Lynden Garden MESP Erosion Hazard and Mitigation Assessment

299 Lynden Road, City of Brantford

Prepared for:
Natalie Shurigina
Sorbara Group of Companies
3700 Steeles Avenue West, Suite 800
Woodbridge, ON L4L 8M9

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GEO MORPHIX
Geomorphology
Earth Science
Observations

Report Prepared by:	GEO Morphix Ltd. 36 Main Street North PO Box 205 Campbellville, ON L0P 1B0
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Prepared by:	Jan Franssen, Ph.D., Karine Smith, M.Sc.
Approved by:	Paul Villard, Ph.D., P.Geo., CAN-CISEC, EP, CERP

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1 Introduction

GEO Morphix Ltd. was retained to complete a fluvial geomorphological characterization and erosion mitigation assessment in support of proposed stormwater management (SWM) facilities at the development at 299 Lynden Road in the City of Brantford, Ontario. The proposed development site, hereon referred to as the 'subject lands', is an area of approximately 77.7 ha, bounded by Lynden Road to the south, a residential neighborhood to the east, a forested valley to the north, and a Canadian National Rail (CNR) line to the east. Silver Creek a tributary of Fairchild Creek flows west to east, along the southern boundary of the property. Two smaller tributaries of Garden Avenue Drain extend south from the site boundary at Lynden Road. These watercourses constitute the zone of potential impact associated with the proposed SWM facilities and are consequently the subject of the fluvial assessments. To support the development application for the site, an erosion hazard assessment and delineation of constraints associated with the subject watercourse was completed to inform future development limits to the north. In addition, an erosion threshold and mitigation assessment was completed in support of the two proposed stormwater management facilities that will service drainage from the subject lands.

The following activities were completed to characterize existing conditions, delineate limits of the erosion hazard, and complete an erosion mitigation assessment in support of the proposed stormwater management strategy:

- Review topographic and geologic maps and previously completed reporting for the site
- Complete a desktop analysis which includes a historical assessment using aerial photographs to identify changes to the system due to land use and past channel modifications
- Delineate watercourse reaches through a desktop exercise
- Conduct rapid field assessments to document the channel conditions, reach-scale observations of channel substrate, flow behaviour, geomorphological units, and locations of any valley wall contact, and areas of active erosion within the receiving watercourses
- Obtain and review historical and recent aerial photographs to determine the limits of the meander belt width associated with Silver Creek
- Complete a detailed geomorphological field assessment to determine an erosion threshold or flow target for stormwater management design
- Define an erosion threshold for the receiving watercourses using an in-house model that predicts the discharge at which the dominant channel material will become entrained
- Perform continuous erosion exceedance modelling of existing and proposed conditions in support of the development of an effective erosion mitigation scenario

2 Background Review

2.1 North Brantford and Tutela Heights Subwatershed Study

The North Brantford and Tutela Heights Subwatershed Study (SWS) was reviewed to help inform the erosion hazard and mitigation assessments. The purpose of the aforementioned SWS is to facilitate future development, and the associated planning, engineering, and environmental studies, within the Expanded Urban Settlement area of the Boundary Adjustment Lands in the City of Brantford. The SWS characterizes existing watercourses, drainage features, natural heritage systems, and groundwater resources within the study area. Potential impacts to these systems are explored and high-level management frameworks are provided for appropriate mitigation.

Of relevance to the 299 Lynden Road development, the North Brantford and Tutela Heights SWS characterized site drainage patterns and surficial geology, and provided information on several stream reaches of Silver Creek and the Garden Avenue tributary of Fairchild Creek. Erosion thresholds were determined for multiple channels within the primary SWS study area but were not completed for any of the watercourses within the zone-of-impact associated with the 299 Lynden Road Development.

Within the SWS, the surficial geology of tablelands in subject lands were characterized solely as clays. A drainage divide was identified within the subject lands, with the northern portion draining to Silver Creek and the southern portion draining to the Garden Ave tributary. The Garden Ave tributary was identified as a likely-ephemeral system with little to no flow observed during the SWS field assessments. The feature eventually outlets to Fairchild Creek south of Highway 403.

Silver Creek flows through a steep, incised valley to the immediate north of the subject lands, with sands and modern alluvial deposits identified on the valley floor and clays on the valley walls. The valley floor is predominantly wetland/marsh-type land cover and is characterized as an NHS with a 30 m buffer. Multiple observations of exposed parent till material were noted upstream of the subject lands, along the extent of Silver Creek assessed for the SWS. Much of the Silver Creek drainage originates from urban residential lands with minimal SWM controls, which is reflected by the relatively high debris lines that indicate high-flow conditions. Several reaches assessed in the residential areas have straightened channels, but the stream is largely naturalized downstream of these residential areas. Degradation and widening were identified as the dominant channel-forming processes within Silver Creek, with vegetated slumps frequently observed.

The Braneida Stormwater Management Facility Retrofit and Downstream Channel Remediation Municipal Class Environmental Assessment completed by Ecosystem Recovery Inc. (2021) was also reviewed to help inform erosion mitigation for the tributary of Fairchild Creek located south of the subject lands. The aforementioned report includes geomorphic assessments for delineated reaches within the tributary, and an erosion threshold analysis for the most sensitive reach. The assessed area of the tributary of Fairchild Creek within the Braneida Stormwater Management report included reaches located southwest of the subject lands. The tributary is located within the Norfolk Sand Plain physiographic region, and surficial geology consists of modern alluvium and fine-textured glaciolacustrine deposits, namely clay (OGS 2010). The tributary flows through predominantly agricultural land, with undercutting, incision and encroachment observed throughout the channel. The tributary is classified as low-gradient and unconfined, with relatively straight or slightly meandering planform. An erosion threshold of 0.27 m^3/s was determined for the most sensitive reach within the study area, based on the critical velocity required for mobilization of uniform clay materials (Fischenich 2001).

2.2 Physiography and Geology

Channel morphodynamics are largely governed by the flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity. Understanding local surficial geology is important for determining an appropriate erosion hazard limit, as the stability of the channel banks and valley slope is dependent, at least in part, on the composition of soils and underlying parent materials (MNR, 2002).

The subject lands are completely located within the Sand Plains of the Norfolk Sand physiographic region with the sediments from deltaic deposits associated with glacial Lakes Whittlesey and Warren (Chapman and Putnam, 1984). Published mapping indicates that the local surficial geology along the Silver Creek valley consists of modern alluvial deposits of clay, silt, sand, and gravel

(OGS, 2010). The tableland area within the subject lands contains fine-textured glaciolacustrine deposits of silt and clay, with smaller proportions of sand and gravel. This is consistent with field observations of exposed till which consisted of a stratified clay. Depositional facies of these deposits are characterized as ranging from massive (structureless) to well-laminated.

A supplementary geotechnical investigation was completed by Terrapex Environmental Ltd. (2022). Nine boreholes were drilled throughout the subject lands, from which soil samples were recovered and analyzed in lab. The analyses identified a 150 to 250 mm layer of topsoil throughout the site. The underlying native soils were characterized as predominantly clayey silt with occasional silty clay layers. Trace amounts of sand were observed within several borehole samples.

3 Site History

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics and potentially how past changes may affect channel planform in the future.

Aerial photographs for the years 1945, 1964, 1972 and 1982 from the National Air Photo Library, and digital orthoimages for the years 2003, 2013, 2016, 2018, and 2019 from Google Earth Pro were reviewed. Select imagery is provided in **Appendix B** for reference.

In 1945, the subject lands and surrounding area was dominated by agricultural and rural land use and land cover. The railway which bisects the subject lands had been previously constructed prior to 1945. Riparian vegetation is limited, and woodlots within the subject lands are fragmented. Where visible, Silver Creek exhibits an irregular meandering planform. Between 1945 and 1972, there were limited changes in land use and riparian vegetation. Multiple remnant beds are visible in the 1964 aerial image, indicating the channel had historically migrated within its valley. A section of straightened channel is visible, indicating the channel was straightened prior to 1964.

By 1982, land use had changed upstream of Silver Creek with increased industrial and housing development. Active construction and completed homes along what is now Brantwood Park Road are visible. However, the surrounding lands remained largely for agricultural and rural uses. There are little to no distinguishable changes to the channel planform between 1964 and 1982.

Housing and industrial development was largely completed between 1984 and 2003. Riparian vegetation within the study site established and matured. Through to 2019, little to no changes were noted to land use and land cover, and to the channel planform.

4 Watercourse Characteristics

4.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a particular reach, for example, as it relates to a proposed activity.

Reaches are typically delineated based on changes in the following:

- Channel planform

- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Channel confluences (tributary junctions)
- Soil type and surficial geology
- Historical channel modifications

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards *et al.* (1997), Brierley and Fryirs (2005), and the Toronto and Region Conservation Authority (2004). Reach delineation for Silver Creek was completed through a desktop assessment and then field-verified. Seven (7) reaches were delineated within the subject lands. Reach delineation was also completed for the tributary of Fairchild Creek to the south, to provide context on all watercourses within the zone of impact. A summary of the reach delineation results is outlined in **Table 1**. Field verification was not completed for the tributary of Fairchild Creek as part of this study; therefore, defining characteristics are not described. The study area and associated reach delineation is shown in **Appendix A**, for reference.

Table 1: Reach delineation summary

Reach Name	Approx. Channel Length (m)	Approx. Gradient* (%)	Defining Characteristics
SC-A-1	288	0.35	• Incised channel in ravine-like setting with exposed till and frequent valley wall contact • Moderate gradient with low-sinuosity planform • Developed riffle-pool sequences
SC-A-2	456	0.33	• Moderate gradient and meandering planform • Frequent valley wall contact and erosion along both banks with till exposure • Cantilever bank failure common, exposed roots and undercutting along banks
SC-A-3	248	0.14	• Low gradient with sinuous planform and pool-morphology dominant • Exposed sculpted till prevalent • Medial bars and sand deposits common
SC-A-4	305	0.53	• Moderate gradient with recovering planform from historical straightening • Run-morphology dominant • Slumping banks common
SC-A-5	462	0.12	• Low gradient with meandering planform • Developed riffle-pool sequences
SC-A-6	482	0.25	• Low gradient with meandering planform • Narrow riparian corridor with agricultural activity disturbance • Pool-morphology dominant
TFC3	441	0.56	n/a
TFC4	82	0.21	n/a
TFC4-1	137	0.55	n/a
TFC5	274	0.39	n/a
TFC6	430	0.33	n/a
TFC7-1	251	0.91	n/a
TFC7-2-1	121	0.77	n/a
TFC7-1-1	194	1.13	n/a
TFC7-1-2	581	0.61	n/a

* Estimated from provincial LiDAR data (LIO, 2023)

4.2 General Reach Observations

Field investigations for Silver Creek were completed on July 7, 2022, and included the following:

- Habitat sketch maps based on Newson and Newson (2000) outlining channel substrate, flow patterns, geomorphological units (e.g., riffle, run, pool), and riparian vegetation for the extent of each reach assessed
- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Bed and bank material composition and structure
- Observations of erosion, scour or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures

These observations and measurements are summarized below. The field descriptions are supplemented and supported with representative photographs, which are included in **Appendix D**. Field sheets, including those completed for rapid geomorphic assessments, are provided in **Appendix E**. General channel characteristics for each reach are summarized below in **Table 2**.

Table 2: General channel characteristics by reach

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Substrate Conditions	Dominant Riparian Conditions	Notes
SC-A-1	4.35	1.12	Clay/silt to cobble	Continuous mature trees	Exposed till and sand deposits common, abundant valley wall contact (VWC), exposed roots and leaning trees observed
SC-A-2	3.67	0.87	Clay/silt to gravel	Fragmented, sub-mature, mixed trees and shrubs	Exposed till frequently observed, large undercuts and exposed roots common, VWC along both banks observed
SC-A-3	3.87	0.98	Clay/silt to cobble	Fragmented, sub-mature, mixed trees and shrubs, grasses	Occasional exposed till observed, narrower channel, bank slumping common, grassier immediate riparian conditions
SC-A-4	3.99	1.07	Clay/silt and sand	Fragmented, sub-mature, mixed trees and shrubs, grasses	Limited riparian buffer and overhead cover, exposed till frequently observed, limited riffle-pool development, run-morphology dominated
SC-A-5	5.13	1.23	Clay/silt to cobble	Fragmented, sub-mature, mixed herbaceous vegetation and shrubs	Silt deposits common within pools, exposed till observed, steep and exposed/eroded banks common throughout, frequent VWC observed
SC-A-6	5.15	1.32	Clay/silt to cobble	Fragmented mature trees	Past modifications to channel and substrate observed (farm crossing), narrow riparian corridor, basal scour common throughout, occasional VWC, substantial siltation common
POI2	0.60	0.18	Clay/silt and sand	Fragmented, sub-mature, mixed trees and shrubs	Poorly defined swale-type feature flows into/through forested wetland area, dry during time of assessment

Reach SC-A-1 along Silver Creek is approximately 300 m in length. The channel was observed to be a highly entrenched channel within confined valley settings. The channel exhibits a low-sinuosity planform, a moderate gradient, making frequent contact with the valley wall. The riparian vegetation is fragmented and narrow, and mainly consists of trees and herbaceous shrubs. The substrate of the valley walls consist of an exposed clayey till. The bed substrate of the channel consists of a layer of small cobbles which sit loosely on the sub pavement, the same material as the eroded valley walls. The banks of the reach are generally unstable, with multiple instances of slumping observed. The reach exhibits highly developed riffle-pool sequences, likely due to the mobile bedload and the frequency of competent flows within this confined valley setting.

Reach SC-A-2 is approximately 450 long and is similar to **Reach SC-A-1**. The channel is highly entrenched within a confined valley setting. The channel exhibits a meandering planform and makes frequent valley wall contact, which has eroded and exposed the clayey till subpavement. Both banks of the reach are unstable and erosion is present along both banks. Cantilever bank failure is common here. Geomorphological structures in this reach are well developed, such as pool-riffle sequences and point bars. The bed substrate consists of a cobble material which sits on the clayey-till subpavement, evidence of a highly entrenched system which continues to incise downwards. The reach exhibits evidence of aggradation, degradation, and widening with medial bars, cut face of bar forms, and fallen trees all observed.

Reach SC-A-3 is an approximately 250 m long and is defined as a moderately entrenched channel within a confined valley setting. The channel exhibits a sinuous planform with a low gradient. There is evidence of aggradation as the channel is mainly pool dominated and the pools are highly silted. Sandy sediment streaks, medial bars, and non-accreted point bars were observed. The banks are highly unstable with frequent signs of bank erosion such as slumping, falling, undercutting, sloughing, sliding, and slab failure. The banks are mainly composed of layer of well-vegetated topsoil which sits on top a clayey sculpted till material. This clayey sculpted till comprises the bed subpavement as well. Riparian vegetation along the reach offers fragmented coverage. Dominant riparian vegetation is characterized by grasses and trees.

Reach SC-A-4 is approximately 300 m in length and is defined as a highly entrenched channel within a confined valley setting. This channel was historically straightened and the current planform exhibits a recovering planform pattern. The channel exhibits a moderate gradient with run-dominated morphology. Sandy streak-deposits and medial bars consisting of gravel and sand were observed. The banks of this reach are highly unstable with undercuts up to 0.5 m in depth. Slumped and falling banks were observed in the reach, facilitating vegetation growth within, and narrowing the wetted perimeter of the low-flow channel. The height of the valley is lower here, with more-gentle bank angles, compared to the upstream reaches assessed. The dominant riparian vegetation cover consists of grasses and herbaceous shrubs. A number of large woody debris jams have created areas of localized scour and widening.

Reach SC-A-5 is approximately 470 m in length and is defined as a moderate gradient reach which is highly sensitive and deemed to be in adjustment. The channel exhibits a meandering planform within a confined valley and has developed distinguishable pool-riffle sequences. Siltation is common throughout the reach. The banks of this reach are highly unstable with fracture lines and slumping banks observed. Channel undercuts measured were up to 1.1 m in width and large woody debris jams were observed along the reach. The channel had worn into the underlying clayey till deposit, as observed throughout the segment of Silver Creek which was assessed. The water quality of the channel was turbid and opaque indicating possible sedimentation or aggradational issues. The pool-riffle form was observed to be evolving into a low bed relief form upon reaching the rail crossing at the downstream extent. Pool depths were around 0.8 m during the time of assessment.

Reach SC-A-6 is approximately 480 m in length and is defined as a low-gradient reach which originates at the culvert which conveys the channel beneath a CN railway. The culvert structure consists of a concrete headwall and apron, with gabion basket wingwalls. The gabion basket wingwalls are in poor condition and emptying. The reach is a partially confined valley reach with a narrow riparian corridor. The channel exhibits a meandering planform with a low gradient. A tractor crossing has disturbed the channel at this location. The reach is defined by being highly silted, especially in the pools. At the time of field observation, water was highly turbid and opaque with sediments and the reach is pool morphology dominant. Pools are up to 1.5 m in depth and there is woody debris within the channel and cutbanks with evidence of recent treefall. The banks along this reach are unstable but well-vegetated.

The channel stemming from **POI2** is a best characterized as a vegetated swale feature with poorly defined banks. No flow was observed at the time of assessment. Where the channel flows alongside the railway, the bed substrate of this feature consists of rip-rap and stone.

4.3 Rapid Field Assessments

Channel stability and susceptibility to erosion were objectively assessed through the application of the Ontario Ministry of the Environment (MOE; 2003) Rapid Geomorphic Assessment (RGA) technique. The RGA evaluates degradation, aggradation, widening, and planimetric form adjustment at the reach scale. The end result of the RGA is to produce a score, or stability index, which evaluates the degree to which a stream has departed from its equilibrium condition. A stream with a score of less than 0.20 is defined as in regime, indicating minimal changes to its shape or processes over time. A score of 0.21 to 0.40 indicates that a stream is in transition or stress and is experiencing major changes to process and form outside the natural range of variability. A score of greater than 0.41 indicates that a stream is in extreme adjustment, exhibiting a new stream type, or is in the process of adjusting to a new equilibrium (MOE, 2003; VANR, 2007).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system and consider the ecological functioning of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (35-42) degree of stream health.

The reaches were also classified according to the Downs (1995) Model of Channel Evolution and the River Styles Framework (Brierley and Fryirs, 2005). The Downs (1995) model describes successional stages of a channel as a result of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the fluvial system. The River Styles Framework provides a geomorphological approach to examining river character, behaviour, condition, and recovery potential.

The results of the reach classifications are summarized in **Table 3.** Rapid level assessments were not applied to reaches characterized as either swales or wetland features, as this assessment technique is not appropriate for those feature types. Silver Creek reaches, including **Reaches SC-A-1**, **SC-A-2**, **SC-A-3**, **SC-A-4**, and **SC-A-5**, scored relatively high RGA scores with most reaches classified as 'In Adjustment'. The dominant process in almost all Silver Creek reaches is widening with minor aggradation. **Reaches SC-A-2**, **SC-A-3**, **SC-A-4**, and **SC-A-5** were identified through the RGA as the most erosion-sensitive reaches throughout the extent assessed. The RSAT scores along Silver Creek ranged from 'fair' to 'good'.

Table 3: Reach classifications summary by reach

Reach Name	RGA Score	Dominant Process	RSAT Score	River Styles Framework	Downs Model Classification
SC-A-1	0.36	Widening	24	8 – Mixed load meandering	e - enlarging
SC-A-2	0.48	Widening	23	8 – Mixed load meandering	e - enlarging
SC-A-3	0.48	Widening	22	8 – Mixed load meandering	e - enlarging
SC-A-4	0.48	Widening	21	7 – Mixed load low-sinuosity meandering	R - recovering
SC-A-5	0.47	Widening/ Aggradation	22	8 – Mixed load meandering	C - compound
SC-A-6	0.45	Widening	24	8 – Mixed load meandering	C - compound
POI-2	n/a – swale feature				

4.4 Detailed Geomorphological Assessment

For Silver Creek, the receiving channel reach within the zone-of-impact most susceptible to erosion was selected based on field observations, as confirmed by both the RGA and RSAT following the rapid geomorphological assessment. The sensitive reach for Silver Creek, **Reach SC-A-5**, was surveyed to characterize bankfull channel conditions and the results of the detailed assessment were used to inform the erosion threshold assessment. The detailed assessment for **Reach SC-A-5** was completed August 8th, 2022. A summary of measured and computed values is presented in **Table 4** and the detailed assessment summary is provided in **Appendix F.**

The following activities were completed:

- Longitudinal profile along the channel bed to determine slope
- Eight representative cross-sectional surveys of the watercourse to determine average channel dimensions
- Two monumented cross sections including erosion pins in each bank to measure change in bank conditions over time
- Detailed instream measurements at each cross-section including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density
- Bed material sampling at each cross-section following a modified Wolman's (1954) Pebble Count Technique or substrate sample
- Monumented geo-referenced photographs taken at each cross-section

Eight representative cross-sections were surveyed, and channel measurements were then used to calculate bankfull flow characteristics such as discharge, average velocity, and erosion or sediment transport sensitivity. As part of the detailed assessment, a longitudinal survey of the bed was completed to determine slope and a composite sample was taken to characterize bed materials. The detailed survey was completed for a 100 m section of channel upstream of the pond. The results of the survey for **Reach SC-A-5** determined that the reach had an average bankfull width of 6.02 m, and an average bankfull depth of 1.01 m. The bed substrate generally consisted of a veneer of fine sediment and organic matter (e.g., <2.0 mm) with some cobbles,

overlaying dense clayey-till. The bankfull gradient measured for **Reach SC-A-5** was 0.34%, and the bed gradient was 0.32%.

The results of the detailed assessment are presented in **Table 4**. A summary of the detailed assessment is provided in **Appendix F** for reference.

Table 4: Detailed assessment results for Reach SC-A-5

Channel parameter	SC-A-5
Measured	
Average bankfull channel width (m)	6.02
Average bankfull channel depth (m)	1.01
Bankfull channel gradient (%)	0.32
D_{50} (mm)	<2
D_{84} (mm)	7.00
Manning's n roughness coefficient	0.053
Computed	
Bankfull discharge (m^3/s) *	6.70
Average bankfull velocity (m/s)	1.11
Unit stream power at bankfull discharge (W/m^2)	37.12
Tractive force at bankfull (N/m^2)	33.59
Flow competency for D_{84} (m/s)***	0.48

* Based on Manning's equation
** Based on Shields diagram from Miller et al. (1997)
*** Based on Komar (1987)

5 Erosion Threshold Analysis

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material. As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. Erosion thresholds were modelled from detailed field observations of **Reaches SC-5-A**. Additionally, existing erosion thresholds for the tributary of Fairchild Creek to the south were analyzed to determine an appropriate critical discharge for the receiving watercourse. The erosion threshold is the theoretical point, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on bed and bank materials. Due to variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides the more conservative and limiting estimate.

5.1 Methodology

Threshold targets are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach could also be applied. For cohesive materials, a method such as that described by Komar (1987), or empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1994), could be applied.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge. Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity, U, or Shear Stress, t, is calculated at various depths for a representative cross section until the average velocity or shear stress slightly exceeds the critical threshold of the bed material. The velocity is determined using a Manning's approach, where the Manning's n value is visually estimated through a method described by Acrement and Schneider (1989), calculated using the Limerino (1970) approach, or back-calculated from in-situ flow measurements. The velocity is mathematically represented as:

$$U = \frac{1}{n} d^{2/3} S^{1/2} \qquad \text{[Eq. 1.]}$$

where, *d* is depth of water, *S* is channel slope, and *n* is the Manning's roughness coefficient.

The shear stress is determined using the depth-slope product, which can be applied to the bed of open channels containing fluid undergoing steady flows. The shear stress is mathematically represented as:

$$t = d\rho g S_{bed} \qquad \text{[Eq. 2.]}$$

Where, *t* is shear stress, *d* is the water depth, *ρ* is water density, *g* is acceleration due to gravity, and S_{bed} is the channel bed slope.

Because only 75% of bed shear stress applies to channel banks in uniform cross sections (Chow, 1959), the erosion threshold is scaled appropriately for these materials.

5.2 Results

An in-house erosion threshold database was consulted to identify potential existing thresholds of relevance to the proposed development. An erosion threshold of 0.239 m^3/s was previously determined for a reach within the tributary of Fairchild Creek, **TFC4-1**, located immediately south of the property boundary. The threshold was based on the critical shear stress for the bank materials, which were classified as lean clayey soils (Chow 1959). Reach **TFC4-1** shares the same surficial geology and physiography as the Braneida study area to the east, which outlined an erosion threshold of 0.27 m^3/s (Ecosystem Recovery Inc. 2021). To ensure a conservative approach, the smaller of the two thresholds, 0.239 m^3/s, was used for the erosion exceedance analysis outlined in **Section 6**. The location of the defined erosion threshold along Reach **TFC4-1** is shown in **Appendix A**, for reference.

For **Reach SC-5-A**, the bed and bank materials showed significant variance, and erosion thresholds were subsequently determined for both. The bed materials were characterized as mostly loose, silty and clayey deposits of alluvial mud, overlaying a firm till-like clay subpavement. To remain conservative, the loose alluvial mud materials were selected to inform erosion threshold criteria. As per Julien (1994), these materials are predicted to have a permissible velocity of 0.61

m/s. From this, a critical discharge of 1.192 m^3/s was determined for the bed materials within **Reach SC-A-5**. The bank materials were identified as a fairly compact till-like clay, which has a corresponding permissible shear stress of 7.00 N/m^2 (Chow, 1959). From this, a critical discharge of 0.497 m^3/s was determined and, due to being lower than the bed material erosion threshold, defines the erosion threshold for reach **SC-A-5**. The summarized results of the erosion threshold assessment are provided in **Table 5**, below.

Table 5: Erosion Thresholds for Reach SC-5-A and TFC4-1

Channel parameter	SC-5-A
Bankfull Conditions	
Average bankfull width (m)	6.02
Average bankfull depth (m)	1.01
Channel gradient (%)	0.32
D_{50} (mm)	<2
D_{84} (mm)	7.00
Manning's n roughness coefficient	0.053
Bankfull discharge (m^3/s)	6.70
Bankfull velocity (m/s)	1.11
Channel Bed Erosion Threshold	
Bed material	Alluvial mud (Julien, 1994)
Apparent shear stress acting on bed (N/m^2)	13.56
Critical shear stress acting on bed (N/m^2)	-
Apparent velocity at the bed (m/s)	-
Critical velocity at the bed (m/s)	0.61
Critical discharge (m^3/s)	1.192
Channel Banks Erosion Threshold	
Bank material	Fairly compact clay (till) (Chow, 1959)
Critical shear stress acting on banks (N/m^2)	7.00
Apparent velocity at the banks (m/s)	0.35
Critical discharge (m^3/s)	0.497
Limiting critical discharge (m^3/s)	**0.497**

6 Post- to Pre-Development Erosion Exceedance Analysis

Using the results of the erosion threshold analysis and hydrological modelling provided by TYLin (2022) for post- and pre-development conditions, additional analyses regarding the impacts of SWM controls on potential erosion within the watercourses were completed with our own in-house model, based on four indices:

1) Cumulative time of exceedance
2) Number of exceedance events
3) Cumulative effective discharge volume
4) Cumulative effective work index (i.e. cumulative effective stream power)

These indices have been applied elsewhere in CH, TRCA, CVC, and other jurisdictions. Collectively these indicies provide an evaluation of the number of exceedance events, and the duration and magnitude of erosion exceedance events. We note that the most relevant indicator is the cumulative effective stream power, as it reflects both the duration and magnitude of erosion exceedance events.

Time of exceedance, number of exceedances, and cumulative effective discharge and volume can be simply calculated by relating the discharge record to the critical discharge defined via erosion threshold analysis (detailed above). The cumulative time of exceedance is simply the summed duration of time where discharge exceeds the established erosion threshold, and the number of exceedances is the count of erosion exceedance events throughout the discharge record. The cumulative effective discharge represents the average magnitude of discharge exceeding the erosion threshold during a given erosion event, whereas the cumulative effective volume represents the total discharge volume that exceeds the erosion threshold throughout the modelled discharge record.

For more relevant indicators, namely the cumulative effective work index, hydraulic information is required. Our model applies the discharge to a characteristic cross-section. Using a Manning's approach, the discharge at each time step in the continuous hydrological model is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross-section and channel roughness. This provides analysis that is site appropriate and specific.

The post- and pre-development hydrological modelling reflects changes to the hydrological regime resulting from SWM measures being implemented within the catchment. Continuous flow data was provided by Urbantech (2023) in 15-minute increments spanning from 1950 to 2006. The hydrological modeling was analyzed to calculate the aforementioned erosion indices and to identify changes in the erosive potential within **SC-A-5** and **TFC4-1** following development. A full series of post- and pre-development hydrographs, overlain with the respective erosion thresholds and bankfull discharges, are provided in **Appendix G**, for reference.

6.1 Methods

To calculate work terms, both velocity and shear stress were calculated at each time step. Through an iterative process, water depth and velocity were calculated for each discharge passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels. Velocity, U, is calculated for each panel using the Manning's approach. This is a conservative approach as it allows dissipation of flood energy in the floodplain.

The total discharge, Q_T at each time step is based on the summation of the discharge of all panels, Q_i, such that:

$$Q_{T=} \sum Q_i \quad \text{[Eq. 3.]}$$

Q_i is discharge through a panel (which is set at 10 percent of the cross-section). Q_i is defined as:

$$Q_i = U_i w_i d_i \quad \text{[Eq. 4.]}$$

where, w_i and d_i are width and depth for each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area.

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate a maximum bed shear stress, $\tau_{o_{\max}}$ based on:

$$\tau_{o_{\max}} = d_{\max} \rho g S_{\text{bed}} \quad \text{[Eq. 5.]}$$

where, $d_{\max}$ is the maximum water depth, ρ is water density, g is acceleration due to gravity, and S_{bed} is the channel bed slope.

Cumulative total work, ω_{tot} is defined as:

$$\omega_{\text{tot}} = \sum \tau_{0_{\max}} . U_{\text{avg}} . \Delta t \quad \text{[Eq. 6.]}$$

where, U_{avg} is average velocity (Q_{tot}/A_{tot}, where A_{tot} is wetted area), while cumulative effective work index (ω_{eff}) is defined by:

$$\omega_{\text{eff}} = \sum \tau - \tau_{cr} . U . \Delta t, \omega < 0 = 0 \quad \text{[Eq. 7.]}$$

where, τ_{cr} is the critical shear stress.

Time of exceedance t_{ex} defined as:

$$t_{\text{ex}} = \sum \Delta t \ \text{ for } (Q_T > Q_{\text{threshold}}) \quad \text{[Eq. 8.]}$$

where, $Q_{\text{threshold}}$ is the discharge at the erosion threshold.

The cumulative effective discharge volume (CED) is defined as:

$$CED = \sum Q \text{ (for } Q > Q_{threshold}) \quad \text{[Eq. 9.]}$$

The number of exceedance events is simply the count of all instances where discharge exceeds the established threshold.

We note that the most relevant indicator is the cumulative effective stream power, as it reflects both the magnitude and duration of erosion events. However, due to the lack of hydrological data available within the receiving watercourses, the exceedance analysis was reviewed based on cumulative effective discharge at the site level (i.e. the average magnitude of flow exceeding the threshold during a given erosion event). Consequently, the cumulative effective work index was excluded from the results analysis, as it requires channel cross sections and therefore is only applicable to in-channel (i.e., not site-level) erosion exceedance analyses.

