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SUBJECT: **BANKFULL CHARACTERISTICS AND EROSION THRESHOLDS FOR TRCA REGIONAL MONITORING PROGRAM DETAILED SITES**

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Introduction

This report provides information which compliments the fluvial geomorphology component of the TRCA Regional Monitoring Program (*Regional Monitoring Program – Fluvial Geomorphology Component – Etobicoke Creek, Mimico Creek and Humber River Watersheds*, PARISH Geomorphic Ltd., June 26, 2002; *Regional Monitoring Program – Fluvial Geomorphology Component – Don River, Rouge River and Highland Creek Watersheds (Draft)*, PARISH Geomorphic Ltd., March 21, 2003). Currently the data base consists of 100 detailed monitoring sites covering the Don River, Etobicoke Creek, Highland Creek, Humber River, Mimico Creek, and Rouge River watersheds. These sites, along with those selected for the third phase of the TRCA Regional Monitoring Program, provide representation of the variability of the watersheds within the jurisdiction of the TRCA.

This report provides an at-a-glance summary of the bankfull characteristics and erosion thresholds for the 100 sites that have been characterized (see tables in **Appendix A**). The bankfull characteristics and process observations from each detailed site are also provided to set the context for the thresholds, more detailed description of each site can be found in the TRCA Regional Monitoring Database or in the hard copy reports *Regional Monitoring Program – Fluvial Geomorphology Component – Etobicoke Creek, Mimico Creek and Humber River Watersheds* (PARISH Geomorphic Ltd., June 26, 2002) and *Regional Monitoring Program – Fluvial Geomorphology Component – Don River, Rouge River and Highland Creek Watersheds (Draft)* (PARISH Geomorphic Ltd., March 21, 2003). Within the tables (**Appendix A**), sites are grouped by watershed and relative proximity. The location of the detailed sites are provided in the maps contained in **Appendix B**, which are reproduced from *Regional Monitoring*

Program – Fluvial Geomorphology Component – Etobicoke, Mimico and Humber Creek Watersheds (PARISH Geomorphic Ltd., June 26, 2002) and *Regional Monitoring Program – Fluvial Geomorphology Component – Don River, Rouge River and Highland Creek Watersheds (Draft)* (PARISH Geomorphic Ltd., March 21, 2003).

Methods

At each of the detailed sites, cross-sections were measured at ten locations, including pools, riffles and transitional areas. Each cross-section bankfull width and depth, entrenchment, as well as low flow dimensions were recorded. Substrate was sampled using a modified Wolman pebble count. Sub-pavement was also characterized at each cross-section. Bank assessment included measurements of height, angle, bank composition, *in-situ* shear strength, vegetation and rooting depth. These 10 cross-sections were placed over a minimum of two meander wavelengths. A level survey of the site extending upstream and downstream of the 10 cross-section locations was also conducted. The survey included bankfull elevations, maximum pool depth, top and bottom of riffles and any obstruction to flow and provided measures of energy gradient, inter-pool gradient and riffle gradient.

The collection of detailed field information allows for the performance of analyses based on critical shear stress and permissible velocities in order to identify erosion thresholds. Streams continually adjust their dimensions to accommodate changes in their sediment transport and discharge regimes. As such, thresholds of particle movement and transport will vary spatially and temporally as watercourses adjust to local variations in slope, bed material, discharge and modifying factors. The calculations performed to determine critical discharge for bed materials were based on formulas for critical shear stress (Shields, modified by Miller et al., 1977) and permissible velocity (Chow, 1959; Neill, 1967; Komar, 1987; Fischenich, 2001). Selection of appropriate thresholds was, in part, dictated by indicators of active processes (e.g. deposition, entrenchment, and excessive bank erosion). Generally, shear stress and permissible velocity equations for non-cohesive materials were applied to the bed materials. The erosion thresholds were based on the threshold for the D_{50} (median grain size), which is the general practice. If a large portion of the bed material was cohesive and the erosion threshold associated with cohesive component was greater than the threshold associated with the D_{50}, then the cohesive materials estimated shear strength was used to provide a characteristic threshold. These thresholds were based on tables provided

in Chow (1959). Finally, if there was evidence of excessive bank erosion, a threshold related to the bank material was also calculated. The relative proportion of bank shear stress to the maximum shear stress was calculated. Threshold depths were based on this proportion. The lower of bank and bed threshold (or more conservative measure) was used to define the critical threshold for the channel.

With respect to the tables contained in **Appendix A**, several clarifications are required. As many of the models are based on a trapezoidal channel geometry, a single characteristic riffle cross section was extracted from each detailed site for threshold analysis. The depth and the corresponding simplified geometry were used to produce a meaningful threshold discharge.

Several clarifications are needed with respect to the results provided in the following tables (**Appendix A**). First, it should be noted that the critical depth calculated by the models is, more specifically, a maximum critical depth of the defined trapezoid. Consequently, in some cases the critical depth of a site is greater than the average bankfull depth. In most cases the maximum bankfull depth would still prove larger than the maximum critical depth. If, in fact, the discharge values calculated by the models exceed bankfull discharge, the models assume that these flows are contained within the general geometry of the bankfull cross section and do not account for the geometry of the floodplain. In these cases, the discharge value provided may be taken as a minimum potential discharge. The Manning's 'n' values provided in **Appendix A** were for bankfull conditions and were derived from visual estimates to account for factors such as channel geometry and the presence of wood debris and vegetation. Manning's 'n' values for threshold conditions, usually much lower flows, were based primarily on Limerinos' (1970) equation using average bankfull depth and the D_{84} for a site. In some cases, a visual estimation was used to account for added roughness associated with channel geometry and flow obstructions such as vegetation and woody debris.

Summary

The erosion thresholds and bankfull descriptions in this report provide both good spatial coverage and representation of the variability of the watersheds examined. This tool provides a baseline by which future reports can be compared and evaluated.

The thresholds should be treated as a guide to threshold values that can be expected within the studied watersheds. It should be noted that the erosion thresholds were based on monitoring sites which were selected to provide a broad coverage of the possible valley segments within the watersheds listed above. These values should be used as a guide, and may need to be supplemented with more detailed assessments for specific applications, for several reasons. Firstly, the selection of sites was based on coverage of variability, not sensitivity. Generally, if an erosion assessment was completed for development, using a stormwater management facility for example, the erosion assessment would include the identification of the most sensitive reaches. These reaches would then provide the controlling thresholds. Secondly, many of these valley segments could be broken into smaller reaches, allowing identification of localized areas of channel sensitivity. Thirdly, with continued urbanization and associated stream adjustment, it can be expected that these erosion thresholds would vary over time.

References

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Appendix A

Table 1. Don River erosion thresholds.

Parameter	GD-1	D-3	D-3b
Average Bankfull Width (m)	7.66	5.31	9.76
Average Bankfull Depth (m)	0.57	0.72	0.76
Bankfull Gradient (%)	0.18	0.33	0.54
Bed Material D_{50} (m)	0.00046	0.010	0.050
Bed Material D_{84} (m)	0.020	0.080	0.16
Bedrock Exposure/Control	No	No	No
Bank Materials	Si/vfs/fs	Si/vfs/fs	Si/vfs/fs/cl
Manning's n at Bankfull	0.040	0.040	0.040
Average Bankfull Velocity (ms^{-1})	0.82	1.34	1.78
Average Bankfull Discharge (m^3s^{-1})	2.55	6.80	20.45
Flow competence (ms^{-1}) @ D_{50}	--	0.58	1.20
Flow competence (ms^{-1}) @ D_{84}	0.78	1.48	2.01
Tractive Force at Bankfull (Nm^{-2})	11.96	29.08	50.64
Critical Shear (Nm^{-2}) @ D_{50}	3.59[1]	**7.43**	36.42
Critical Shear (Nm^{-2}) @ D_{84}	14.20	57.98	112.97
Bank Shear (Nm^{-2})	**3.59[1]**	--	**12.45[2]**
Stream Power (Wm^{-1})	72.11	258.82	1880.07
Stream Power per Unit Width (Wm^{-2})	15.68	45.73	156.67
Critical Discharge (m^3s^{-1})	1.06	0.70	1.74
Critical Depth (m)	0.40	0.27	0.31
Critical Velocity (ms^{-1})	0.94	0.59	0.74
Site Description	- valley wall contact, banks eroded, large log causing scour, tree roots exposed, major woody debris, point bar formation near d/s end of segment	- both banks eroding, bank protection, exposed clay subpavement, medial deposition, valley wall contact, major bank slumping, overhanging trees	- Woody debris, banks eroded, no bed morphology, valley wall contact, lateral deposition
Method	**Fischenich (2001)**	**Komar (1987)**	**Fischenich (2001)**

