 12,678.75
			Sub Total	\$ 44,527	\$ 51,206
Morrison Creek - West of Botany Hill					
Fill	Volume (m ³)	40	\$ 46	\$ 1,852	\$ 2,130.03
Landscaping	Area (m ²)	107	\$ 23	\$ 2,477	\$ 2,848.92
Site Access/Removals/Replacements	Each	1	\$ 23,153	\$ 23,153	\$ 26,625.38
Mobilization and Demobilization	Each	1	\$ 11,025	\$ 11,025	\$ 12,678.75
			Sub Total	\$ 38,507	\$ 44,283
Wedgewood Creek - West of Wedgewood Drive					
Fill	Volume (m ³)	98	\$ 46	\$ 4,538	\$ 5,218.57
Landscaping	Area (m ²)	260	\$ 23	\$ 6,020	\$ 6,922.60
Site Access/Removals/Replacements	Each	2	\$ 23,153	\$ 46,305	\$ 53,250.75
Mobilization and Demobilization	Item	2	\$ 11,025	\$ 22,050	\$ 25,357.50
			Sub Total	\$ 78,913	\$ 90,749
Wedgewood Creek - South of Cynthia Lane					
Fill	Volume (m ³)	99	\$ 46	\$ 4,584	\$ 5,271.82
Landscaping	Area (m ²)	264	\$ 23	\$ 6,112	\$ 7,029.10
Site Access/Removals/Replacements	Each	1	\$ 23,153	\$ 23,153	\$ 26,625.38
Mobilization and Demobilization	Item	1	\$ 11,025	\$ 11,025	\$ 12,678.75
			Sub Total	\$ 44,874	\$ 51,605
			Grand Total	\$ 206,820	\$ 237,843

Total Cost for Morrison	\$ 83,033.69	\$ 95,489
Total Cost for Wedgewood	\$ 123,786.50	\$ 142,354

Culvert Upgrades

	Item	Unit of Measure	Estimated Quantity	Unit Cost (\$) ¹	Total Cost (\$)	With Contingency (%15)
Culvert Upgrades (Proposed Sizing)	Morrison - Lakeshore Rd (14.6 x 3.35)	Length (m)	10	\$ 67,605	\$ 676,053	\$ 777,460.95
	Morrison - Chartwell Rd (N. of Linbrook Rd - 6.4 x 2.13)	Length (m)	15	\$ 29,635	\$ 444,528	\$ 511,207.20
	Morrison - Linbrook Rd (7.32 x 2.13)	Length (m)	6.9	\$ 42,369	\$ 292,347	\$ 336,198.61
	Morrison - Chartwell Rd (S. of Linbrook Rd - 6.4 x 1.5)	Length (m)	16.3	\$ 29,635	\$ 483,054	\$ 555,511.82
	Wedgewood - Lakeshore Rd (14.6 x 3.05)	Length (m)	15.1	\$ 67,605	\$ 1,020,840	\$ 1,173,966.03
	Wedgewood - Warren Dr Park (7.3 x 1.52)	Length (m)	29.5	\$ 33,803	\$ 997,178	\$ 1,146,754.90
	Wedgewood - Wedgewood Dr (7.3 x 1.52)	Length (m)	21.2	\$ 33,803	\$ 716,616	\$ 824,108.61
	Wedgewood - Cornwall Rd (N. of SWM Facility - 7.3 x 1.52)	Length (m)	33.6	\$ 33,803	\$ 1,135,769	\$ 1,306,134.40
				Sub-Total	\$ 5,766,385	\$ 6,631,343
Miscellaneous	Item	Unit of Measure	Estimated Quantity	Unit Cost (\$)	Total Cost (\$)	With Contingency (%15)
	Dewatering	Unit	8	28940.625	\$ 231,525	\$ 266,253.75
	Temporary Flow Controls	Unit	8	34728.75	\$ 277,830	\$ 319,504.50
	Traffic Control	Unit	8	23152.5	\$ 185,220	\$ 213,003.00
Notes: 1 - Costing does not include utilities or removal of municipal infrastructure				Sub-Total	\$ 694,575	\$ 798,761
				Grand Total	\$ 6,460,960	\$ 7,430,104

¹. Unit Cost is based on Deck Area of \$4000/m²

Cornwall Road Park Flood Storage Tank						
	Item	Unit of Measure	Estimated Quantity	Unit Cost (\$)	Total Cost (\$)	With Contingency (%15)
PIPES	Inlet Structure/ Headwall	each	2	\$ 34,729	\$ 69,458	\$ 79,876.13
	3 m x 2.4 m inlet box culvert (twin)	Length (m)	12	\$ 43,786	\$ 525,432	\$ 604,246.91
	Outlet Headwall	each	1	\$ 5,788	\$ 5,788	\$ 6,656.34
				Sub-Total	\$ 600,678	\$ 690,779
TANK	Item	Unit of Measure	Estimated Quantity	Unit Cost (\$)	Total Cost (\$)	With Contingency (%15)
	Tank	Volume (m3)	10800	\$ 405	\$ 4,375,823	\$ 5,032,195.88
	Excavated Soil Treatment	Volume (m3)	18000	\$ 58	\$ 1,041,863	\$ 1,198,141.88
	Pump System	LS	1	\$ 115,763	\$ 115,763	\$ 133,126.88
				Sub-Total	\$ 5,533,448	\$ 6,363,465
Erosion and Sedimentation	Item	Unit of Measure	Estimated Quantity	Unit Cost (\$)	Total Cost (\$)	With Contingency (%15)
	ESC and Dewatering	Unit	1	\$ 57,881	\$ 57,881	\$ 66,563.44
				Sub-Total	\$ 57,881	\$ 66,563
Miscellaneous	Item	Unit of Measure	Estimated Quantity	Unit Cost (\$)	Total Cost (\$)	With Contingency (%15)
	Mobilization and Demobilization	LS	1	\$ 11,576	\$ 11,576	\$ 13,312.69
	Revegetation	Area (m2)	150	\$ 174	\$ 26,047	\$ 29,953.55
	Topsoil and sod	Area (m2)	4320	\$ 6	\$ 25,005	\$ 28,755.41
Notes: 1 - Costing does not include utilities or removal of municipal infrastructure				Sub-Total	\$ 62,628	\$ 72,022
				Grand Total	\$ 6,254,634	\$ 7,192,829
				Cost per m3 of storage	\$	666