Given the hydrological modelling constraints, the site-level assessment of the potential impacts of the proposed development on the receiving watercourses required a modified framework that utilized unitary erosion thresholds to determine scaled site-level critical discharges (i.e., "allowable" release rates). A unitary erosion threshold was established for each receiving watercourse using drainage areas obtained from Urbantech (2023) and the Ontario Watershed Information Tool (OWIT). Unitary thresholds were determined using Equation 4, below:

$$ET_{unitary} = ET \,/\, DA \qquad \text{[Eq. 10.]}$$

where, *ET* is the erosion threshold in m^3/s for the subject reach, and *DA* is the drainage area in hectares. The resulting unitary erosion thresholds for each receiving watercourse were subsequently multiplied with the drainage areas of the associated hydrological modelling nodes to determine the threshold release rates. For the drainage swale **POI2**, the lower of the two unitary threshold values was adopted, as it provides a more conservative estimate. The results are presented in **Table 6**, below.

Table 6: Site-level threshold release rates for the proposed developments

Receiving Watercourse Reach	Associated SWM Outlet or POI	Existing Drainage Area (ha)	Unitary Erosion Threshold ($m^3/s/ha$)	Hydrological Model Drainage Area (ha)	Threshold Release Rate (m^3/s)
SC-A-5	Outlet E & C	600.24	0.000828	72.36	0.060
TFC4-1	Outlet D & B	367.13	0.000651	45.67	0.030
POI2	POI2	367.13	0.000651	7.29	0.005

The site-level threshold release rates of 0.060 m^3/s, 0.030 m^3/s, and 0.005 m^3/s were determined for the associated receiving watercourse reaches **SC-A-5**, **TFC4-1**, and **POI2**, respectively. We note that under existing conditions the majority of the drainage area for Silver Creek upstream of **SC-A-5** is developed, and that OFAT typically overestimates the catchment areas in these scenarios. Consequently, it is possible that this drainage area has been overestimated leading to the calculation of a particularly conservative unitary erosion threshold and site-level scaled threshold release rate.

Using the computed site-level threshold release rates, an exceedance analysis was completed using the results of continuous hydrological modelling for the site between the years of 1950 and 2005 provided by Urbantech (2023).

6.2 Results

The full series of post- to pre-development hydrographs are included in **Appendix G**, and include the erosion threshold based on discharge, for reference. **Table 7** provides the results of the assessment based on the hydrographs provided by Urbantech (2023).

Table 7: Results of the post- to pre-development erosion exceedance analysis

Simulation			CED (m^3)	t_{ex} (hrs)	# of Exceedances
Flows to POI 2	**Scaled Q_{crit}: 0.005 m^3/s**	**Pre**	246,012	4,636	745
		Post	202,311	3,895	1306
		Change (%)	**-17.76**	**-15.97**	**75.30**
Flows to Critical Reach TFC4-1	**Scaled Q_{crit}: 0.030 m^3/s**	**Pre**	1,846,750	6,573	1,031
		Post	1,459,980	12,278	1,342
		Change (%)	**-20.94**	**86.81**	**30.16**
Flows to Critical Reach SC-A-5	**Scaled Q_{crit}: 0.060 m^3/s**	**Pre**	982,545	3,096	381
		Post	41,451	287	144
		Change (%)	**-95.78**	**-90.72**	**-62.20**

We note that the lack of an in-channel hydrological model exaggerates the severity of changes to the geomorphic regime, as there are little-to-no contributing areas within the hydrological model that would remain un-developed and serve as a 'buffer' to the relative changes in effective discharge. Due to the site-level assessment framework, extrapolating the results of this analysis to apply to the receiving watercourses inherently assumes that the entirety of their respective drainage areas would behave hydrologically identical to the study area. The upstream catchment for **Reach SC-A-5** is fully urbanized with minimal SWM controls, and as such, would theoretically contribute a disproportionate amount of runoff and channel flow relative to the proposed 299 Lynden Road development with SWM controls. Thus, the results of this analysis must be interpreted accordingly.

The erosion exceedance analysis indicates a reduction in erosion potential within the receiving swale-type channel associated with **POI2**. The cumulative effective volume (CED) and cumulative exceedance duration (t_{ex}) are predicted to decrease by 18% and 16%, respectively, whereas the number of exceedances is predicted to increase by 75%. This indicates more-frequent, lower-magnitude erosion events within the receiving reach with a decrease in the overall long-term rate of erosion. As POI2 is associated with a swale-type channel, a minimal decrease in long-term erosion is not expected significantly impact this feature.

Flows to **Reach TFC4-1** from the development site are predicted to generally mimic existing contributions and consequently maintain the long-term rate of erosion. The CED is predicted to decrease by 21%, while the t_{ex} and number of exceedances are predicted to increase by 87% and 30%. This indicates a post-development flow regime characterized by longer and more-frequent, but lower-magnitude exceedance events that are not expected to significantly increase erosion or sedimentation rates beyond their natural range of variability for this location.

Within the context of the modelling approach, the results of the erosion exceedance assessment indicate a significant reduction in long-term rates of erosion within the receiving **Reach SC-A-5**

along Silver Creek. The CED is predicted to decrease by 96%, and the duration and number of exceedances are predicted to decrease by 91% and 62%, respectively. These results demonstrate events of lower magnitude and frequency, and thus increases in post-development erosion are not expected along **Reach SC-A-5**. The hydrological model is based on flows received from approximately 12% of the catchment area for **Reach SC-A-5**. Therefore, a decrease in erosion potential based on this relatively small portion of the reach drainage area is not expected to significantly impact overall channel morphology.

We note that these results can be further refined during detailed design stages through minor pond design revision (e.g., orifice plate sizing), LID implementation, and model-expansion, where necessary. As such, we do not foresee the requirement for revision to the current SWM plan at this stage. The proposed 48-72 hr extended detention of the 25 mm event, combined with LID measures, are expected to sufficiently mitigate erosion within the receiving watercourses.

7 Erosion Hazard Assessment

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no topographical constraints. A meander belt width assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is therefore useful for determining the potential hazard to proposed activities in the vicinity of a stream.

When defining the erosion hazard for a creek system, the MNRF (2002) and TRCA (2004) protocols treat confined and unconfined valley systems differently. Confined systems are those where the watercourse is contained within a defined valley, where contact between the watercourse and a valley wall is possible. The erosion hazard for confined systems is typically defined based on a valley toe erosion allowance and stable slope allowance. In contrast, unconfined systems are those with poorly defined valleys or slopes well-outside where the channel could realistically migrate. The erosion hazard for unconfined systems is delineated by a meander belt width.

A meander belt width can be applied based on 20 times the bankfull channel width. Alternatively, the meander belt width can be determined through a detailed geomorphological study that examines the largest channel meanders observed through historical and recent aerial photograph interpretation. The meander belt width can then be graphically defined using orthorectified aerial imagery by determining the channel centerline and the channel's central tendency (i.e., meander belt axis). In cases where the channel is not discernible in aerial photographs or the channel has been substantially modified, empirical models can be used to estimate the meander belt width.

As noted in **Section 3.2** of this report, **Reaches SC-A-1**, **SC-A-2**, **SC-A-3**, and **SC-A-4** along Silver Creek were classified as confined. Natural meanders are present within the subject lands and were measured in the 2018 aerial image. The largest meander amplitude was measured along **Reach SC-A-2**, at 28.7 m. From this the following equation was utilized to define a meander belt with:

$$B_w = M_{amp} + W_b * 20\%_{FOS} \quad \text{[Eq. 11.]}$$

where B_w is meander belt width (m), M_{amp} is the largest meander amplitude, W_b is bankfull cross-section (m), and $_{FOS}$ is a 20% factor of safety that was applied. Based on the largest meander amplitude of 28.7 m and a bankfull width of 4.35 m, a final meander belt width of 40 m was determined for the subject reaches.

A map showing the extent of the delineated meander belt width is provided in **Appendix C**. In areas where it extends beyond the toe of slope, we have truncated the meander belt width along the toe of slope. In these areas the erosion hazard is associated with the geotechnical long-term stable slope with details provided in the 2020 geotechnical investigation by Terraprobe (Terraprobe 2020).

8 Summary

GEO Morphix was retained to complete an erosion hazard and mitigation assessment in support of the proposed development and associated stormwater management at 299 Lynden Road, Brantford, Ontario. Field characterizations of all potentially impacted watercourse features were completed to assess their sensitivity to erosion. Detailed geomorphological field assessments were completed at the most erosion-sensitive reaches along each of the receiving watercourses. The results of the detailed field assessments where used to determine erosion thresholds (critical discharges) for **Reach SC-A-5** in Silver Creek and **Reach TFC4-1** in the Garden Avenue tributary of Fairchild Creek. A post- to pre-development erosion exceedance analysis was completed to predict potential impacts to long-term rates of erosion within the receiving watercourses. Through this, it was determined that the proposed SWM facilities will adequately control flows such that erosion or sedimentation will not be significantly exacerbated as a consequence of development. We note that these results can be further refined at detailed design stages. An erosion hazard assessment was completed to delineate and inform development constraints in the proximity of Silver Creek. Through this, a 40 m meander belt width was assigned. In areas where the meander belt width extends beyond the toe of slope, the erosion hazard is then associated with the geotechnical long-term stable slope.

We trust this report meets your requirements at the time. Should you have any questions please contact the undersigned.

Respectfully submitted,

aul Villard Ph.D., P.Geo., CAN-CISEC, EP, CERP
Director, Principal Geomorphologist

Jan Franssen, Ph.D.
Senior Watershed Scientist

Karine Smith, M.Sc.
Environmental Scientist

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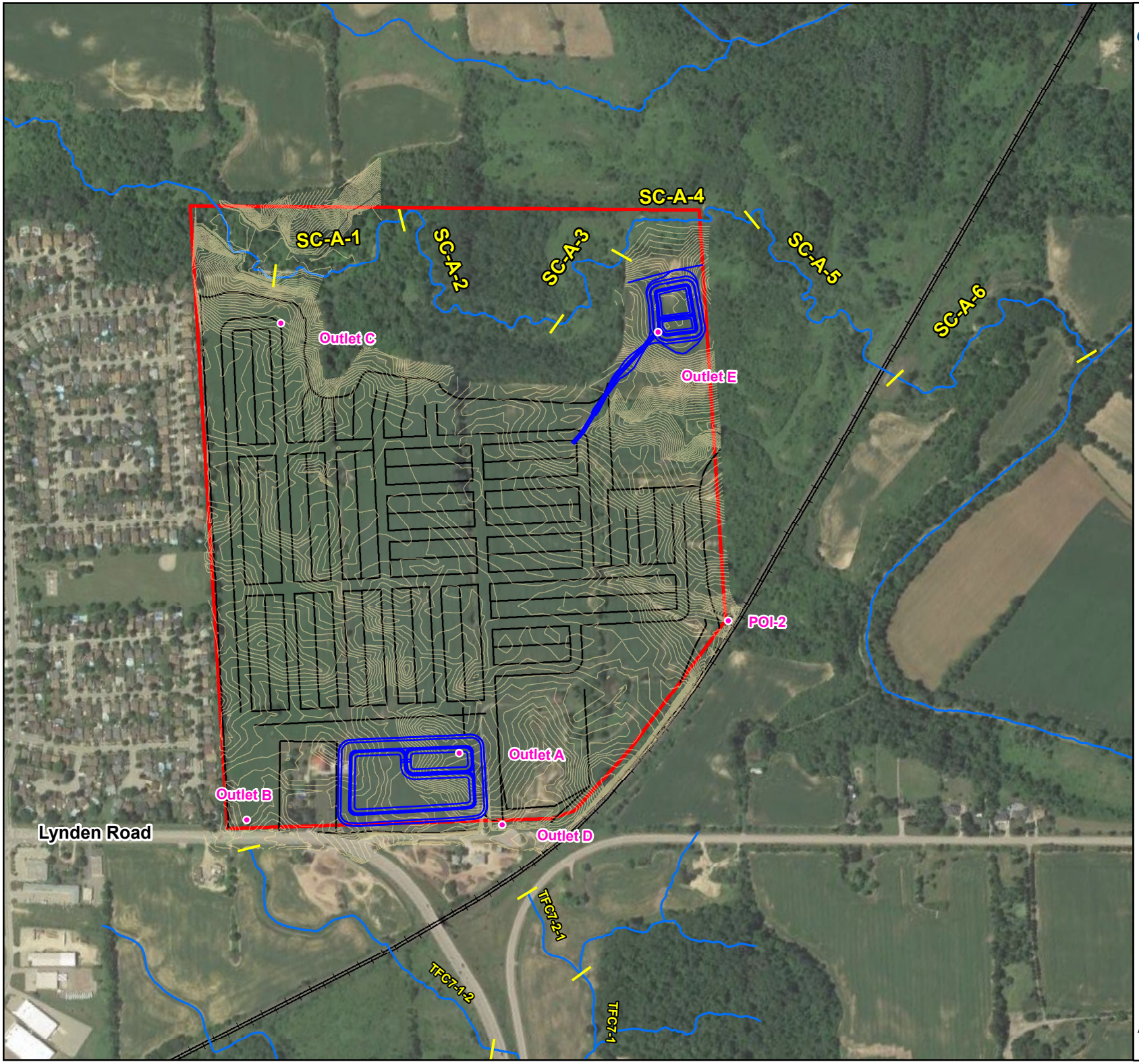
Appendix A
Reach Delineation and Study Area



GEO MORPHIX™

Reach Delineation and Study Area

Lynden Road

Brantford, Ontario

Legend

- Reach Break and ID
- Outlet Location
- Watercourse
- 0.5 m Contour
- ORWN Track
- SWM Pond
- Base Plan
- Approximate Study Area

N

0 150 300

Metres

Imagery: Google Earth, 2018. Watercourse: MNRF, 2021. 0.5 m Contour, Base Plan, Outlet: Urbantech, 2022. Approximate Study Area, Reach Break and ID: GEO Morphix Ltd., 2022. Detailed Assessment: GEO Morphix Ltd., 2020. Print Date: April 2023. PN22045. Drawn By: M.O., J.T.

GEO MORPHIX™

Silver Creek Erosion Assessment

Lynden Road

Brantford, Ontario

Legend

- Reach Break and ID
- Outlet Location
- Detailed Assessment
- 0.5 m Contour
- Watercourse
- SWM Pond
- Base Plan
- ORWN Track
- Approximate Study Area

N

0 125 250

Metres

Imagery: Google Earth, 2018. Watercourse: MNRF, 2021. 0.5 m Contour, Base Plan, Outlet: Urbantech, 2022. Approximate, Study Area, Reach Break and ID: GEO Morphix Ltd., 2022. Print Date: January 2023. PN22045. Drawn By: M.O., J.T.

GEO MORPHIX™

Garden Avenue Tributary Erosion Assessment

Lynden Road

Brantford, Ontario

Legend

- Reach Break and ID
- Outlet Location
- Detailed Assessment/ Erosion Threshold
- SWM Pond
- Watercourse
- Base Plan
- ORWN Track
- Approximate Study Area

N

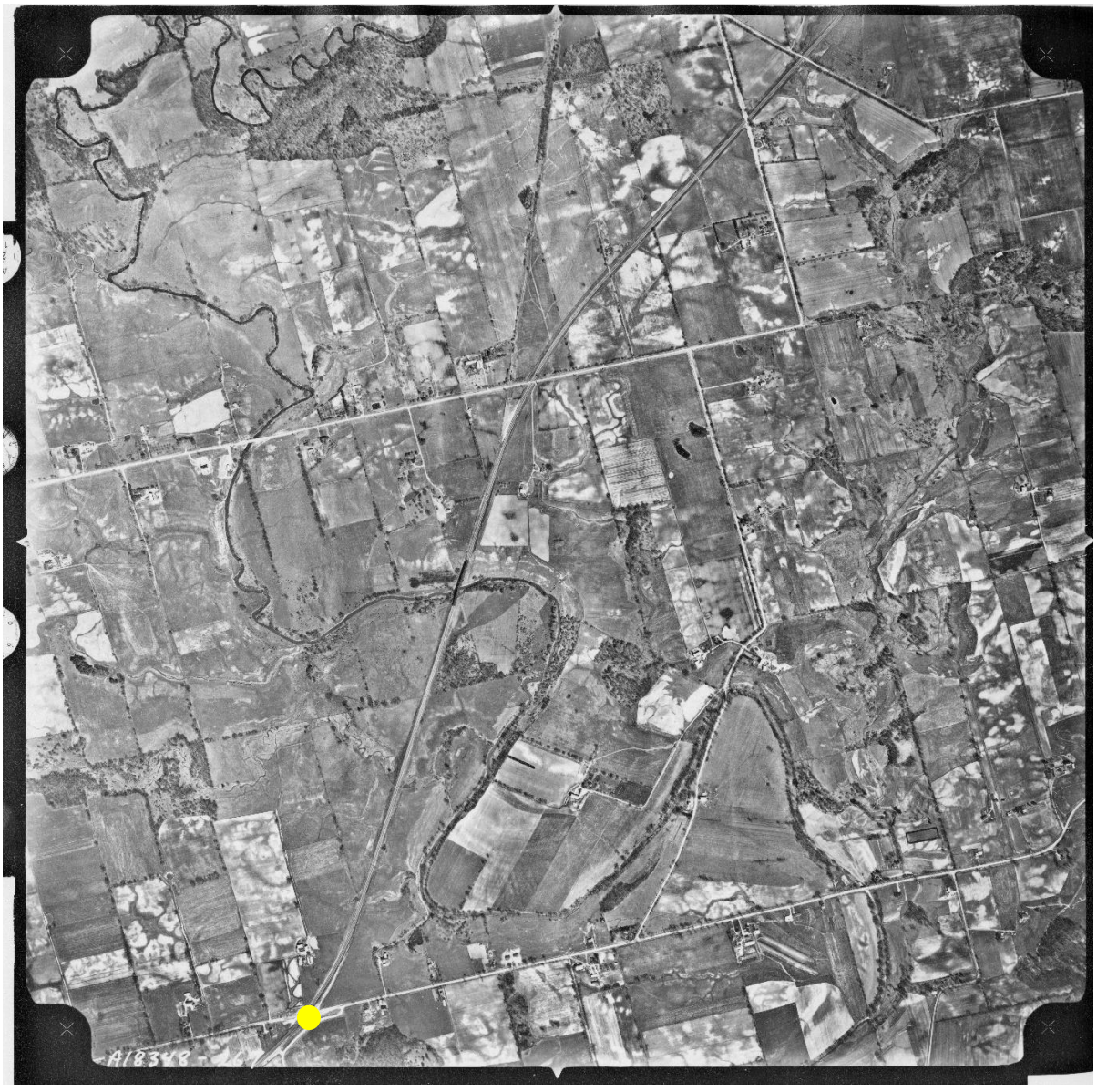
0 125 250

Metres

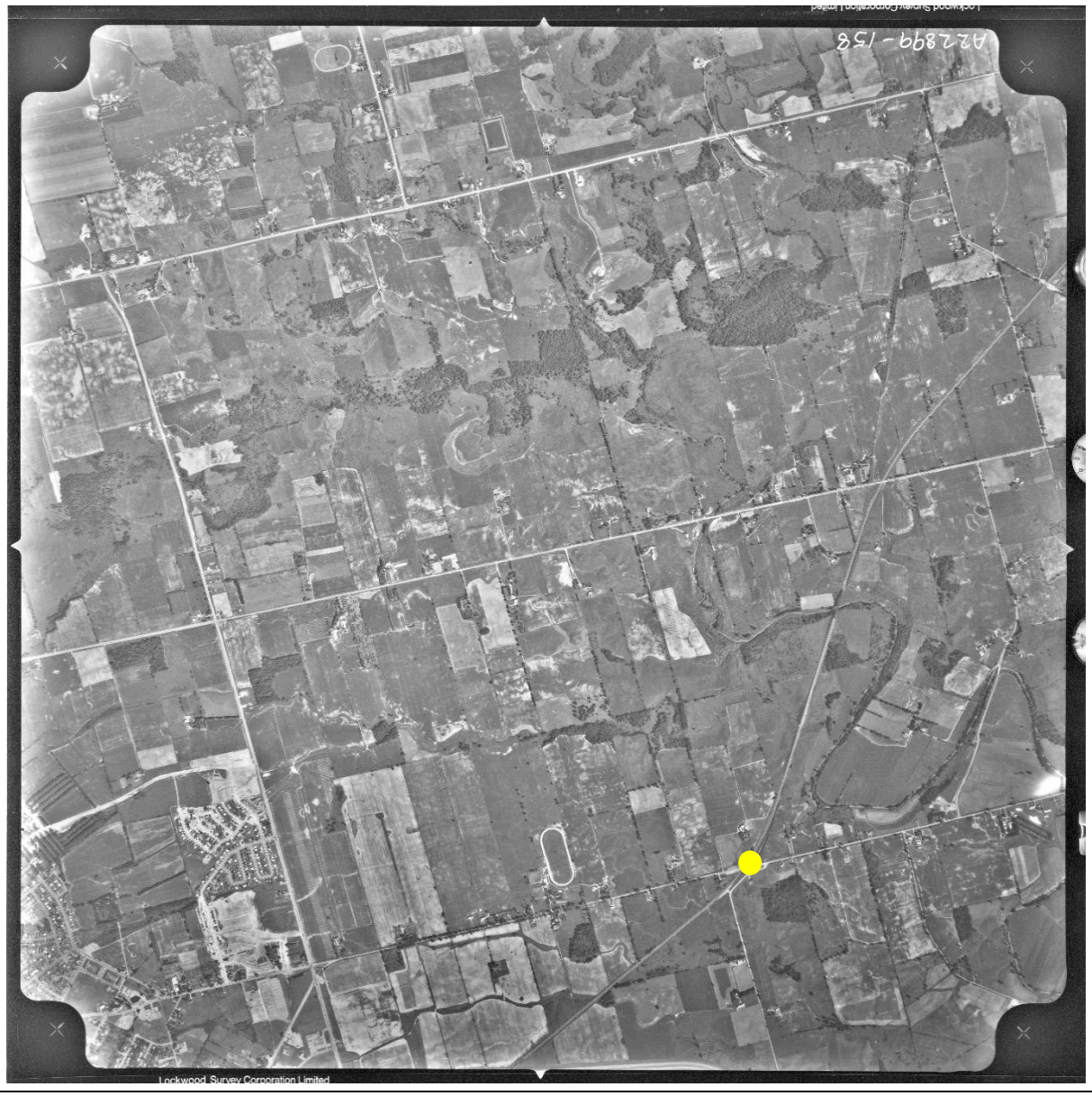
Imagery: Google Earth, 2018. Watercourse: MNRF, 2021. 0.5 m Contour, Base Plan, Outlet: Urbantech, 2022. Approximate, Study Area, Reach Break and ID: GEO Morphix Ltd., 2022. Detailed Assessment: GEO Morphix Ltd., 2020. Print Date: January 2023. PN22045. Drawn By: M.O., J.T.

Appendix B
Historical Aerial Photographs

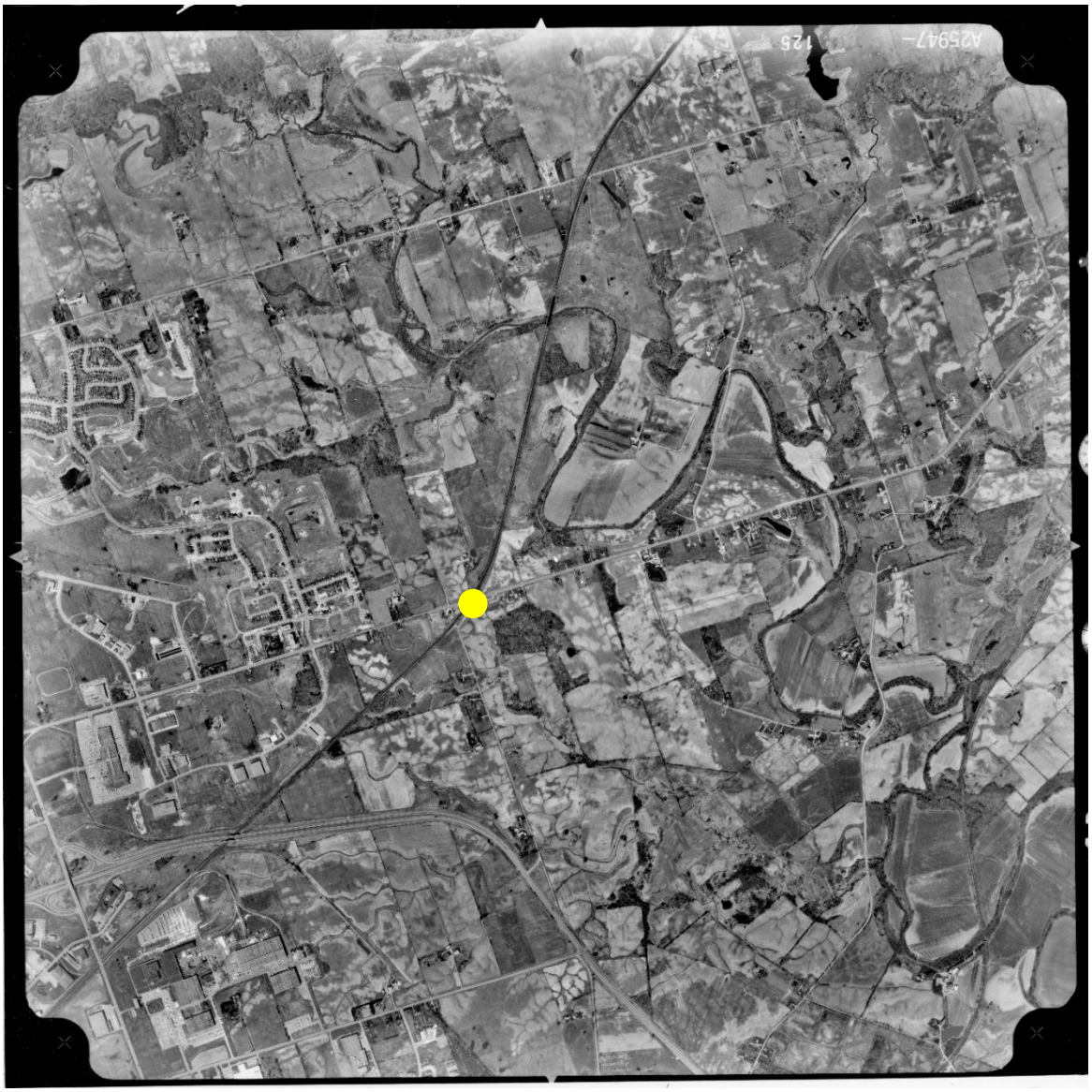
Yellow Point Location: Lynden Road and Canadian National Railway
Year: 1945
Scale: 1:20,000
Source: National Air Photo Library



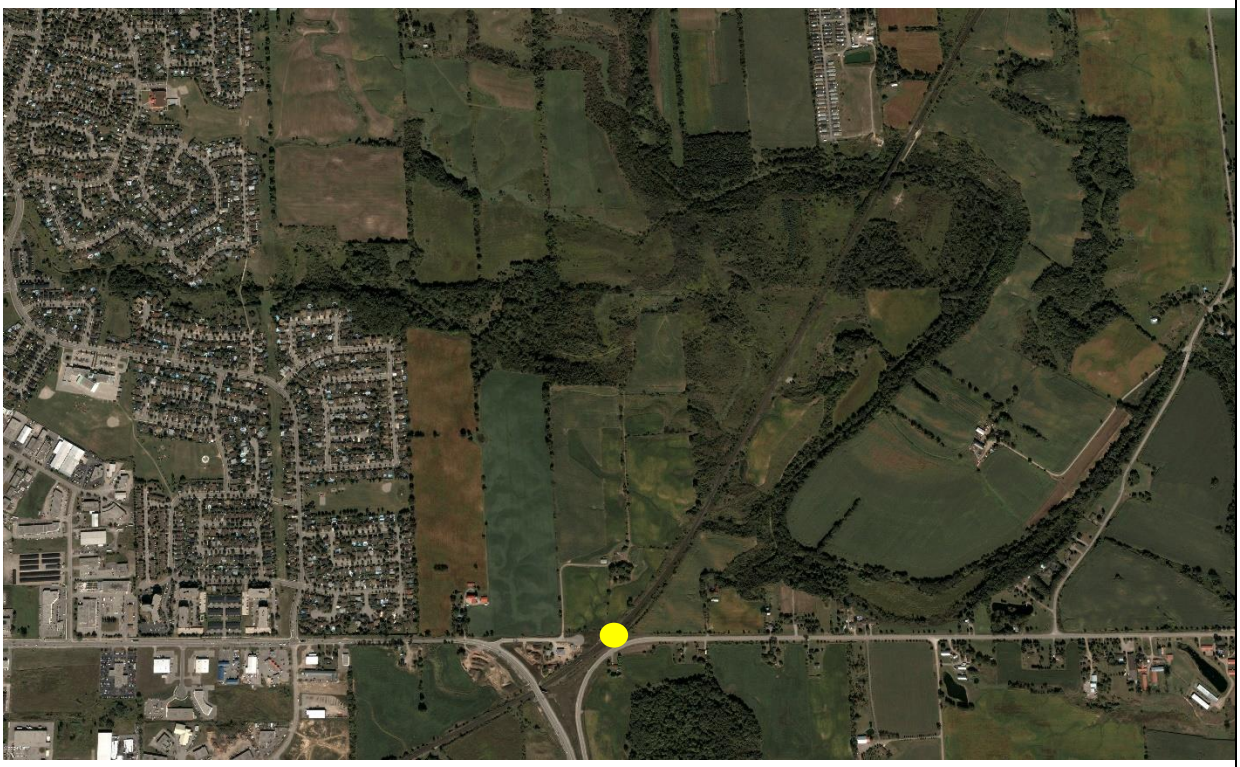
Yellow Point Location: Lynden Road and Canadian National Railway
Year: 1964
Scale: 1:20,000
Source: National Air Photo Library



Yellow Point Location: Lynden Road and Canadian National Railway
Year: 1972
Scale: 1:25,000
Source: National Air Photo Library