[1] Loam / sandy clay loose [2] Alluvial silt

Parameter	D-4	D-4a	D-4b	D-26	D-31
Average Bankfull Width (m)	10.56	10.35	13.57	9.38	9.21
Average Bankfull Depth (m)	0.72	0.73	0.95	0.51	0.58
Bankfull Gradient (%)	0.35	0.14	0.11	0.15	0.81
Bed Material D_{50} (m)	0.029	0.016	0.029	0.027	0.029
Bed Material D_{84} (m)	0.084	0.090	0.19	0.19	0.087
Bedrock Exposure/Control	No	No	No	No	No
Bank Materials	Si/vfs/fs	Si/vfs/fs/cl	Cl/si/vfs/fs	Fs/ms/cs/si	Si/vfs/fs/cl
Manning's n at Bankfull	0.035	0.035	0.035	0.040	0.040
Average Bankfull Velocity (ms^{-1})	1.32	0.94	1.14	2.16	1.63
Average Bankfull Discharge (m^3s^{-1})	9.74	10.27	4.99	8.09	7.83
Flow competence (ms^{-1}) @ D_{50}	0.93	0.72	0.93	0.89	0.93
Flow competence (ms^{-1}) @ D_{84}	1.52	1.57	2.19	2.20	1.54
Tractive Force at Bankfull (Nm^{-2})	23.55	11.25	11.72	87.37	48.97
Critical Shear (Nm^{-2}) @ D_{50}	20.90	12.02	5.90	**19.38**	**20.98**
Critical Shear (Nm^{-2}) @ D_{84}	61.40	65.70	42.83	137.30	63.59
Bank Shear (Nm^{-2})	**3.59**[1]	**3.59**[1]	**3.59**[1]	--	--
Stream Power (Wm^{-1})	328.64	138.90	108.96	1001.33	1326.10
Stream Power per Unit Width (Wm^{-2})	30.43	10.37	9.64	156.46	170.01
Critical Discharge (m^3s^{-1})	0.73	4.08	2.16	1.39	1.42
Critical Depth (m)	0.18	0.52	0.53	0.29	0.28
Critical Velocity (ms^{-1})	0.47	0.64	0.44	0.89	0.93
Site Description	-large woody debris, bank protection has fallen into channel, both banks eroded, valley wall contact, trees falling into channel	- Both banks eroded, exposed clay subpavement, tree roots exposed, deposition by bank, valley wall eroded, medial deposition, woody debris, bank protection near golf course property	-valley wall contact, tree roots exposed, both banks eroded, point bar development, exposed clay subpavement, large rocks in channel, medial deposition, undercut banks	- Eroding and undercut banks, fallen trees, deposition by right bank, large rocks in channel, concrete slabs in the middle of channel at d/s portion of site	- Fallen trees and exposed roots, medial deposition, eroded banks, eroded man holes, valley wall contact,
Method	**Fischenich (2001)**	**Fischenich (2001)**	**Fischenich (2001)**	**Komar (1987)**	**Komar (1987)**

[1] Loam / sandy clay loose

Parameter	D-5	D-7	D-13	D-14
Average Bankfull Width (m)	4.13	7.99	10.22	7.49
Average Bankfull Depth (m)	0.45	0.62	0.73	0.71
Bankfull Gradient (%)	0.99	0.41	0.54	0.38
Bed Material D_{50} (m)	0.0038	0.0081	0.012	0.050
Bed Material D_{84} (m)	0.012	0.059	0.062	0.14
Bedrock Exposure/Control	No	No	No	No
Bank Materials	Si/cl/vfs	Si/vfs/fs/cl	Vfs/fs/ms	Fs/ms/cs/vcs
Manning's n at Bankfull	0.035	0.035	0.040	0.035
Average Bankfull Velocity (ms^{-1})	1.66	1.00	1.86	1.51
Average Bankfull Discharge (m^3s^{-1})	3.11	12.28	20.46	6.46
Flow competence (ms^{-1}) @ D_{50}	0.34	0.52	0.62	1.19
Flow competence (ms^{-1}) @ D_{84}	0.62	1.29	1.32	1.93
Tractive Force at Bankfull (Nm^{-2})	43.45	19.66	53.96	29.56
Critical Shear (Nm^{-2}) @ D_{50}	2.77	**21.12**	**8.67**	36.06
Critical Shear (Nm^{-2}) @ D_{84}	**12.62***	135.63	45.09	102.99
Bank Shear (Nm^{-2})	--	--	--	**3.59[1]**
Stream Power (Wm^{-1})	445.48	173.08	1373.75	205.94
Stream Power per Unit Width (Wm^{-2})	107.34	19.23	127.20	38.14
Critical Discharge (m^3s^{-1})	0.24	0.70	1.027	1.50
Critical Depth (m)	0.13	0.18	0.20	0.10
Critical Velocity (ms^{-1})	1.00	0.52	0.62	0.82
Site Description	Substantial transient fines in the channel	- High eroding banks, large willow, exposed roots along both banks, exposed clay subpavement	- Clay subpavement exposed, banks eroded with exposed tree roots, point bar development, vertical banks, major woody debris, leaning trees	- Banks eroded, concrete slabs in channel, banks eroded above bankfull, deposition, tree roots exposed, large boulders embedded in bank
Method	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**	**Fischenich (2001)**

* Critical discharge based on D_{84} as fines appeared transient

[1] Loam / sandy clay loose

Parameter	D-17	D-19	D-22	D-30	D-20
Average Bankfull Width (m)	18.98	16.36	10.21	7.89	22.04
Average Bankfull Depth (m)	0.95	0.92	0.71	0.56	1.10
Bankfull Gradient (%)	0.32	0.36	0.19	0.16	0.14
Bed Material D_{50} (m)	0.066	0.047	0.011	0.053	0.014
Bed Material D_{84} (m)	0.19	0.14	0.15	0.13	0.085
Bedrock Exposure/Control	No	No	No	No	Yes
Bank Materials	Si/vfs/fs	Si/vfs/fs/ms	Si/vfs/fs/ms	Si/vfs/cl/ms	Si/vfs/fs/cl
Manning's n at Bankfull	0.035	0.040	0.035	0.040	0.040
Average Bankfull Velocity (ms^{-1})	2.14	1.84	3.62	2.26	1.38
Average Bankfull Discharge (m^3s^{-1})	57.14	56.54	27.33	11.62	72.92
Flow competence (ms^{-1}) @ D_{50}	1.36	1.16	0.59	1.23	0.67
Flow competence (ms^{-1}) @ D_{84}	2.20	1.93	1.96	1.83	1.53
Tractive Force at Bankfull (Nm^{-2})	47.87	48.13	165.13	94.33	24.75
Critical Shear (Nm^{-2}) @ D_{50}	48.37	33.94	**7.79**	38.68	**10.20**
Critical Shear (Nm^{-2}) @ D_{84}	137.16	103.07	106.93	91.53	62.06
Bank Shear (Nm^{-2})	**3.59**[1]	**3.59**[1]	--	**18.20**[2]	--
Stream Power (Wm^{-1})	1540.90	2116.79	4457.09	1743.09	1643.30
Stream Power per Unit Width (Wm^{-2})	88.05	94.08	512.31	207.51	56.28
Critical Discharge (m^3s^{-1})	2.67	1.56	0.82	1.52	9.34
Critical Depth (m)	0.33	0.20	0.22	0.21	0.54
Critical Velocity (ms^{-1})	0.59	0.35	1.13	0.98	0.67
Site Description	- Banks eroded, exposed tree roots, valley wall contact, stones embedded in bank, large cobbles in channel	- Concrete slabs protecting bank, undercut and eroded banks, exposed tree roots, point bar development	- Gabion failed, channel eroded into clay subpavement, valley wall contact,	- Both banks eroded with tree roots exposed, large cobbles in channel, woody debris, banks undercut, point bar development	- Concrete slabs protecting bank, banks poorly vegetated, bankfull not well defined, eroded, banks, exposed bedrock, exposed roots on bank, slope failure
Method	**Chow (1959)**	**Chow (1959)**	**Fischenich (2001)**	**Fischenich (2001)**	**Komar (1987)**

[1] Loam / sandy clay loose
[2] consolidated clay

Table 2. Etobicoke Creek erosion thresholds.

Parameter	GET-1	GET-2	GET-3	GET-4	GET-5
Average Bankfull Width (m)	21.97	8.17	20.32	13.12	8.51
Average Bankfull Depth (m)	0.92	0.52	0.80	0.66	0.78
Bankfull Gradient (%)	0.56	0.014	0.39	0.77	0.46
Bed Material D_{50} (m)	0.044	0.011	0.039	0.055	0.011
Bed Material D_{84} (m)	0.19	0.10	0.19	0.21	0.091
Bedrock Exposure / Control	Yes	No	Yes	Yes	Yes
Bank Materials	--	--	--	--	--
Manning's n at Bankfull	0.044	0.041	0.046	0.037	0.036
Average Bankfull Velocity (ms^{-1})	1.50	1.63	1.17	1.79	1.85
Average Bankfull Discharge (m^3s^{-1})	29.80	7.67	19.04	15.95	11.94
Flow competence (ms^{-1}) @ D_{50}	1.12	0.60	1.07	1.25	0.59
Flow competence (ms^{-1}) @ D_{84}	2.19	1.67	2.24	2.33	1.58
Tractive Force at Bankfull (Nm^{-2})	50.50	70.05	30.59	49.85	35.14
Critical Shear (Nm^{-2}) @ D_{50}	**31.75**	**8.12**	**28.65**	**39.96**	**7.95**
Critical Shear (Nm^{-2}) @ D_{84}	136.35	75.50	142.42	155.71	66.55
Bank Shear (Nm^{-2})	--	--	--	--	--
Stream Power (Wm^{-1})	1407.30	1038.48	728.26	952.60	846.95
Stream Power per Unit Width (Wm^{-2})	65.80	124.76	36.12	71.92	118.79
Critical Discharge (m^3s^{-1})	4.50	0.79	6.38	5.88	0.594
Critical Depth (m)	0.45	0.26	0.53	0.60	0.24
Critical Velocity (ms^{-1})	0.84	1.02	0.82	1.25	0.59
Site Description	Bedrock bed Incision Large lateral bars, knickpoint in profile Gabion, armour stone along banks Valley wall erosion Uprooted trees Relatively stable Natural	Substantial bank erosion Medial bar Woody debris Pool-riffle Small flow Gabion Cobble, gravel Appears natural in forest, altered in golf course but unstable in both.	Steep valley walls Bank erosion Incising Channel confined by valley walls Knickpoint Valley wall contact Upstream end experiencing siltation Bedrock bed Natural	Several areas of significant erosion, minor woody debris. Upper reach stable with low sinuosity.	Beaver dam at bottom of reach. u/s split in channel Exposed bedrock (shale) Storm drain Bank slumping Lateral bar formation Alluvial deposits Scour pool
Method	**Fischenich (2001)**	**Chow (1959)**	**Fischenich (2001)**	**Komar (1987)**	**Komar (1987)**