Appendix J
Archaeological and Cultural Heritage
Assessment

The **purpose of the checklist** is to determine:

- if a property(ies) or project area may contain archaeological resources i.e., have archaeological potential
- it includes all areas that may be impacted by project activities, including – but not limited to:
 - the main project area
 - temporary storage
 - staging and working areas
 - temporary roads and detours

Processes covered under this checklist, such as:

- *Planning Act*
- *Environmental Assessment Act*
- *Aggregates Resources Act*
- *Ontario Heritage Act* – Standards and Guidelines for Conservation of Provincial Heritage Properties

Archaeological assessment

If you are not sure how to answer one or more of the questions on the checklist, you may want to hire a licensed consultant archaeologist (see page 4 for definitions) to undertake an archaeological assessment.

The assessment will help you:

- identify, evaluate and protect archaeological resources on your property or project area
- reduce potential delays and risks to your project

Note: By law, archaeological assessments **must** be done by a licensed consultant archaeologist. Only a licensed archaeologist can assess – or alter – an archaeological site.

What to do if you:

- **find an archaeological resource**

If you find something you think may be of archaeological value during project work, you must – by law – stop all activities immediately and contact a licensed consultant archaeologist

The archaeologist will carry out the fieldwork in compliance with the *Ontario Heritage Act* [s.48(1)].

- **unearth a burial site**

If you find a burial site containing human remains, you must immediately notify the appropriate authorities (i.e., police, coroner's office, and/or Registrar of Cemeteries) and comply with the *Funeral, Burial and Cremation Services Act*.

Other checklists

Please use a separate checklist for your project, if:

- you are seeking a Renewable Energy Approval under Ontario Regulation 359/09 – separate checklist
- your Parent Class EA document has an approved screening criteria (as referenced in Question 1)

Please refer to the Instructions pages when completing this form.

Project or Property Name

Flood Mitigation Opportunities Study Lower Morrison and Lower Wedgewood Creeks

Project or Property Location (upper and lower or single tier municipality)

Cornwall Road Park, 439 Cornwall Road, Oakville. Property location is the west side of the park.

Proponent Name

Town of Oakville

Proponent Contact Information

Diana Michalakos, Diana.Michalakos@oakville.ca

Screening Questions

1. Is there a pre-approved screening checklist, methodology or process in place? Yes No

If Yes, please follow the pre-approved screening checklist, methodology or process.

If No, continue to Question 2.

2. Has an archaeological assessment been prepared for the property (or project area) and been accepted by MTCS? Yes No

If Yes, do not complete the rest of the checklist. You are expected to follow the recommendations in the archaeological assessment report(s).

The proponent, property owner and/or approval authority will:

- summarize the previous assessment
- add this checklist to the project file, with the appropriate documents that demonstrate an archaeological assessment was undertaken e.g., MTCS letter stating acceptance of archaeological assessment report

The summary and appropriate documentation may be:

- submitted as part of a report requirement e.g., environmental assessment document
- maintained by the property owner, proponent or approval authority

If No, continue to Question 3.

3. Are there known archaeological sites on or within 300 metres of the property (or the project area)? Yes No

4. Is there Aboriginal or local knowledge of archaeological sites on or within 300 metres of the property (or project area)? Yes No

5. Is there Aboriginal knowledge or historically documented evidence of past Aboriginal use on or within 300 metres of the property (or project area)? Yes No

6. Is there a known burial site or cemetery on the property or adjacent to the property (or project area)? Yes No

7. Has the property (or project area) been recognized for its cultural heritage value? Yes No

If Yes to any of the above questions (3 to 7), do not complete the checklist. Instead, you need to hire a licensed consultant archaeologist to undertake an archaeological assessment of your property or project area.

If No, continue to question 8.

8. Has the entire property (or project area) been subjected to recent, extensive and intensive disturbance? Yes No

If Yes to the preceding question, do not complete the checklist. Instead, please keep and maintain a summary of documentation that provides evidence of the recent disturbance.

An archaeological assessment is not required.

If No, continue to question 9.

	Yes	No
9. Are there present or past water sources within 300 metres of the property (or project area)?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
If Yes , an archaeological assessment is required.		
If No , continue to question 10.		

	Yes	No
10. Is there evidence of two or more of the following on the property (or project area)?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<ul style="list-style-type: none">• elevated topography• pockets of well-drained sandy soil• distinctive land formations• resource extraction areas• early historic settlement• early historic transportation routes		
If Yes , an archaeological assessment is required.		
If No , there is low potential for archaeological resources at the property (or project area).		
The proponent, property owner and/or approval authority will:		
<ul style="list-style-type: none">• summarize the conclusion• add this checklist with the appropriate documentation to the project file		
The summary and appropriate documentation may be:		
<ul style="list-style-type: none">• submitted as part of a report requirement e.g., under the <i>Environmental Assessment Act, Planning Act</i> processes• maintained by the property owner, proponent or approval authority		

Instructions

Please have the following available, when requesting information related to the screening questions below:

- a clear map showing the location and boundary of the property or project area
 - large scale and small scale showing nearby township names for context purposes
- the municipal addresses of all properties within the project area
- the lot(s), concession(s), and parcel number(s) of all properties within a project area

In this context, the following definitions apply:

- **consultant archaeologist** means, as defined in Ontario regulation as an archaeologist who enters into an agreement with a client to carry out or supervise archaeological fieldwork on behalf of the client, produce reports for or on behalf of the client and provide technical advice to the client. In Ontario, these people also are required to hold a valid professional archaeological licence issued by the Ministry of Tourism, Culture and Sport.
- **proponent** means a person, agency, group or organization that carries out or proposes to carry out an undertaking or is the owner or person having charge, management or control of an undertaking.