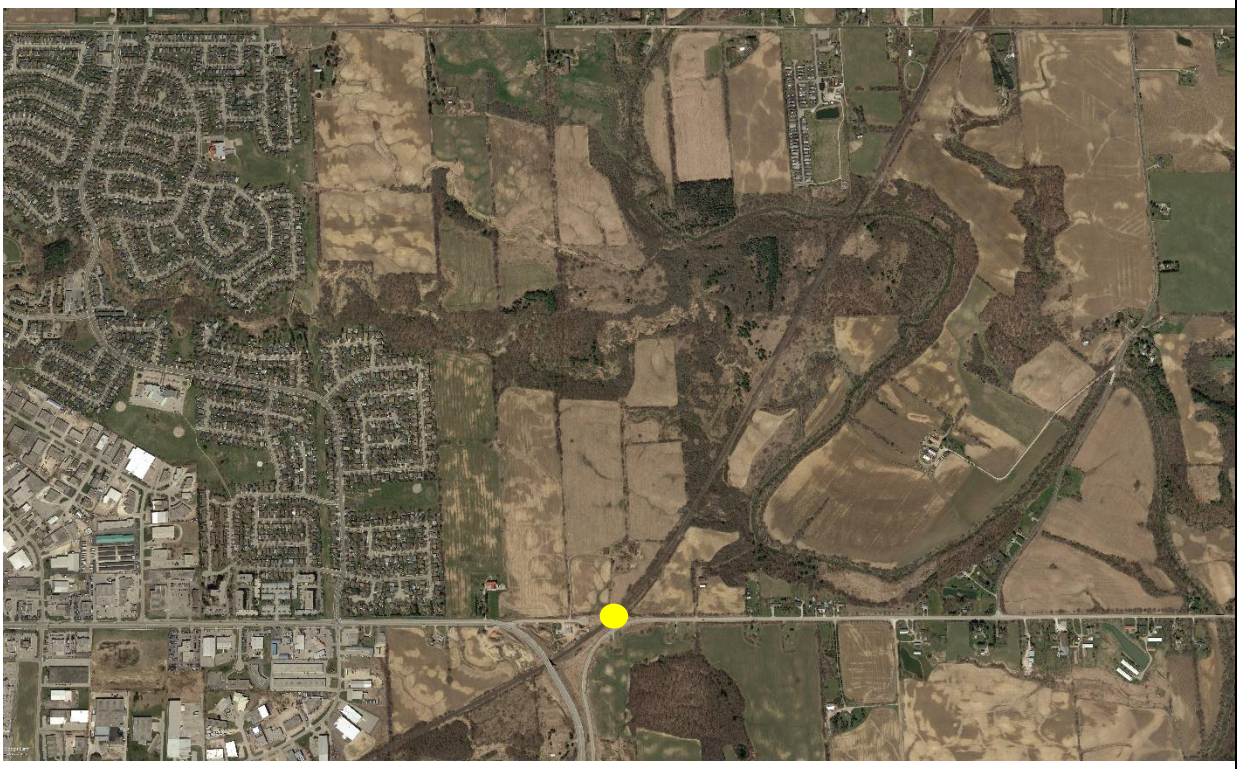


Yellow Point Location: Lynden Road and Canadian National Railway
Year: 1982
Scale: 1:25,000
Source: National Air Photo Library



Yellow Point Location: Lynden Road and Canadian National Railway
Year: 2003
Scale: Orthoimagery
Source: Google Earth Pro

Yellow Point Location: Lynden Road and Canadian National Railway
Year: 2013
Scale: Orthoimagery
Source: Google Earth Pro

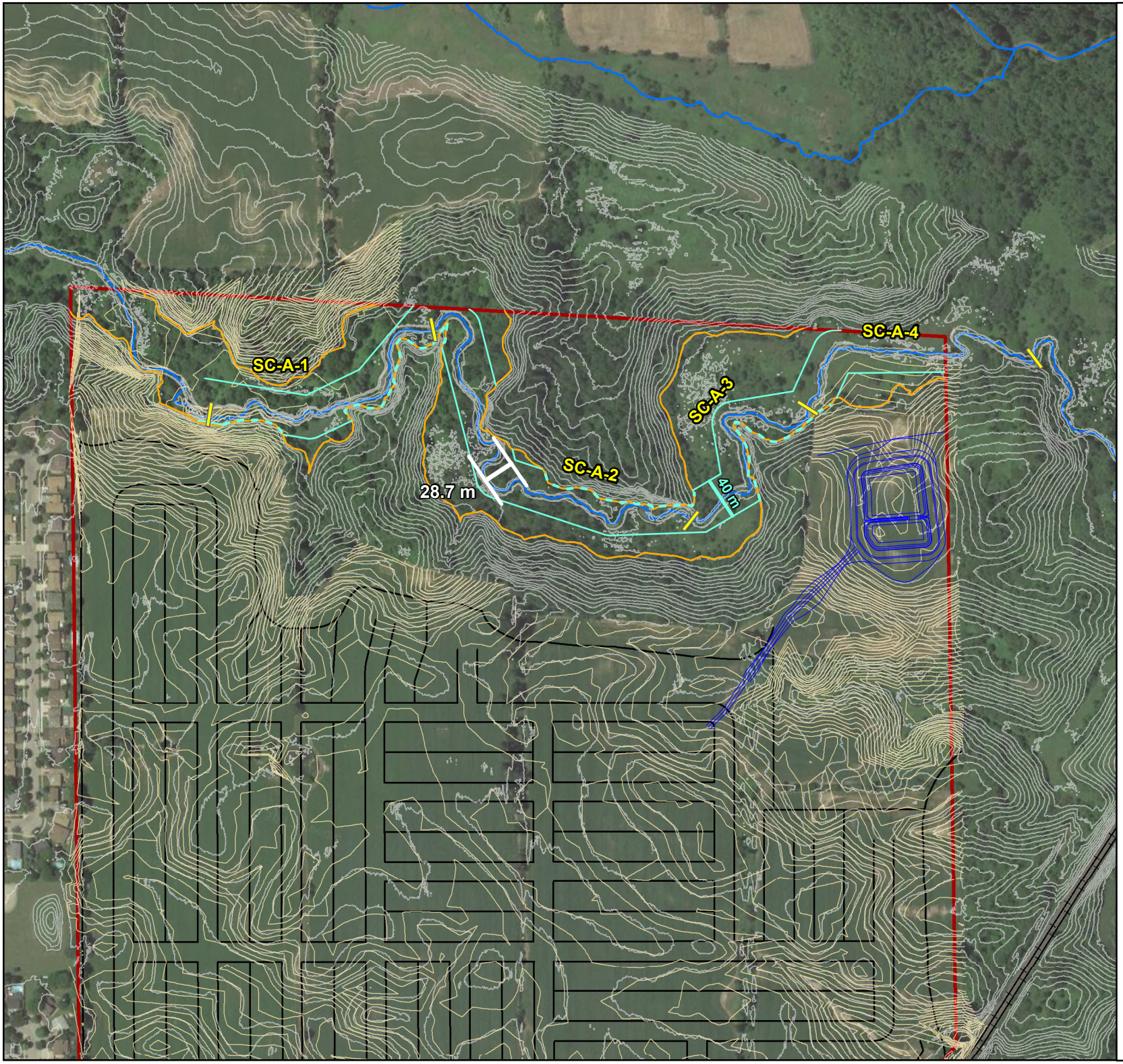


Yellow Point Location: Lynden Road and Canadian National Railway
Year: 2016
Scale: Orthoimagery
Source: Google Earth Pro

Yellow Point Location: Lynden Road and Canadian National Railway
Year: 2018
Scale: Orthoimagery
Source: Google Earth Pro

Yellow Point Location: Lynden Road and Canadian National Railway
Year: 2019
Scale: Orthoimagery
Source: Google Earth Pro

Appendix C
Erosion Hazard Delineation



GEO MORPHIX™

Erosion Hazard Delineation

Lynden Road

Brantford, Ontario

Legend

- Reach Break and ID
- Meander Belt Width (40 m)
- Truncated Meander Belt Width
- Approximate Toe of Slope
- Watercourse
- 0.5 m Contour
- 0.5 m Contour (LiDAR Derived)
- Largest Meander Amplitude
- SWM Pond
- Base Plan
- Approximate Study Area

N

0 80 160

Metres

Imagery: Google Earth, 2018. Watercourse: MNRF, 2021. 0.5 m Contour, Base Plant : Urbantech, 2022. Approximate Study Area, Reach Break and ID, Largset Meander Amplitude, Toe of Slope: GEO Morphix Ltd., 2022. 0.5 m Contour (LiDAR Derived): MNRF, 2019. Print Date: April 2023. PN22045. Drawn By: M.O., J.T.

Appendix D
Photographic Record

Photo 1 Reach SC-A-5 – Silver Creek, Lynden Road, Brantford	 Reach SC-A-1 is highly entrenched and situated within a confined valley. Bank undercutting and valley wall contacts were common. Yellow arrow denotes flow direction
Photo 2 Reach SC-A-5 – Silver Creek, Lynden Road, Brantford	 Riffle-pool sequencing was well established and bed materials ranged from exposed till to cobbles.

Photo 3 Reach SC-A-5 – Silver Creek, Lynden Road, Brantford	
	Riparian conditions are characterized by continuous coverage of mature trees, woody debris was commonly observed in the cutbank.
Photo 4 Reach SC-A-2 – Silver Creek, Lynden Road, Brantford	
	Reach SC-A-2 was situated within a confined valley. Leaning trees and undercutting were observed frequently, indicating evidence of channel widening.

Photo 5 Reach SC-A-2 – Silver Creek, Lynden Road, Brantford	
	Bank angles ranged from 60° to undercutting and average bankfull widths and depths were 3.6 m and 0.87 m, respectively.
Photo 6 Reach SC-A-2 – Silver Creek, Lynden Road, Brantford	
	This Reach had a moderate gradient and was highly entrenched.

Photo 7 Reach SC-A-3 – Silver Creek, Lynden Road, Brantford	
	Reach SC-A-3 was situated in a confined valley. Surrounding land use was characterized as forests and agricultural lands.
Photo 8 Reach SC-A-3 – Silver Creek, Lynden Road, Brantford	
	Riffle-pool sequencing was present with bed materials ranging from clay and silt to cobbles in the riffles and clay, silt and sand in the pools.

Photo 9 Reach SC-A-3 – Silver Creek, Lynden Road, Brantford	
	Riparian conditions were characterized as dominated by grasses and herbaceous plants with few mature trees. Bank slumps were commonly observed along this reach.
Photo 10 Reach SC-A-4 – Silver Creek, Lynden Road, Brantford	
	Reach SC-A-4 had a moderate gradient with irregular meanders and was situated within a confined valley

Photo 11 Reach SC-A-4 – Silver Creek, Lynden Road, Brantford	
Medial bars, siltation in the pools, and sand deposits in the overbank zone were frequently observed, indicating evidence of aggradation.	
Photo 12 Reach SC-A-4 – Silver Creek, Lynden Road, Brantford	
Bank angles ranged from 60° to 90° with localized undercutting. Bank material was comprised of clay and silt.	

Photo 13 Reach SC-A-5 – Silver Creek, Lynden Road, Brantford	
	Photograph taken at upstream extent of Reach SC-A-5. This was a confined channel with continuous riparian coverage of mature trees.
Photo 14 Reach SC-A-5 – Silver Creek, Lynden Road, Brantford	
	This Reach had a high density of woody debris jams both in the channel and the cutbank.

Photo 15 Reach SC-A-5 – Silver Creek, Lynden Road, Brantford	
	Substrate within this reach ranged from exposed till to small cobbles.
Photo 16 Reach SC-A-5 – Silver Creek, Lynden Road, Brantford	
	This Reach became deeper and wider downstream and riffle-pool sequencing became absent as the channel was dominated primarily by runs.

Photo 17 Reach SC-A-6 – Silver Creek, Lynden Road, Brantford	
	Reach SC-A-6 began at an outlet beneath a railroad crossing. A scour pool had formed downstream of the outlet and undermined gabion baskets were present.
Photo 18 Reach SC-A-6 – Silver Creek, Lynden Road, Brantford	
	This reach was situated within a confined valley and valley wall contacts were commonly observed.

Photo 19
Reach SC-A-6 – Silver Creek, Lynden Road, Brantford

Bank angles ranged from 60° to 90° and average bankfull widths and depths were 5.15 m and 1.32 m, respectively

Photo 20
Reach SC-A-6 – Silver Creek, Lynden Road, Brantford

Photograph taken at the downstream extent where Reach SC-A-6 confluences with Fairchild Creek.

Photo 21 Reach PO12 – Tributary of Fairchild Creek, Lynden Road, Brantford	
Reach PO12 initiates adjacent to a railroad crossing and flows southeast to Fairchild Creek. This is feature was characterized as a headwater reach within an unconfined floodplain.	
Photo 22 Reach PO12 – Tributary of Fairchild Creek, Lynden Road, Brantford	
This Reach had poorly defined bed and banks with heavy vegetation encroachment into the channel.	

Appendix E
Field Observations

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-5, Silver Creek
Weather:	Sunny 24°C	**Location:**	Lynden Rd., Brantford
Field Staff:	AA AV.	**Watershed/Subwatershed:**	Fairchilds Creek

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

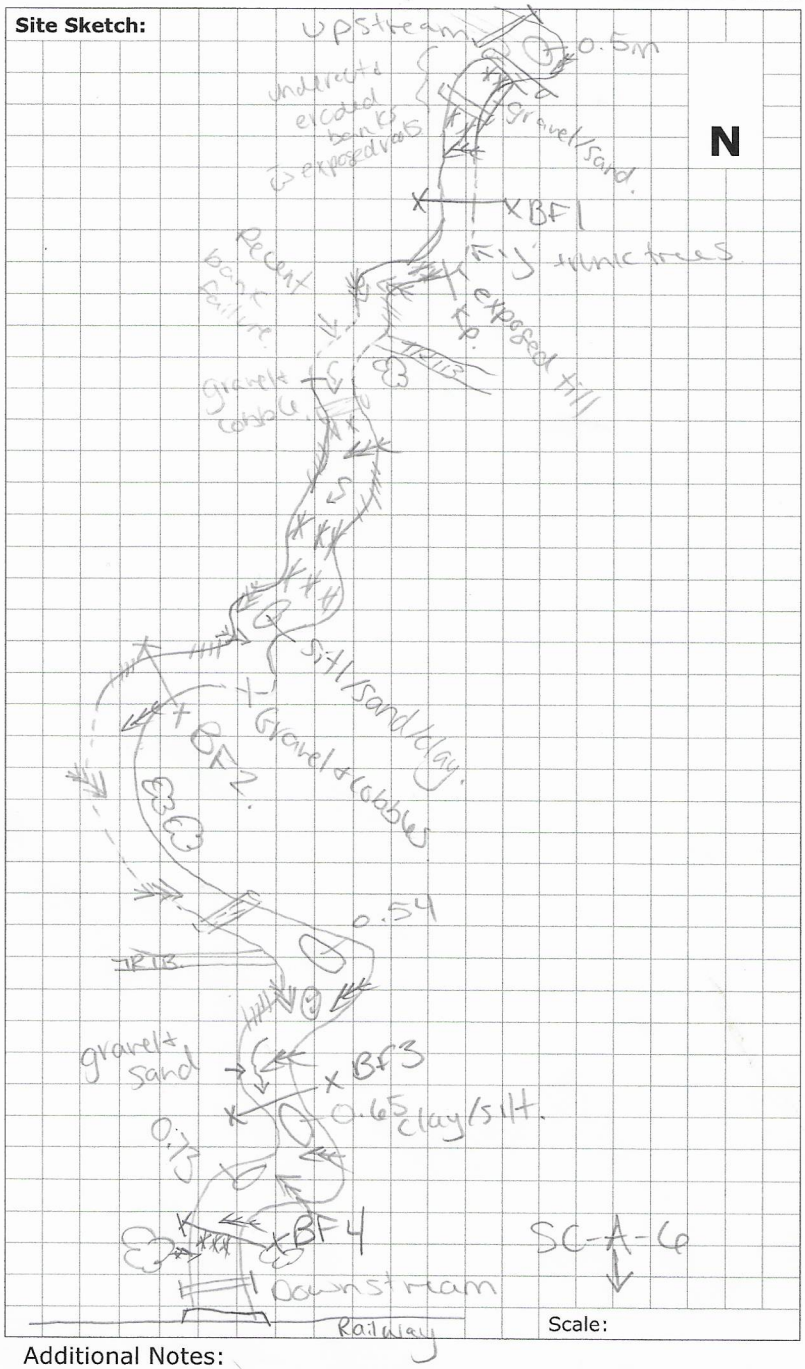
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Additional Notes:

- silt/clay common throughout reach.
- clay/till present along bed.

Completed by: AA Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-5
Weather:	Sunny 24°C	**Watershed/Subwatershed:**	Fairchilds Creek
Field Staff:	AAJ AV.	**Location:**	Lyndon Rd. Brantford

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		1	5/7
	2	Coarse materials in riffles embedded		1	
	3	Siltation in pools	1		
	4	Medial bars	1		
	5	Accretion on point bars	1		
	6	Poor longitudinal sorting of bed materials	1		
	7	Deposition in the overbank zone	1		
		Sum of indices =	5	2	0.714
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	1		2/10
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)	N/A		
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets	N/A		
	6	Cut face on bar forms		1	
	7	Head cutting due to knickpoint migration		1	
	8	Terrace cut through older bar material		1	
	9	Suspended armour layer visible in bank		1	
	10	Channel worn into undisturbed overburden / bedrock	1		
		Sum of indices =	2	4	0.33
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	1		5/7
	2	Occurrence of large organic debris	1		
	3	Exposed tree roots	1		
	4	Basal scour on inside meander bends	1		
	5	Basal scour on both sides of channel through riffle		1	
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach		1	
	8	Exposed length of previously buried pipe / cable / etc.	N/A		
	9	Fracture lines along top of bank	1		
	10	Exposed building foundation	N/A		
		Sum of indices =	5	2	0.714
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		1	1/7
	2	Single thread channel to multiple channel		1	
	3	Evolution of pool-riffle form to low bed relief form	1		
	4	Cut-off channel(s)		1	
	5	Formation of island(s)		1	
	6	Thalweg alignment out of phase with meander form		1	
	7	Bar forms poorly formed / reworked / removed		1	
		Sum of indices =	1	6	0.14

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.47

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☐ 0.21 - 0.40	☑ 0.41

Completed by: AA. Checked by: _____

Rapid Stream Assessment Technique

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-5
Weather:	Sunny 24°C	**Location:**	Lyden Rd., Brantford
Field Staff:	AA ~~J~~ AV.	**Watershed/Subwatershed:**	Fairchilds Creek

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ **0** ☐ **1** ☐ **2**	☐ **3** ☐ **4** ☐ **5**	☑ **6** ☐ **7** ☐ **8**	☐ **9** ☐ **10** ☐ **11**
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ **0** ☐ **1** ☐ **2**	☐ **3** ☐ **4**	☐ **5** ☐ **6**	☐ **7** ☐ **8**

Date:	2022-07-27	Reach:	SC-A-5	Project Code:	22045

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☑ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☑ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 22	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: AA Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-5, Silver Creek
Weather:	Sunny 24°C	**Location:**	Lynden Rd., Brantford
Field Staff:	AA, AV	**Watershed/Subwatershed:**	Fairchilds Creek
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1/2 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 3 | **Flow Type** (Table 5): 1 | ☑ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6): 4/4
Species: Mixed

Coverage:
- ☐ None
- ☑ Fragmented
- ☐ Continuous

Channel widths:
- ☐ 1-4
- ☑ 4-10
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☑ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7): 2

Aquatic/Instream Vegetation

Type (Table8): 6 | Coverage of Reach (%): 5

Woody Debris
- ☑ Present in Cutbank
- ☑ Present in Channel
- ☐ Not Present

Density of WD:
- ☐ Low
- ☑ Moderate
- ☐ High

WDJ/50m: 3

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 3

Channel Characteristics

Sinuosity (Type) (Table 9): 2
Sinuosity (Degree) (Table 10): 3
Gradient (Table 11): 2
Number of Channels (Table 12): 1
Entrenchment (Table 13): 2
Type of Bank Failure (Table 14): 1/2
Downs's Classification (Table 15): C *

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☑	☑	☑	☑	☐	☐	☐
Pool Substrate	☑	☑	☐	☐	☐	☐	☐
Bank Material	☑	☑	☐	☐	☐	☐	☐

Bankfull Width (m)	4.59	4.0	6.84	**Wetted Width (m)**	2.46	1.28	2.4 (4) 3.0
Bankfull Depth (m)	1.2	1.2	1.1	**Wetted Depth (m)**	0.14	0.25	0.17 (4) 0.47
Riffle/Pool Spacing (m)		**% Riffles:**		**% Pools:**		**Meander Amplitude:**	
Pool Depth (m)	0.81	**Riffle Length (m)**	9.6	**Undercuts (m)**	1.1		
Velocity (m/s)	0.09	0.12	0.04	**Wiffle ball / ADV / Estimated**			

(4) 5.10 1.40

Bank Angle
- ☐ 0 – 30
- ☐ 30 – 60
- ☐ 60 – 90
- ☐ Undercut

Bank Erosion
- ☐ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

Comments:

Notes:

Completed by: AA Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SGA-2
Weather:	Sunny 22°C	**Location:**	Lynden Rd., Brantford
Field Staff:	AA AV.	**Watershed/Subwatershed:**	Fairchilds Creek.

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

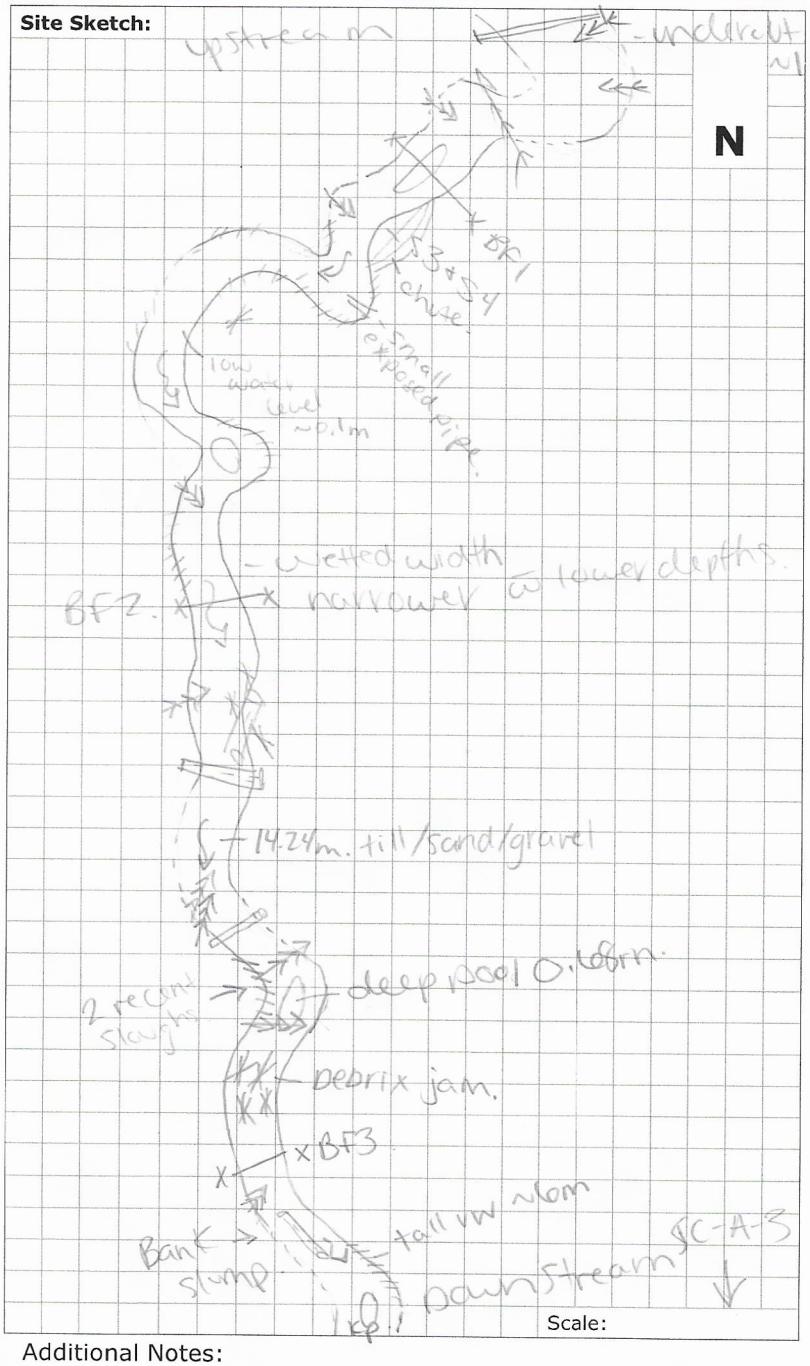
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Additional Notes:

- Valley wall contact along both sides of reach
- exposed till predominant through channel.
- large undercuts common.
- exposed tree roots common

Completed by: AA Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-2, Silver Creek
Weather:	Sunny 22°C	**Watershed/Subwatershed:**	Fairchilds Creek
Field Staff:	AAV AV.	**Location:**	Lynden Rd., Brantford.

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		1	4/7
	2	Coarse materials in riffles embedded		1	
	3	Siltation in pools	1		
	4	Medial bars	1		
	5	Accretion on point bars	1		
	6	Poor longitudinal sorting of bed materials		1	
	7	Deposition in the overbank zone	1		
		Sum of indices =	4	3	0.57
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		3/5
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)	N/A		
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets	N/A		
	6	Cut face on bar forms	1		
	7	Head cutting due to knickpoint migration		1	
	8	Terrace cut through older bar material		1	
	9	Suspended armour layer visible in bank	1		
	10	Channel worn into undisturbed overburden / bedrock	1		
		Sum of indices =	3	2	0.6
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	1		4/8
	2	Occurrence of large organic debris	1		
	3	Exposed tree roots	1		
	4	Basal scour on inside meander bends	1		
	5	Basal scour on both sides of channel through riffle	1		
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach		1	
	8	Exposed length of previously buried pipe / cable / etc.		1	
	9	Fracture lines along top of bank	1		
	10	Exposed building foundation	N/A		
		Sum of indices =	6	2	6.75
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		1	0/7
	2	Single thread channel to multiple channel		1	
	3	Evolution of pool-riffle form to low bed relief form		1	
	4	Cut-off channel(s)		1	
	5	Formation of island(s)		1	
	6	Thalweg alignment out of phase with meander form		1	
	7	Bar forms poorly formed / reworked / removed		1	
		Sum of indices =	0	7	0

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.48

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☐ 0.21 - 0.40	☑ 0.41

Completed by: AA Checked by: _____

Rapid Stream Assessment Technique

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-2
Weather:	Sunny 20°C	**Location:**	Lynden Rd, Brantford
Field Staff:	AA YAV.	**Watershed/Subwatershed:**	Fairchilds Creek

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8

Date:	2022-07-27	Reach:	SC-A-2	Project Code:	22045

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C N/A
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☑ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 23	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: AA Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-2, Silver Creek.
Weather:	Sunny 22°C	**Location:**	Lynden Rd, Brantford.
Field Staff:	AA, AV.	**Watershed/Subwatershed:**	Fairchilds Creek
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6): 1/4
Species: Mixed

Coverage:
- ☐ None
- ☑ Fragmented
- ☐ Continuous

Channel widths
- ☐ 1-4
- ☑ 4-10
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☑ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7): 2

Aquatic/Instream Vegetation

Type (Table8): N/A | Coverage of Reach (%): /

Woody Debris
- ☑ Present in Cutbank
- ☑ Present in Channel
- ☐ Not Present

Density of WD:
- ☐ Low
- ☑ Moderate
- ☐ High

WDJ/50m: 2

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity (Type) (Table 9): 2
Sinuosity (Degree) (Table 10): 3
Gradient (Table 11): 2
Number of Channels (Table 12): 1

Entrenchment (Table 13): 3
Type of Bank Failure (Table 14): 1/2/5
Downs's Classification (Table 15): e

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☑	☑	☑	☐	☐	☐	☐
Pool Substrate	☑	☑	☐	☐	☐	☐	☐
Bank Material	☑	☑	☐	☐	☐	☐	☐

Bankfull Width (m)	4.022	3.19	3.59	**Wetted Width (m)**	1.95	1.27	2.45
Bankfull Depth (m)	0.9	0.7	1	**Wetted Depth (m)**	0.31	0.07	0.13
Velocity (m/s)	0.06	0.33	0.18	**Wiffle ball / ADV / Estimated**			

Riffle/Pool Spacing (m): _____ **% Riffles:** _____ **% Pools:** _____ **Meander Amplitude:** N/E

Pool Depth (m): 0.53 **Riffle Length (m):** 14.24 **Undercuts (m):** 1 m

Bank Angle
- ☐ 0 – 30
- ☐ 30 – 60
- ☐ 60 – 90
- ☑ Undercut

Bank Erosion
- ☐ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☑ 60 – 100%

Comments: 0.66

Notes:

Completed by: AA Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-3
Weather:	Sunny 22°C	**Location:**	Lynden Rd., Brantford
Field Staff:	AA, AV.	**Watershed/Subwatershed:**	Fairchilds Creek.

Features
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type
- **H1** Standing water
- **H2** Scarcely perceptible flow
- **H3** Smooth surface flow
- **H4** Upwelling
- **H5** Rippled
- **H6** Unbroken standing wave
- **H7** Broken standing wave
- **H8** Chute
- **H9** Free fall

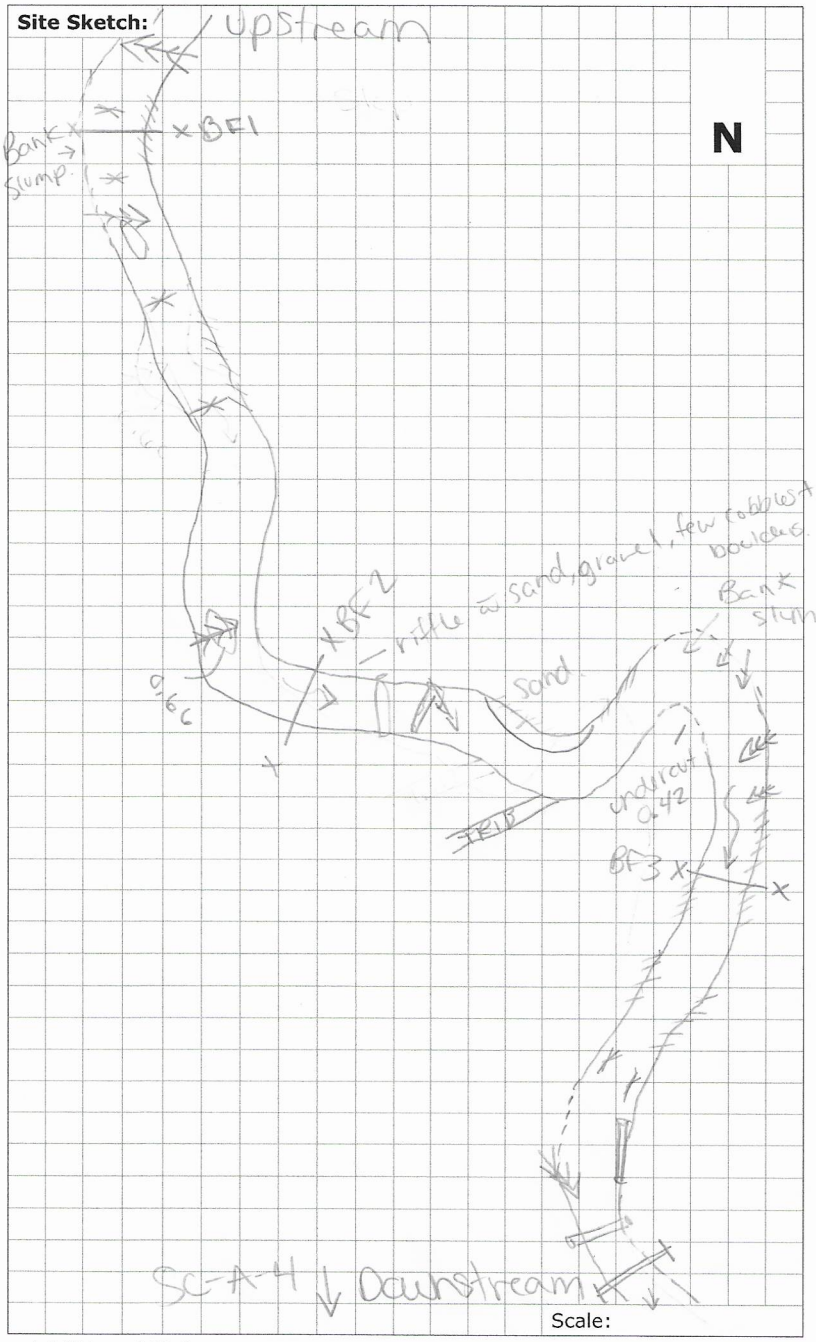
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Additional Notes:

- slopes have more grass/herbaceous than previous reaches (less exposed till) ↳ from old bank failures.
- narrower wetted width.
- sand deposits observed on point bars + overbank zone.