Parameter	GET-6	GET-7	GET-8	GET-9	GET-10
Average Bankfull Width (m)	9.99	5.51	10.43	6.54	3.22
Average Bankfull Depth (m)	0.78	0.44	0.76	0.42	0.40
Bankfull Gradient (%)	0.13	0.21	0.96	0.056	0.77
Bed Material D_{50} (m)	0.014	0.00027	0.010	Clay/silt	0.000012
Bed Material D_{84} (m)	0.074	0.16	0.086	Clay/silt	0.015
Bedrock Exposure/Control	No	No	No	No	No
Bank Materials	--	--	--	--	--
Manning's n at Bankfull	0.035	0.035	0.036	0.033	0.033
Average Bankfull Velocity (ms^{-1})	0.88	0.74	2.34	0.94	1.44
Average Bankfull Discharge (m^3s^{-1})	7.14	1.79	19.14	1.07	1.90
Flow competence (ms^{-1}) @ D_{50}	0.67	--	0.58	--	--
Flow competence (ms^{-1}) @ D_{84}	1.43	2.08	1.54	--	0.68
Tractive Force at Bankfull (Nm^{-2})	9.92	8.82	71.56	2.26	30.09
Critical Shear (Nm^{-2}) @ D_{50}	**10.23**	**0.20**	**7.61**	--	**12.45**
Critical Shear (Nm^{-2}) @ D_{84}	53.80	120.79	63.03	--	10.83
Bank Shear (Nm^{-2})	--	--	--	**9.60**	--
Stream Power (Wm^{-1})	91.05	25.66	1802.10	13.03	188.03
Stream Power per Unit Width (Wm^{-2})	9.22	4.65	171.0	1.99	58.67
Critical Discharge (m^3s^{-1})	7.14	0.05	1.61	30.82	0.25
Critical Depth (m)	0.52	0.19	0.28	1.76	0.16
Critical Velocity (ms^{-1})	0.67	0.22	1.00	2.15	1.02
Site Description	Storm sewer Woody debris Turbid water Bare banks Garbage in channel	Rip rap along both banks Lots of purple loosestrife in channel Major woody debris Turbid water Armor stone Garbage in channel Engineered	Planform migration, Channel splitting	Bank slumps Stagnant, turbid water Siltation Major bank slumping Entrenched channel Bank erosion Altered	Cattails in channel Eroded banks Entrenched channel Stagnant water Siltation Valley wall contact Scour pool
Method	**Komar (1987)**	**Neill (1967)**	**Komar (1987)**	**Chow (1959)**	**Fischenich (2001)**

Table 3. Highland Creek erosion thresholds.

Parameter	GH-1	H-2a	H-2b
Average Bankfull Width (m)	9.27	9.65	12.39
Average Bankfull Depth (m)	0.88	0.99	0.77
Bankfull Gradient (%)	0.21	0.37	0.52
Bed Material D_{50} (m)	0.0023	0.018	0.078
Bed Material D_{84} (m)	0.075	0.095	0.19
Bedrock Exposure/Control	No	No	No
Bank Materials	Cl/si/fs	Vfs/fs/si/ms	Vfs/fs/ms
Manning's n at Bankfull	0.026	0.035	0.035
Average Bankfull Velocity (ms^{-1})	1.25	1.36	1.58
Average Bankfull Discharge (m^3s^{-1})	10.89	10.22	15.62
Flow competence (ms^{-1}) @ D_{50}	0.29	0.75	1.46
Flow competence (ms^{-1}) @ D_{84}	1.44	1.61	2.21
Tractive Force at Bankfull (Nm^{-2})	19.27	25.20	34.15
Critical Shear (Nm^{-2}) @ D_{50}	3.59[1]	**13.40**	**56.67**
Critical Shear (Nm^{-2}) @ D_{84}	54.34	69.49	138.32
Bank Shear (Nm^{-2})	**3.59[1]**	--	--
Stream Power (Wm^{-1})	235.80	627.37	594.72
Stream Power per Unit Width (Wm^{-2})	25.35	58.09	40.18
Critical Discharge (m^3s^{-1})	1.34	2.48	4.74
Critical Depth (m)	0.31	0.36	0.49
Critical Velocity (ms^{-1})	0.54	0.75	1.10
Site Description	- vertical banks with undercuts, thatch in shrubs 1.2 m above bankfull, mid channel sand/gravel deposit, right bank slumping, filter cloth across bed of channel, exposed clay sub-pavement on left bank	- gabions on right bank, sand deposits along left bank, exposed tree roots and toe erosion along right bank, undercut right bank, left bank slumping and toe erosion, rock dam along right bank, thalweg along left bank	- boulders used as bank protection along left bank, right bank is vertical with overbank sand deposition, gravel deposition close to right bank, central thalweg, thatch at bankfull on both banks, point bar along right banktoe erosion along left bank, near mid segment, exposed tree roots on both banks
Method	**Fischenich (2001)**	**Komar (1987)**	**Komar (1987)**

[1] Loam / sandy clay loose

Parameter	H-4a	H-6	H-9	H-10
Average Bankfull Width (m)	15.64	10.33	17.74	25.09
Average Bankfull Depth (m)	0.58	0.61	0.94	0.90
Bankfull Gradient (%)	0.71	0.46	0.57	0.37
Bed Material D_{50} (m)	0.042	0.028	0.019	0.015
Bed Material D_{84} (m)	0.16	0.088	0.090	0.062
Bedrock Exposure / Control	No	No	No	No
Bank Materials	Fs / cl / vfs / si	Si / vfs / cl / fs	Cl / fs / ms	Vfs / fs / ms
Manning's n at Bankfull	0.035	0.035	0.040	0.035
Average Bankfull Velocity (ms^{-1})	2.41	1.72	2.12	1.88
Average Bankfull Discharge (m^3s^{-1})	25.28	8.56	39.39	38.26
Flow competence (ms^{-1}) @ D_{50}	1.10	0.91	0.76	0.69
Flow competence (ms^{-1}) @ D_{84}	2.06	1.55	1.56	1.32
Tractive Force at Bankfull (Nm^{-2})	69.65	37.56	66.82	40.96
Critical Shear (Nm^{-2}) @ D_{50}	**30.30**	**20.03**	**13.62**	**11.14**
Critical Shear (Nm^{-2}) @ D_{84}	119.38	64.10	65.19	45.52
Bank Shear (Nm^{-2})	--	--	--	--
Stream Power (Wm^{-1})	1488.63	543.71	2580.97	1547.78
Stream Power per Unit Width (Wm^{-2})	141.77	90.62	166.41	85.99
Critical Discharge (m^3s^{-1})	4.74	1.63	1.90	2.95
Critical Depth (m)	0.49	0.39	0.28	0.28
Critical Velocity (ms^{-1})	1.10	0.91	0.76	0.69
Site Description	- lots of woody debris in channel, thalweg towards left bank, valley wall by left bank slumping, chute beside right bank full, major large deposition along right bank, point bar by left bank, both banks eroding**,** exposed clay in lower segment of site	-both banks eroded and slumping, engineered, straight channel, rip-rap on both banks, thalweg by right bank, top of bank deposition on both banks, medial deposition by left bank	- thalweg along right bank, point bar along left bank, vertical eroded valley wall on right bank, both banks eroded, large rocks and concrete slabs in channel, trees falling into channel, medial deposition	- valley wall eroded on left bank, gravel deposition along right bank, right bank eroded, migrating point bar forming riffles, overhanging trees along left bank, right bank toe erosion, medial deposition
Method	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**

Table 4. Humber River erosion thresholds.