1. Is there a pre-approved screening checklist, methodology or process in place?

An existing checklist, methodology or process may be already in place for identifying archaeological potential, including:

- one prepared and adopted by the municipality e.g., archaeological management plan
- an environmental assessment process e.g., screening checklist for municipal bridges
- one that is approved by the Ministry of Tourism, Culture and Sport under the Ontario government's Standards & Guidelines for Conservation of Provincial Heritage Properties [s. B.2.]

2. Has an archaeological assessment been prepared for the property (or project area) and been accepted by MTCS?

Respond 'yes' to this question, if all of the following are true:

- an archaeological assessment report has been prepared and is in compliance with MTCS requirements
 - a letter has been sent by MTCS to the licensed archaeologist confirming that MTCS has added the report to the Ontario Public Register of Archaeological Reports (Register)
- the report states that there are no concerns regarding impacts to archaeological sites

Otherwise, if an assessment has been completed and deemed compliant by the MTCS, and the ministry recommends further archaeological assessment work, this work will need to be completed.

For more information about archaeological assessments, contact:

- approval authority
- proponent
- consultant archaeologist
- Ministry of Tourism, Culture and Sport at archaeology@ontario.ca

3. Are there known archaeological sites on or within 300 metres of the property (or project area)?

MTCS maintains a database of archaeological sites reported to the ministry.

For more information, contact MTCS Archaeological Data Coordinator at archaeology@ontario.ca.

4. Is there Aboriginal or local knowledge of archaeological sites on or within 300 metres of the property?

Check with:

- Aboriginal communities in your area
- local municipal staff

They may have information about archaeological sites that are not included in MTCS' database.

Other sources of local knowledge may include:

- property owner
- local heritage organizations and historical societies
- local museums
- municipal heritage committee
- published local histories

5. Is there Aboriginal knowledge or historically documented evidence of past Aboriginal use on or within 300 metres of the property (or property area)?

Check with:

- Aboriginal communities in your area
- local municipal staff

Other sources of local knowledge may include:

- property owner
- local heritage organizations and historical societies
- local museums
- municipal heritage committee
- published local histories

6. Is there a known burial site or cemetery on the property or adjacent to the property (or project area)?

For more information on known cemeteries and/or burial sites, see:

- Cemeteries Regulation Unit, Ontario Ministry of Consumer Services – for database of registered cemeteries
- Ontario Genealogical Society (OGS) – to locate records of Ontario cemeteries, both currently and no longer in existence; cairns, family plots and burial registers
- Canadian County Atlas Digital Project – to locate early cemeteries

In this context, ‘adjacent’ means ‘contiguous’, or as otherwise defined in a municipal official plan.

7. Has the property (or project area) been recognized for its cultural heritage value?

There is a strong chance there may be archaeological resources on your property (or immediate area) if it has been listed, designated or otherwise identified as being of cultural heritage value by:

- your municipality
- Ontario government
- Canadian government

This includes a property that is:

- designated under *Ontario Heritage Act* (the OHA), including:
 - individual designation (Part IV)
 - part of a heritage conservation district (Part V)
 - an archaeological site (Part VI)
- subject to:
 - an agreement, covenant or easement entered into under the OHA (Parts II or IV)
 - a notice of intention to designate (Part IV)
 - a heritage conservation district study area by-law (Part V) of the OHA
- listed on:
 - a municipal register or inventory of heritage properties
 - Ontario government’s list of provincial heritage properties
 - Federal government’s list of federal heritage buildings
- part of a:
 - National Historic Site
 - UNESCO World Heritage Site
- designated under:
 - *Heritage Railway Station Protection Act*
 - *Heritage Lighthouse Protection Act*
- subject of a municipal, provincial or federal commemorative or interpretive plaque.

To determine if your property or project area is covered by any of the above, see:

- Part A of the MTCS Criteria for Evaluating Potential for Built Heritage and Cultural Heritage Landscapes

Part VI – Archaeological Sites

Includes five sites designated by the Minister under Regulation 875 of the Revised Regulation of Ontario, 1990 (Archaeological Sites) and 3 marine archaeological sites prescribed under Ontario Regulation 11/06.

For more information, check Regulation 875 and Ontario Regulation 11/06.

8. Has the entire property (or project area) been subjected to recent extensive and intensive ground disturbance?

Recent: after-1960

Extensive: over all or most of the area

Intensive: thorough or complete disturbance

Examples of ground disturbance include:

- quarrying
- major landscaping – involving grading below topsoil
- building footprints and associated construction area
 - where the building has deep foundations or a basement
- infrastructure development such as:
 - sewer lines
 - gas lines
 - underground hydro lines
 - roads
 - any associated trenches, ditches, interchanges. **Note:** this applies only to the excavated part of the right-of-way; the remainder of the right-of-way or corridor may not have been impacted.