Completed by: AA. Checked by: _____

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-3
Weather:	Sunny 22°C	**Watershed/Subwatershed:**	Fairchilds Creek
Field Staff:	AA AN	**Location:**	Lynden Rd, Brantford

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		1	4/7
	2	Coarse materials in riffles embedded		1	
	3	Siltation in pools	1		
	4	Medial bars	1		
	5	Accretion on point bars	1		
	6	Poor longitudinal sorting of bed materials		1	
	7	Deposition in the overbank zone	1		
		Sum of indices =	4	3	0.57
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		3/5
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)	N/A		
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets	N/A		
	6	Cut face on bar forms	1		
	7	Head cutting due to knickpoint migration		1	
	8	Terrace cut through older bar material		1	
	9	Suspended armour layer visible in bank	1		
	10	Channel worn into undisturbed overburden / bedrock	1		
		Sum of indices =	3	2	0.6
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	1		6/8
	2	Occurrence of large organic debris	1		
	3	Exposed tree roots	1		
	4	Basal scour on inside meander bends	1		
	5	Basal scour on both sides of channel through riffle	1		
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach		1	
	8	Exposed length of previously buried pipe / cable / etc.		1	
	9	Fracture lines along top of bank	1		
	10	Exposed building foundation	N/A		
		Sum of indices =	6	2	0.75
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		1	
	2	Single thread channel to multiple channel		1	
	3	Evolution of pool-riffle form to low bed relief form		1	
	4	Cut-off channel(s)		1	
	5	Formation of island(s)		1	
	6	Thalweg alignment out of phase with meander form		1	
	7	Bar forms poorly formed / reworked / removed		1	
		Sum of indices =	0	7	0

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.48

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☐ 0.21 - 0.40	☑ 0.41

Completed by: AA Checked by: _____

Rapid Stream Assessment Technique

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-3
Weather:	Sunny 22°C	**Location:**	Lynden Rd, Brantford
Field Staff:	AA AV	**Watershed/Subwatershed:**	Fairchilds Creek.

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☑ 5	☐ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☑ 4	☐ 5 ☐ 6	☐ 7 ☐ 8

Date:	2022-07-27	Reach:	SC-A-3	Project Code:	22045

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☑ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☑ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☑ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 22	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: [signature] Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-3 Silver Creek
Weather:	Sunny 22°C	**Location:**	Lynden Rd., Brantford
Field Staff:	~~AA~~ AV	**Watershed/Subwatershed:**	Fairchilds Creek.
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6): 1/4
Species: Mixed.

Coverage:
- ☐ None
- ☑ Fragmented
- ☐ Continuous

Channel widths:
- ☐ 1-4
- ☑ 4-10
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☑ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7): 2

Aquatic/Instream Vegetation

Type (Table8): N/A | Coverage of Reach (%): /

Woody Debris
- ☑ Present in Cutbank
- ☑ Present in Channel
- ☐ Not Present

Density of WD:
- ☐ Low
- ☑ Moderate
- ☐ High

WDJ/50m: 1

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity (Type) (Table 9): 2
Sinuosity (Degree) (Table 10): 2
Gradient (Table 11): 2
Number of Channels (Table 12): 1
Entrenchment (Table 13): 3
Type of Bank Failure (Table 14): 1/2/5
Downs's Classification (Table 15): E

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☑	☑	☑	☐	☐	☐	☐
Pool Substrate	☑	☑	☐	☐	☐	☐	☐
Bank Material	☑	☑	☐	☐	☐	☐	☑

Bankfull Width (m)	3.65	4.31	3.66	**Wetted Width (m)**	1.8	1.1	1.31
Bankfull Depth (m)	1	0.83	1.1	**Wetted Depth (m)**	0.16	0.1	0.07

Riffle/Pool Spacing (m): | **% Riffles:** | **% Pools:** | **Meander Amplitude:** –

Pool Depth (m): 0.6 | **Riffle Length (m):** 12.5 | **Undercuts (m):** 0.37 | **Comments:**

Velocity (m/s): 0.13 | 0.15 | 0.2 | **Wiffle ball / ADV / Estimated**

Bank Angle
- ☐ 0 – 30
- ☐ 30 – 60
- ☑ 60 – 90
- ☐ Undercut

Bank Erosion
- ☐ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☑ 60 – 100%

Notes:

Completed by: AA | Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-6
Weather:	Sunny 24°C	**Location:**	Lynden Rd. Brantford
Field Staff:	AA AV	**Watershed/Subwatershed:**	Fairchilds Creek

Features
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

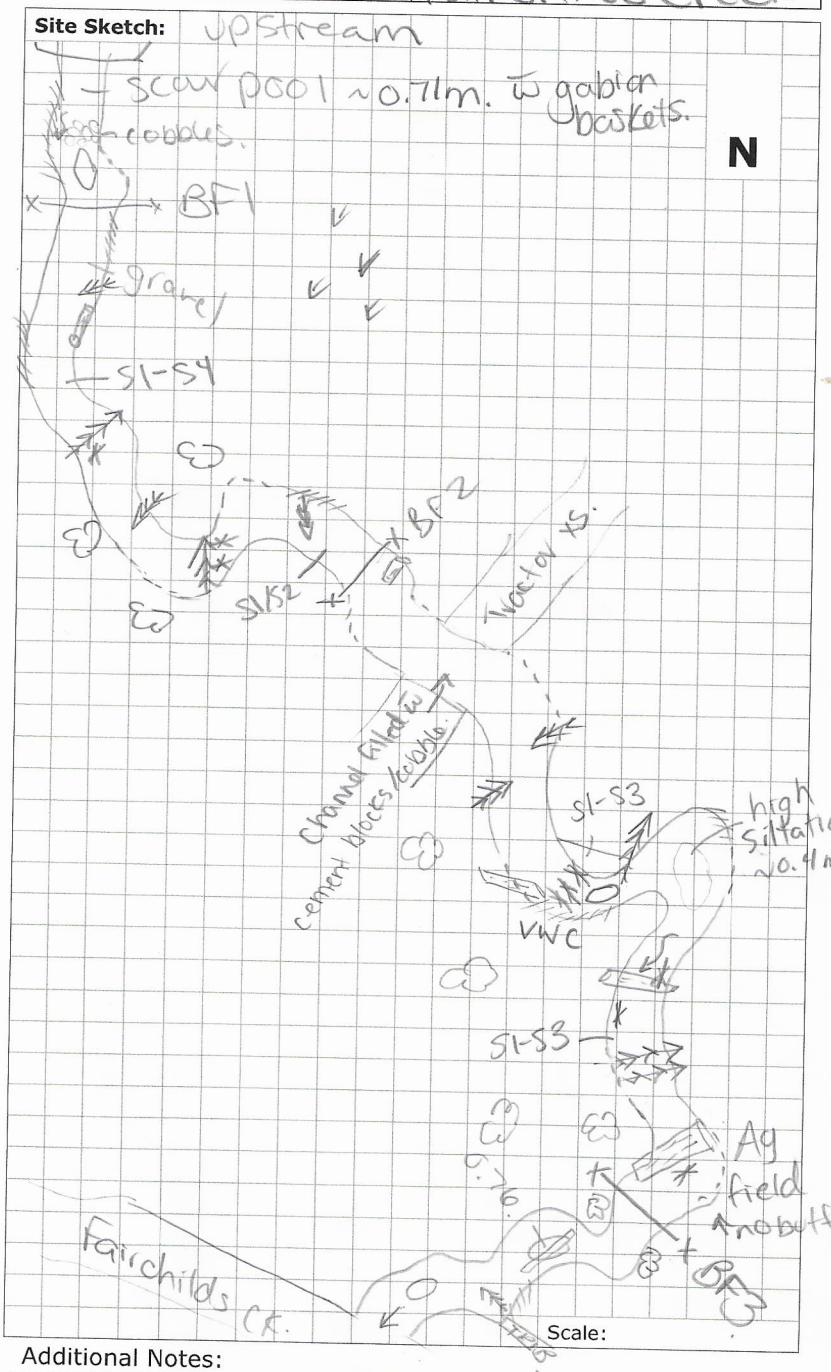
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Additional Notes:

- Basal scour common throughout channel
- predominantly runs, few pools/riffles.
- valley wall contact in some locations
- exposed clay evident in channel/banks
- siltation common ~0.42cm in some locations.

Completed by: AA. Checked by: _____

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-6
Weather:	Sunny 24°C	**Watershed/Subwatershed:**	Fairchilds Creek.
Field Staff:	AA AV	**Location:**	Lynden Rd, Brantford

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		1	3/7
	2	Coarse materials in riffles embedded		1	
	3	Siltation in pools	1		
	4	Medial bars		1	
	5	Accretion on point bars	1		
	6	Poor longitudinal sorting of bed materials	1		
	7	Deposition in the overbank zone		1	
		Sum of indices =	3	4	0.43
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	1		5/8
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)	N/A		
	4	Undermined gabion baskets / concrete aprons / etc.	1		
	5	Scour pools downstream of culverts / storm sewer outlets	1		
	6	Cut face on bar forms		1	
	7	Head cutting due to knickpoint migration		1	
	8	Terrace cut through older bar material		1	
	9	Suspended armour layer visible in bank	1		
	10	Channel worn into undisturbed overburden / bedrock	1		
		Sum of indices =	5	3	0.625
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	1		6/10
	2	Occurrence of large organic debris	1		
	3	Exposed tree roots	1		
	4	Basal scour on inside meander bends	1		
	5	Basal scour on both sides of channel through riffle	1		
	6	Outflanked gabion baskets / concrete walls / etc.		1	
	7	Length of basal scour >50% through subject reach	1		
	8	Exposed length of previously buried pipe / cable / etc.	N/A		
	9	Fracture lines along top of bank		1	
	10	Exposed building foundation	N/A		
		Sum of indices =	6	2	0.75
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		1	0/7
	2	Single thread channel to multiple channel		1	
	3	Evolution of pool-riffle form to low bed relief form		1	
	4	Cut-off channel(s)		1	
	5	Formation of island(s)		1	
	6	Thalweg alignment out of phase with meander form		1	
	7	Bar forms poorly formed / reworked / removed		1	
		Sum of indices =	0	7	0

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.45

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☐ 0.21 - 0.40	☑ 0.41

Completed by: AA. Checked by: _____

Rapid Stream Assessment Technique

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-6 Silver Creek
Weather:	Sunny 24°C	**Location:**	Lynden Rd., Brantford
Field Staff:	~~AA~~ AV	**Watershed/Subwatershed:**	Fairchilds Creek

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☑ 5	☐ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8

Date:	2022-07-27	Reach:	SC-A-6	Project Code:	22045

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C (NOT MEASURED)
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☑ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 24	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: _____ Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-6 Silver Creek
Weather:	Sunny 24°C	**Location:**	Lynden Rd Brantford
Field Staff:	AA J AV	**Watershed/Subwatershed:**	Fairchilds Creek
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1/3 | **Valley Type** (Table 2): 3 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 3 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6): 1
Species: Trees

Coverage:
- ☐ None
- ☑ Fragmented
- ☐ Continuous

Channel widths
- ☑ 1-4 LB
- ☑ 4-10 RB
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☐ Established (5-30)
- ☑ Mature (>30)

Encroachment: (Table 7): 2

Aquatic/Instream Vegetation

Type (Table8): N/A | Coverage of Reach (%): N/A

Woody Debris
- ☑ Present in Cutbank
- ☑ Present in Channel
- ☐ Not Present

Density of WD:
- ☐ Low
- ☑ Moderate
- ☐ High

WDJ/50m: 3

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 3

Channel Characteristics

Sinuosity (Type) (Table 9): 2
Sinuosity (Degree) (Table 10): 2
Gradient (Table 11): 2
Number of Channels (Table 12): 1
Entrenchment (Table 13): 2
Type of Bank Failure (Table 14): 1/2
Downs's Classification (Table 15):

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☑	☑	☑	☑	☐	☐	☐
Pool Substrate	☑	☑	☐	☐	☐	☐	☐
Bank Material	☑	☑	☑	☐	☐	☐	☑

Bankfull Width (m)	6.8	4.55	4.11	**Wetted Width (m)**	4.1	3.2	3.1
Bankfull Depth (m)	1.3	1.4	1.25	**Wetted Depth (m)**	0.37	0.48	0.35

Riffle/Pool Spacing (m): | **% Riffles:** | **% Pools:** | **Meander Amplitude:**

Pool Depth (m): ~1.5 | **Riffle Length (m):** 11.91 | **Undercuts (m):** 0.9

Velocity (m/s): / / / **Wiffle ball / ADV / Estimated**

Bank Angle
- ☐ 0 – 30
- ☐ 30 – 60
- ☑ 60 – 90
- ☐ Undercut

Bank Erosion
- ☐ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☑ 60 – 100%

Comments:

Notes:

Completed by: _____ Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-4
Weather:	Sunny 24°C	**Location:**	Lynden Rd, Brantford
Field Staff:	AA AV.	**Watershed/Subwatershed:**	Fairchilds Creek.

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

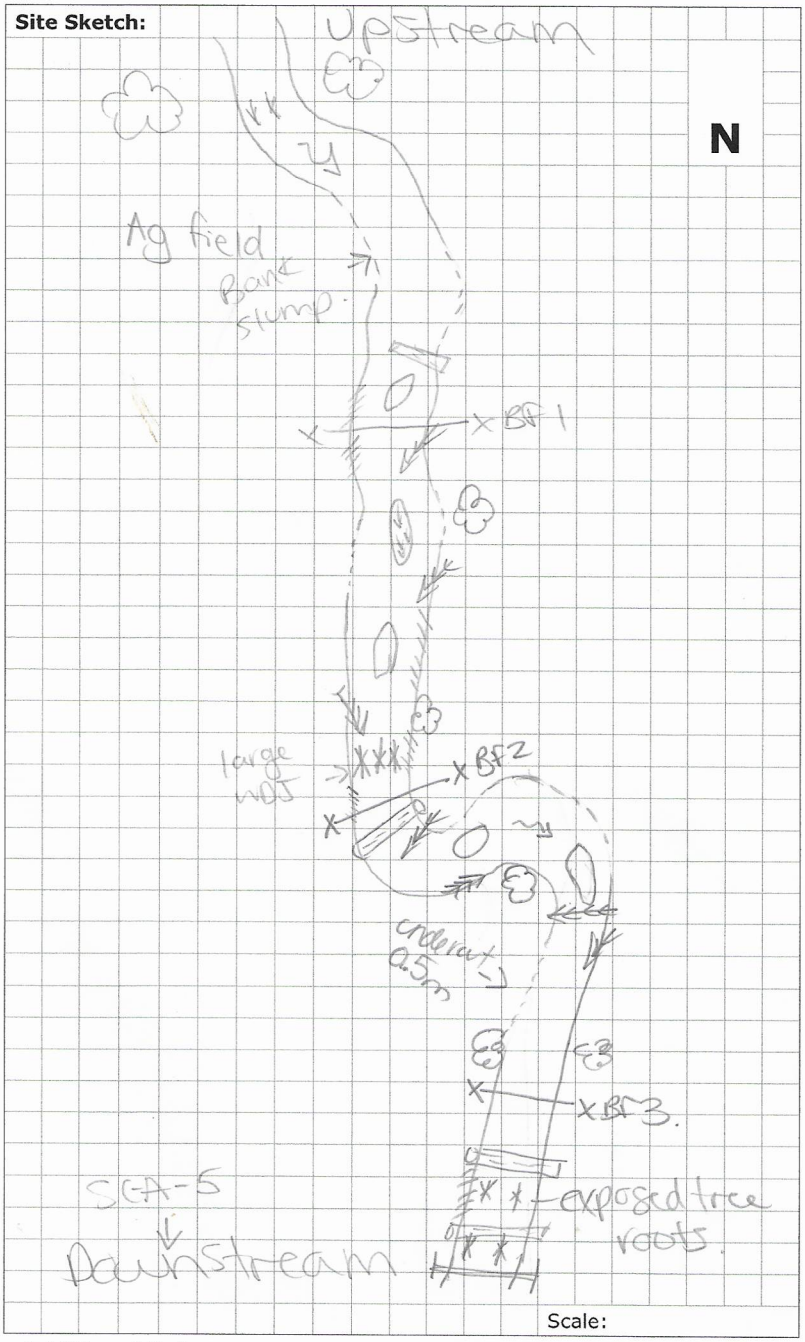
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Scale:

Additional Notes:

- no riparian buffer through upstream portion
- exposed till predominant
- less overhead cover & more encroachment
- lots of slump/falls/sloughs for bank failures.
- predominantly runs a few pools & riffles.

Completed by: AA Checked by: _____

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-4
Weather:	Sunny 24°C	**Watershed/Subwatershed:**	Fairchilds Creek
Field Staff:	AA AV.	**Location:**	Lynden Rd., Brantford

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		1	4/7
	2	Coarse materials in riffles embedded		1	
	3	Siltation in pools	1		
	4	Medial bars	1		
	5	Accretion on point bars	1		
	6	Poor longitudinal sorting of bed materials		1	
	7	Deposition in the overbank zone	1		
		Sum of indices =	4	3	0.57
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		3/5
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)	N/A		
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets	N/A		
	6	Cut face on bar forms	1		
	7	Head cutting due to knickpoint migration		1	
	8	Terrace cut through older bar material		1	
	9	Suspended armour layer visible in bank	1		
	10	Channel worn into undisturbed overburden / bedrock	1		
		Sum of indices =	3	2	0.6
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	1		5/8
	2	Occurrence of large organic debris	1		
	3	Exposed tree roots	1		
	4	Basal scour on inside meander bends	1		
	5	Basal scour on both sides of channel through riffle		1	
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach		1	
	8	Exposed length of previously buried pipe / cable / etc.		1	
	9	Fracture lines along top of bank	1		
	10	Exposed building foundation	N/A		
		Sum of indices =	5	3	0.625
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		1	1/7
	2	Single thread channel to multiple channel		1	
	3	Evolution of pool-riffle form to low bed relief form	1		
	4	Cut-off channel(s)		1	
	5	Formation of island(s)		1	
	6	Thalweg alignment out of phase with meander form		1	
	7	Bar forms poorly formed / reworked / removed		1	
		Sum of indices =	1	6	0.14

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.48

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☐ 0.21 - 0.40	☑ 0.41

Completed by: AA. Checked by: _____

Rapid Stream Assessment Technique

Project Code: 2045

Date:	2022-07-27	**Stream/Reach:**	SC-A-4, Silver Creek
Weather:	Sunny 24°C	**Location:**	Lynden Rd., Brantford
Field Staff:	AA AV	**Watershed/Subwatershed:**	Fairchilds Creek.

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☑ 5	☐ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☑ 4	☐ 5 ☐ 6	☐ 7 ☐ 8

Date:	2022-07-27	Reach:	SC-A-4	Project Code:	PN22045

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C N/A
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 21	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: AA Checked by: _____

GEO | MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-4, Silver Creek,
Weather:	Sunny 24°C	**Location:**	Lynden Rd., Brantford
Field Staff:	AA, AV.	**Watershed/Subwatershed:**	Fairchilds Creek.
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1/3 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 7 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6): 2/4
Species: Mixed

Coverage:
- ☐ None
- ☑ Fragmented
- ☐ Continuous

Channel widths
- ☐ 1-4
- ☑ 4-10
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☑ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7): 3

Aquatic/Instream Vegetation

Type (Table8): NA | Coverage of Reach (%): /

Woody Debris
- ☑ Present in Cutbank
- ☑ Present in Channel
- ☐ Not Present

Density of WD:
- ☑ Low
- ☐ Moderate
- ☐ High

WDJ/50m: 1

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity (Type) (Table 9): 2
Sinuosity (Degree) (Table 10): 2
Gradient (Table 11): 2
Number of Channels (Table 12): 1
Entrenchment (Table 13): 3
Type of Bank Failure (Table 14): 1/5
Downs's Classification (Table 15): e*

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☑	☑	☐	☐	☐	☐	☐
Pool Substrate	☑	☑	☐	☐	☐	☐	☐
Bank Material	☑	☑	☐	☐	☐	☐	☑

Bankfull Width (m)	3.7	3.5	4.76	**Wetted Width (m)**	1.92	1.08	2.66
Bankfull Depth (m)	1.1	0.9	1.2	**Wetted Depth (m)**	0.3	0.16	0.32

Riffle/Pool Spacing (m): | **% Riffles:** 10 | **% Pools:** 40 | **Meander Amplitude:**

Pool Depth (m): 0.53 | **Riffle Length (m):** 0.76 | **Undercuts (m):** 0.26 0.30

Velocity (m/s): / | 0.13 | / | **Wiffle ball / ADV / Estimated**

flow to slow

Bank Angle
- ☐ 0 – 30
- ☑ 30 – 60
- ☐ 60 – 90
- ☐ Undercut

Bank Erosion
- ☐ < 5%
- ☐ 5 – 30%
- ☑ 30 – 60%
- ☐ 60 – 100%

Comments: _____

Notes: _____

Completed by: AA. Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-1, Silver Creek
Weather:	Sunny 20°C	**Location:**	Lynden Rd. Brantford
Field Staff:	AA AV	**Watershed/Subwatershed:**	Fairchilds Creek.

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

- **H1** Standing water
- **H2** Scarcely perceptible flow
- **H3** Smooth surface flow
- **H4** Upwelling
- **H5** Rippled
- **H6** Unbroken standing wave
- **H7** Broken standing wave
- **H8** Chute
- **H9** Free fall

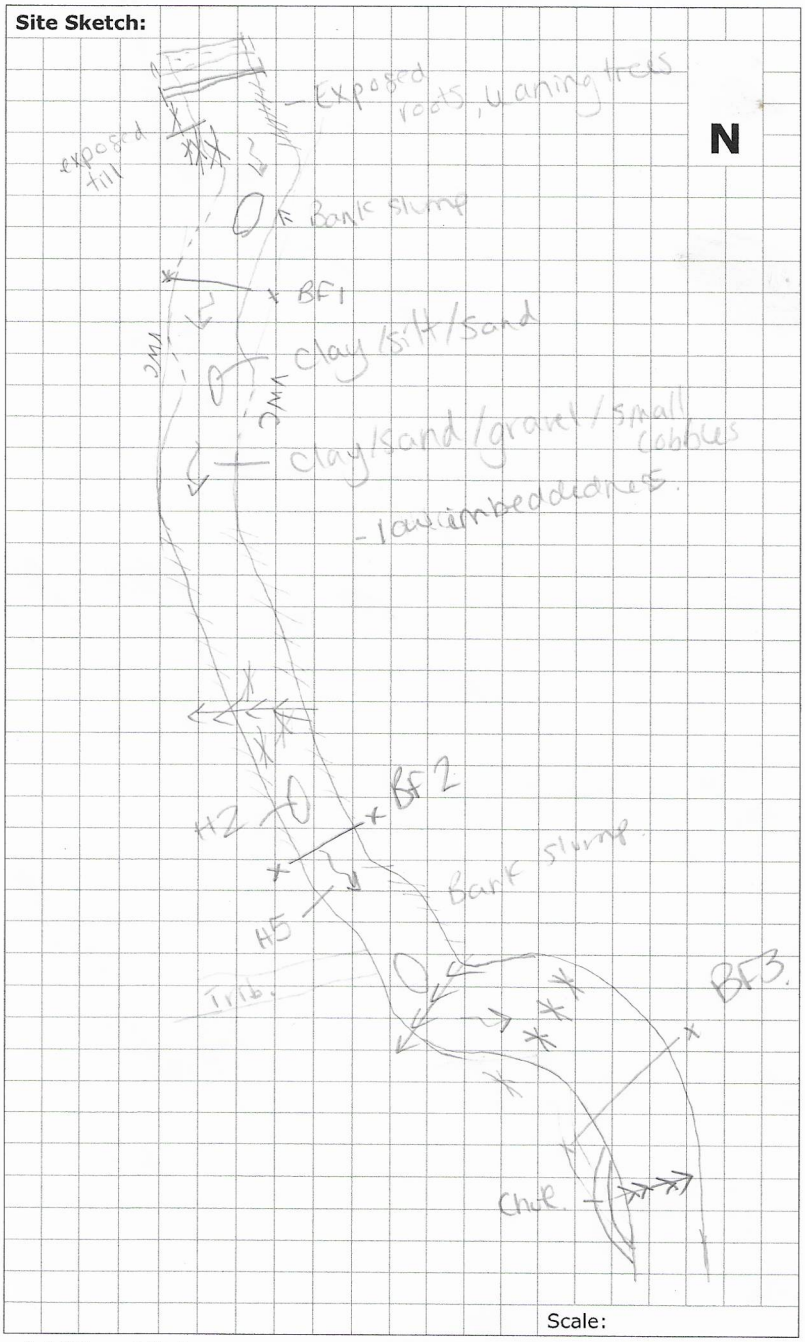
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Scale:

Additional Notes:

- Exposed till for most of channel
- sand deposits common
- VWC along most of reach w/ trunk trees + exposed roots

Completed by: AA Checked by: _____

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SC-A-1, Silver Creek
Weather:	Sunny 20°C	**Watershed/Subwatershed:**	Fairchilds Creek
Field Staff:	AA, AV	**Location:**	Lynden Rd, Brantford

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		1	3/7
	2	Coarse materials in riffles embedded		1	
	3	Siltation in pools	1		
	4	Medial bars		1	
	5	Accretion on point bars		1	
	6	Poor longitudinal sorting of bed materials	1		
	7	Deposition in the overbank zone	1		
		Sum of indices =	3	4	0.429
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		2/5
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)	N/A		
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets	N/A		
	6	Cut face on bar forms		1	
	7	Head cutting due to knickpoint migration		1	
	8	Terrace cut through older bar material		1	
	9	Suspended armour layer visible in bank	1		
	10	Channel worn into undisturbed overburden / bedrock	1		
		Sum of indices =	2	3	0.4
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	1		5/8
	2	Occurrence of large organic debris	1		
	3	Exposed tree roots	1		
	4	Basal scour on inside meander bends	1		
	5	Basal scour on both sides of channel through riffle	1		
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach		1	
	8	Exposed length of previously buried pipe / cable / etc.		1	
	9	Fracture lines along top of bank		1	
	10	Exposed building foundation	N/A		
		Sum of indices =	5	3	0.625
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		1	0/7
	2	Single thread channel to multiple channel		1	
	3	Evolution of pool-riffle form to low bed relief form		1	
	4	Cut-off channel(s)		1	
	5	Formation of island(s)		1	
	6	Thalweg alignment out of phase with meander form		1	
	7	Bar forms poorly formed / reworked / removed		1	
		Sum of indices =	0	7	

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.36

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☑ 0.21 - 0.40	☐ 0.41

Completed by: _____ Checked by: _____

Rapid Stream Assessment Technique

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	SCA-1, Silver Creek
Weather:	Sunny 20°C	**Location:**	Lynden Rd, Brantford
Field Staff:	AAJ AV	**Watershed/Subwatershed:**	Fairchilds Creek

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☑ 4 ☐ 5	☐ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8

Date:	2022-07-27	Reach:	SC-A-1	Project Code:	22045

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☑ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☑ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 24	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

N/A

Completed by: _____ Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	Silver Creek SC-A-1
Weather:	Sunny 18°C	**Location:**	Lynden Rd, Brantford.
Field Staff:	AA AV	**Watershed/Subwatershed:**	Fairchilds Creek.
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6): 1
Species: Trees

Coverage:
- ☐ None
- ☐ Fragmented
- ☑ Continuous

Channel widths
- ☐ 1-4
- ☑ 4-10
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☐ Established (5-30)
- ☑ Mature (>30)

Encroachment: (Table 7): 2

Aquatic/Instream Vegetation

Type (Table8): N/A | Coverage of Reach (%): /

Woody Debris
- ☑ Present in Cutbank
- ☑ Present in Channel
- ☐ Not Present

Density of WD:
- ☐ Low
- ☑ Moderate
- ☐ High

WDJ/50m: 1

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity (Type) (Table 9): 1
Sinuosity (Degree) (Table 10): 2
Gradient (Table 11): 2
Number of Channels (Table 12): 1
Entrenchment (Table 13): 3
Type of Bank Failure (Table 14): 1/2
Downs's Classification (Table 15): e

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☑	☑	☑	☑	☐	☐	☐
Pool Substrate	☑	☑	☐	☐	☐	☐	☐
Bank Material	☑	☑	☐	☐	☐	☐	☐

Bankfull Width (m)	4.13	4.72	4.20	**Wetted Width (m)**	2.30	2.38	1.74
Bankfull Depth (m)	1	1.25	1.1	**Wetted Depth (m)**	0.11	0.27	0.10

Riffle/Pool Spacing (m): 25 | **% Riffles:** 50 | **% Pools:** 50 | **Meander Amplitude:** 1

Pool Depth (m): 0.61 | **Riffle Length (m):** 10.2 | **Undercuts (m):** 0.31

Velocity (m/s): 0.16 | / | 0.15 | **Wiffle ball / ADV / Estimated**

A

Bank Angle
- ☐ 0 – 30
- ☐ 30 – 60
- ☑ 60 – 90
- ☐ Undercut

Bank Erosion
- ☐ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☑ 60 – 100%

Comments: _____

Notes:

to slow to measure

Completed by: AA. Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 22045

Date:	2022-07-27	**Stream/Reach:**	P012
Weather:	Sunny 24°C	**Location:**	Lynden Rd., Brantford.
Field Staff:	AA, AV.	**Watershed/Subwatershed:**	Fairchilds Creek
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 12 | **Channel Zone** (Table 4): 1 | **Flow Type** (Table 5): 3 | ☐ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6) 1/4 | Species: Mixed

Coverage: ☐ None ☑ Fragmented ☐ Continuous

Channel widths: ☐ 1-4 ☑ 4-10 ☐ > 10

Age Class (yrs): ☐ Immature (<5) ☑ Established (5-30) ☐ Mature (>30)

Encroachment: (Table 7) 4

Aquatic/Instream Vegetation

Type (Table8): N/A | Coverage of Reach (%): N/A

Woody Debris: ☐ Present in Cutbank ☐ Present in Channel ☑ Not Present

Density of WD: ☐ Low ☐ Moderate ☐ High | WDJ/50m:

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): N/A

Channel Characteristics

Sinuosity (Type) (Table 9): 1 | **Sinuosity (Degree)** (Table 10): 1 | **Gradient** (Table 11): 1 | **Number of Channels** (Table 12): 1

Entrenchment (Table 13): 1 | **Type of Bank Failure** (Table 14): 1 | **Downs's Classification** (Table 15):

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☐	☐	☐	☐	☐	☐
Pool Substrate	☐	☐	☐	☐	☐	☐	☐
Bank Material	☑	☑	☐	☐	☐	☐	☑

Bankfull Width (m)	0.53	0.55	0.73	**Wetted Width (m)**	—	—	—
Bankfull Depth (m)	0.17	0.17	0.19	**Wetted Depth (m)**	—	—	—

Riffle/Pool Spacing (m): | **% Riffles:** | **% Pools:** | **Meander Amplitude:**

Pool Depth (m): | **Riffle Length (m):** | **Undercuts (m):**

Velocity (m/s): | **Wiffle ball / ADV / Estimated**

Bank Angle: ☑ 0 – 30 ☐ 30 – 60 ☐ 60 – 90 ☐ Undercut

Bank Erosion: ☑ < 5% ☐ 5 – 30% ☐ 30 – 60% ☐ 60 – 100%

Comments: channel was dry, no riffles/pools.