Parameter	GHU-1	GHU-2	GHU-3	GHU-4	GHU-5
Average Bankfull Width (m)	52.91	46.37	20.21	6.34	30.25
Average Bankfull Depth (m)	1.19	0.93	0.63	0.69	1.05
Bankfull Gradient (%)	0.17	0.34	0.58	0.45	0.226
Bed Material D_{50} (m)	0.000039	0.12	0.033	0.012	0.019
Bed Material D_{84} (m)	0.00040	0.21	0.18	0.056	0.11
Bedrock Exposure/Control	No	No	Yes	No	Yes
Bank Materials	Si/vfs/ms/cl	Si/cl/vfs	Si/cl/vfs	Si/vfs/cl	Si/vfs/cl
Manning's n at Bankfull	0.035	0.035	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	1.08	1.99	1.61	1.59	1.76
Average Bankfull Discharge (m^3s^{-1})	58.93	132.13	16.29	6.61	68.91
Flow competence (ms^{-1}) @ D_{50}	--	1.80	0.99	0.62	0.76
Flow competence (ms^{-1}) @ D_{84}	0.13	2.32	2.15	1.26	1.70
Tractive Force at Bankfull (Nm^{-2})	14.73	43.37	36.07	33.43	32.46
Critical Shear (Nm^{-2}) @ D_{50}	**3.83**[+]	88.21	**23.96**	**8.74**	**13.55**
Critical Shear (Nm^{-2}) @ D_{84}	--	154.49	130.75	40.94	78.23
Bank Shear (Nm^{-2})	--	**18.20**[1]	--	--	--
Stream Power (Wm^{-1})	2437.81	3572.12	698.36	217.16	95.78
Stream Power per Unit Width (Wm^{-2})	39.64	69.77	43.65	40.22	35.15
Critical Discharge (m^3s^{-1})	4.44	17.01	5.74	0.49	8.74
Critical Depth (m)	0.23	0.47	0.51	0.21	0.52
Critical Velocity (ms^{-1})	0.44	0.78	0.99	0.62	0.76
Site Description	-uneven banks with erosion present, dry tributary present, woody debris in channel, low sinuosity	- bank is terracing with minor slumping and fallen trees, some large boulders in channel, island present	-one side of channel is low lying floodplain access, bankfull not well defined, valley contact with coarse shale deposits, bedrock exposed	- heavy bank erosion, low sinuosity, exposed tree roots, large slump along one bank	-bank slumping, vertical and eroding banks, sandy deposits
Method	**Chow (1959)**	**Fischenich (2001)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**

[+] Heavy clay soil loose to fairly compact
[1] mixed alluvium from clay to cobble

Parameter	GHU-6	GHU-7	GHU-8	GHU-9	GHU-10
Average Bankfull Width (m)	4.07	9.26	5.22	6.91	11.86
Average Bankfull Depth (m)	0.60	0.62	0.32	0.40	0.59
Bankfull Gradient (%)	0.36	0.46	0.74	0.61	0.14
Bed Material D_{50} (m)	0.000050	0.0215	0.00042	0.0279	0.0057
Bed Material D_{84} (m)	0.042	0.11	0.040	0.13	0.088
Bedrock Exposure/Control	No	Yes	No	Yes	No
Bank Materials	Cl/si/vfs/fs	Vcs/pebble	Cl/si	Si/cl/vfs	Si/cl/fs/vfs
Manning's n at Bankfull	0.035	0.04	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	1.00	1.43	1.69	1.22	0.76
Average Bankfull Discharge (m^3s^{-1})	1.51	6.63	2.72	3.46	4.96
Flow competence (ms^{-1}) @ D_{50}	--	0.81	--	0.91	0.44
Flow competence (ms^{-1}) @ D_{84}	1.10	1.74	1.07	1.85	1.55
Tractive Force at Bankfull (Nm^{-2})	15.73	34.89	41.48	24.07	8.27
Critical Shear (Nm^{-2}) @ D_{50}	**4.79+**	**15.66**	**3.83***	**20.32**	**4.15**
Critical Shear (Nm^{-2}) @ D_{84}	30.37	82.67	28.84	94.55	63.81
Bank Shear (Nm^{-2})	--	--	--	--	--
Stream Power (Wm^{-1})	60.95	312.20	233.21	131.39	85.28
Stream Power per Unit Width (Wm^{-2})	17.93	52.03	82.99	18.58	7.90
Critical Discharge (m^3s^{-1})	0.65	1.36	0.03	1.68	4.74
Critical Depth (m)	0.14	0.38	0.05	0.39	0.34
Critical Velocity (ms^{-1})	0.94	0.82	0.27	0.91	0.44
Site Description	-eroded and slumping banks, siltation in pools, relatively narrow section of river	-eroding banks, valley wall contact, exposed bedrock, woody debris in floodplain, mid channel bar, beaver pond present downstream	- bankfull poorly defined, both banks eroding, dry channel, side channels present, semi-braided, woody debris in channel	-entrenched channel, heavy bank erosion, channel is dry with some stagnant water pools, narrow channel	- eroded slumping banks, woody debris in channel
Method	**Chow (1959)**	**Komar (1987)**	**Chow (1959)**	**Komar (1987)**	**Komar (1987)**

+ Cohesive clay * Sandy clay

Parameter	GHU-11	GHU-12	GHU-13	GHU-14	GHU-15
Average Bankfull Width (m)	12.31	5.09	6.78	5.99	6.30
Average Bankfull Depth (m)	0.68	0.40	0.30	0.42	0.34
Bankfull Gradient (%)	0.29	0.92	0.49	0.48	0.57
Bed Material D_{50} (m)	0.0125	0.00078	0.0000087	0.0056	0.0006
Bed Material D_{84} (m)	0.0962	0.0477	0.0098	0.0758	0.0605
Bedrock Exposure/Control	No	No	No	No	Yes
Bank Materials	Cl/fs/si/vfs	Cl/fs/vfs/si	Cl/si/vfs/fs	Si/cl/ms/vfs	Cl/si/fs/ms
Manning's n at Bankfull	0.035	0.040	0.040	0.040	0.035
Average Bankfull Velocity (ms^{-1})	1.09	1.34	0.78	1.08	1.16
Average Bankfull Discharge (m^3s^{-1})	8.76	3.26	1.36	1.68	2.33
Flow competence (ms^{-1}) @ D_{50}	0.63	--	--	0.44	--
Flow competence (ms^{-1}) @ D_{84}	1.62	1.17	0.56	1.45	1.31
Tractive Force at Bankfull (Nm^{-2})	17.00	37.79	14.39	23.04	22.09
Critical Shear (Nm^{-2}) @ D_{50}	**9.10**	**4.79**[+]	**4.79**[+]	**4.08**	**4.79**[+]
Critical Shear (Nm^{-2}) @ D_{84}	70.07	34.74	7.14	55.21	44.07
Bank Shear (Nm^{-2})	--	--	--	--	--
Stream Power (Wm^{-1})	230.79	366.57	116.76	78.05	123.27
Stream Power per Unit Width (Wm^{-2})	17.20	63.20	20.13	24.39	24.31
Critical Discharge (m^3s^{-1})	2.54	0.069	0.18	0.19	0.063
Critical Depth (m)	0.35	0.05	0.10	0.16	0.09
Critical Velocity (ms^{-1})	0.63	0.30	0.62	0.41	0.33
Site Description	-left bank eroded, point bar on right bank, woody debris in channel on left side, some slumping on left bank, valley wall contact right bank	- right bank/ valley wall eroded, tree roots ex-posed, left bank eroding, downstream part changes from right to left bank valley wall contact	-left bank ver low, wide bankfull area, high right bank, wet-land appearance, some old slumps in channel	- right bank slumping and eroding, willow tress overhanging left bank, undercutting right bank, chute on right bank, siltation in pools	-fairly entrenched, bedrock exposed, dry channel, rip-rap and erosion along both banks, channel mostly vegetated, lots of woody debris, exposed tree roots, multiple channels,
Method	**Komar (1987)**	**Fischenich (2001)**	**Chow (1959)**	**Komar (1987)**	**Fischenich (2001)**

[+] Cohesive clay

Parameter	GHU-16	GHU-17	GHU-18	GHU-19	GHU-20
Average Bankfull Width (m)	3.96	5.48	7.38	6.05	6.61
Average Bankfull Depth (m)	0.25	0.48	0.42	0.29	0.59
Bankfull Gradient (%)	0.59	0.34	1.03	0.71	0.46
Bed Material D_{50} (m)	Silt	0.0065	0.019	0.019	0.00013
Bed Material D_{84} (m)	0.00010	0.078	0.10	0.057	0.014
Bedrock Exposure/Control	No	No	No	No	No
Bank Materials	Si/cl/vfs	Si/cl/fs/ms	Si/cl/vfs/fs	Si/fs/ms/cs	Si/vfs/fs
Manning's n at Bankfull	0.035	0.035	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	1.09	1.21	1.82	0.99	1.43
Average Bankfull Discharge (m^3s^{-1})	1.52	7.26	7.49	2.43	5.95
Flow competence (ms^{-1}) @ D_{50}	--	0.47	0.76	0.76	0.078
Flow competence (ms^{-1}) @ D_{84}	--	1.46	1.68	1.27	0.66
Tractive Force at Bankfull (Nm^{-2})	20.23	25.13	61.23	22.45	28.51
Critical Shear (Nm^{-2}) @ D_{50}	**12.45+**	**4.73**	**13.48**	**13.48**	0.10
Critical Shear (Nm^{-2}) @ D_{84}	--	56.45	76.04	41.52	9.98
Bank Shear (Nm^{-2})	--	--	--	--	**3.83***
Stream Power (Wm^{-1})	268.05	281.80	782.06	185.15	307.34
Stream Power per Unit Width (Wm^{-2})	67.01	35.27	115.01	24.36	46.57
Critical Discharge (m^3s^{-1})	0.98	0.58	0.88	0.43	0.18
Critical Depth (m)	0.22	0.20	0.22	0.20	0.08
Critical Velocity (ms^{-1})	0.79	0.47	0.76	0.76	0.48
Site Description	- dry, channel, low banks, several large slumps, alternating wide and narrow channel, banks heavily vegetated	- banks slumping and eroding, upstream has a backwater effect, valley wall contact, well vegetated banks	-eroded and slumping banks, land use is open field and forest	- bankfull not well defined, dry channel, erosion and undercutting bank, valley wall contact, large boulders in channel, some braiding	- valley wall contact, woody debris in channel, straight section, vertical, eroding banks, some floodplain access
Method	**Fischenich (2001)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**	**Chow (1959)**