A ground disturbance does **not** include:

- agricultural cultivation
- gardening
- landscaping

Site visits

You can typically get this information from a site visit. In that case, please document your visit in the process (e.g., report) with:

- photographs
- maps
- detailed descriptions

If a disturbance isn't clear from a site visit or other research, you need to hire a licensed consultant archaeologist to undertake an archaeological assessment.

9. Are there present or past water bodies within 300 metres of the property (or project area)?

Water bodies are associated with past human occupations and use of the land. About 80-90% of archaeological sites are found within 300 metres of water bodies.

Present

- Water bodies:
 - primary - lakes, rivers, streams, creeks
 - secondary - springs, marshes, swamps and intermittent streams and creeks
- accessible or inaccessible shoreline, for example:
 - high bluffs
 - swamps
 - marsh fields by the edge of a lake
 - sandbars stretching into marsh

Water bodies not included:

- man-made water bodies, for example:
 - temporary channels for surface drainage
 - rock chutes and spillways
 - temporarily ponded areas that are normally farmed
 - dugout ponds
- artificial bodies of water intended for storage, treatment or recirculation of:
 - runoff from farm animal yards
 - manure storage facilities
 - sites and outdoor confinement areas

Past

Features indicating past water bodies:

- raised sand or gravel beach ridges – can indicate glacial lake shorelines
- clear dip in the land – can indicate an old river or stream
- shorelines of drained lakes or marshes
- cobble beaches

You can get information about water bodies through:

- a site visit
- aerial photographs
- 1:10,000 scale Ontario Base Maps - or equally detailed and scaled maps.

10. Is there evidence of two or more of the following on the property (or project area)?

- elevated topography
- pockets of well-drained sandy soil
- distinctive land formations
- resource extraction areas
- early historic settlement
- early historic transportation routes

• **Elevated topography**

Higher ground and elevated positions - surrounded by low or level topography - often indicate past settlement and land use.

Features such as eskers, drumlins, sizeable knolls, plateaus next to lowlands, or other such features are a strong indication of archaeological potential.

Find out if your property or project area has elevated topography, through:

- site inspection
- aerial photographs
- topographical maps

• **Pockets of well-drained sandy soil, especially within areas of heavy soil or rocky ground**

Sandy, well-drained soil - in areas characterized by heavy soil or rocky ground - may indicate archaeological potential

Find out if your property or project area has sandy soil through:

- site inspection
- soil survey reports

- **Distinctive land formations**

Distinctive land formations include – but are not limited to:

- waterfalls
- rock outcrops
- rock faces
- caverns
- mounds, etc.

They were often important to past inhabitants as special or sacred places. The following sites may be present – or close to – these formations:

- burials
- structures
- offerings
- rock paintings or carvings

Find out if your property or project areas has a distinctive land formation through:

- a site visit
- aerial photographs
- 1:10,000 scale Ontario Base Maps - or equally detailed and scaled maps.

- **Resource extraction areas**

The following resources were collected in these extraction areas:

- food or medicinal plants e.g., migratory routes, spawning areas, prairie
- scarce raw materials e.g., quartz, copper, ochre or outcrops of chert
- resources associated with early historic industry e.g., fur trade, logging, prospecting, mining

Aboriginal communities may hold traditional knowledge about their past use or resources in the area.

- **Early historic settlement**

Early Euro-Canadian settlement include – but are not limited to:

- early military or pioneer settlement e.g., pioneer homesteads, isolated cabins, farmstead complexes
- early wharf or dock complexes
- pioneers churches and early cemeteries

For more information, see below – under the early historic transportation routes.

- **Early historic transportation routes** - such as trails, passes, roads, railways, portage routes, canals.

For more information, see:

- historical maps and/or historical atlases
 - for information on early settlement patterns such as trails (including Aboriginal trails), monuments, structures, fences, mills, historic roads, rail corridors, canals, etc.
 - Archives of Ontario holds a large collection of historical maps and historical atlases
 - digital versions of historic atlases are available on the Canadian County Atlas Digital Project
- commemorative markers or plaques such as local, provincial or federal agencies
- municipal heritage committee or other local heritage organizations
 - for information on early historic settlements or landscape features (e.g., fences, mill races, etc.)
 - for information on commemorative markers or plaques

Project or Property Name

Flood Mitigation Opportunities Study Lower Morrison and Lower Wedgewood Creeks

Project or Property Location (upper and lower or single tier municipality)

Cornwall Road Park, 439 Cornwall Road, Oakville. Property location is the west side

Proponent Name

Town of Oakville

Proponent Contact Information

Telephone Number

Fax Number

Email Address

Diana Michalakos@oakville.ca

Screening Questions

1. Is the project/property located in a flood-prone area?

Yes No

[Redacted]

2. Does the project/property have any flood-related risks or concerns?

Yes No

[Redacted]

- [Redacted]
- [Redacted]
- [Redacted]

[Redacted]

- [Redacted]
- [Redacted]

[Redacted]

3. Is the project/property located in a flood-prone area?

Yes No

4. Does the project/property have any flood-related risks or concerns?

Yes No

5. Is the project/property located in a flood-prone area?

Yes No

6. Does the project/property have any flood-related risks or concerns?

Yes No

7. Is the project/property located in a flood-prone area?

Yes No

[Redacted]

8. Does the project/property have any flood-related risks or concerns?

Yes No

[Redacted]

10. *Is the proposed project or activity a "major project" as defined in the Environmental Assessment Act?*
 Yes No

10. *Is the proposed project or activity a "major project" as defined in the Environmental Assessment Act?*
 Yes No

11. *Is the proposed project or activity a "major project" as defined in the Environmental Assessment Act?*
 Yes No

12. *Is the proposed project or activity a "major project" as defined in the Environmental Assessment Act?*
 Yes No

13. *Is the proposed project or activity a "major project" as defined in the Environmental Assessment Act?*
 Yes No

14. *Is the proposed project or activity a "major project" as defined in the Environmental Assessment Act?*
 Yes No

15. If the proposed project or activity is a "major project" as defined in the Environmental Assessment Act, is it also a "major project" as defined in the Environmental Assessment Act Planning Act?