Notes: bankful measurements taken before banks became undefined.

- small feature with poorly defined banks.
- channel was dry
- RSAT/RGA not applicable.
- flows from ditch along train tracks to forested wetland
- cobbles at upstream extent (may be placed from train tracks)

Completed by: AA | Checked by: _____

GEO | MORPHIX
Geomorphology Earth Science Observations

Detailed Assessment (Level) **Project Code:** 22045

Date:	2022-08-30	**Reach:**	SCA-5
Weather:	overcast 22°C	**Location:**	Lynden Rd
Field Staff:	JT AA	**Watershed/Subwatershed:**	Silver Creek

Top	Middle	Bottom	Angle	Water	XS	Notes
2632	2576	2500	255	2416		
2705	2640	2574	249	2525	0935	XS1
2798	2740	2683	241	2525		
2780	2731	2680	235	2525		
2705	2662	2618	226	2473		
2673	2648	2648	220	2464	1205	XS2
2559	2525	2500	211	2425		
2578	2550	2535	201	2407		
2500	2481	2452	176	2381		
2442	2424	2406	150	2350		
2432	2405	2382	125	2346	0550	XS3
2421	2395	2370	115	2346		
2490	2440	2390	105	2335		
2435	2386	2333	106	2318		
2415	2360		107	2318		
2466	2391		108	2345		
2505	2425	2355	109	2335		
	2425	2345	105	2315		
	2085	1996	115			TP1 FS
2725	2650		335			TP1 BS

Survey Direction
- ☑ Upstream to Downstream
- ☐ Downstream to Upstream

Cross-sections
No. of Cross-sections: _____
Monitoring Cross-sections:
- ☐ None
- ☐ Yes

If yes, which ones: ____ & ____

Rain in last 24 hours
- ☐ None
- ☐ Yes: Amount _____ mm

Valley Type:
Confined | Partially | Unconfined

Channel Zone:
Headwater | Transfer | Deposition

Land Use: Agri

Aquatic Vegetation: n/a

Coverage of Reach: 0 %

Riparian Vegetation: forest

Extent of Riparian Cover:
Fragment | None | Continuous

Riparian Cover (channel widths):
1-4 | 4-10 | >10

Age Class of Riparian Vegetation:
Immature (<5 yrs) | Established (5-30 yrs) | Mature (>30 yrs)

Extent of Encroachment:
None | Minimal | Moderate | Heavy | Extreme

Density of Woody Debris:
Low | Moderate | High

☑ **Overall Photographs Taken**

Blockage(s) in Channel:
Infrastructure | Dam | LWD

Completed by: _____ Checked By: _____

Page ____ of ____

2

2/3

GEO | MORPHIX
Geomorphology Earth Science Observations

Detailed Assessment (Level) **Project Code:** 22045

Date:	2022-08-30	**Reach:**	SC-A-5
Weather:	average 22°	**Location:**	Lynder Rd
Field Staff:	JT AA	**Watershed/Subwatershed:**	Silver Creek

Top	Middle	Bottom	Angle	Water	XS	Notes
	3035	2945	345	2980		3m D/S
3120	3045	2960	348	2975	0492*	
3125	3050	2980	350	2975		
3185	3129	3090	348	2985		
3105	3051	3005	350	2987		
3087	3052	3017	355	3000		
3079	3044	3022	4	3010		
3114	3090	3068	17	3052		
3172	3153	3148	35	3060	0220*	YSE
3179	3160	3141	66	3062		
3178	3172	3151	97	3060		
3235	3215	3198	121	3065		
3277	3245	3209	134	3140		LWD
3285	3240	3200	153	3135		
3211	3260	3212	131	3135	0885	
3315	3261	3210	128	3135		

Survey Direction

- ☒ Upstream to Downstream
- ☐ Downstream to Upstream

Cross-sections

No. of Cross-sections: _____

Monitoring Cross-sections:

- ☐ None
- ☐ Yes

If yes, which ones: ____ & ____

Rain in last 24 hours

- ☐ None
- ☐ Yes: Amount _____ mm

Valley Type:
Confined Partially Unconfined

Channel Zone:
Headwater Transfer Deposition

Land Use: _____

Aquatic Vegetation: _____

Coverage of Reach: _____%

Riparian Vegetation: _____

Extent of Riparian Cover:
Fragment None Continuous

Riparian Cover (channel widths):
1-4 4-10 >10

Age Class of Riparian Vegetation:
Immature (<5 yrs) Established (5-30 yrs) Mature (>30 yrs)

Extent of Encroachment:
None Minimal Moderate Heavy Extreme

Density of Woody Debris:
Low Moderate High

☐ **Overall Photographs Taken**

Blockage(s) in Channel:
Infrastructure Dam LWD

Completed by: _____ Checked By: _____

Page ____ of ____

GEO MORPHIX
Geomorphology Earth Science Observations

3/3

Detailed Assessment (Level) **Project Code:** 22045

Date:		**Reach:**	
Weather:		**Location:**	
Field Staff:		**Watershed/Subwatershed:**	

Top	Middle	Bottom	Angle	Water	XS	Notes
3391	3336		124	3205		
0454	0385	0322	112			TP: FS
1028	0925	0832	344			TP: FS
3755	3830	3914	340	3680		2m dist
3934	3775	3701	342	3690		
3860	3805	3740	344	3690		
3864	3811	3753	345	3695		
3800	3750	3700	351	3695	0929	XS7
3795	3775	3755	10	3700		
3848	3838	3828	4	3700		
3867	3852	3836	345	3700		
3900	3884	3869	320	3710		
4020	4005	3988	300	3710		
3950	3938	3907	282	3710		
3905	3880	3854	263	3710		
3895	3875	3835	252	3713		
3875	3845	3815	239	3715		
3879	3844	3807	230	3713		
3914	3872	3830	224	3715	2795	XS8
3935	3885	3842	211	3715		
4015	3970	3905	212	3720		

Survey Direction

☐ Upstream to Downstream

☐ Downstream to Upstream

Cross-sections

No. of Cross-sections: _____

Monitoring Cross-sections:

☐ None

☐ Yes

If yes, which ones: ____ & ____

Rain in last 24 hours

☐ None

☐ Yes: Amount _____ mm

Valley Type:

Confined Partially Unconfined

Channel Zone:

Headwater Transfer Deposition

Land Use: _____

Aquatic Vegetation: _____

Coverage of Reach: _____%

Riparian Vegetation: _____

Extent of Riparian Cover:

Fragment None Continuous

Riparian Cover (channel widths):

1-4 4-10 >10

Age Class of Riparian Vegetation:

Immature Established Mature

(<5 yrs) (5-30 yrs) (>30 yrs)

Extent of Encroachment:

None Minimal Moderate

Heavy Extreme

Density of Woody Debris:

Low Moderate High

☐ **Overall Photographs Taken**

Blockage(s) in Channel:

Infrastructure Dam LWD

Completed by: _____ Checked By: _____

Page ____ of ____

GEO MORPHIX
Geomorphology Earth Science Observations

Cross-Section Characteristics

Project Code: 22045

Date:	2022-08-30	**Reach/Cross-section:**	XS1
Weather:	Overcast 22°C	**Location:**	Lynden Rd, Brantford
Field Staff:	JT AA	**Watershed/Subwatershed:**	Silver Creek

					Notes
0.6	0553				
1.1	0500				
1.4	0465				
1.6	0472				
2.00	0678	BF			
2.6	1001				
3.0	2159				
3.3	2383				
3.5	2734				
3.85	2938				
4.2	2977				
4.6	3036				
4.9	3070				
5.2	3084				
5.7	3111				
6.1	3176				
6.5	3288				
6.9	3273				
7.2	3245				
7.4	3178				
7.65	3054	WL			
7.9	2911				
8.2	2791				
8.5	2691				
8.8	2580				
9.1	2355				
9.3	1112				
9.5	0829				
9.9	0770				
10.5	0691				
11.0	0531				
11.2	0438				

Cross-sectional Morphology

☑ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 6	11. 3.2	21. 3	31. 1.2
2. 5	12. 0.4	22. 7	32. 0.2
3. 5	13. 0.4	23. 5.5	33. 0.2
4. 4.7	14. 0.2	24. 1.5	34. 1.4
5. 4.4	15. 1.2	25. 1.4	35. 1.35
6. 1.5	16. 5	26. 2.4	36. 1.6
7. SAND	17. 4	27. 2	37. 2
8. SAND	18. 2.2	28. 9.5	38. 1.4
9. 5.6	19. 1.5	29. 5.4	39. 2.5
10. 6.5	20. 0.5	30. 1.8	40. 2.6

Particle Shape:

☐ Platy ☑ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embededness: 50 %

Subpavement: Till

Sorting: ☐ Well ☑ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: _____ %

Velocity and Discharge

Velocity: **Method:**

☐ Estimated _____ m/s ☐ Wiffle ball
☐ Measured _____ m/s ☐ Current Meter

Discharge: ☐ ADV

☐ Estimated _____ m^3/s ☐ Marsh McBirney
☐ Measured _____ m^3/s ☐ Other

Completed by: AA Checked by: _____

Page ____ of ____

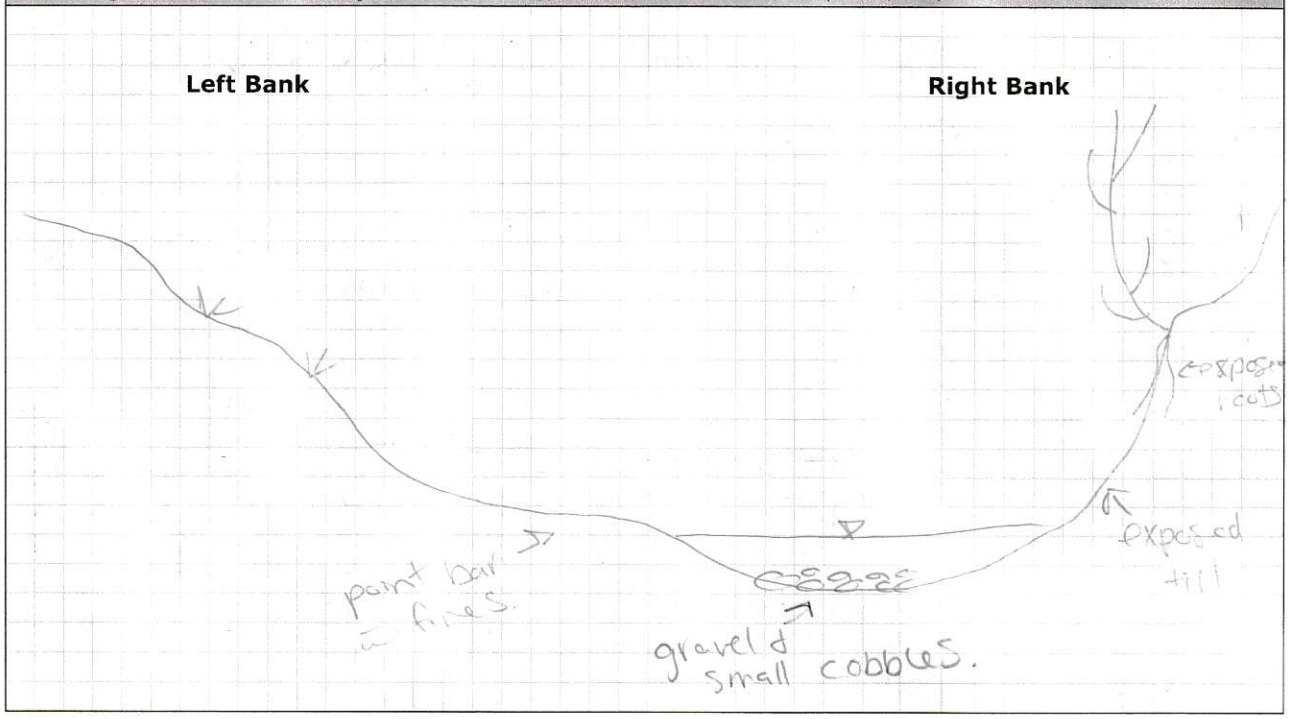
GEO MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code: 22045

Date:	2022-08-30	**Reach/XS:**	XS1

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials			**Right Bank Materials**		
☐ Bedrock	☐ Gravel		☐ Bedrock	☐ Gravel	
☐ Till	☐ Small Cobble		☑ Till	☐ Small Cobble	
☐ Clay	☐ Large Cobble		☐ Clay	☐ Large Cobble	
☐ Silt	☐ Small Boulder		☐ Silt	☐ Small Boulder	
☐ Sand	☐ Large Boulder		☑ Sand	☐ Large Boulder	
Bank Height:	1.8	m	Bank Height:	1.8	m
Bank Angle:	60	°	Bank Angle:	60	°
Root Depth:	1.2	m	Root Depth:	0.7	m
Root Density:	15	%	Root Density:	5	%
Undercut:	0	m	Undercut:	0	m
Erosion Pin:		m	Erosion Pin:		m
Penetrometer:		kg/cm²	Penetrometer:		kg/cm²
Foot Used:	☐ Yes ☐ No		Foot Used:	☐ Yes ☐ No	

Additional Notes

Erosion pins installed.

Photo Order: US, DS, LB, RB

Completed by: AA Checked by: _____

Page ____ of ____

GEO MORPHIX
Geomorphology Earth Science Observations

Cross-Section Characteristics

Project Code: P2045

Date:	2022-05-30	**Reach/Cross-section:**	XS2
Weather:	Overcast 22C	**Location:**	Lynden Rd, Brantford
Field Staff:	JT AA	**Watershed/Subwatershed:**	Silver Creek

					Notes
0.6	0840				
1.3	0995				
1.6	1066	BF			
1.0	1035				
2.3	2167				
2.7	2207				
3.10	2354				
3.5	2471				
3.9	2570				
4.20	2715				
4.60	2873				
5.15	3050	WS			
5.5	3180				
5.8	3248				
6.2	3255				
6.5	3181				
6.9	3090				
7.2	3005				
7.5	2831				
7.8	2582				
8.0	2357				
8.2	0602				
8.5	0295				
8.8	0113				
9.2	0035				

Cross-sectional Morphology

☐ Riffle ☐ Pool ☑ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. _____	11. _____	21. _____	31. _____
2. _____	12. _____	22. _____	32. _____
3. _____	13. _____	23. _____	33. _____
4. _____	14. _____	24. _____	34. _____
5. _____	15. _____	25. _____	35. _____
6. _____	16. _____	26. _____	36. _____
7. _____	17. _____	27. _____	37. _____
8. _____	18. _____	28. _____	38. _____
9. _____	19. _____	29. _____	39. _____
10. _____	20. _____	30. _____	40. _____

Particle Shape:

☐ Platy ☐ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embededness: _____ %

Subpavement: Till

Sorting: ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: _____ %

Velocity and Discharge

Velocity: **Method:**

☐ Estimated _____ m/s ☐ Wiffle ball
☐ Measured _____ m/s ☐ Current Meter

Discharge: ☐ ADV

☐ Estimated _____ m^3/s ☐ Marsh McBirney
☐ Measured _____ m^3/s ☐ Other

Completed by: AA Checked by: _____

Page ____ of ____

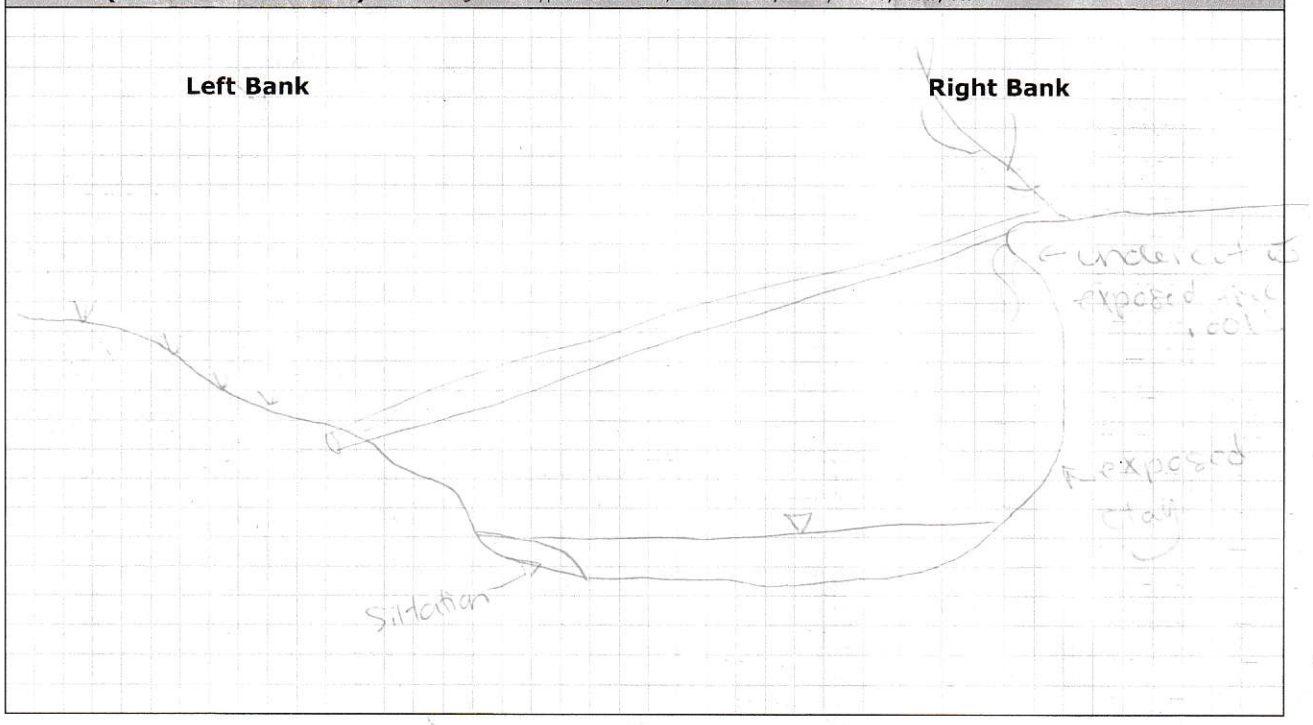
GEO MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code: 2745

Date:	2021-08-30	Reach/XS:	XS2

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials		Right Bank Materials	
☐ Bedrock	☐ Gravel	☐ Bedrock	☐ Gravel
☐ Till	☐ Small Cobble	☐ Till	☐ Small Cobble
☐ Clay	☐ Large Cobble	☐ Clay	☐ Large Cobble
☐ Silt	☐ Small Boulder	☐ Silt	☐ Small Boulder
☐ Sand	☐ Large Boulder	☐ Sand	☐ Large Boulder
Bank Height: 1.25 m		Bank Height: 1.7 m	
Bank Angle: 45 °		Bank Angle: 90 °	
Root Depth: 0.5 m		Root Depth: 1.2 m	
Root Density: 20 %		Root Density: 20 %	
Undercut: 0 m		Undercut: 0.75 m	
Erosion Pin: ____ m		Erosion Pin: ____ m	
Penetrometer: ____ kg/cm²		Penetrometer: ____ kg/cm²	
Foot Used: ☐ Yes ☐ No		Foot Used: ☐ Yes ☐ No	

Additional Notes

Photo Order:

Completed by: _____ Checked by: _____

Page ____ of ____

GEO MORPHIX
Geomorphology Earth Science Observations

Cross-Section Characteristics

Project Code: 22045...

Date:	2022-08-30	**Reach/Cross-section:**	XS3
Weather:	Overcast 22°C	**Location:**	Lynden Rd, Brantford
Field Staff:	JT AA	**Watershed/Subwatershed:**	Silver Creek

					Notes
0.0	0487				
1.0	0476				
1.3	0493				
1.6	0513				
1.8	0603				
1.95	0740				
2.10	2118				
2.50	2410				
2.9	2458				
3.20	2507				
3.70	2649				
4.10	2830				
4.45	3000				
4.80	3040	WL			
5.30	3148				
5.70	3173				
6.00	3184				
6.40	3175				
6.90	3186				
7.30	3052				
7.46	2862				
7.75	2717				
8.00	2554				
8.40	2425				
8.60	2313				
8.70	6818				
8.80	0443	BF			
9.20	0413				
9.60	0404				
10.0	0440				

Cross-sectional Morphology

☑ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☑ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. ____	11. ____	21. ____	31. ____
2. ____	12. ____	22. ____	32. ____
3. ____	13. ____	23. ____	33. ____
4. ____	14. ____	24. ____	34. ____
5. ____	15. ____	25. ____	35. ____
6. ____	16. ____	26. ____	36. ____
7. ____	17. ____	27. ____	37. ____
8. ____	18. ____	28. ____	38. ____
9. ____	19. ____	29. ____	39. ____
10. ____	20. ____	30. ____	40. ____

Particle Shape:

☐ Platy ☐ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embededness: _____ %

Subpavement: 7111

Sorting: ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: _____ %

Velocity and Discharge

Velocity:

☐ Estimated _____ m/s
☐ Measured _____ m/s

Method:

☐ Wiffle ball
☐ Current Meter
☐ ADV
☐ Marsh McBirney
☐ Other

Discharge:

☐ Estimated _____ m^3/s
☐ Measured _____ m^3/s

Completed by: AA Checked by: _____

Page ____ of ____

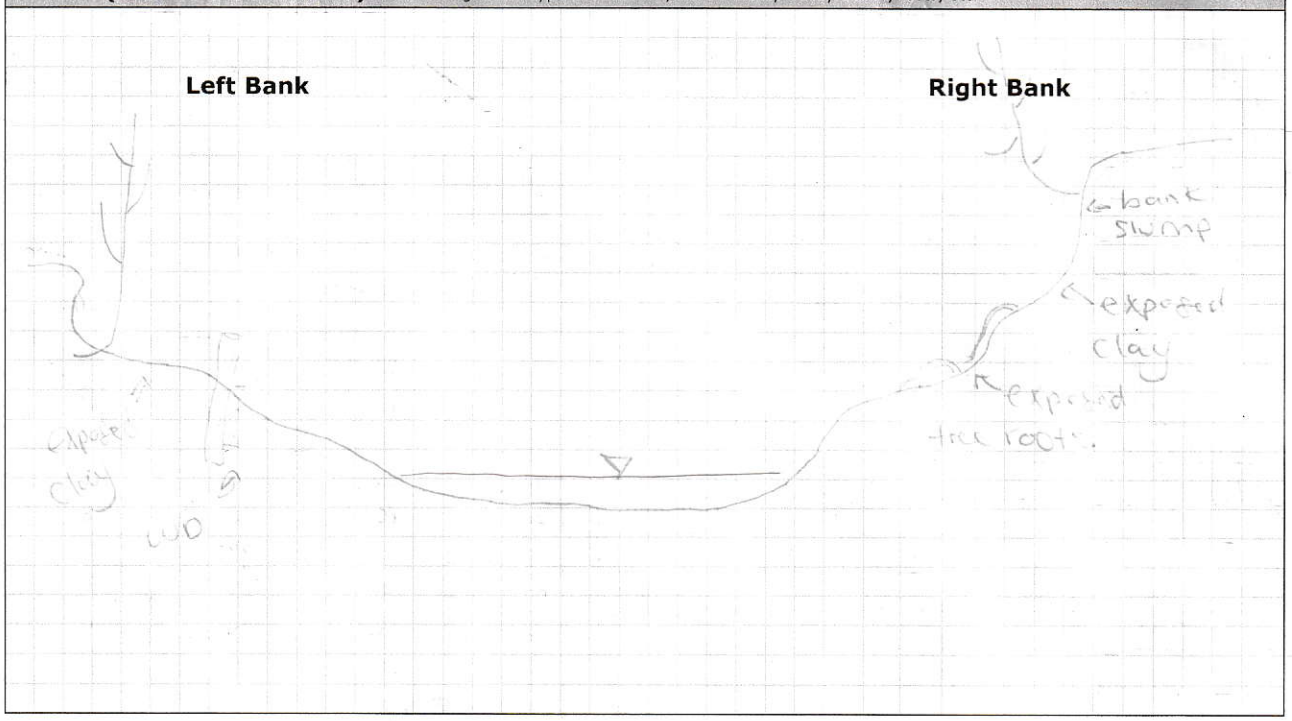
GEO MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code: 22045

Date:	2022-08-30	Reach/XS:	XS2

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials		Right Bank Materials	
☐ Bedrock	☐ Gravel	☐ Bedrock	☐ Gravel
☐ Till	☐ Small Cobble	☐ Till	☐ Small Cobble
☐ Clay	☐ Large Cobble	☐ Clay	☐ Large Cobble
☐ Silt	☐ Small Boulder	☐ Silt	☐ Small Boulder
☐ Sand	☐ Large Boulder	☐ Sand	☐ Large Boulder
Bank Height: 1.40 m		Bank Height: 1.65 m	
Bank Angle: 45 °		Bank Angle: 80 °	
Root Depth: 1.0 m		Root Depth: 1.50 m	
Root Density: 15 %		Root Density: 30 %	
Undercut: 0.29 m		Undercut: 0 m	
Erosion Pin: ____ m		Erosion Pin: ____ m	
Penetrometer: ____ kg/cm²		Penetrometer: ____ kg/cm²	
Foot Used: ☐ Yes ☐ No		Foot Used: ☐ Yes ☐ No	

Additional Notes

Photo Order:

Completed by: _____ Checked by: _____

Page ____ of ____

GEO | MORPHIX
Geomorphology
Earth Science
Observations

Cross-Section Characteristics

Project Code: 22045

Date:	2022-08-30	**Reach/Cross-section:**	X4
Weather:	Sunny 22°C	**Location:**	Lynden Rd, Brantford
Field Staff:	JT JAA	**Watershed/Subwatershed:**	Silver Creek.

