December 24, 2020
WE 20032

Mr. Peter Kulkarni, MCIP, RPP, LEED AP
Director, Development
Triovest Realty Advisors Inc.
40 University Ave, Suite 1200
Toronto, Ontario
M5J 1T1

Dear Mr. Kulkarni:

RE: iPort Cambridge Fluvial Geomorphic Assessment
Cambridge, Ontario

Water's Edge was authorized by Triovest Realty Advisors Inc to complete a fluvial geomorphic assessment of Allendale Creek as required by the Grand River Conservation Authority to address stormwater management facility discharges from the development to the creek.

We have completed our assessment of the creek in accordance with the approved project Terms of Reference. Data sources for the analysis include:

- Physiography of Southern Ontario by Chapman & Putnam (1984) (digital data from the Ontario Geological Survey);
- Ontario Flow Assessment Tool III (OFAT) (from Ministry of Natural Resources and Forestry);
- Ontario Base Mapping;
- Draft Plan of Subdivision (30T-20102) 250 Allendale Road and 105 Middle Block Road;
- IPort Cambridge Industrial Subdivision Stormwater Management report (2020 report prepared by EXP);
- East Side Land Master Drainage Plan (2013 report prepared by Aquafor Beech)
- Discussions with Triovest and EXP;
- Site inspection and survey by Water's Edge staff.

A site inspection and survey were completed by Water's Edge staff on September 2, 2020. The site inspection was undertaken following a review of available resources to confirm site and general system characteristics.

1 WATERSHED AND SITE CONDITIONS

1.1 General Watershed Conditions

Allendale Creek is a seasonal tributary of the Grand River. It currently drains agricultural fields, and meanders through a valley between two of these fields. Due to the limited size and nature of the watercourse, no flows were observed during our site inspection. Allendale Creek can be seen in **Figure 1**.

Based on the Ontario Flow Assessment Tool III (OFAT III), the study area has a total drainage area of 0.43 km^2, with an average watershed slope of 2.4%. The reach exhibits a mean annual flow of 0 m^3/s (OFAT, 2020). From the Stormwater Management Report (EXP, 2020), the two, five and one hundred-year flows are 0.51 m^3/s, 1.26 m^3/s, and 3.71 m^3/s. Note that erosion scars found in the creek indicate that the creek does regularly receive discharge and that base flow conditions are important for habitat conditions.