- Yes No

Instructions

1. List the three main components of the Environmental Assessment Act.

- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)

2. Explain the purpose of the Environmental Assessment Act.

- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)

3. Describe the role of the Environmental Assessment Board.

[Environmental Assessment Board](#)

- [Environmental Assessment Board](#)
- [Environmental Assessment Board](#)
- [Environmental Assessment Board](#)
- [Environmental Assessment Board](#)

4. Identify the key provisions of the Environmental Assessment Act.

[Environmental Assessment Act](#)

- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)

[Environmental Assessment Act](#)

[Environmental Assessment Act](#)

- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)
- [Environmental Assessment Act](#)

5. Discuss the importance of the Environmental Assessment Act.

[Environmental Assessment Act](#)

[Environmental Assessment Act](#)

[local heritage organizations and historical societies](#), [Association for Great Lakes Maritime History](#) ([Save Ontario Shipwrecks](#), [Ontario Underwater Council](#)), [Preserve Our Wrecks](#), [Ontario Marine Heritage Committee](#))

- [municipal heritage committees](#)

- [local heritage organizations and historical societies](#)

- [municipal heritage committees](#)

- [database of registered cemeteries](#) - [to locate records of Ontario cemeteries](#), both currently and no longer

- [locate early cemeteries](#)

Introduction text

- Item 1
- Item 2
- Item 3

Table of Contents

- *Ontario Heritage Act*
- *Heritage Railway Station Protection Act*
- *Heritage Lighthouse Protection Act*
- *Heritage Railway Station Protection Act*
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- *Heritage Lighthouse Protection Act*

Additional text or notes

Section header or title

- [Criteria for Evaluating Potential for Built Heritage and Cultural Heritage Landscapes](#)

Additional text or notes

Regulation 875 and Ontario Regulation 11/06.

1. What is the difference between a primary and a secondary source?

- Primary source: original source of information
- Secondary source: information derived from primary sources
- Examples:
 - Primary: newspaper article, photograph, video, interview
 - Secondary: textbook, encyclopedia, review article

2. What are the characteristics of a primary source?

- Created at the time of the event
- Close to the source of information
- Often subjective
- May be biased

3. What are the characteristics of a secondary source?

- Created after the event
- Further from the source of information
- Often objective
- May be more accurate

4. Why is it important to distinguish between primary and secondary sources?

5. What are the characteristics of a primary source?

- Created at the time of the event
- Close to the source of information
- Often subjective
- May be biased

6. What are the characteristics of a secondary source?

- Created after the event
- Further from the source of information
- Often objective
- May be more accurate

7. Why is it important to distinguish between primary and secondary sources?

Section 1: Introduction

The purpose of this document is to provide a comprehensive overview of the project's objectives, scope, and methodology. It is intended for use by all stakeholders involved in the project, including project managers, team members, and external partners.

1.1 Project Objectives and Scope

The primary objective of this project is to develop a robust system that addresses the following requirements:

- System architecture and data flow

1.2 System Architecture

The system architecture is designed to be modular and scalable, allowing for future expansion and integration with other systems.

The system will be developed using the following technologies:

• **Backend:** Java, Spring Boot

• **Frontend:** React, Redux

• **Database:** PostgreSQL

The system will be deployed on a cloud-based infrastructure, ensuring high availability and scalability. The architecture is designed to be secure and compliant with industry standards.

The system will be developed in the following phases:

• **Phase 1:** Requirements gathering and analysis

• **Phase 2:** System design and architecture

• **Phase 3:** Development and testing

• **Phase 4:** Deployment and monitoring

• **Phase 5:** Maintenance and support

• **Phase 6:** User training and documentation

• **Phase 7:** Project closure and evaluation

• **Phase 8:** Post-project review and feedback

In addition, the following resources were collected in these extraction activities:

- **Historical records:** e.g. migratory routes, spawning areas, prairie
- **Geological data:** e.g. quartz, copper, ochre or outcrops of chert
- **Archival documents:** e.g. fur trade, logging, etc.

These resources may hold traditional knowledge about their past use or location.

1.3 Data Collection and Analysis

The data collection process involves the following steps:

1. **Identify data sources:** Determine the locations and types of data sources to be collected.

2. **Collect data:** Gather the data from the identified sources.

3. **Analyze data:** Process and analyze the collected data to extract meaningful information.

1.4 Data Management and Storage

- **Maps and atlases:**
 - Information on early settlement patterns such as trails (including Aboriginal trails), monuments, structures, fences, mills, historic roads, rail corridors, canals, etc.
 - [Archives of Ontario](#) holds a large collection of historical maps and atlases
 - [Canadian County Atlas Digital Project](#) provides access to historical maps and atlases
 - [provincial](#) or [federal](#) agencies
- [municipal heritage committees](#) or [other local heritage organizations](#)

The data management and storage process involves the following steps:

1. **Design data storage architecture:** Determine the storage architecture and data flow.

2. **Implement data storage:** Set up the data storage infrastructure.

3. **Monitor data storage:** Monitor the data storage infrastructure for performance and security.