+ Cohesive alluvial silt * Sandy clay

Parameter	GHU-21	GHU-22	GHU-23	GHU-24	GHU-25
Average Bankfull Width (m)	14.79	2.79	10.54	7.71	8.68
Average Bankfull Depth (m)	0.79	0.48	0.67	0.79	0.70
Bankfull Gradient (%)	0.14	0.06	0.54	0.17	0.18
Bed Material D_{50} (m)	0.0055	0.0033	0.00493	0.0024	0.0097
Bed Material D_{84} (m)	0.0733	0.0055	0.072	0.0473	0.0629
Bedrock Exposure / Control	No	No	No	No	No
Bank Materials	Cl/si/vfs	Si/vfs/cl/fs	Si/vfs/cl/fs	Cl/si/vfs	Cl/si/vfs
Manning's n at Bankfull	0.035	0.035	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	0.92	0.43	1.61	1.01	0.96
Average Bankfull Discharge (m^3s^{-1})	10.78	0.34	10.32	5.26	6.80
Flow competence (ms^{-1}) @ D_{50}	0.43	0.34	0.41	0.30	0.56
Flow competence (ms^{-1}) @ D_{84}	1.42	0.43	1.41	1.16	1.33
Tractive Force at Bankfull (Nm^{-2})	10.91	2.88	35.46	13.19	12.47
Critical Shear (Nm^{-2}) @ D_{50}	4.01	2.40	3.59	1.75	7.07
Critical Shear (Nm^{-2}) @ D_{84}	53.39	4.01	52.44	34.45	45.82
Bank Shear (Nm^{-2})	--	--	--	--	--
Stream Power (Wm^{-1})	153.79	3.53	560.63	92.67	122.62
Stream Power per Unit Width (Wm^{-2})	10.39	2.20	58.40	14.04	12.23
Critical Discharge (m^3s^{-1})	1.46	0.15	0.44	0.21	1.57
Critical Depth (m)	0.30	0.15	0.14	0.15	0.33
Critical Velocity (ms^{-1})	0.43	0.34	0.41	0.30	0.56
Site Description	-secondary channel, both banks eroding, valley wall contact, lots of organics in channel	- erosion and slumping banks, dense grasses on both banks, woody debris embedded in channel, valley wall contact	- valley wall contact, both banks eroding, tree roots exposed, floodplain access, wood debris on both banks	- rip-rap along bank, minor wood debris in channel, leaning trees, medial bar present, roots exposed	-mid-pool aggradation, both banks eroding, small point bar present, overburden failure and slumping banks, entrenched, major woody debris
Method	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**

Parameter	GHU-26	GHU-27	GHU-28	GHU-29	GHU-30
Average Bankfull Width (m)	3.99	14.56	7.97	15.30	5.78
Average Bankfull Depth (m)	0.32	0.80	0.78	0.77	0.24
Bankfull Gradient (%)	0.98	0.29	0.09	0.13	0.6
Bed Material D_{50} (m)	0.00021	0.0185	0.00041	0.009	0.0000076
Bed Material D_{84} (m)	0.032	0.080	0.034	0.056	0.0035
Bedrock Exposure/Control	No	No	No	No	No
Bank Materials	Si/cl/fs/ms	Si/cl/vfs/cs	Si/fs/vfs	Cl/si/vfs	Si/cl/vfs/fs
Manning's n at Bankfull	0.035	0.035	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	1.79	1.11	0.68	0.85	0.95
Average Bankfull Discharge (m^3s^{-1})	2.87	12.40	4.17	9.16	1.17
Flow competence (ms^{-1}) @ D_{50}	--	0.76	--	0.54	--
Flow competence (ms^{-1}) @ D_{84}	0.97	1.48	1.00	1.25	0.35
Tractive Force at Bankfull (Nm^{-2})	48.27	17.45	6.27	9.55	16.53
Critical Shear (Nm^{-2}) @ D_{50}	**3.83***	**13.48**	**3.83***	**6.56**	**4.79+**
Critical Shear (Nm^{-2}) @ D_{84}	23.16	58.05	24.77	40.43	--
Bank Shear (Nm^{-2})	--	--	--	--	--
Stream Power (Wm^{-1})	340.93	347.61	45.85	273.08	247.09
Stream Power per Unit Width (Wm^{-2})	106.54	19.10	5.33	18.96	56.16
Critical Discharge (m^3s^{-1})	0.02	4.49	1.40	2.34	0.10
Critical Depth (m)	0.04	0.39	0.43	0.37	0.08
Critical Velocity (ms^{-1})	0.26	0.76	0.59	0.54	0.76
Site Description	-dry channel, aggradation, eroding banks, confined channel, valley wall contact, medial deposits, some braiding, fallen trees	- bank erosion, woody debris near bank, bar formation, tree roots exposed	- iron stains by bank, bank erosion and slumping, , wood debris in channel, down-cutting in pool, medial bar, entrenched, exposed clay subpavement	-bank erosion, floodplain access, wood debris, mid channel bar, undercutting, valley wall contact	- vegetation in channel, dry channel, major wood debris, floodplain access, bank erosion
Method	**Chow (1959)**	**Komar (1987)**	**Chow (1959)**	**Komar (1987)**	**Chow (1959)**

* Loose sandy clay + Cohesive clay

Parameter	GHU-31	GHU-32	GHU-33	GHU-34	GHU-35
Average Bankfull Width (m)	3.20	2.37	14.88	9.22	8.12
Average Bankfull Depth (m)	0.28	0.42	0.83	0.64	0.59
Bankfull Gradient (%)	0.25	0.36	0.070	0.43	0.78
Bed Material D_{50} (m)	Clay	0.0000062	0.0142	0.0011	0.0077
Bed Material D_{84} (m)	0.0000071	0.000045	0.10	0.025	0.12
Bedrock Exposure/Control	No	No	No	No	No
Bank Materials	Cl/si	Cl/si/vfs	Cl/si/vfs/fs	Si/cl/vfs	Cl/si/vfs/fs
Manning's n at Bankfull	0.035	0.035	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	0.56	0.98	0.65	1.38	54.98
Average Bankfull Discharge (m^3s^{-1})	0.35	0.84	6.20	6.84	2.21
Flow competence (ms^{-1}) @ D_{50}	--	--	0.67	0.21	0.51
Flow competence (ms^{-1}) @ D_{84}	--	0.047	1.64	0.87	1.81
Tractive Force at Bankfull (Nm^{-2})	6.06	15.20	5.47	26.74	43686.58
Critical Shear (Nm^{-2}) @ D_{50}	**12.45**	**3.83**$^{+}$	**10.34**	**0.80**	**5.61**
Critical Shear (Nm^{-2}) @ D_{84}	--	--	72.55	18.36	90.17
Bank Shear (Nm^{-2})	--	--	--	--	--
Stream Power (Wm^{-1})	34.14	96.59	40.61	155.32	1456.82
Stream Power per Unit Width (Wm^{-2})	13.66	48.29	3.38	19.91	20811.66
Critical Discharge (m^3s^{-1})	0.78*	0.62	5.54	0.072	0.40
Critical Depth (m)	0.51	0.11	0.86	0.050	0.13
Critical Velocity (ms^{-1})	0.71	1.04	0.67	0.21	0.51
Site Description	-dry channel, deep valley, fine substrate, vegetated banks, floodplain access, minor bank erosion, tree roots exposed	-sinuous, "U" shaped channel, steep eroding banks, exposed roots, woody debris in channel	- uneven eroding banks, sands embedding course materials, valley wall contact, exposed clay subpavement	-eroding banks, tree roots exposed, wood debris in channel, floodplain access, organics in channel, mid channel bar	- leaning tees on with exposed roots, eroded banks large rocks in channel, foam noticed, some bank undercutting
Method	**Fischenich (2001)**	**Chow (1959)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**

$^{+}$ Cohesive

* based on bankfull channel geometry does not account for floodplain

Table 5. Mimico Creek erosion thresholds.

Parameter	GMI-1	GMI-2	GMI-3	GMI-4	GMI-5
Average Bankfull Width (m)	14.33	14.37	10.37	8.01	8.13
Average Bankfull Depth (m)	0.72	0.73	0.70	0.73	0.70
Bankfull Gradient (%)	0.68	0.49	0.18	0.09*****	0.13
Bed Material D_{50} (m)	0.031	0.032	0.050	0.014	0.012
Bed Material D_{84} (m)	0.19	0.19	0.13	0.084	0.071
Bedrock Exposure/Control	Yes	No	No	No	No
Bank Materials	Cl/vfs/fs	Si/vfs/fs/cl	Cl/si/vfs/fs	Si/cl/vfs/fs	Si/cl/vfs
Manning's n at Bankfull	0.035	0.035	0.035	0.040	0.040
Average Bankfull Velocity (ms^{-1})	1.99	2.45	0.84	0.57	0.74
Average Bankfull Discharge (m^3s^{-1})	16.18	49.70	6.62	3.08	3.24
Flow competence (ms^{-1}) @ D_{50}	0.95	0.97	1.19	0.66	0.61
Flow competence (ms^{-1}) @ D_{84}	2.19	2.21	1.84	1.51	1.41
Tractive Force at Bankfull (Nm^{-2})	51.70	65.07	12.50	5.88	7.76
Critical Shear (Nm^{-2}) @ D_{50}	22.29	23.24	36.27	10.12	8.52
Critical Shear (Nm^{-2}) @ D_{84}	135.63	138.32	92.87	60.82	51.79
Bank Shear (Nm^{-2})	--	--	--	3.59	--
Stream Power (Wm^{-1})	836.15	1974.87	116.06	92.18	112.96
Stream Power per Unit Width (Wm^{-2})	79.63	134.34	10.46	11.48	15.69
Critical Discharge (m^3s^{-1})	1.01	2.65	9.30	2.05	1.70
Critical Depth (m)	0.25	0.34	0.94	0.54	0.48
Critical Velocity (ms^{-1})	0.52	0.60	1.05	0.54	0.62
Site Description	-Undermined gabion banks, knickpoint riffles, undercut and slumped banks; banks eroding, gabions and rock armour the banks	- Weir, concrete outfall, clay till bed exposed; gabion bank protection; armour stones, valley wall erosion, major wood debris in channel, bank erosion and slumping visible, deposits present	- Gabions and large stones used for bank stabilization, minor bank erosion, bullrushes in channel, coarse deposition visible in reach	- Armoured banks; signs of old gabions, major bank erosion thoughout site, bullrushes in channel, woody debris, overbank deposition, slumping banks	- Eroded valley wall, major bank erosion, rip-rap banks in some sections, willow roots visible
Method	**Fischenich (2001)**	**Fischenich (2001)**	**Fischenich (2001)**	**Komar (1987)**	**Komar (1987)**

***** Apparent backwater effects

Table 6. Rouge River erosion thresholds.