					Notes
		RTK			

Cross-sectional Morphology

☐ Riffle ☐ Pool ☑ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. ____	11. ____	21. ____	31. ____
2. ____	12. ____	22. ____	32. ____
3. ____	13. ____	23. ____	33. ____
4. ____	14. ____	24. ____	34. ____
5. ____	15. ____	25. ____	35. ____
6. ____	16. ____	26. ____	36. ____
7. ____	17. ____	27. ____	37. ____
8. ____	18. ____	28. ____	38. ____
9. ____	19. ____	29. ____	39. ____
10. ____	20. ____	30. ____	40. ____

Particle Shape:

☐ Platy ☐ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embededness: ____________ %

Subpavement: Till

Sorting: ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: ____________ %

Velocity and Discharge

Velocity:

☐ Estimated ________ m/s
☐ Measured ________ m/s

Discharge:

☐ Estimated ________ m^3/s
☐ Measured ________ m^3/s

Method:

☐ Wiffle ball
☐ Current Meter
☐ ADV
☐ Marsh McBirney
☐ Other

Completed by: AA. Checked by: ________

Page ____ of ____

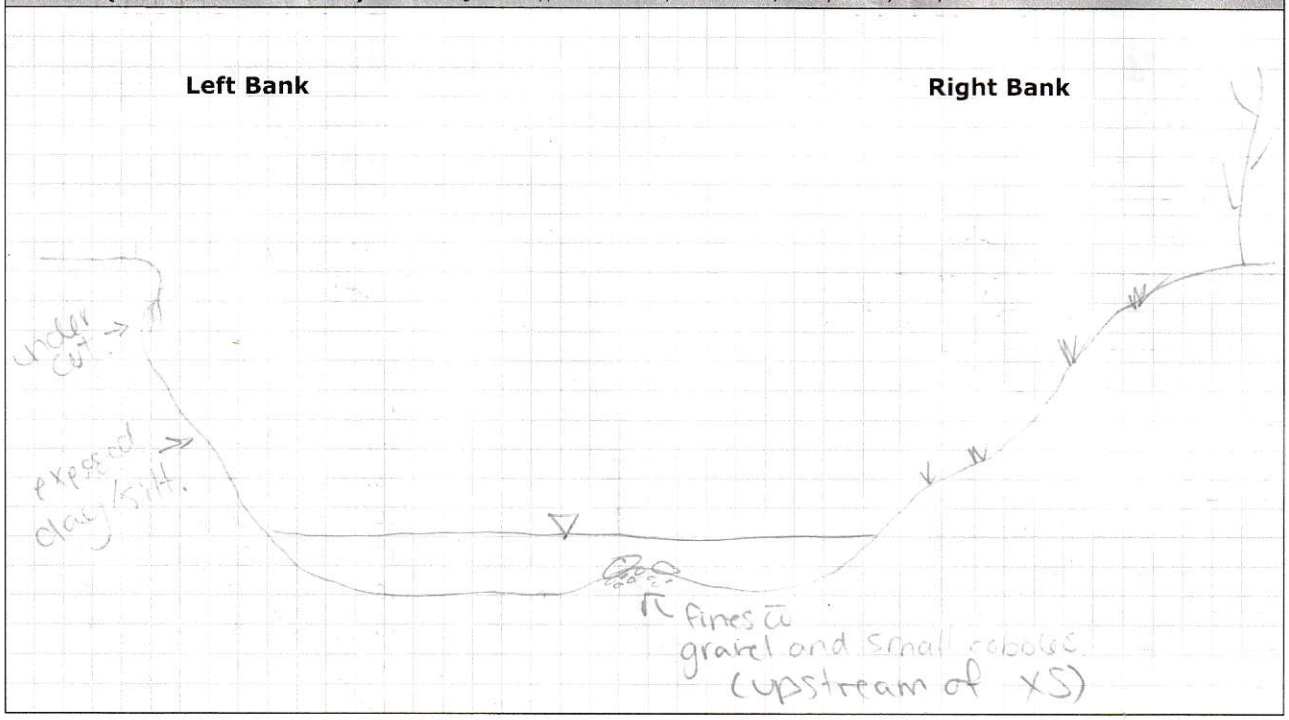
GEO MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code: 22045

Date:	2022 08-30	**Reach/XS:**	XS4

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials			**Right Bank Materials**		
☐ Bedrock	☐ Gravel		☐ Bedrock	☐ Gravel	
☐ Till	☐ Small Cobble		☐ Till	☐ Small Cobble	
☐ Clay	☐ Large Cobble		☐ Clay	☐ Large Cobble	
☐ Silt	☐ Small Boulder		☐ Silt	☐ Small Boulder	
☐ Sand	☐ Large Boulder		☐ Sand	☐ Large Boulder	
Bank Height:	1.82	m	Bank Height:	1.90	m
Bank Angle:	80	°	Bank Angle:	50	°
Root Depth:	1.20	m	Root Depth:	0.5	m
Root Density:	15	%	Root Density:	20	%
Undercut:	0.3	m	Undercut:	0	m
Erosion Pin:		m	Erosion Pin:		m
Penetrometer:		kg/cm²	Penetrometer:		kg/cm²
Foot Used:	☐ Yes ☐ No		Foot Used:	☐ Yes ☐ No	

Additional Notes

Photo Order: US, DS, LB, RB

Completed by: AA Checked by: _____

Page ____ of ____

GEO MORPHIX
Geomorphology Earth Science Observations

Cross-Section Characteristics

Project Code: 22045

Date:	2022-08-30	**Reach/Cross-section:**	XS5
Weather:	Sunny 22°C	**Location:**	Lynden Rd Brantford
Field Staff:	TT AA	**Watershed/Subwatershed:**	Silver Creek

					Notes
1.00	0081				
1.50	0100				
2.00	0138				
2.50	0179				
3.00	0263				
3.30	0391				
3.31	2275				
3.45	2469				
3.60	2625				
3.70	2716	WE			
3.95	3010				
4.40	2963				
4.80	2971				
5.20	2896				
5.50	2878				
5.80	2872				
6.20	2798				
6.60	2709				
7.00	2639				
7.40	2581				
7.80	2472				
8.20	2296				
8.50	2128				
8.85	6934				
9.0	0778				
9.30	0280	BF			
9.50	0079				
10.00	0060				
10.40	0073				

Cross-sectional Morphology

☐ Riffle ☐ Pool ☑ Run ☐ Other

Substrate

Sample:

☑ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 5	11. SAND	21. 0.7	31. 0.5
2. 2.2	12. ↓	22. 0.7	32. 1.8
3. 1.2	13. ↓	23. 0.5	33. 1.1
4. 0.6	14. 0.7	24. 1.6	34. 1.2
5. 0.7	15. 0.9	25. 0.7	35. 0.6
6. 0.6	16. 2.8	26. 1.1	36. 0.3
7. 0.3	17. 4.2	27. 0.9	37. 1.1
8. 0.4	18. 3.7	28. 0.7	38. Clay
9. 0.7	19. 1.8	29. 0.7	39. ↓
10. 0.2	20. 1.6	30. 0.4	40. ↓

Particle Shape:

☐ Platy ☑ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embeddedness: 50 %

Subpavement: Till

Sorting: ☐ Well ☑ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: _____ %

Velocity and Discharge

Velocity: **Method:**

☐ Estimated _____ m/s ☐ Wiffle ball
☐ Measured _____ m/s ☐ Current Meter

Discharge: ☐ ADV

☐ Estimated _____ m^3/s ☐ Marsh McBirney
☐ Measured _____ m^3/s ☐ Other

Completed by: AA Checked by: _____

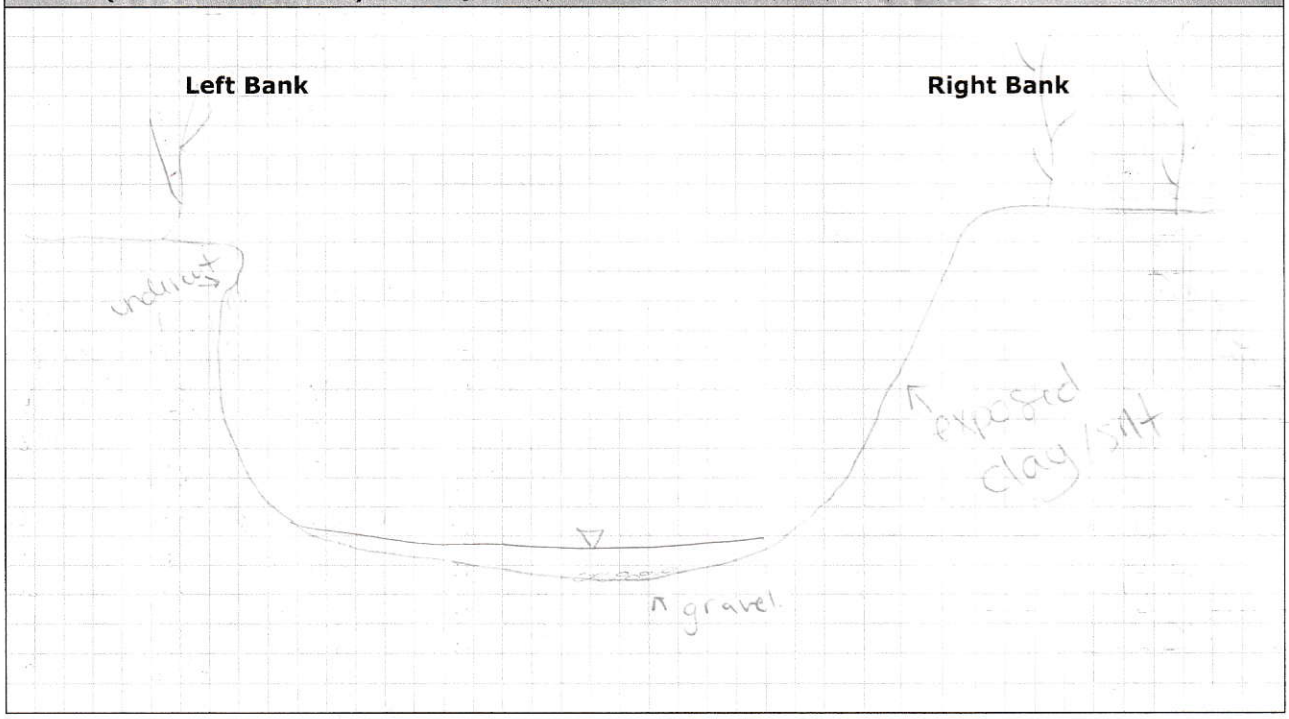
GEO | MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code: 27045

Date:	2022-08-30	Reach/XS:	XS5

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials		Right Bank Materials	
☐ Bedrock	☐ Gravel	☐ Bedrock	☐ Gravel
☐ Till	☐ Small Cobble	☐ Till	☐ Small Cobble
☑ Clay	☐ Large Cobble	☑ Clay	☐ Large Cobble
☑ Silt	☐ Small Boulder	☑ Silt	☐ Small Boulder
☑ Sand	☐ Large Boulder	☑ Sand	☐ Large Boulder
Bank Height: 1.75 m		Bank Height: 1.90 m	
Bank Angle: 75 °		Bank Angle: >90 °	
Root Depth: 0.5 m		Root Depth: 1.2 m	
Root Density: 5 %		Root Density: 35 %	
Undercut: 0 m		Undercut: 0.28 m	
Erosion Pin: 0.2 m		Erosion Pin: 0.2 m	
Penetrometer: ____ kg/cm²		Penetrometer: ____ kg/cm²	
Foot Used: ☐ Yes ☐ No		Foot Used: ☐ Yes ☐ No	

Additional Notes

Erosion pins installed to 0.2m

Photo Order: US, DS, LB, RB

Completed by: AA Checked by: _____

Page ____ of ____

GEO | MORPHIX

Geomorphology
Earth Science
Observations

Cross-Section Characteristics **Project Code:** 22045

Date:	2022-08-30	**Reach/Cross-section:**	XS6
Weather:	Overcast 22°C	**Location:**	Lincoln Rd, Brantford
Field Staff:	JT AA	**Watershed/Subwatershed:**	Silver Creek

					Notes
RTK					

Cross-sectional Morphology

☐ Riffle ☑ Pool ☐ Run ☐ Other

Substrate

Sample:

☑ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. ____	11. ____	21. ____	31. ____
2. ____	12. ____	22. ____	32. ____
3. ____	13. ____	23. ____	33. ____
4. ____	14. ____	24. ____	34. ____
5. ____	15. ____	25. ____	35. ____
6. ____	16. ____	26. ____	36. ____
7. ____	17. ____	27. ____	37. ____
8. ____	18. ____	28. ____	38. ____
9. ____	19. ____	29. ____	39. ____
10. ____	20. ____	30. ____	40. ____

Particle Shape:

☐ Platy ☐ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embededness: ____________ %

Subpavement: Till

Sorting: ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: ____________ %

Velocity and Discharge

Velocity:

☐ Estimated ________ m/s
☐ Measured ________ m/s

Discharge:

☐ Estimated ________ m^3/s
☐ Measured ________ m^3/s

Method:

☐ Wiffle ball
☐ Current Meter
☐ ADV
☐ Marsh McBirney
☐ Other

Completed by: AA Checked by: ________

Page ____ of ____

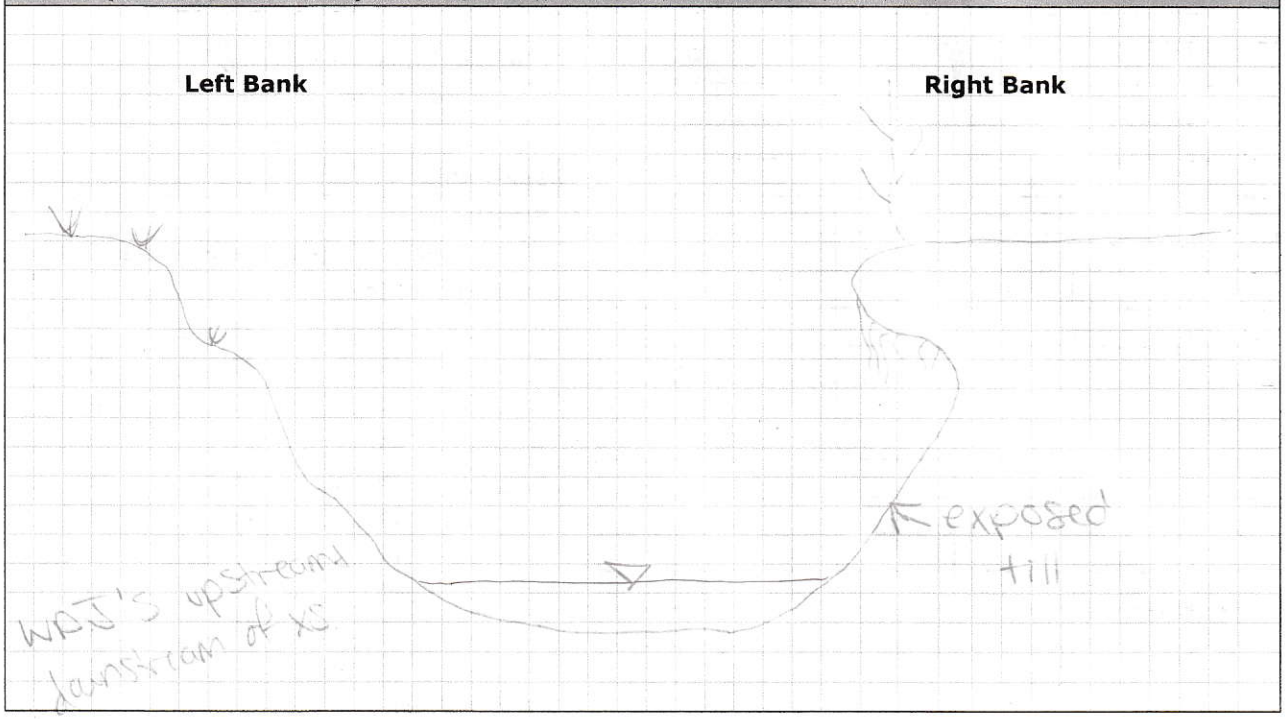
GEO MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code: 22045

Date:	2022-08-30	Reach/XS:	XS6

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock		☐ Gravel	
☐ Till		☐ Small Cobble	
☑ Clay		☐ Large Cobble	
☑ Silt		☐ Small Boulder	
☐ Sand		☐ Large Boulder	
Bank Height:	1.2	m	
Bank Angle:	75	°	
Root Depth:	0.5	m	
Root Density:	50	%	
Undercut:	0.59	m	
Erosion Pin:		m	
Penetrometer:		kg/cm²	
Foot Used:	☐ Yes	☐ No	

Right Bank Materials

☐ Bedrock		☐ Gravel	
☐ Till		☐ Small Cobble	
☑ Clay		☐ Large Cobble	
☑ Silt		☐ Small Boulder	
☑ Sand		☐ Large Boulder	
Bank Height:	1.85	m	
Bank Angle:	90	°	
Root Depth:	1.00	m	
Root Density:	25	%	
Undercut:	0	m	
Erosion Pin:		m	
Penetrometer:		kg/cm²	
Foot Used:	☐ Yes	☐ No	

Additional Notes

Photo Order: US, DS, LB, RB

Completed by: AA Checked by: _____

Page ____ of ____

GEO MORPHIX
Geomorphology Earth Science Observations

Cross-Section Characteristics

Project Code: 22045

Date:	2022-08-30	**Reach/Cross-section:**	XS 7
Weather:	Overcast 22°C	**Location:**	Lynden Rd, Brantford
Field Staff:	JT, AA	**Watershed/Subwatershed:**	Silver Creek

Dist	Ele				Notes
2.90	2316				
3.40	2419				
3.70	2532				
3.90	2660	BF.			
4.0	3010				
4.10	3107				
4.15	3560				
4.30	3818				
4.80	4022				
5.10	4059	WL			
5.30	4099				
5.55	4139				
5.80	4173				
6.1	4157				
6.45	4210				
6.90	4105				
7.20	4039				
7.50	3760				
7.75	3703				
8.00	3573				
8.40	3379				
8.70	3109				
8.80	2949				
8.85	2820				
9.25	2145				
9.70	2152				
10.20	2140				
10.70	2142				

Cross-sectional Morphology

☐ Riffle ☐ Pool ☑ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. _____	11. _____	21. _____	31. _____
2. _____	12. _____	22. _____	32. _____
3. _____	13. _____	23. _____	33. _____
4. _____	14. _____	24. _____	34. _____
5. _____	15. _____	25. _____	35. _____
6. _____	16. _____	26. _____	36. _____
7. _____	17. _____	27. _____	37. _____
8. _____	18. _____	28. _____	38. _____
9. _____	19. _____	29. _____	39. _____
10. _____	20. _____	30. _____	40. _____

Particle Shape:

☐ Platy ☐ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embededness: _____ %

Subpavement: Till

Sorting: ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: _____ %

Velocity and Discharge

Velocity: **Method:**

☐ Estimated _____ m/s ☐ Wiffle ball
☐ Measured _____ m/s ☐ Current Meter

Discharge: ☐ ADV

☐ Estimated _____ m^3/s ☐ Marsh McBirney
☐ Measured _____ m^3/s ☐ Other

Completed by: AA Checked by: _____

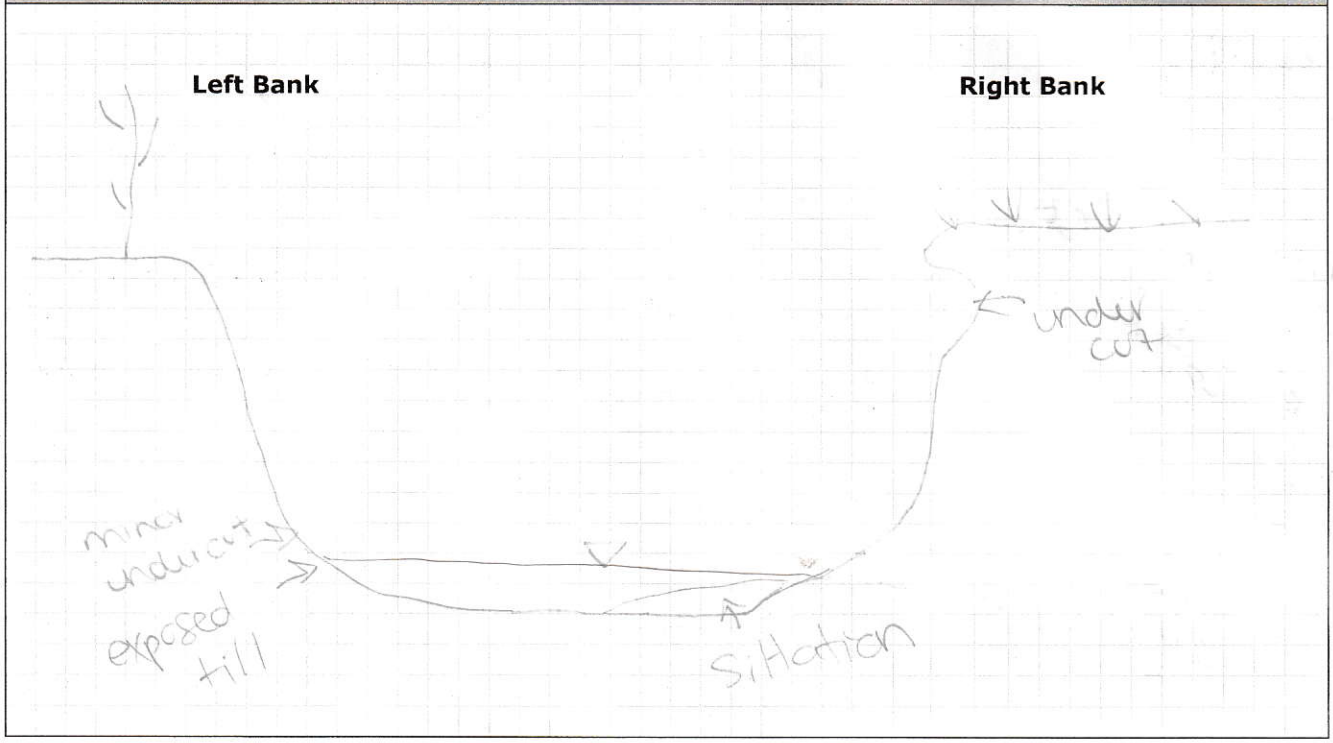
GEO MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code:

Date:	2022-02-30	Reach/XS:	XS 7

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials		Right Bank Materials	
☐ Bedrock	☐ Gravel	☐ Bedrock	☐ Gravel
☐ Till	☐ Small Cobble	☐ Till	☐ Small Cobble
☐ Clay	☐ Large Cobble	☐ Clay	☐ Large Cobble
☑ Silt	☐ Small Boulder	☑ Silt	☐ Small Boulder
☑ Sand	☐ Large Boulder	☑ Sand	☐ Large Boulder
Bank Height: 1.75 m		Bank Height: 2.00 m	
Bank Angle: 85 °		Bank Angle: 70 °	
Root Depth: 1.10 m		Root Depth: 0.75 m	
Root Density: 30 %		Root Density: 10 %	
Undercut: 0.25 m		Undercut: 0.27 m	
Erosion Pin: ____ m		Erosion Pin: ____ m	
Penetrometer: ____ kg/cm²		Penetrometer: ____ kg/cm²	
Foot Used: ☐ Yes ☐ No		Foot Used: ☐ Yes ☐ No	

Additional Notes

Photo Order: US, DS, LB, RB

Completed by: _____ Checked by: _____

Page ____ of ____

GEO | MORPHIX
Geomorphology
Earth Science
Observations

Cross-Section Characteristics **Project Code:** 22045

Date:	2022-08-30	Reach/Cross-section:	X8
Weather:	Overcast 22°C	Location:	
Field Staff:	JT AA	Watershed/Subwatershed:	

					Notes
RTK					

Cross-sectional Morphology

☐ Riffle ☐ Pool ☑ Run ☐ Other

Substrate

Sample:

☑ Bed ☑ Bank ☑ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. Fines	11. ___	21. ___	31. ___
2. ___	12. ___	22. ___	32. ___
3. ___	13. ___	23. ___	33. ___
4. ___	14. ___	24. ___	34. ___
5. ___	15. ___	25. ___	35. ___
6. ___	16. ___	26. ___	36. ___
7. ___	17. ___	27. ___	37. ___
8. ___	18. ___	28. ___	38. ___
9. ___	19. ___	29. ___	39. ___
10. ___	20. ___	30. ___	40. ___

Particle Shape:

☐ Platy ☐ Sub-angular ☐ Well Rounded
☐ Very Angular ☐ Angular ☐ Sub-Rounded
☐ Rounded

Embededness: ________ %

Subpavement: Till

Sorting: ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Observed ☐ Not Observed

If Observed:

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active: ________ %

Velocity and Discharge

Velocity:

☐ Estimated ______ m/s
☐ Measured ______ m/s

Discharge:

☐ Estimated ______ m^3/s
☐ Measured ______ m^3/s

Method:

☐ Wiffle ball
☐ Current Meter
☐ ADV
☐ Marsh McBirney
☐ Other

Completed by: AA Checked by: ________

Page ____ of ____

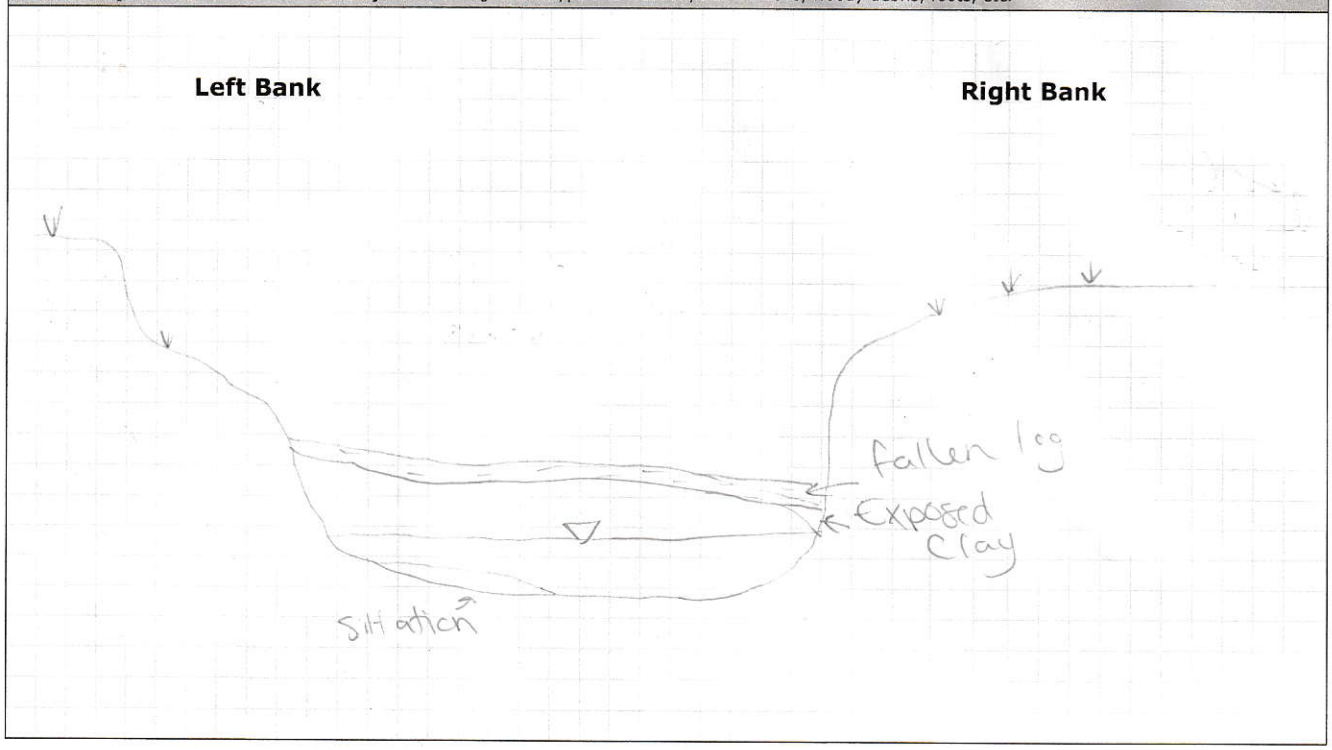
GEO MORPHIX
Geomorphology Earth Science Observations

Bank Characteristics

Project Code: 22C45

Date:	2022-08-30	Reach/XS:	XS8

Sketch (Viewed Downstream) Include: vegetation type and location, soil horizons, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☑ Clay	☐ Large Cobble		
☑ Silt	☐ Small Boulder		
☑ Sand	☐ Large Boulder		
Bank Height:	1.72	m	
Bank Angle:	60	°	
Root Depth:	0.2	m	
Root Density:	25	%	
Undercut:	0	m	
Erosion Pin:		m	
Penetrometer:		kg/cm²	
Foot Used:	☐ Yes	☐ No	

Right Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☑ Clay	☐ Large Cobble		
☑ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	1.41	m	
Bank Angle:	75	°	
Root Depth:	1	m	
Root Density:	25	%	
Undercut:	0	m	
Erosion Pin:		m	
Penetrometer:		kg/cm²	
Foot Used:	☐ Yes	☐ No	

Additional Notes

Photo Order: US, DS, LB, RB

Completed by: _____ Checked by: _____

Page ____ of ____

Appendix F
Detailed Assessments

Detailed Geomorphological Assessment Summary

Reach SC-A-5

Project Number:	PN22045	**Date:**	2022-08-30
Client:	Sorbara	**Length Surveyed (m):**	100.3
Location:	Lynden Rd., Brantford	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	597 ha	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	Laminated Glaciolacustrine Till	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Agricultural	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	Mature (>30 years)
Dominant Instream Vegetation Type:	N/A	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	N/A	**Density of Woody Debris:**	High

Hydrology

Measured Discharge (m^3/s):	0.07	**Calculated Bankfull Discharge (m^3/s):**	6.70
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.11
Modelled 2-year Velocity (m/s):	Not modelled		

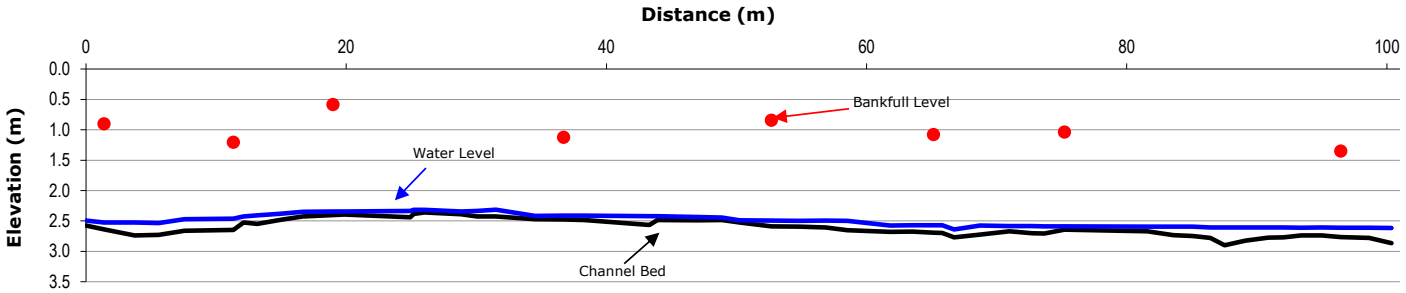
Profile Characteristics

Bankfull Gradient (%):	0.34
Channel Bed Gradient (%):	0.32
Riffle Gradient (%):	1.70
Riffle Length (m):	9.55
Riffle-Pool Spacing (m):	15.69

Planform Characteristics

Sinuosity:	1.45
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	1.22	2.00	1.68
Bank Angle (deg):	45	90	71
Root Depth (m):	0.20	1.50	0.90
Root Density (%):	5	50	22
Bank Undercut (m):	0	0.75	0.17

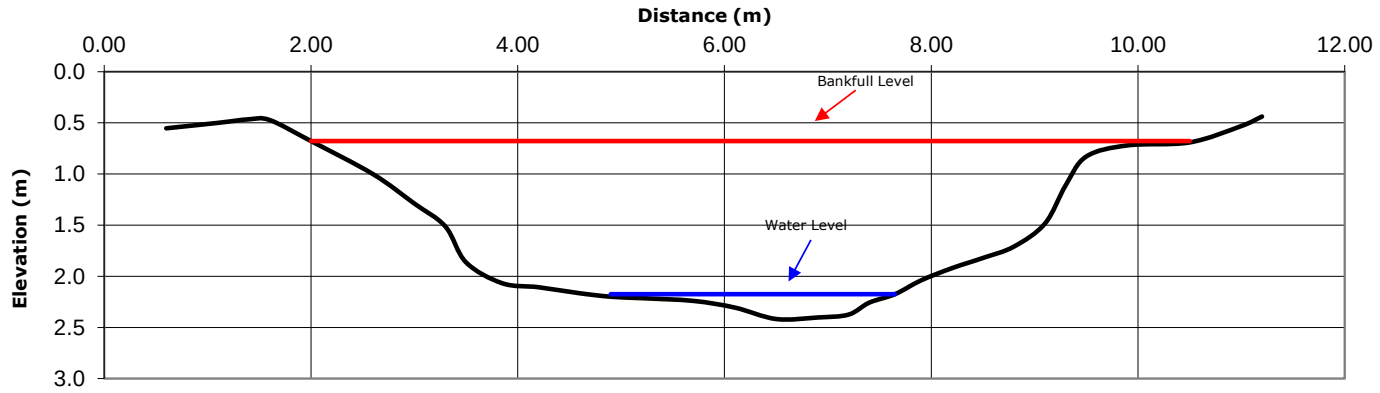
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):			

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	4.70	8.50	6.02
Average Bankfull Depth (m):	0.80	1.20	1.01
Bankfull Width/Depth (m/m):	4	8	6
Wetted Width (m):	1.73	2.90	2.18
Average Water Depth (m):	0.08	0.17	0.12
Wetted Width/Depth (m/m):	11	26	20
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.00	0.29	0.21
Manning's *n*:		0.053	

Photograph at cross section 1 (looking upstream)

Representative Cross-Section 1



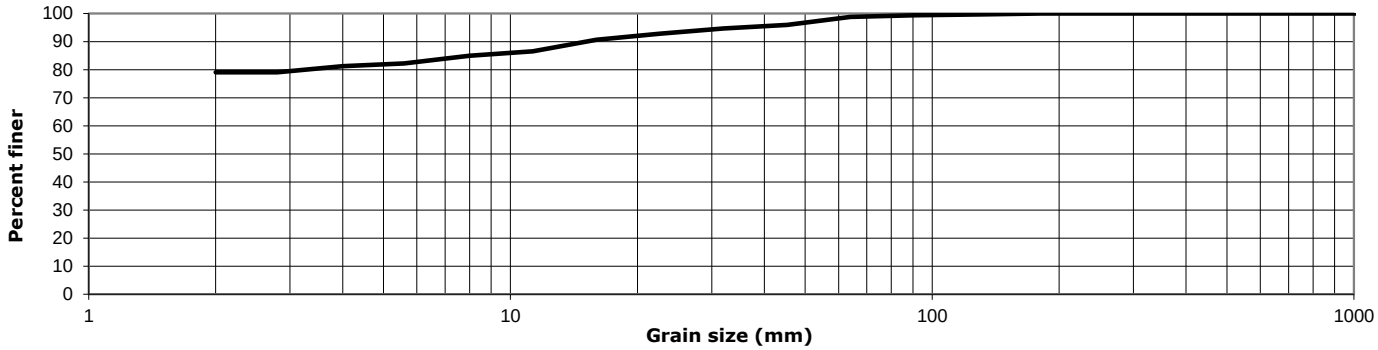
Substrate Characteristics

Particle Size (mm)

D_{10}:	<2
D_{50}:	<2
D_{84}:	7.0

Subpavement:	Till
Particle shape:	Sub-angular
Embeddedness (%):	50
Particle range (riffle):	Clay to gravel
Particle Range (pool):	Clay/silt and sand