The **purpose of the checklist** is to determine:

- if a property(ies) or project area:
 - is a recognized heritage property
 - may be of cultural heritage value
- it includes all areas that may be impacted by project activities, including – but not limited to:
 - the main project area
 - temporary storage
 - staging and working areas
 - temporary roads and detours

Processes covered under this checklist, such as:

- *Planning Act*
- *Environmental Assessment Act*
- *Aggregates Resources Act*
- *Ontario Heritage Act* – Standards and Guidelines for Conservation of Provincial Heritage Properties

Cultural Heritage Evaluation Report (CHER)

If you are not sure how to answer one or more of the questions on the checklist, you may want to hire a qualified person(s) (see page 5 for definitions) to undertake a cultural heritage evaluation report (CHER).

The CHER will help you:

- identify, evaluate and protect cultural heritage resources on your property or project area
- reduce potential delays and risks to a project

Other checklists

Please use a separate checklist for your project, if:

- you are seeking a Renewable Energy Approval under Ontario Regulation 359/09 – separate checklist
- your Parent Class EA document has an approved screening criteria (as referenced in Question 1)

Please refer to the Instructions pages for more detailed information and when completing this form.

Project or Property Name

Flood Mitigation Opportunities Study Lower Morrison and Lower Wedgewood Creeks

Project or Property Location (upper and lower or single tier municipality)

Cornwall Road Park, 439 Cornwall Road, Oakville. Property location is the west side of the park

Proponent Name

Town of Oakville

Proponent Contact Information

Diana Michalakos, Diana.Michalakos@oakville.ca

Screening Questions

	Yes	No
1. Is there a pre-approved screening checklist, methodology or process in place?	<input type="checkbox"/>	<input checked="" type="checkbox"/>

If Yes, please follow the pre-approved screening checklist, methodology or process.

If No, continue to Question 2.

Part A: Screening for known (or recognized) Cultural Heritage Value

	Yes	No
2. Has the property (or project area) been evaluated before and found not to be of cultural heritage value?	<input type="checkbox"/>	<input checked="" type="checkbox"/>

If Yes, do **not** complete the rest of the checklist.

The proponent, property owner and/or approval authority will:

- summarize the previous evaluation and
- add this checklist to the project file, with the appropriate documents that demonstrate a cultural heritage evaluation was undertaken

The summary and appropriate documentation may be:

- submitted as part of a report requirement
- maintained by the property owner, proponent or approval authority

If No, continue to Question 3.

	Yes	No
3. Is the property (or project area):		
a. identified, designated or otherwise protected under the <i>Ontario Heritage Act</i> as being of cultural heritage value?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. a National Historic Site (or part of)?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c. designated under the <i>Heritage Railway Stations Protection Act</i> ?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. designated under the <i>Heritage Lighthouse Protection Act</i> ?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e. identified as a Federal Heritage Building by the Federal Heritage Buildings Review Office (FHBRO)?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f. located within a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site?	<input type="checkbox"/>	<input checked="" type="checkbox"/>

If Yes to any of the above questions, you need to hire a qualified person(s) to undertake:

- a Cultural Heritage Evaluation Report, if a Statement of Cultural Heritage Value has not previously been prepared or the statement needs to be updated

If a Statement of Cultural Heritage Value has been prepared previously and if alterations or development are proposed, you need to hire a qualified person(s) to undertake:

- a Heritage Impact Assessment (HIA) – the report will assess and avoid, eliminate or mitigate impacts

If No, continue to Question 4.

Part B: Screening for Potential Cultural Heritage Value

	Yes	No
4. Does the property (or project area) contain a parcel of land that:		
a. is the subject of a municipal, provincial or federal commemorative or interpretive plaque?	<input type="checkbox"/>	<input type="checkbox"/> 4
b. has or is adjacent to a known burial site and/or cemetery?	<input type="checkbox"/>	<input type="checkbox"/> 4
c. is in a Canadian Heritage River watershed?	<input type="checkbox"/>	<input type="checkbox"/> 4
d. contains buildings or structures that are 40 or more years old?	<input type="checkbox"/>	<input type="checkbox"/> 4

Part C: Other Considerations

	Yes	No
5. Is there local or Aboriginal knowledge or accessible documentation suggesting that the property (or project area):		
a. is considered a landmark in the local community or contains any structures or sites that are important in defining the character of the area?	<input type="checkbox"/>	<input type="checkbox"/> 4
b. has a special association with a community, person or historical event?	<input type="checkbox"/>	<input type="checkbox"/> 4
c. contains or is part of a cultural heritage landscape?	<input type="checkbox"/>	<input type="checkbox"/> 4

If Yes to one or more of the above questions (Part B and C), there is potential for cultural heritage resources on the property or within the project area.

You need to hire a qualified person(s) to undertake:

- a Cultural Heritage Evaluation Report (CHER)

If the property is determined to be of cultural heritage value and alterations or development is proposed, you need to hire a qualified person(s) to undertake:

- a Heritage Impact Assessment (HIA) – the report will assess and avoid, eliminate or mitigate impacts

If No to all of the above questions, there is low potential for built heritage or cultural heritage landscape on the property.

The proponent, property owner and/or approval authority will:

- summarize the conclusion
- add this checklist with the appropriate documentation to the project file

The summary and appropriate documentation may be:

- submitted as part of a report requirement e.g. under the *Environmental Assessment Act, Planning Act* processes
- maintained by the property owner, proponent or approval authority

Instructions

Please have the following available, when requesting information related to the screening questions below:

- a clear map showing the location and boundary of the property or project area
 - large scale and small scale showing nearby township names for context purposes
- the municipal addresses of all properties within the project area
- the lot(s), concession(s), and parcel number(s) of all properties within a project area

For more information, see the Ministry of Tourism, Culture and Sport's Ontario Heritage Toolkit or Standards and Guidelines for Conservation of Provincial Heritage Properties.