Parameter	R-2	R-4	R-5	R-7
Average Bankfull Width (m)	3.74	2.78	3.49	6.42
Average Bankfull Depth (m)	0.69	0.38	0.48	0.62
Bankfull Gradient (%)	0.15	0.83	0.40	0.47
Bed Material D_{50} (m)	0.0056	0.0059	0.0087	0.0017
Bed Material D_{84} (m)	0.026	0.086	0.084	0.082
Bedrock Exposure/Control	No	No	No	No
Bank Materials	Vfs/fs/si	Vfs/fs/si	Si/vfs/fs	Si/vfs/fs
Manning's n at Bankfull	0.035	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	0.62	1.65	1.29	1.50
Average Bankfull Discharge (m^3s^{-1})	2.51	2.09	2.04	5.84
Flow competence (ms^{-1}) @ D_{50}	0.44	0.45	0.53	0.25
Flow competence (ms^{-1}) @ D_{84}	0.88	1.54	1.52	1.50
Tractive Force at Bankfull (Nm^{-2})	10.48	41.23	23.76	30.93
Critical Shear (Nm^{-2}) @ D_{50}	**4.08**	**4.30**	**6.34**	**1.21**
Critical Shear (Nm^{-2}) @ D_{84}	18.27	62.86	61.18	59.87
Bank Shear (Nm^{-2})	--	--	--	--
Stream Power (Wm^{-1})	49.00	159.44	77.35	156.26
Stream Power per Unit Width (Wm^{-2})	12.25	63.77	29.75	26.94
Critical Discharge (m^3s^{-1})	0.30	0.08	0.24	0.08
Critical Depth (m)	0.20	0.13	0.22	0.10
Critical Velocity (ms^{-1})	0.45	0.44	0.53	0.26
Site Description	- Log crib wall and stones used for bank stabilization, undercut and slumped banks, turbid water, man-made riffles	- Dense vegetation on banks, minor bank erosion, small man-made crossing	- Chutes present, erosion and slumping banks	- Exposed clay subpavement, slumped banks, minor bank erosion
Method	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**

Parameter	R-10	R-11	R-12
Average Bankfull Width (m)	5.64	4.26	5.22
Average Bankfull Depth (m)	0.51	0.48	0.71
Bankfull Gradient (%)	0.58	0.62	0.23
Bed Material D_{50} (m)	0.015	0.025	0.0072
Bed Material D_{84} (m)	0.096	0.10	0.057
Bedrock Exposure/Control	No	No	No
Bank Materials	Si/cl/vfs/fs	Cl/si/vfs/fs	Cl/vfs/fs
Manning's n at Bankfull	0.040	0.035	0.035
Average Bankfull Velocity (ms^{-1})	1.10	1.27	0.99
Average Bankfull Discharge (m^3s^{-1})	2.69	2.38	2.46
Flow competence (ms^{-1}) @ D_{50}	0.69	0.87	0.49
Flow competence (ms^{-1}) @ D_{84}	1.61	1.66	1.27
Tractive Force at Bankfull (Nm^{-2})	24.90	25.84	13.94
Critical Shear (Nm^{-2}) @ D_{50}	**11.14**	**18.06**	**5.24**
Critical Shear (Nm^{-2}) @ D_{84}	69.71	74.88	41.81
Bank Shear (Nm^{-2})	--	--	--
Stream Power (Wm^{-1})	108.42	123.46	59.95
Stream Power per Unit Width (Wm^{-2})	19.36	28.06	14.99
Critical Discharge (m^3s^{-1})	0.76	0.95	0.32
Critical Depth (m)	0.26	0.33	0.24
Critical Velocity (ms^{-1})	0.70	0.87	0.49
Site Description	- Exposed clay subpavement, island present, bank erosion, woody debris in channel	- Undercut and slumped banks, high flow channel present	- Major willow roots in channel, minor bed morphology, forested area
Method	**Komar (1987)**	**Komar (2001)**	**Komar (1987)**

Parameter	R-13	R-14	R-16	R-17
Average Bankfull Width (m)	2.81	6.86	4.21	5.66
Average Bankfull Depth (m)	0.28	0.42	0.47	0.55
Bankfull Gradient (%)	0.73	0.20	0.19	0.41
Bed Material D_{50} (m)	0.0032	0.000064	0.0023	0.0059
Bed Material D_{84} (m)	0.015	0.003	0.029	0.063
Bedrock Exposure/Control	No	No	No	No
Bank Materials	Cl/si/vfs/fs	Si/fs/vfs	Cl/si/vfs	Si/vfs/fs
Manning's n at Bankfull	0.040	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	0.88	0.73	0.72	1.25
Average Bankfull Discharge (m^3s^{-1})	0.80	1.63	1.23	3.81
Flow competence (ms^{-1}) @ D_{50}	0.34	- -	0.29	0.45
Flow competence (ms^{-1}) @ D_{84}	0.69	0.11	0.93	1.33
Tractive Force at Bankfull (Nm^{-2})	19.04	8.44	8.18	22.71
Critical Shear (Nm^{-2}) @ D_{50}	**2.33**	**2.40***	**1.68**	**4.27**
Critical Shear (Nm^{-2}) @ D_{84}	11.07	--	21.12	45.82
Bank Shear (Nm^{-2})	--	--	--	--
Stream Power (Wm^{-1})	91.98	148.52	50.19	160.05
Stream Power per Unit Width (Wm^{-2})	27.05	28.56	13.00	29.64
Critical Discharge (m^3s^{-1})	0.041	0.14	0.11	0.27
Critical Depth (m)	0.050	0.12	0.96	0.16
Critical Velocity (ms^{-1})	0.34	0.37	0.29	0.45
Site Description	- Many gravel deposits, moderate toe erosion, woody debris jam, riparian vegetation mowed to edge of bank	- Very low bank, accessible to floodplain, valley wall erosion, no bed morphology, sand substrate, woody debris in channel, floodplain has high water content	- Large amounts of organic material on bed, minor bank slumping and erosion, dense grasses and herbs on both banks	- Macrophytes in channel, slumped and undercut banks, vegetated island, golf course surrounds site, banks comprised of clay
Method	**Komar (1987)**	**Chow (1959)**	**Komar (1987)**	**Komar (1987)**

* Loose sandy clay

Parameter	**R-21**	**R-24**	**R-25**	**R-26**	**R-27**
Average Bankfull Width (m)	15.65	8.07	16.69	15.54	16.43
Average Bankfull Depth (m)	1.09	0.49	0.90	0.72	0.71
Bankfull Gradient (%)	0.020	0.37	0.23	0.47	0.85
Bed Material D_{50} (m)	0.0061	0.0057	0.019	0.062	0.069
Bed Material D_{84} (m)	0.12	0.047	0.088	0.16	0.24
Bedrock Exposure/Control	No	No	No	No	No
Bank Materials	Si/vfs/cl/fs	Si/vfs/cl/fs	Si/fs/cl/ms	Si/vfs/fs/cl	Si/vfs/fs/cl
Manning's n at Bankfull	0.035	0.040	0.035	0.035	0.040
Average Bankfull Velocity (ms^{-1})	0.44	1.16	1.40	1.48	1.85
Average Bankfull Discharge (m^3s^{-1})	8.42	4.22	19.75	14.95	22.12
Flow competence (ms^{-1}) @ D_{50}	0.45	0.44	0.76	1.32	1.39
Flow competence (ms^{-1}) @ D_{84}	1.79	1.16	1.55	2.04	2.48
Tractive Force at Bankfull (Nm^{-2})	2.26	24.33	23.39	30.14	59.87
Critical Shear (Nm^{-2}) @ D_{50}	**4.44**	**4.15**	**13.55**	45.09	**50.55**
Critical Shear (Nm^{-2}) @ D_{84}	87.70	34.31	64.39	116.03	178.09
Bank Shear (Nm^{-2})	--	--	--	**12.45***	--
Stream Power (Wm^{-1})	15.59	200.66	402.73	463.10	1445.18
Stream Power per Unit Width (Wm^{-2})	0.94	37.16	29.68	29.88	86.69
Critical Discharge (m^3s^{-1})	6.66	0.29	3.77	7.21	13.39
Critical Depth (m)	1.22	0.15	0.47	1.02	0.68
Critical Velocity (ms^{-1})	0.45	0.44	0.76	0.55	1.38
Site Description	- Rip-rap bank protection, no bed morphology, minor erosion throughout the site	- Major woody debris in channel, bank erosion throughout the site, garbage on top of banks and in the channel	-Vertical, eroded banks, island present, clay bed exposed, coarse sand deposits	- Valley wall erosion, armour stone protection, clay subpavement exposed, fresh deposits, island present, moderate bank erosion	- Large boulders in channel, boulders embedded in banks, banks composed of hard clay,
Method	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**	**Fischenich (2001)**	**Komar (1987)**