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	33.59
for D_{50}:	n/a	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.48	**Critical Shear Stress (D_{50}) (N/m^2):**	0.00
Unit Stream Power at Bankfull (W/m^2):	37.12		

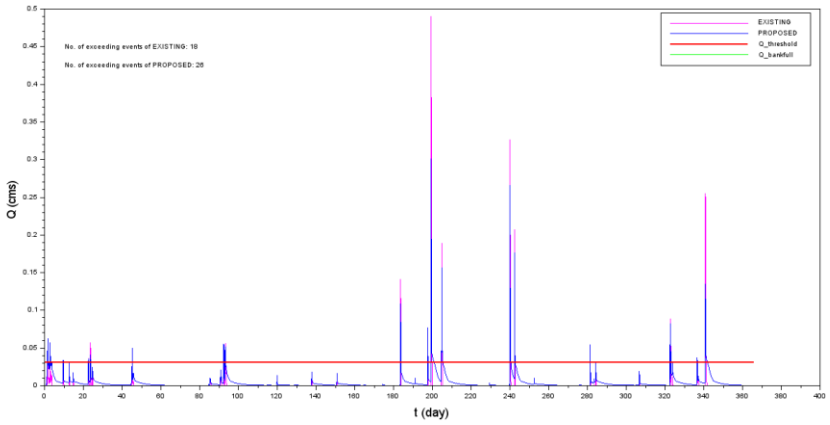
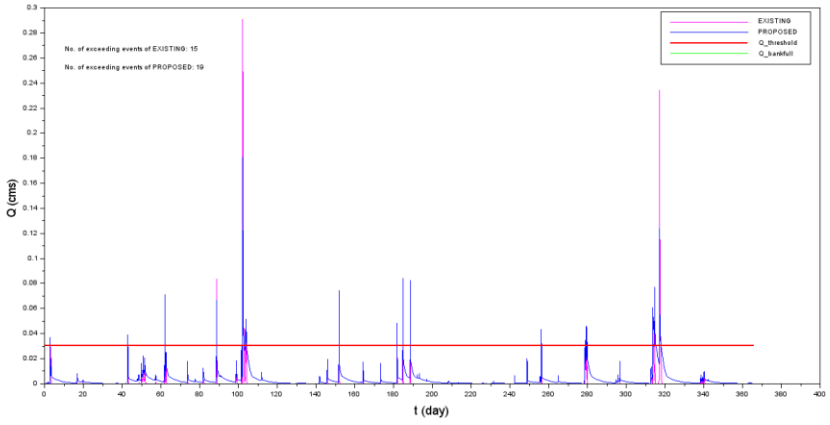
General Field Observations

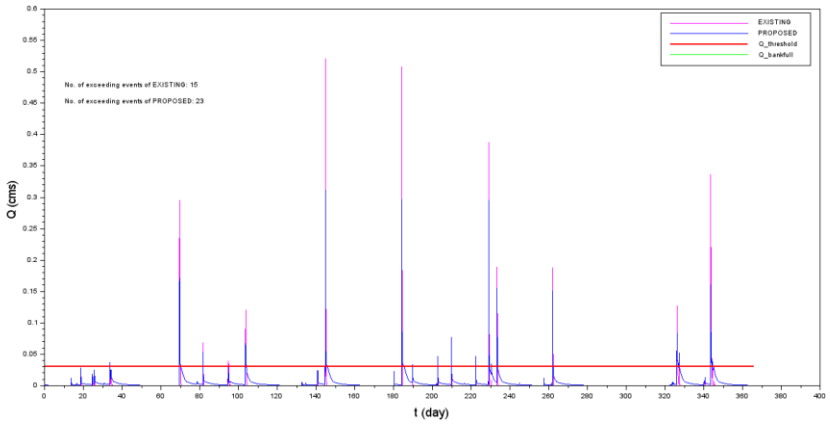
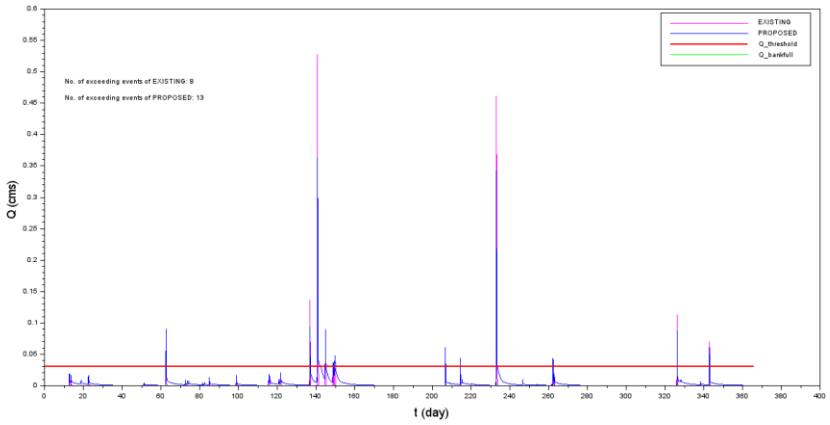
Channel Description

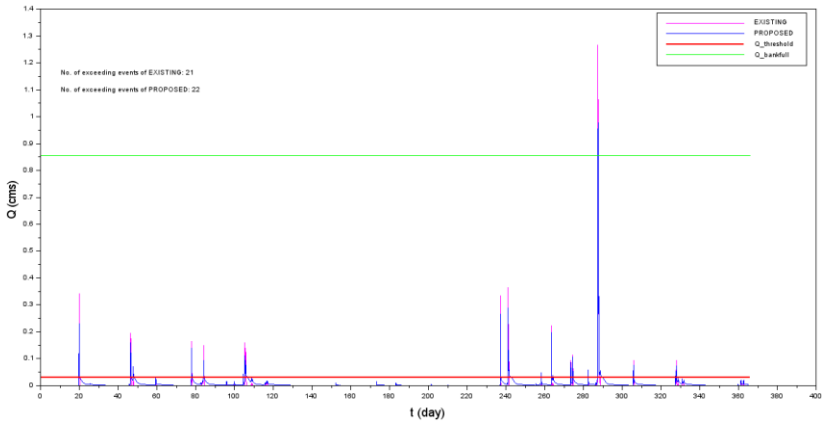
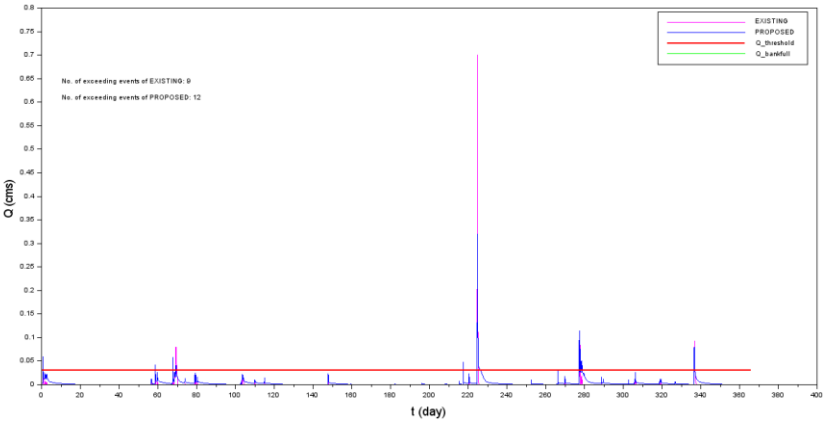
Reach SC-A-5 was an irregularly meandering channel with a moderate gradient, situated within a confined valley. Adjacent land use consisted of forests. Riparian cover was continuous and spanned over 10 channel widths, primarily consisting of trees. Bed substrate was comprised of clay to cobble sized particles. The banks were sparesly vegetated and showed signs of heavy erosion and undercutting throughout the reach. Few locations along the reach had contact with the valley wall. A high density of woody debris was present within the channel and cutbanks at the time of assessment.

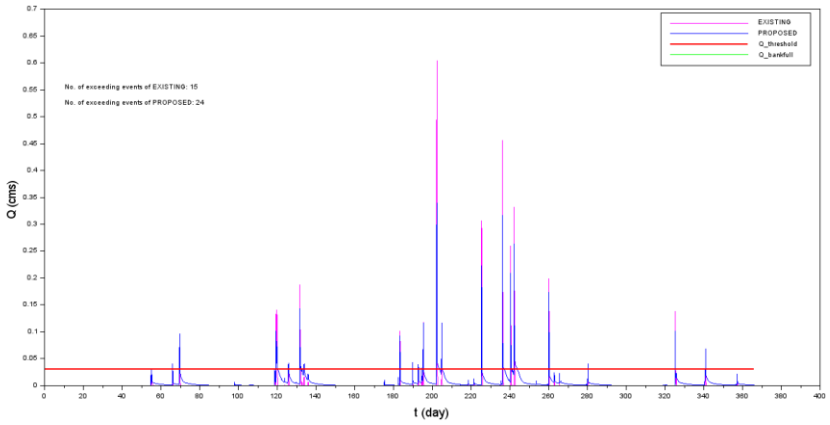
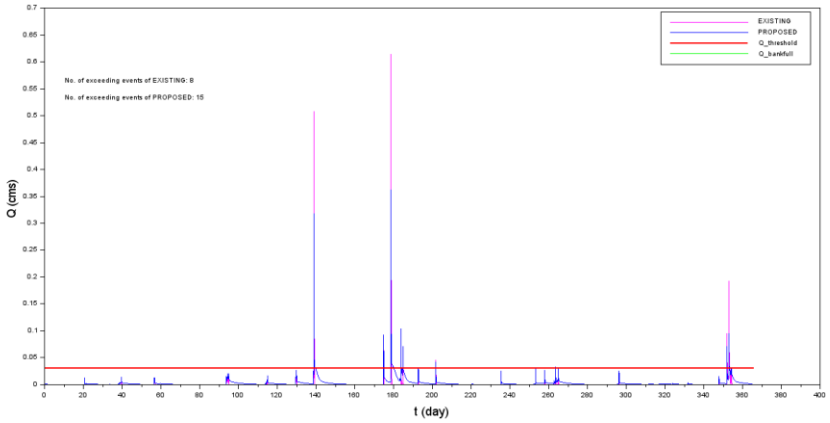
Cross Section 5 - Facing Downstream

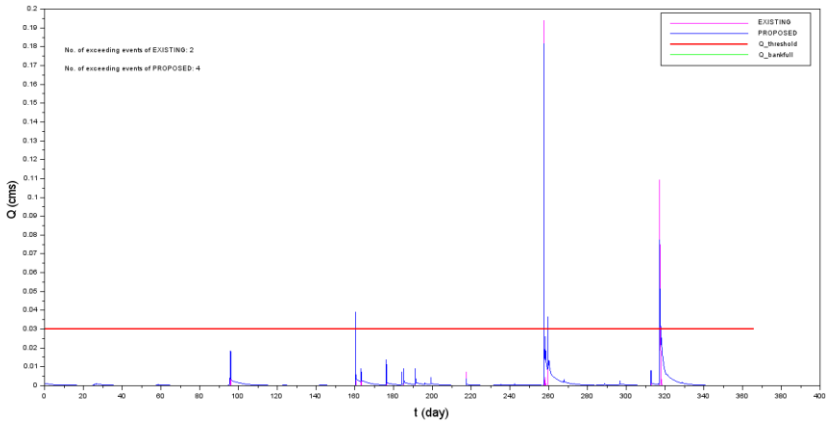
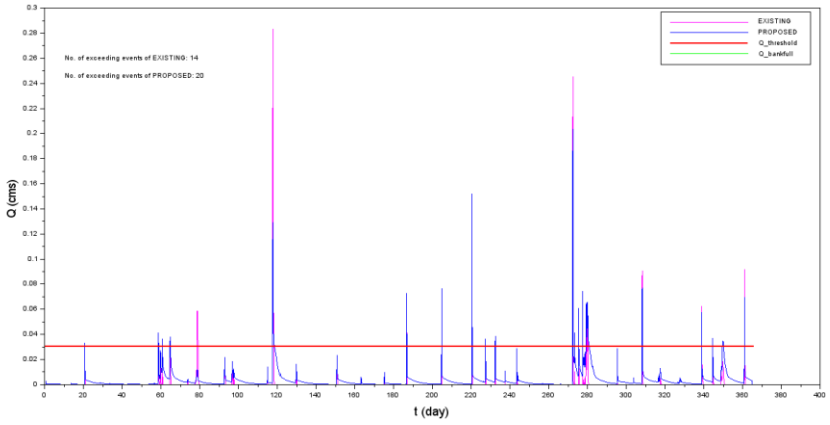
Appendix G
Hydrographs

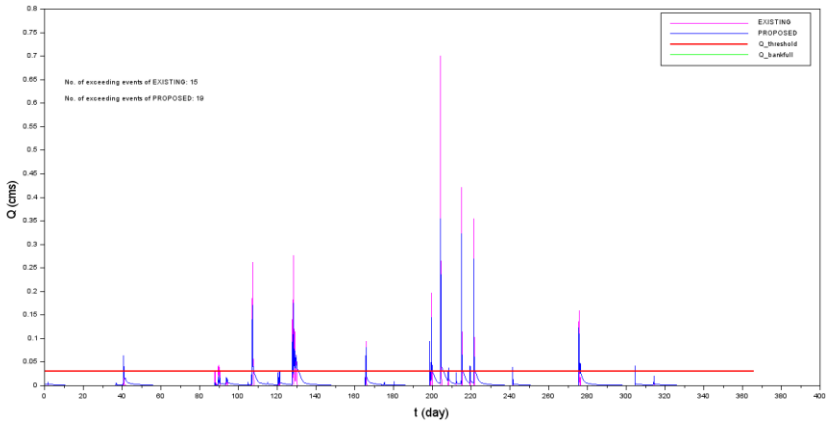
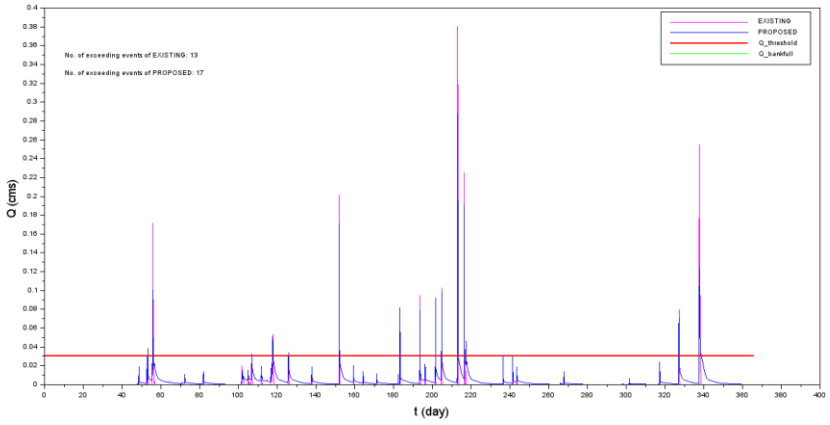
Flows to Critical Reach TFC4-1 1950	
Flows to Critical Reach TFC4-1 1951	

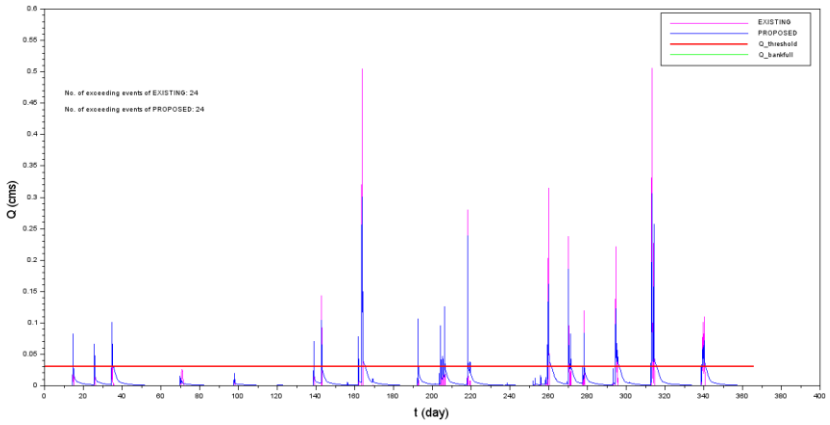
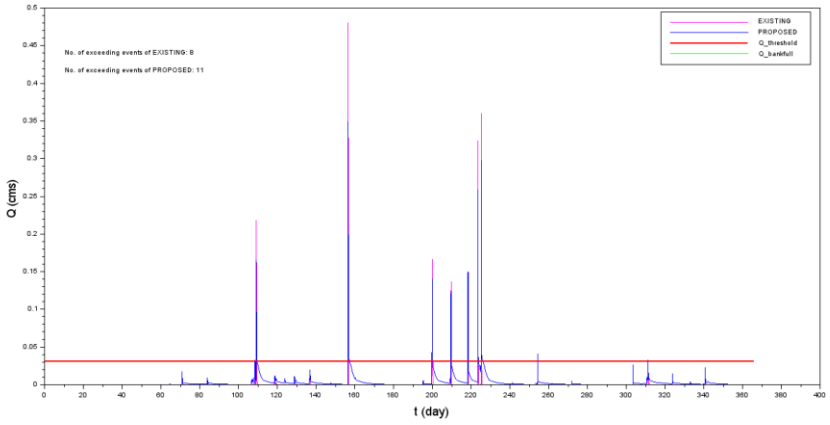
Flows to Critical Reach TFC4-1 1952	
Flows to Critical Reach TFC4-1 1953	

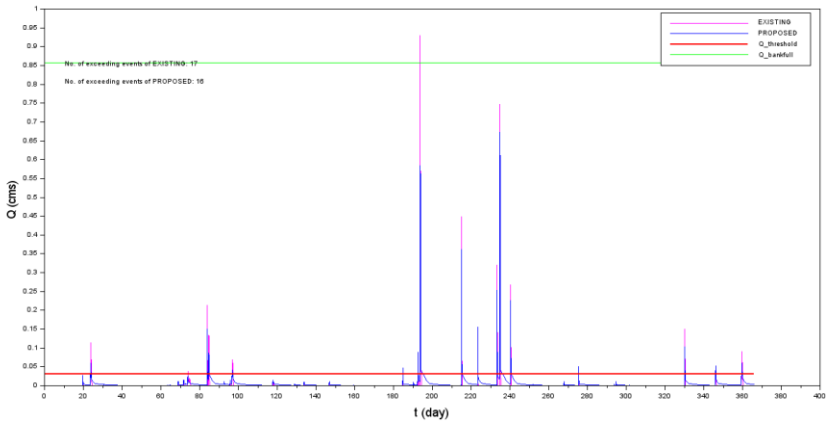
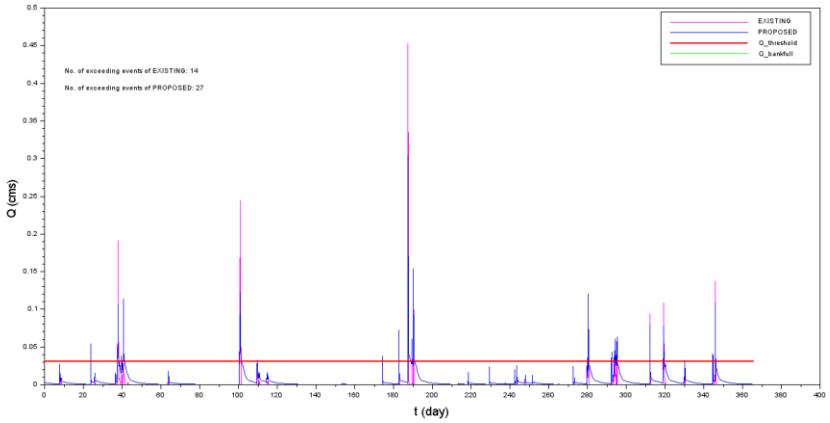
Flows to Critical Reach TFC4-1 1954	
Flows to Critical Reach TFC4-1 1955	

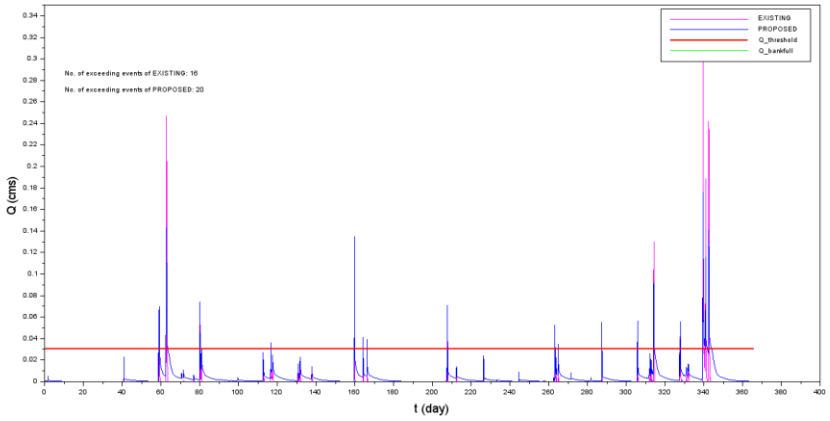
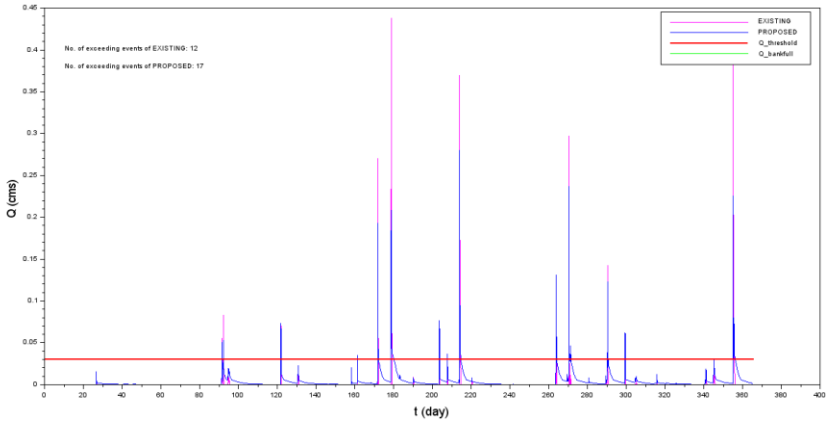
Flows to Critical Reach TFC4-1 1956	
Flows to Critical Reach TFC4-1 1957	

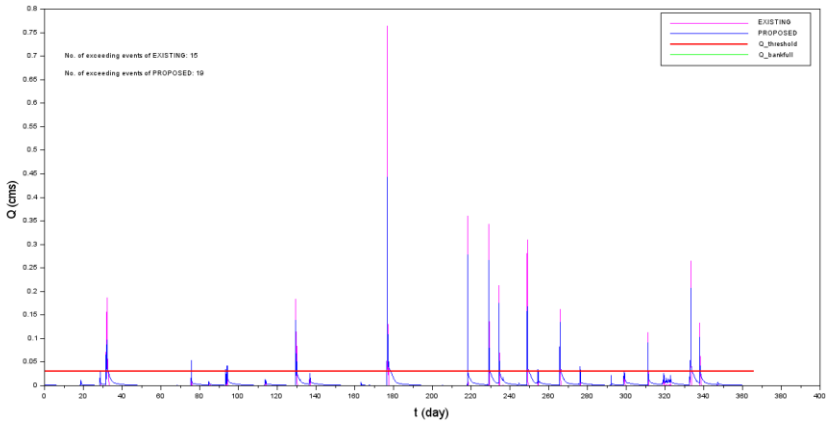
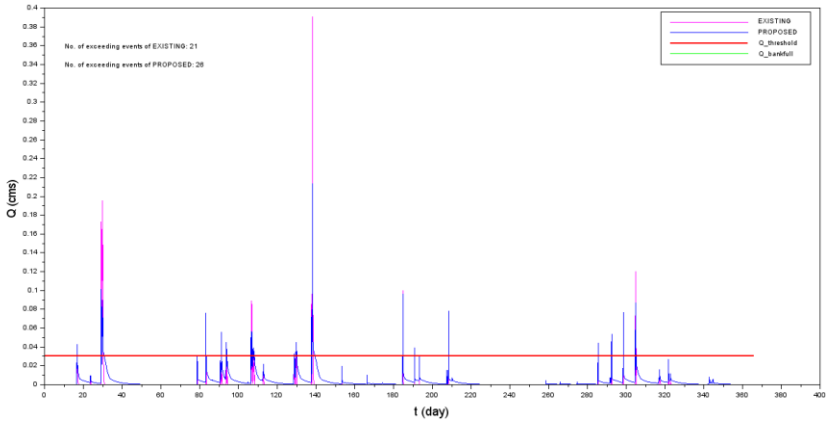
Flows to Critical Reach TFC4-1 1958	
Flows to Critical Reach TFC4-1 1959	

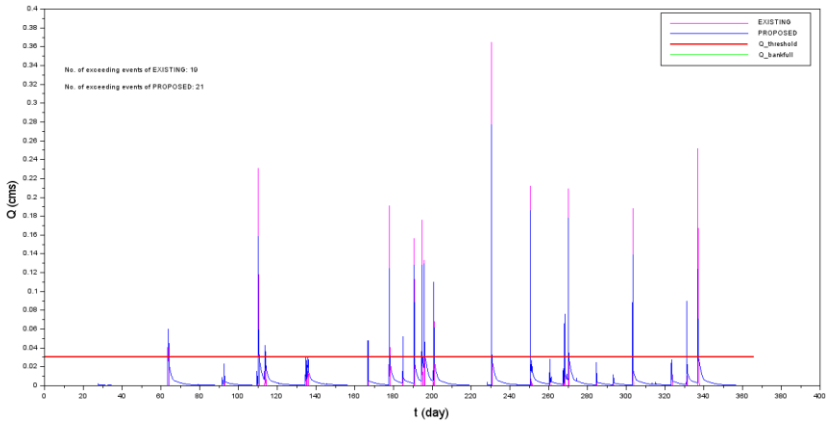
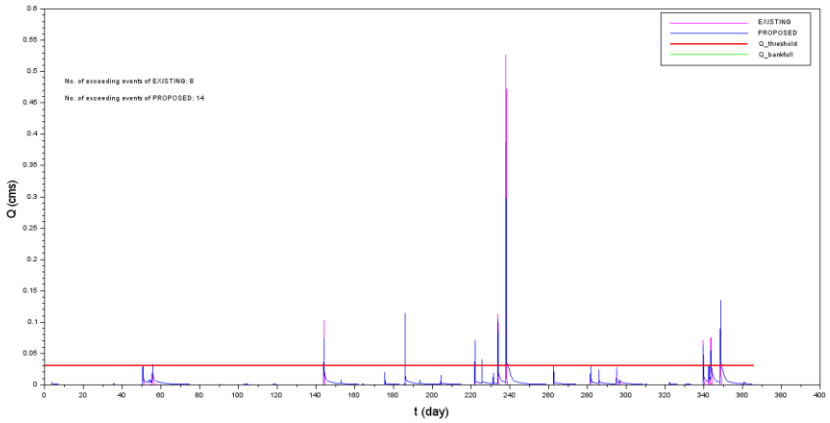
Flows to Critical Reach TFC4-1 1960	
Flows to Critical Reach TFC4-1 1961	

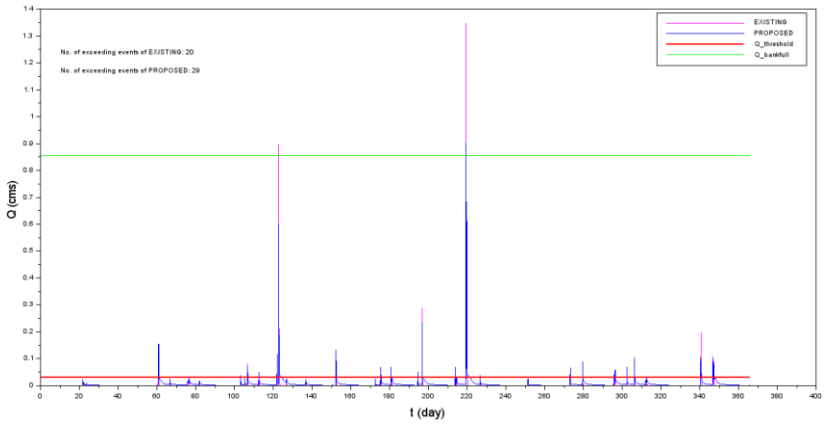
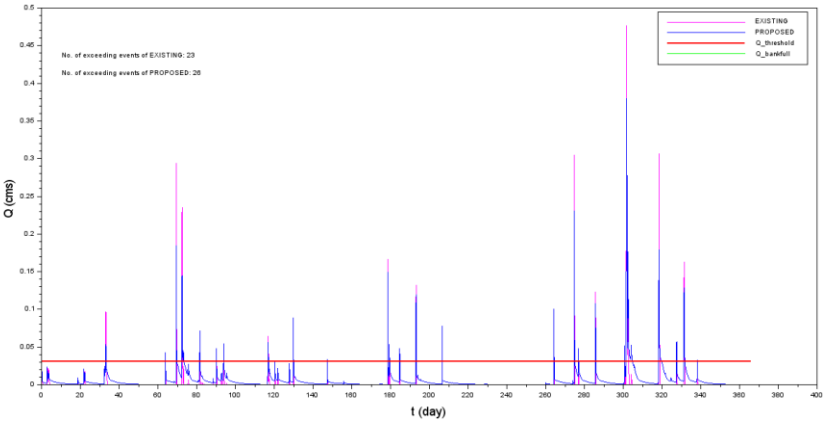
Flows to Critical Reach TFC4-1 1962	
Flows to Critical Reach TFC4-1 1963	

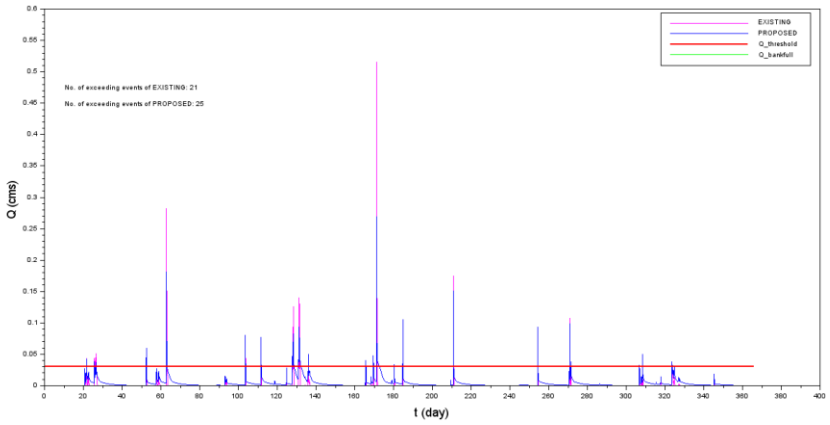
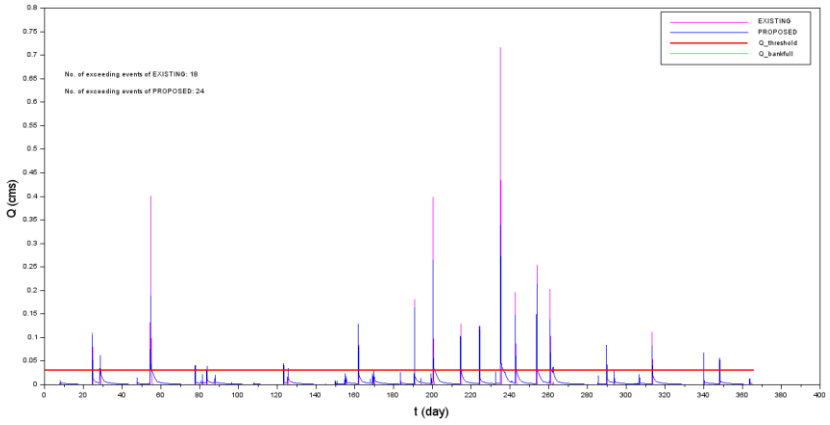
Flows to Critical Reach TFC4-1 1964	
Flows to Critical Reach TFC4-1 1965	