In this context, the following definitions apply:

- **qualified person(s)** means individuals – professional engineers, architects, archaeologists, etc. – having relevant, recent experience in the conservation of cultural heritage resources.
- **proponent** means a person, agency, group or organization that carries out or proposes to carry out an undertaking or is the owner or person having charge, management or control of an undertaking.

1. Is there a pre-approved screening checklist, methodology or process in place?

An existing checklist, methodology or process may already be in place for identifying potential cultural heritage resources, including:

- one endorsed by a municipality
- an environmental assessment process e.g. screening checklist for municipal bridges
- one that is approved by the Ministry of Tourism, Culture and Sport (MTCS) under the Ontario government's Standards & Guidelines for Conservation of Provincial Heritage Properties [s.B.2.]

Part A: Screening for known (or recognized) Cultural Heritage Value

2. Has the property (or project area) been evaluated before and found not to be of cultural heritage value?

Respond 'yes' to this question, if all of the following are true:

A property can be considered not to be of cultural heritage value if:

- a Cultural Heritage Evaluation Report (CHER) - or equivalent - has been prepared for the property with the advice of a qualified person and it has been determined not to be of cultural heritage value and/or
- the municipal heritage committee has evaluated the property for its cultural heritage value or interest and determined that the property is not of cultural heritage value or interest

A property may need to be re-evaluated, if:

- there is evidence that its heritage attributes may have changed
- new information is available
- the existing Statement of Cultural Heritage Value does not provide the information necessary to manage the property
- the evaluation took place after 2005 and did not use the criteria in Regulations 9/06 and 10/06

Note: Ontario government ministries and public bodies [prescribed under Regulation 157/10] may continue to use their existing evaluation processes, until the evaluation process required under section B.2 of the Standards & Guidelines for Conservation of Provincial Heritage Properties has been developed and approved by MTCS.

To determine if your property or project area has been evaluated, contact:

- the approval authority
- the proponent
- the Ministry of Tourism, Culture and Sport

3a. Is the property (or project area) identified, designated or otherwise protected under the *Ontario Heritage Act* as being of cultural heritage value e.g.:

- i. designated under the *Ontario Heritage Act*
 - individual designation (Part IV)
 - part of a heritage conservation district (Part V)

Individual Designation – Part IV

A property that is designated:

- by a municipal by-law as being of cultural heritage value or interest [s.29 of the *Ontario Heritage Act*]
- by order of the Minister of Tourism, Culture and Sport as being of cultural heritage value or interest of provincial significance [s.34.5]. **Note:** To date, no properties have been designated by the Minister.

Heritage Conservation District – Part V

A property or project area that is located within an area designated by a municipal by-law as a heritage conservation district [s. 41 of the *Ontario Heritage Act*].

For more information on Parts IV and V, contact:

- municipal clerk
- Ontario Heritage Trust
- local land registry office (for a title search)

ii. subject of an agreement, covenant or easement entered into under Parts II or IV of the *Ontario Heritage Act*

An agreement, covenant or easement is usually between the owner of a property and a conservation body or level of government. It is usually registered on title.

The primary purpose of the agreement is to:

- preserve, conserve, and maintain a cultural heritage resource
- prevent its destruction, demolition or loss

For more information, contact:

- Ontario Heritage Trust - for an agreement, covenant or easement [clause 10 (1) (c) of the *Ontario Heritage Act*]
- municipal clerk – for a property that is the subject of an easement or a covenant [s.37 of the *Ontario Heritage Act*]
- local land registry office (for a title search)

iii. listed on a register of heritage properties maintained by the municipality

Municipal registers are the official lists - or record - of cultural heritage properties identified as being important to the community.

Registers include:

- all properties that are designated under the *Ontario Heritage Act* (Part IV or V)
- properties that have not been formally designated, but have been identified as having cultural heritage value or interest to the community

For more information, contact:

- municipal clerk
- municipal heritage planning staff
- municipal heritage committee

iv. subject to a notice of:

- intention to designate (under Part IV of the *Ontario Heritage Act*)
- a Heritage Conservation District study area bylaw (under Part V of the *Ontario Heritage Act*)

A property that is subject to a **notice of intention to designate** as a property of cultural heritage value or interest and the notice is in accordance with:

- section 29 of the *Ontario Heritage Act*
- section 34.6 of the *Ontario Heritage Act*. **Note:** To date, the only applicable property is Meldrum Bay Inn, Manitoulin Island. [s.34.6]

An area designated by a municipal by-law made under section 40.1 of the *Ontario Heritage Act* as a **heritage conservation district study area**.

For more information, contact:

- municipal clerk – for a property that is the subject of notice of intention [s. 29 and s. 40.1]
- Ontario Heritage Trust

v. included in the Ministry of Tourism, Culture and Sport's list of provincial heritage properties

Provincial heritage properties are properties the Government of Ontario owns or controls that have cultural heritage value or interest.

The Ministry of Tourism, Culture and Sport (MTCS) maintains a list of all provincial heritage properties based on information provided by ministries and prescribed public bodies. As they are identified, MTCS adds properties to the list of provincial heritage properties.

For more information, contact the MTCS Registrar at registrar@ontario.ca.

3b. Is the property (or project area) a National Historic Site (or part of)?

National Historic Sites are properties or districts of national historic significance that are designated by the Federal Minister of the Environment, under the *Canada National Parks Act*, based on the advice of the Historic Sites and Monuments Board of Canada.

For more information, see the National Historic Sites website.

3c. Is the property (or project area) designated under the *Heritage Railway Stations Protection Act*?

The *Heritage Railway Stations Protection Act* protects heritage railway stations that are owned by a railway company under federal jurisdiction. Designated railway stations that pass from federal ownership may continue to have cultural heritage value.

For more information, see the Directory of Designated Heritage Railway Stations.