* alluvial silt and clay

Parameter	R-32	R-33	R-37	R-38
Average Bankfull Width (m)	4.61	8.76	7.89	10.81
Average Bankfull Depth (m)	0.27	0.55	0.58	0.62
Bankfull Gradient (%)	0.021	0.45	0.15	0.050
Bed Material D_{50} (m)	0.000044	0.0074	0.019	0.0058
Bed Material D_{84} (m)	0.0057	0.050	0.058	0.048
Bedrock Exposure/Control	No	No	No	No
Bank Materials	Cl/si/vfs/fs	Cl/vfs/ms	Si/vfs/cl/fs	Cl/si/vfs/fs
Manning's n at Bankfull	0.045	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	0.16	1.30	0.90	0.42
Average Bankfull Discharge (m^3s^{-1})	0.26	6.91	6.41	1.79
Flow competence (ms^{-1}) @ D_{50}	--	0.50	0.77	0.44
Flow competence (ms^{-1}) @ D_{84}	0.44	1.20	1.28	1.17
Tractive Force at Bankfull (Nm^{-2})	0.70	24.52	10.87	2.60
Critical Shear (Nm^{-2}) @ D_{50}	**3.59+**	**5.39**	**13.84**	**4.22**
Critical Shear (Nm^{-2}) @ D_{84}	--	36.64	41.96	34.60
Bank Shear (Nm^{-2})	--	--	--	--
Stream Power (Wm^{-1})	1.18	337.94	242.33	49.75
Stream Power per Unit Width (Wm^{-2})	0.25	35.20	25.24	6.14
Critical Discharge (m^3s^{-1})	5.54*	0.65	3.56	1.75*
Critical Depth (m)	1.74	0.16	0.53	0.50
Critical Velocity (ms^{-1})	0.47	0.50	0.77	0.44
Site Description	- Straightened channel, dense grasses on banks and in channel, silty substrate, agricultural field surrounds reach	- Woody debris in channel, moderate bank erosion, valley wall present, tree roots exposed	- Exposed clay bed, aggradation, vegetation in channel, erosion and slumping of banks visible throughout site	- Exposed clay subpavement, valley wall erosion, macrophytes in channel, slumped and eroded banks
Method	**Chow (1959)**	**Komar (1987)**	**Komar (1987)**	**Komar (1987)**

+ clayey sand loose

* based on bankfull channel geometry does not account for floodplain

Parameter	**R-39**
Average Bankfull Width (m)	3.09
Average Bankfull Depth (m)	0.21
Bankfull Gradient (%)	0.65
Bed Material D_{50} (m)	0.0054
Bed Material D_{84} (m)	0.031
Bedrock Exposure / Control	No
Bank Materials	Cl / si / vfs / fs,
Manning's n at Bankfull	0.035
Average Bankfull Velocity (ms^{-1})	1.05
Average Bankfull Discharge (m^3s^{-1})	0.74
Flow competence (ms^{-1}) @ D_{50}	0.43
Flow competence (ms^{-1}) @ D_{84}	0.95
Tractive Force at Bankfull (Nm^{-2})	19.50
Critical Shear (Nm^{-2}) @ D_{50}	**3.93**
Critical Shear (Nm^{-2}) @ D_{84}	22.29
Bank Shear (Nm^{-2})	--
Stream Power (Wm^{-1})	55.89
Stream Power per Unit Width (Wm^{-2})	24.30
Critical Discharge (m^3s^{-1})	0.044
Critical Depth (m)	0.090
Critical Velocity (ms^{-1})	0.43
Site Description	- Major root mass in channel, vegetation in channel, minor erosion throughout the site, no bed morphology
Method	**Komar (1987)**

Parameter	R-45	R-47	R-51	R-52	R53
Average Bankfull Width (m)	13.43	10.86	13.39	18.12	16.78
Average Bankfull Depth (m)	0.60	0.59	0.60	0.55	0.70
Bankfull Gradient (%)	0.33	0.43	0.81	1.04	0.42
Bed Material D_{50} (m)	0.071	0.082	0.056	0.063	0.052
Bed Material D_{84} (m)	0.14	0.18	0.17	0.18	0.17
Bedrock Exposure / Control	No	No	No	No	No
Bank Materials	Si / vfs / fs	Fs / vfs / si	Si / vfs / fs	Si / fs / ms	Si / vfs / fs / cl
Manning's n at Bankfull	0.040	0.035	0.035	0.035	0.035
Average Bankfull Velocity (ms^{-1})	1.01	1.45	2.10	1.92	1.43
Average Bankfull Discharge (m^3s^{-1})	6.41	11.02	15.76	19.64	16.03
Flow competence (ms^{-1}) @ D_{50}	1.40	1.50	1.26	1.33	1.22
Flow competence (ms^{-1}) @ D_{84}	1.93	2.14	2.12	2.18	2.09
Tractive Force at Bankfull (Nm^{-2})	19.05	28.67	58.23	54.78	27.98
Critical Shear (Nm^{-2}) @ D_{50}	51.57	59.80	41.08	45.96	37.95
Critical Shear (Nm^{-2}) @ D_{84}	102.99	129.29	126.96	134.17	123.32
Bank Shear (Nm^{-2})	**18.20***	**18.20***	**18.20***	**18.20***	**18.20***
Stream Power (Wm^{-1})	192.43	357.20	490.50	780.84	516.19
Stream Power per Unit Width (Wm^{-2})	17.82	31.89	48.09	41.10	31.28
Critical Discharge (m^3s^{-1})	5.63	3.62	1.89	1.32	2.82
Critical Depth (m)	0.66	0.51	0.33	0.24	0.54
Critical Velocity (ms^{-1})	1.03	0.86	0.80	0.61	0.95
Site Description	- Island present, major WD in channel, lots of tree root exposure, major erosion throughout channel	- Minor erosion, large boulders in channel, boulders and cobbles embedded at toe of banks	- Exposed clay bed, rip-rap left bank, path on top of bank, right bank eroded along entire site	- Valley wall erosion, path area eroding out, large deposits present, large boulders in stream	- Large boulders in channel, both banks eroded, valley wall contact, exposed clay sub-pavement, island, willow shrubs on left bank, deposition, siltation
Method	**Fischenich (2001)**	**Fischenich (2001)**	**Fischenich (2001)**	**Fischenich (2001)**	**Fischenich (2001)**