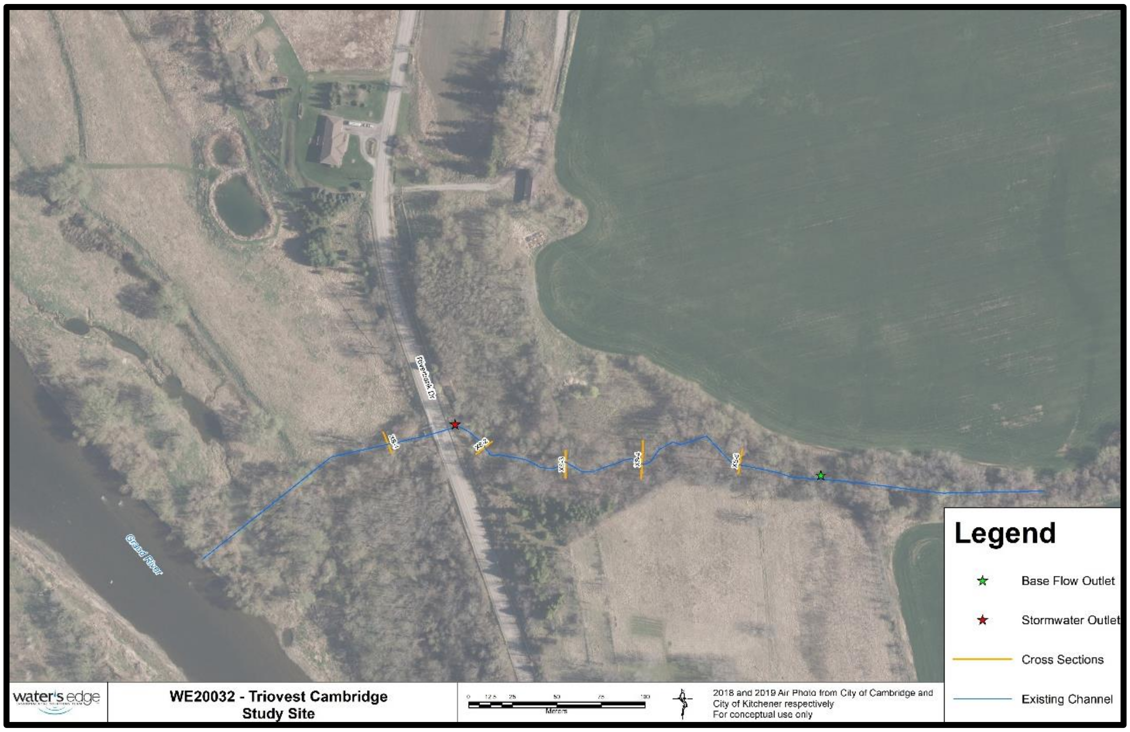

Figure 1: Study site showing the assessed reach of Allendale Creek

1.2 Physiography and Surficial Geology

Reviewing the sites surficial materials is important to evaluate active channel processes. Stream channel form and sediment supply are controlled by the region's physiography and underlying surficial geology.

The study area is found in an ancient spillway within the Guelph Drumlin Field (Chapman & Putnam, 1984). Spillways result in a wide variety of sediment, although it is generally well sorted which was evident in the banks and the bed of the creek. Much of the larger cobbles are the result of stones pulled from the adjacent agricultural fields that were dumped down the bank of the watercourse.

1.3 Watercourse Conditions

A site visit was performed on September 2, 2020 where a geomorphic survey was performed. The reach that was assessed was between Riverbank Drive and the proposed Intermarket Road. A pipe from the stormwater management facility will provide baseflow downstream for Allendale Creek, while the stormwater facility outlet will be upstream from the existing Riverbank Drive culvert. Therefore, the purpose of this assessment is to identify the conditions of the watercourse to ensure that the new flow regime will not exceed the erosion threshold within the creek. Five cross-sections and a longitudinal profile were surveyed to characterize typical bankfull conditions in Allendale Creek and to identify the erosion thresholds. The characteristics are detailed below and summarized in **Table 1.** A Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Technique (RSAT) were also used to characterize the existing watercourse.

Table 1: Geomorphic parameters of watercourse

	Average	Range
Bankfull width (m)	4.42	2.76 – 8.42
Entrenchment Ratio	1.794	1.31 – 2.77
Mean Bankfull depth (m)	0.41	0.27 – 0.49
Max bankfull depth (m)	0.68	0.51 – 0.81
Width/depth ratio	11.04	5.63- 18.71
Bankfull area (m^2)	1.84	1.00- 3.78
Wetted Perimeter (m)	4.83	3.37 -8.82
Hydraulic Radius (m)	0.37	0.25 – 0.43
D_{50} (mm)	8	
D_{84} (mm)	52	
Bankfull Slope (m/m)	0.05	

The watercourse runs from east to west, with photographs found in **Appendix A** and cross-section plots in **Appendix B**. The channel is single threaded, and meanders through a heavily forested valley with steep banks. There are large amounts of agricultural debris (e.g., rolls of fencing, pieces of metal, discarded agricultural equipment), throughout the creek and on the valley walls. There is evidence of erosion at the base of the banks, but trees growing in the banks are straight. As leaning vegetation is an indication of bank migration, this indicates that the channel is not migrating.

1.4 Rapid Geomorphic Assessment (RGA)

Channel stability was assessed using a Rapid Geomorphic Assessment (MOE, 2003). The RGA assessment focuses entirely on the geomorphic component of a river system. The RGA method consists of four factors that summarize various components of channel adjustment, specifically: aggradation, degradation, channel widening and planform adjustment. This methodology has been applied to numerous streams and rivers. Each factor is assessed separately, and the total score indicates the overall stability of the system (**Table 2**).

Table 3 presents the summary of the RGA assessment, with the full assessment in **Appendix C**. Generally, the lower the score, the more stable the channel is. In our assessment, the watercourse was categorized as “Transitional” due to the erosion from the steep banks (**Table 3**).

Table 2: RGA Interpretation

Stability Index (SI) Value	Classification	Interpretation
SI ≤ 0.20	In Regime	The channel morphology is within a range of variance for rivers of similar hydrographic characteristics and evidence of instability is isolated or associated with normal river meander processes.
0.21 ≤ SI ≤0.40	**Transitional/Stressed**	**Channel morphology is within a range of variance for rivers of similar hydrographic characteristics, but the evidence of instability is frequent.**
SI ≥ 0.40	In Adjustment	Channel morphology is not within the range of variance and evidence of instability is wide spread.