3d. Is the property (or project area) designated under the *Heritage Lighthouse Protection Act*?

The *Heritage Lighthouse Protection Act* helps preserve historically significant Canadian lighthouses. The Act sets up a public nomination process and includes heritage building conservation standards for lighthouses which are officially designated.

For more information, see the Heritage Lighthouses of Canada website.

3e. Is the property (or project area) identified as a Federal Heritage Building by the Federal Heritage Buildings Review Office?

The role of the Federal Heritage Buildings Review Office (FHBRO) is to help the federal government protect the heritage buildings it owns. The policy applies to all federal government departments that administer real property, but not to federal Crown Corporations.

For more information, contact the Federal Heritage Buildings Review Office.

See a directory of all federal heritage designations.

3f. Is the property (or project area) located within a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site?

A UNESCO World Heritage Site is a place listed by UNESCO as having outstanding universal value to humanity under the Convention Concerning the Protection of the World Cultural and Natural Heritage. In order to retain the status of a World Heritage Site, each site must maintain its character defining features.

Currently, the Rideau Canal is the only World Heritage Site in Ontario.

For more information, see Parks Canada – World Heritage Site website.

Part B: Screening for potential Cultural Heritage Value

4a. Does the property (or project area) contain a parcel of land that has a municipal, provincial or federal commemorative or interpretive plaque?

Heritage resources are often recognized with formal plaques or markers.

Plaques are prepared by:

- municipalities
- provincial ministries or agencies
- federal ministries or agencies
- local non-government or non-profit organizations

For more information, contact:

- municipal heritage committees or local heritage organizations – for information on the location of plaques in their community
- Ontario Historical Society's Heritage directory – for a list of historical societies and heritage organizations
- Ontario Heritage Trust – for a list of plaques commemorating Ontario's history
- Historic Sites and Monuments Board of Canada – for a list of plaques commemorating Canada's history

4b. Does the property (or project area) contain a parcel of land that has or is adjacent to a known burial site and/or cemetery?

For more information on known cemeteries and/or burial sites, see:

- Cemeteries Regulations, Ontario Ministry of Consumer Services – for a database of registered cemeteries
- Ontario Genealogical Society (OGS) – to locate records of Ontario cemeteries, both currently and no longer in existence; cairns, family plots and burial registers
- Canadian County Atlas Digital Project – to locate early cemeteries

In this context, adjacent means contiguous or as otherwise defined in a municipal official plan.

4c. Does the property (or project area) contain a parcel of land that is in a Canadian Heritage River watershed?

The Canadian Heritage River System is a national river conservation program that promotes, protects and enhances the best examples of Canada's river heritage.

Canadian Heritage Rivers must have, and maintain, outstanding natural, cultural and/or recreational values, and a high level of public support.

For more information, contact the Canadian Heritage River System.

If you have questions regarding the boundaries of a watershed, please contact:

- your conservation authority
- municipal staff

4d. Does the property (or project area) contain a parcel of land that contains buildings or structures that are 40 or more years old?

A 40 year 'rule of thumb' is typically used to indicate the potential of a site to be of cultural heritage value. The approximate age of buildings and/or structures may be estimated based on:

- history of the development of the area
- fire insurance maps
- architectural style
- building methods

Property owners may have information on the age of any buildings or structures on their property. The municipality, local land registry office or library may also have background information on the property.

Note: 40+ year old buildings or structure do not necessarily hold cultural heritage value or interest; their age simply indicates a higher potential.

A building or structure can include:

- residential structure
- farm building or outbuilding
- industrial, commercial, or institutional building
- remnant or ruin
- engineering work such as a bridge, canal, dams, etc.

For more information on researching the age of buildings or properties, see the Ontario Heritage Tool Kit Guide Heritage Property Evaluation.

Part C: Other Considerations

5a. Is there local or Aboriginal knowledge or accessible documentation suggesting that the property (or project area) is considered a landmark in the local community or contains any structures or sites that are important to defining the character of the area?

Local or Aboriginal knowledge may reveal that the project location is situated on a parcel of land that has potential landmarks or defining structures and sites, for instance:

- buildings or landscape features accessible to the public or readily noticeable and widely known
- complexes of buildings
- monuments
- ruins

5b. Is there local or Aboriginal knowledge or accessible documentation suggesting that the property (or project area) has a special association with a community, person or historical event?

Local or Aboriginal knowledge may reveal that the project location is situated on a parcel of land that has a special association with a community, person or event of historic interest, for instance:

- Aboriginal sacred site
- traditional-use area
- battlefield
- birthplace of an individual of importance to the community

5c. Is there local or Aboriginal knowledge or accessible documentation suggesting that the property (or project area) contains or is part of a cultural heritage landscape?

Landscapes (which may include a combination of archaeological resources, built heritage resources and landscape elements) may be of cultural heritage value or interest to a community.

For example, an Aboriginal trail, historic road or rail corridor may have been established as a key transportation or trade route and may have been important to the early settlement of an area. Parks, designed gardens or unique landforms such as waterfalls, rock faces, caverns, or mounds are areas that may have connections to a particular event, group or belief.

For more information on Questions 5.a., 5.b. and 5.c., contact:

- Elders in Aboriginal Communities or community researchers who may have information on potential cultural heritage resources. Please note that Aboriginal traditional knowledge may be considered sensitive.
- municipal heritage committees or local heritage organizations
- Ontario Historical Society's "Heritage Directory" - for a list of historical societies and heritage organizations in the province

An internet search may find helpful resources, including:

- historical maps
- historical walking tours
- municipal heritage management plans
- cultural heritage landscape studies
- municipal cultural plans

Information specific to trails may be obtained through Ontario Trails.