* mixed alluvium from clay to cobble or consolidated clay

Appendix B

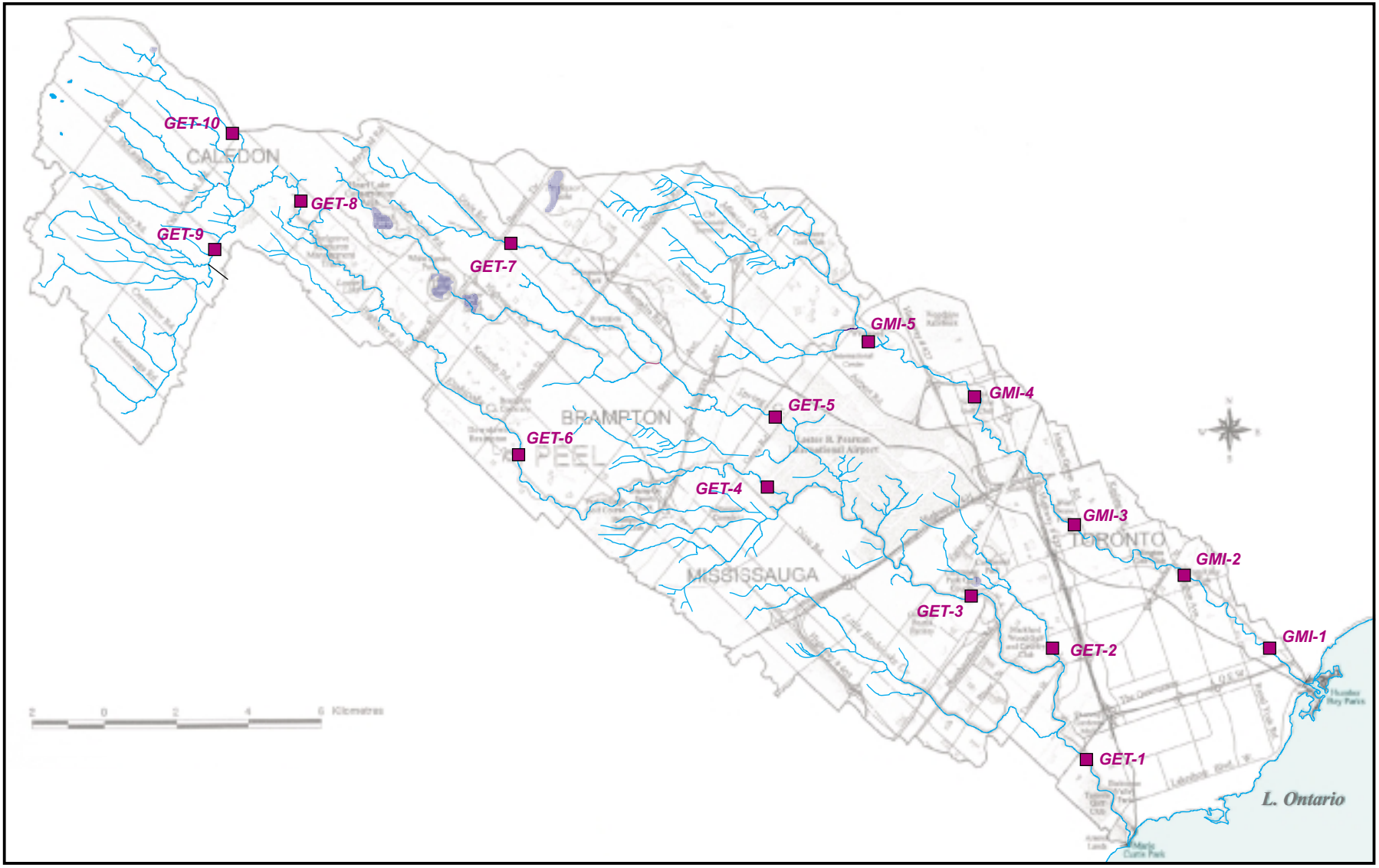

Figure 2. Geomorphic monitoring sites within Etobicoke and Mimico Watersheds (from *TRCA Monitoring Program Report*, 2001).

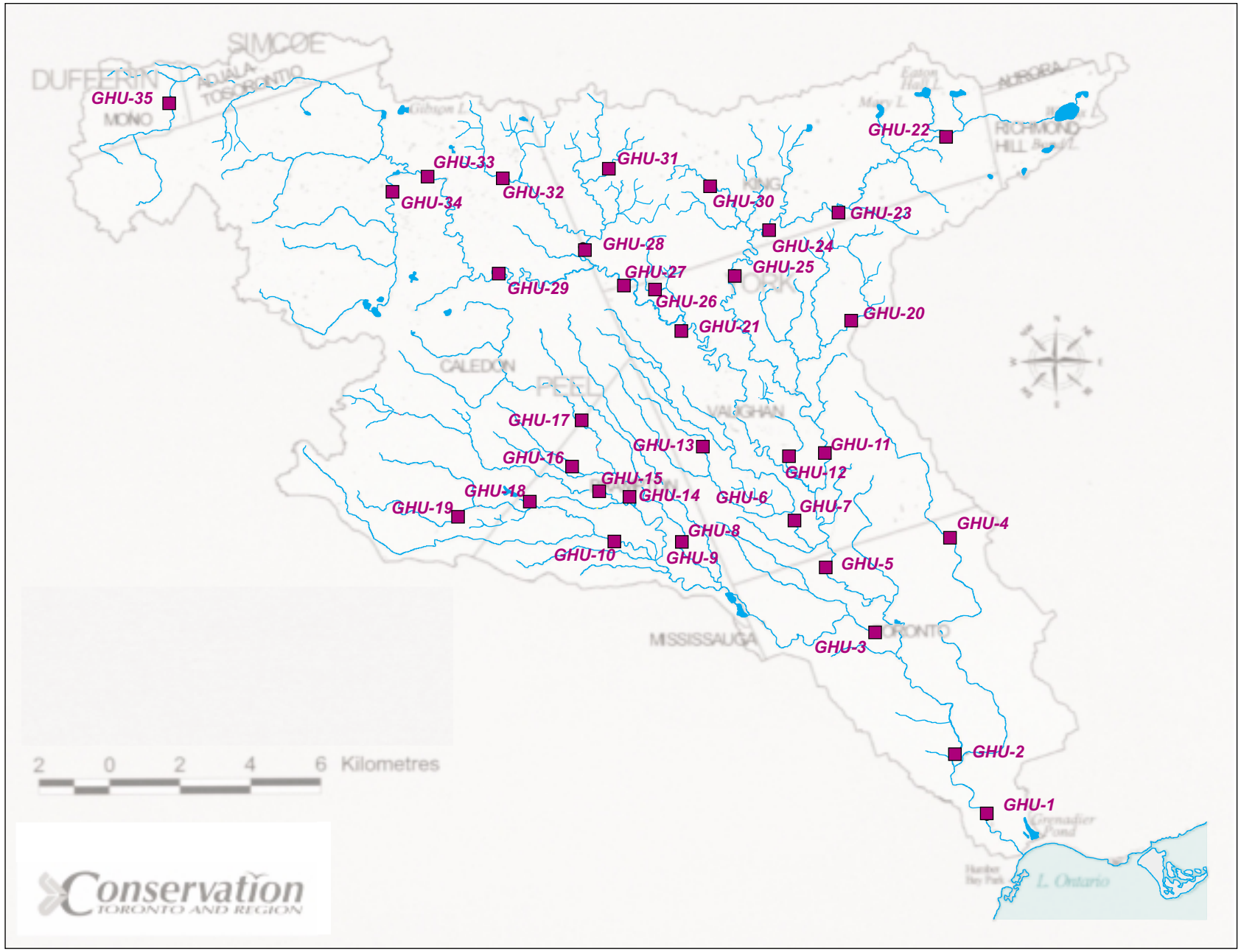

Figure 1. Geomorphic monitoring sites within the Humber River Watershed (from *TRCA Monitoring Program Report*, 2001).

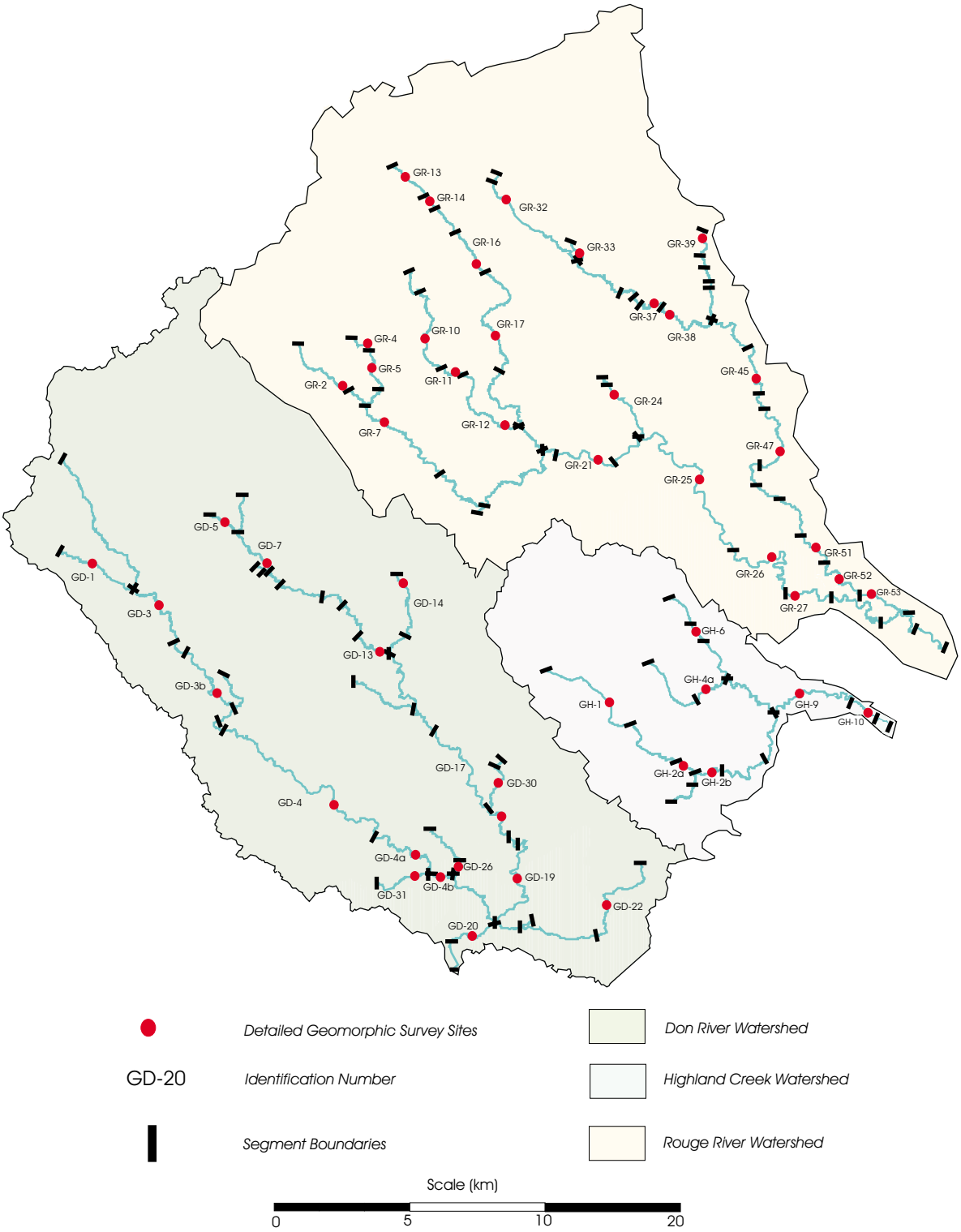

Figure 1: Geomorphic Monitoring Sites within the Don River, Highland Creek and Rouge River Watershed from *Regional Monitoring Program - Fluvial Geomorphology Component Etobicoke Creek, Mimico Creek and Humber River Watersheds* (PARISH Geomorphic Ltd., June 26, 2002).