Table 3: RGA Stability Index

Category	Stability Index
Evidence of Aggradation	0.00
Evidence of Degradation	0.30
Evidence of Widening	0.50
Evidence of Planimetric Form Adjustment	0.00
Stability Index	0.20
Classification	Transitional

1.5 Rapid Stream Assessment Technique (RSAT)

The Rapid Stream Assessment Technique (RSAT) was developed by John Galli and other staff of the Metropolitan Washington (DC) Council of Governments (Galli et al., 1996). The RSAT systematically focuses on conditions reflecting aquatic-system response to watershed urbanization. It groups responses into six categories, presumed to adequately evaluate the conditions of the river system at the time of measurement on a reach-by-reach basis. The six categories are:

1. Channel stability;
2. Channel scouring and sediment deposition;
3. Physical in-stream habitat;
4. Water quality;
5. Riparian habitat conditions; and,
6. Biological conditions.

River channel stability and cross-sectional characterization is a critical component of RSAT. The entire channel was inspected for signs of instability (such as bank sloughing, recently exposed non-woody tree roots, general absence of vegetation within the bottom third of the bank, recent tree falls, etc.) and channel degradation or downcutting (such as high banks in small headwater streams and erosion around man-made structures).

A rapid assessment of soil conditions along the riverbanks is also conducted to identify soil texture and potential erodibility of the watercourse bank. Qualitative water quality measurements were also made (temperature, turbidity, colour and odour) along with an indication of substrate fouling (i.e., the unwanted accumulation of sediment).

RSAT also typically involves a quantitative sampling and evaluation of benthic organisms. As no benthic sampling was undertaken, the score was based on site conditions and general observations of water quality.

Each category was assigned a value which was then summed to provide an overall score and ranking. **Table 4** details the range of scores and rankings with a higher score suggesting a healthier system. Within these broad categories, we evaluated the watercourse and determined the RSAT score as “Good.**”** This score is the result of the steep banks contributing towards erosion (**Table 5**).

Table 4: RSAT Interpretation

RSAT Score	Ranking
41-50	Excellent
31-40	**Good**
21-30	Fair
11-20	Poor
0-10	Degraded

Table 5: RSAT Score

Category	Score
Channel Stability	4.20
Channel Scour and Sediment Deposition	6.00
Physical In-Stream Habitat	5.57
Water Quality	7.00
Riparian Habitat Conditions	6.50
Biological Indicators	4.00
Final	33.27
Interpretation	Good

2 EROSION THRESHOLD ASSESSMENT

2.1 General

A detailed fluvial geomorphological study was completed using a Total Station on September 2, 2020. For the purposes of an erosion threshold assessment, bankfull cross-sections were surveyed at riffle or run locations because it can be expected that channel velocities and shear stresses on the bed are greatest through these sections, therefore providing the most representative values. The longitudinal profile was also surveyed to determine the local energy gradient (slope). As the bed is composed primarily of gravels and cobbles, a pebble count was completed to characterize the bed materials to create a distribution to determine the D_{50} and D_{84} particle sizes.

This detailed field data (cross-section, gradient and particle distribution) was used to estimate the bankfull discharge, shear stress and critical discharge values. Specifically, the critical discharge indicates the point at which sustained flows will tend to entrain and transport sediment. In this analysis, the D_{84} was used as an index size.

To determine the critical shear stress for particle entrainment, the methods presented by Komar (1987), Julien (1995) and Fischenich (2001) were used. These methods adapt and update the work of Shield (1936). The Komar method is most appropriate to gravel sized material, while Fischenich also incorporates finer material (sands). Based on the critical shear stress determined by each method, a critical depth is back-calculated and a critical discharge is determined. This critical discharge is then applied as an erosion threshold target when controlling stormwater releases.

2.2 Erosion Threshold Considerations and Discussion

Using the data collected during the field investigations and desktop analysis, bankfull characteristics for cross-sections were summarized. The bankfull energy gradient, bed materials and drainage area are summarized in **Table 1**. Related hydraulic parameters were determined including stream power, unit stream power, and bed shear stress at each of the evaluated cross-sections (**Table 6**). Results are presented for XS-1 using both the bed material (cobbles) and the bank material (overburden). This shows the dynamic nature of the watercourse, with the implications outlined below.

The outlet from the stormwater management facility will be immediately upstream from the Riverbank Drive culvert. The channel through this reach is characterized by XS-1 as the channel downstream from the culvert will be receiving both the base flow and the stormwater flow. The critical thresholds are outlined in **Table 7.**

Table 6: Hydraulic Parameters

Parameter	Cross-Sections	
	XS-1 (bed)	XS-1 (banks)
Relative Roughness (m)	2.8	10.6
Shear Velocity (m/s)	2.1	0.33
Velocity based on ff/RR (m/s)	3.7	2.85
Bankfull Discharge (m^3/s)	3.1	4.95
Froude #	0.8	1.34
Stream Power (W/m)	911.9	1456.6
Unit Stream Power (W/m^2)	241.3	385.3
Mean Bed Shear (N/m^2)	108.9	108.9

Table 7: Threshold Results

Method	Parameter	Cross Sections	
		XS-1 (bed)	XS-1 (banks)
Komar (1987)	Critical Shear (N/m^2)	94.69	25.49
	Ratio of Critical Shear/Bed Shear	1.15	4.27
	Critical Hydraulic Radius	0.32	0.09
	Critical Flow (m^3/s)	3.50	0.20
	Ratio of Critical Flow/Bankfull Flow	1.13	0.04
Julien (1995)	Critical Shear (N/m^2)	113.63	28.33
	Ratio of Critical Shear/Bed Shear	0.96	3.84
	Critical Hydraulic Radius (m)	0.39	0.10
	Critical Flow (m^3/s)	8.75	0.25
	Ratio of Critical Flow/ Bankfull Flow	2.84	0.05
Fischenich (2001)	Critical Shear (N/m^2)	113.68	28.52
	Ratio of Critical Shear/ Bed Shear	0.96	3.82
	Critical Hydraulic Radius	0.39	0.10
	Critical Flow (m^3/s)	8.76	0.25
	Ratio of Critical Flow/Bankfull Flow	2.83	0.05

The results show that the critical discharge based on channel substrate (bed material) is 3.50 m^3/s (Kumar) and based on bank material (overburden) is 0.20 m^3/s (Kumar). Overall, the different methods (Komar, Julien, and Fischenich) yield similar results for bank materials (Julien and Fischenich are both 0.25 m^3/s) and compare well to previous analyses which state a target release of 0.25 m^3/s. The results show a distinct difference between bed and the bank materials as the bank materials are much more susceptible to erosion, resulting in bank erosion and meander migration due to large flows. Since the Allendale Creek system has a flashy response and would be typically dry shortly after a rainfall event, the threshold stormwater management release rate of 0.25 m^3/s would mean that this stormwater discharge would continue after natural flows have passed. During rain events resulting in flows up to bankfull flow, the natural flow in the system (3.1 m^3/s) is significantly more than the 0.25 m^3/s release rate and the additional flow would not result in any appreciable change in channel conditions.

Based on the above analysis, we concur that 0.25 m^3/s is an acceptable stormwater release rate for this reach of Allendale Creek.

3 CONCLUSIONS

Based on our site assessment and survey, we have the following suggestions to improve channel conveyance and to ensure the ecological and geomorphic health of Allendale Creek:

- The debris found in the creek (wire fence rolls, sheet metal and old agricultural equipment) should be removed;
- A monitoring program should be implemented that includes cross-section surveys and photographs downstream from the base flow and the stormwater outlet to ensure that any geomorphic adjustments downstream from the outlets are within reasonable tolerances; and,
- If stormwater discharge needs to increase beyond the above values, stream restoration would be required to prevent further bank erosion through Allendale Creek.

4 SUMMARY

To complete an erosion threshold analysis for the proposed development, a geomorphic survey was completed at the site. Erosion threshold analysis for the watercourse was performed to identify thresholds for stormwater outlets into Allendale Creek.

Based on our site investigation, assessments, and analyses, we conclude that:

1. While there is evidence of erosion in the watercourse, the valley walls and banks are generally stable.
2. Five cross-sections were identified in the study reach to characterize Allendale Creek. XS-5 was used for the erosion threshold calculations downstream from the base flow outlet, and XS-1 was used for the erosion threshold calculations at the outlet from the stormwater management ponds. Both cross-sections have higher erosion thresholds than the proposed discharges;
3. Should the discharges for either the baseflow or stormwater outlet be increased, channel remediation would be required to reduce the risk of further erosion through the reach; and,

Should you have any questions, please do not hesitate to contact the undersigned.

Respectfully submitted,

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President, Sr. Geomorphologist
Water's Edge Environmental Solutions Team Ltd.

Adam Gibson, B.Sc.,
River Scientist

ATTACHMENTS
Appendix A: Photographs
Appendix B: Profile and Cross Sections
Appendix C: RGA & RSAT Assessment