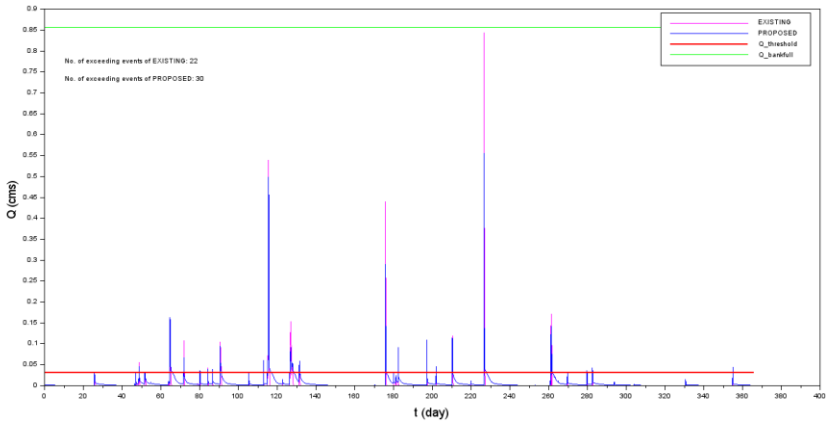
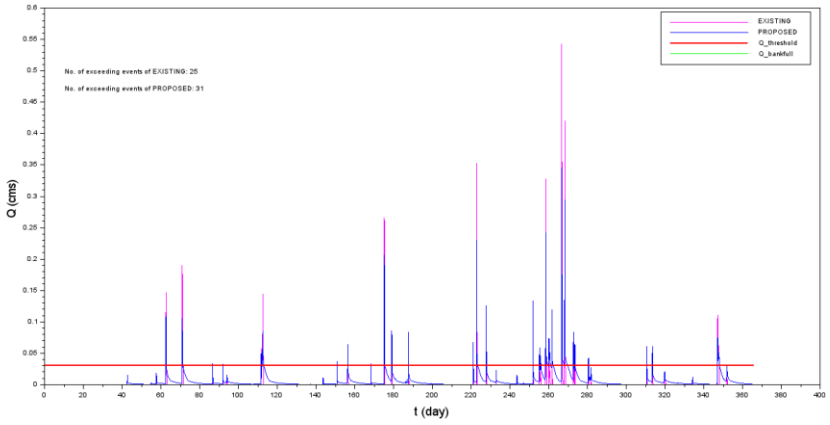
Flows to Critical Reach TFC4-1 1966	
Flows to Critical Reach TFC4-1 1967	

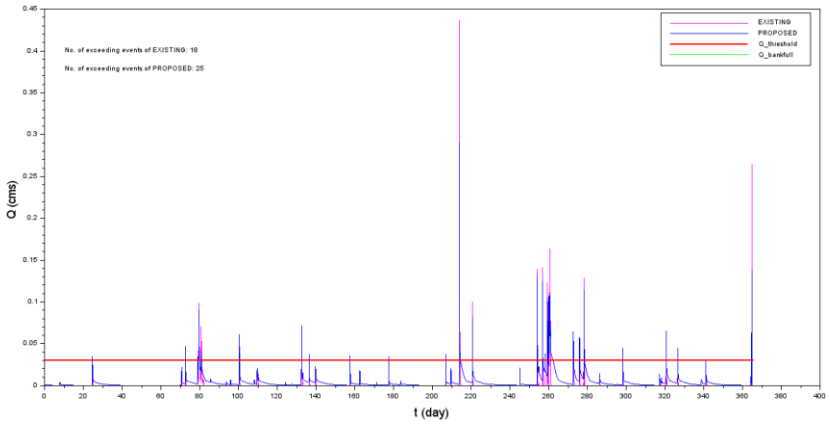
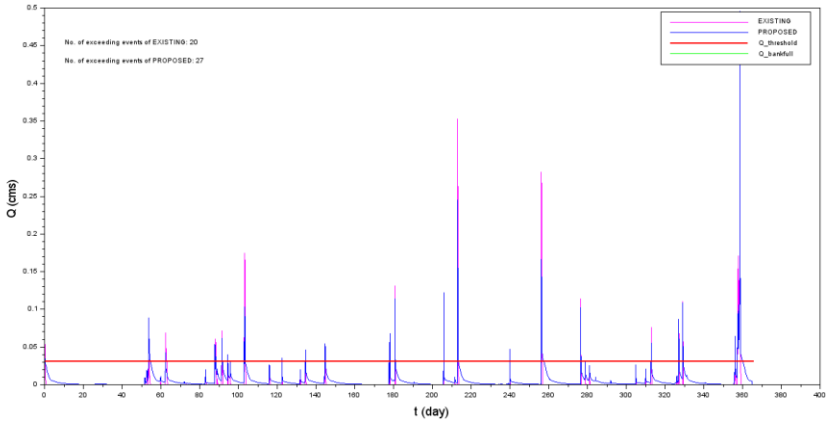
Flows to Critical Reach TFC4-1 1968	
Flows to Critical Reach TFC4-1 1969	

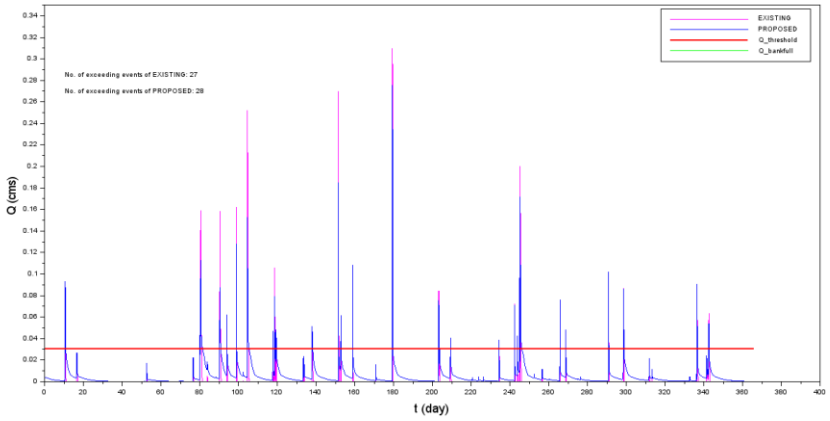
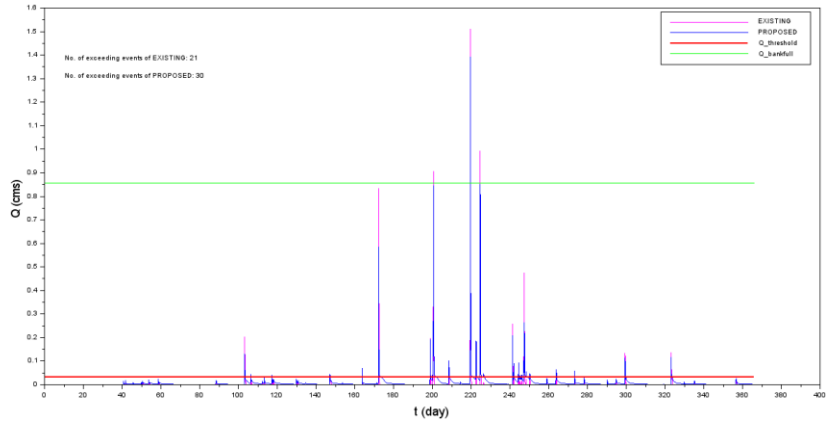
Flows to Critical Reach TFC4-1 1970	
Flows to Critical Reach TFC4-1 1971	

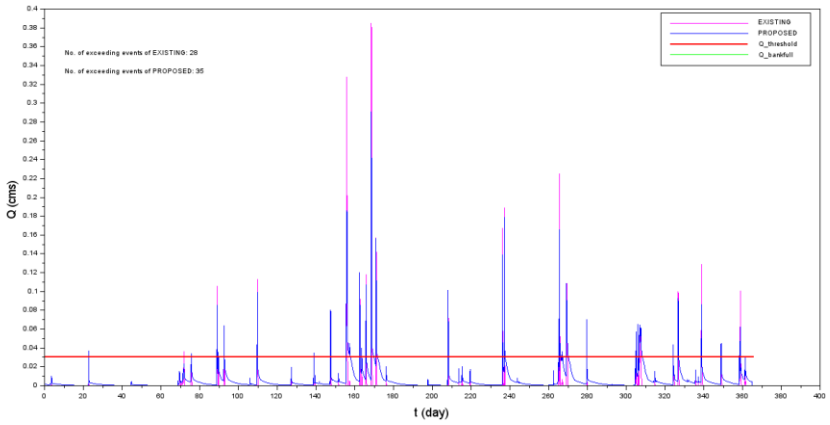
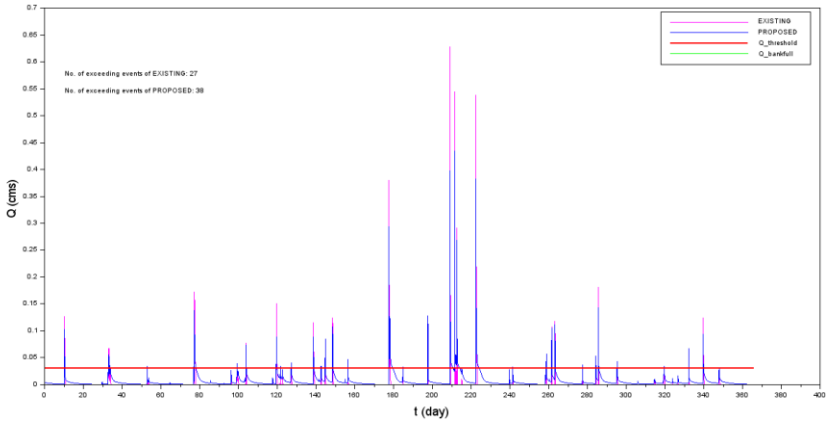
Flows to Critical Reach TFC4-1 1972	
Flows to Critical Reach TFC4-1 1973	

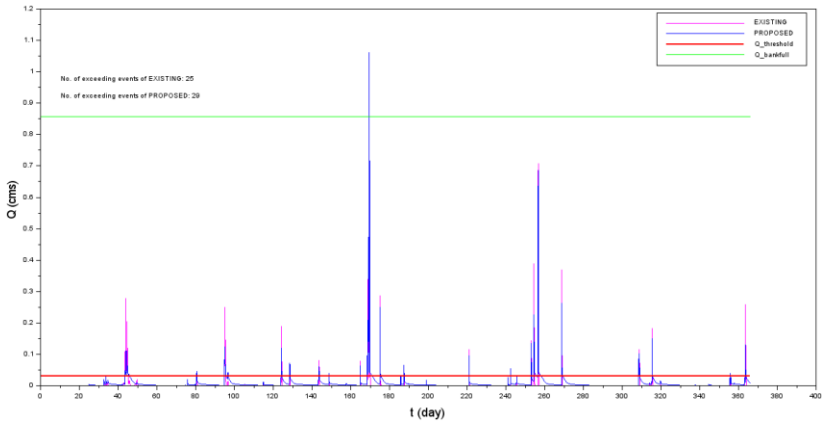
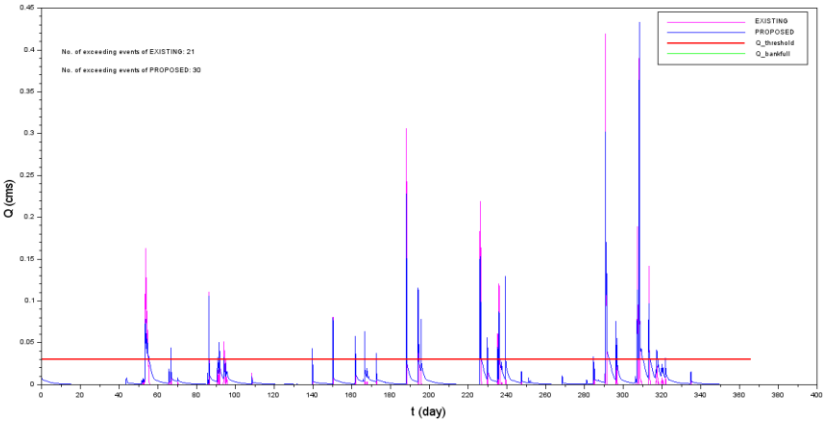
Flows to Critical Reach TFC4-1 1974	
Flows to Critical Reach TFC4-1 1975	

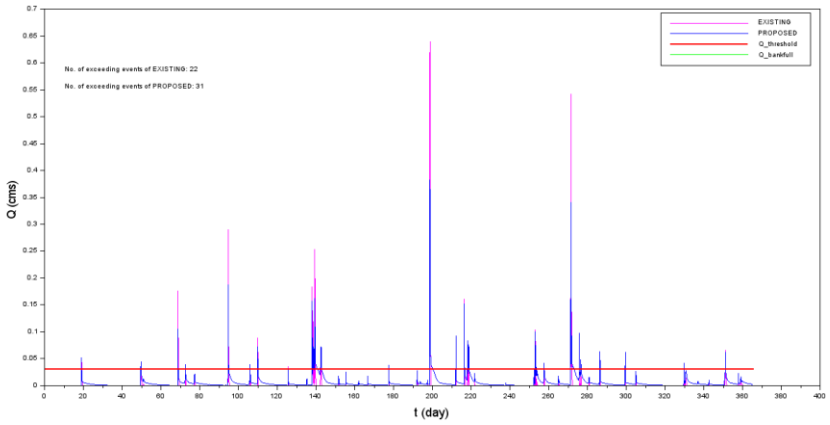
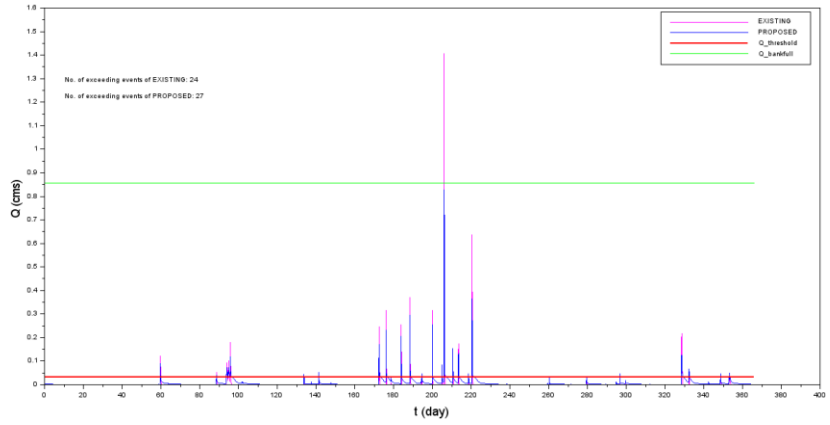
Flows to Critical Reach TFC4-1 1976	
Flows to Critical Reach TFC4-1 1977	

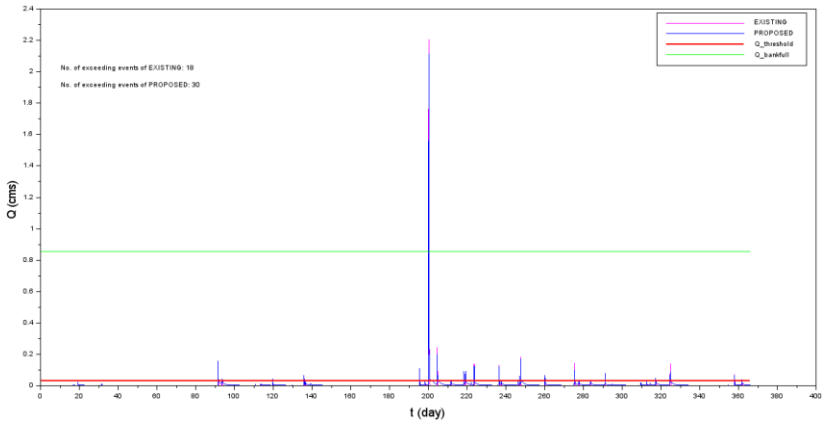
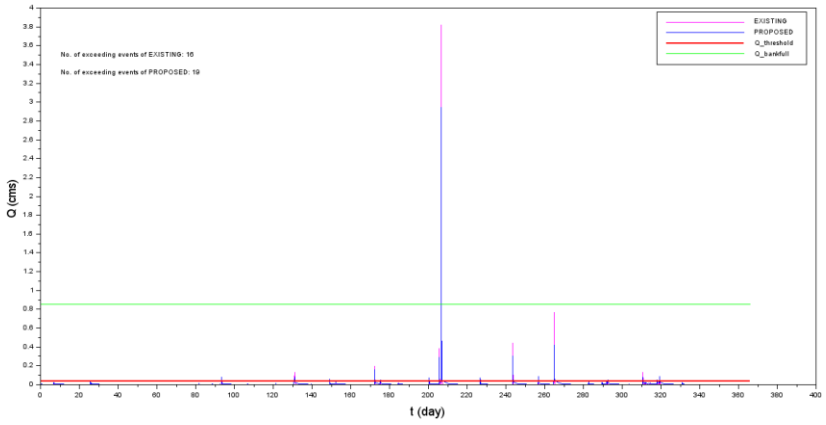
Flows to Critical Reach TFC4-1 1978	
Flows to Critical Reach TFC4-1 1979	

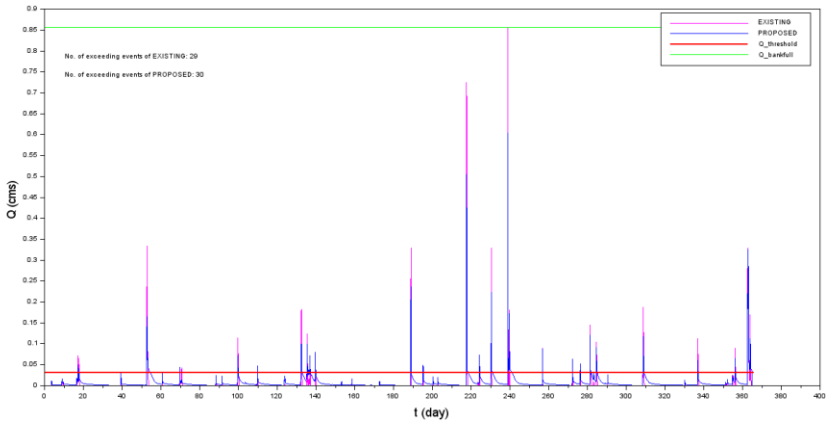
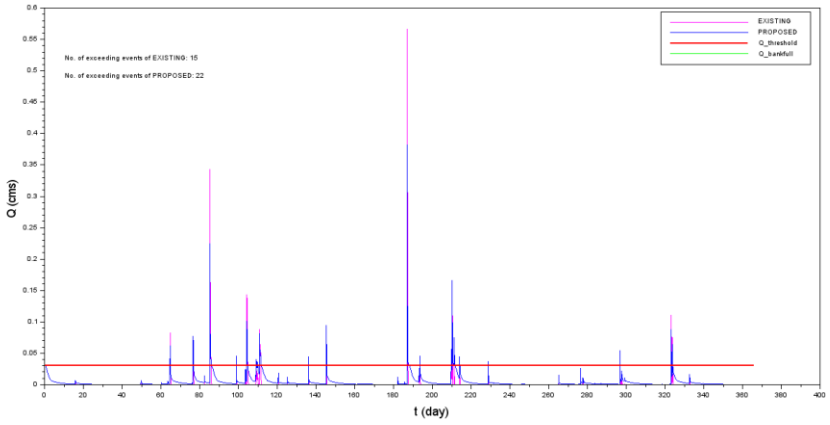
Flows to Critical Reach TFC4-1 1980	
Flows to Critical Reach TFC4-1 1981	

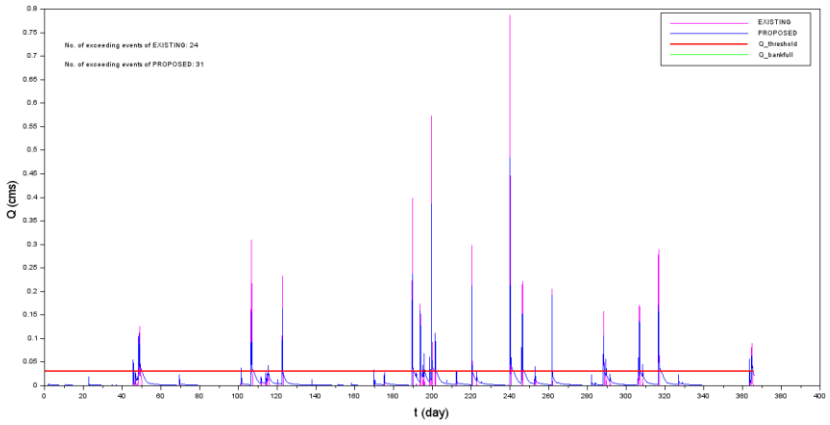
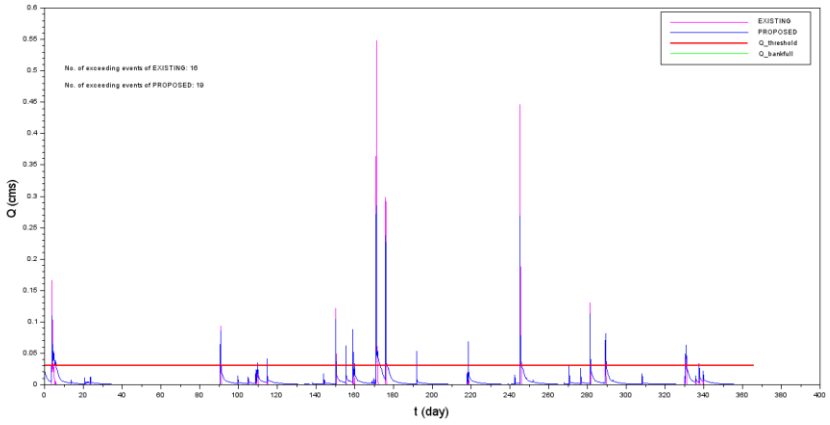
Flows to Critical Reach TFC4-1 1982	
Flows to Critical Reach TFC4-1 1983	

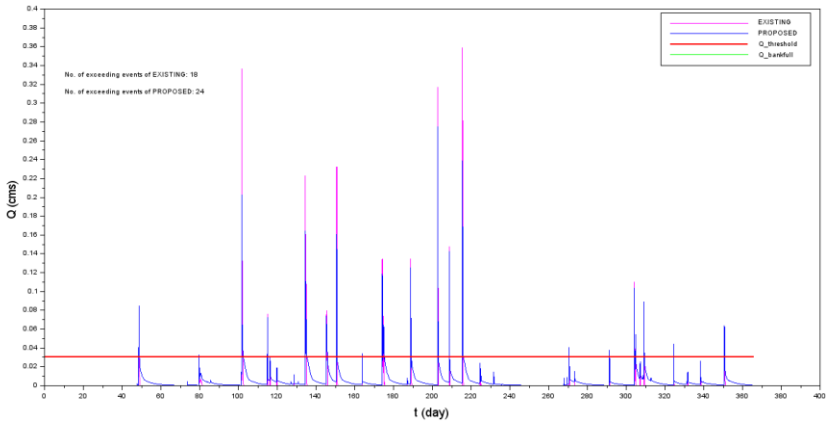
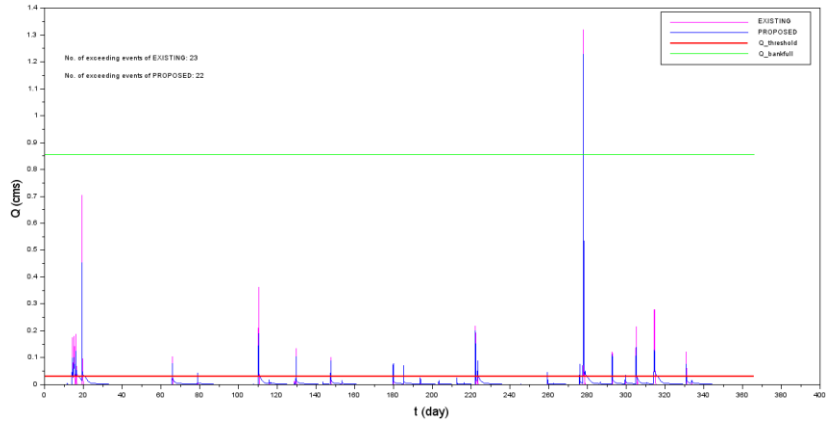
Flows to Critical Reach TFC4-1 1984	
Flows to Critical Reach TFC4-1 1985	

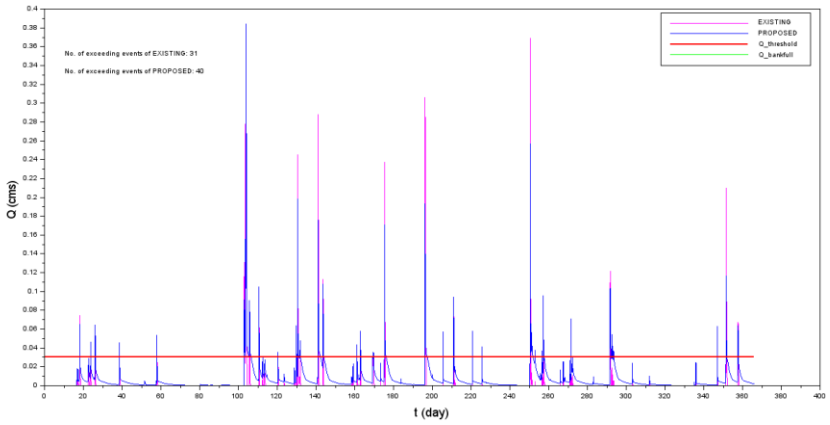
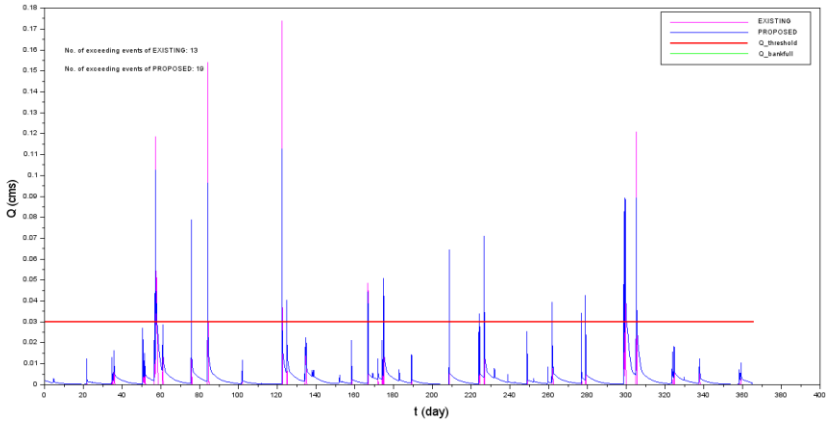
Flows to Critical Reach TFC4-1 1986	
Flows to Critical Reach TFC4-1 1987	

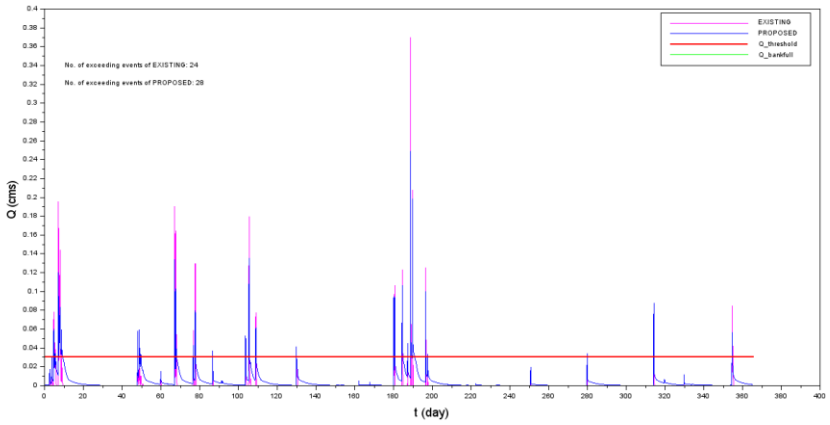
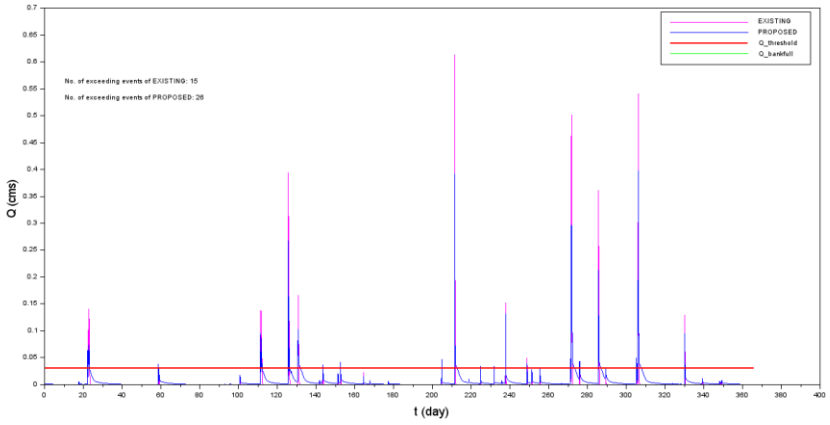
Flows to Critical Reach TFC4-1 1988	
Flows to Critical Reach TFC4-1 1989	

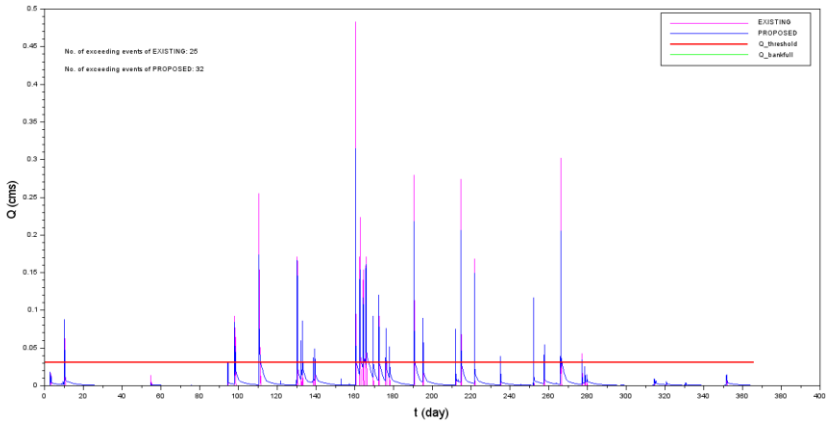
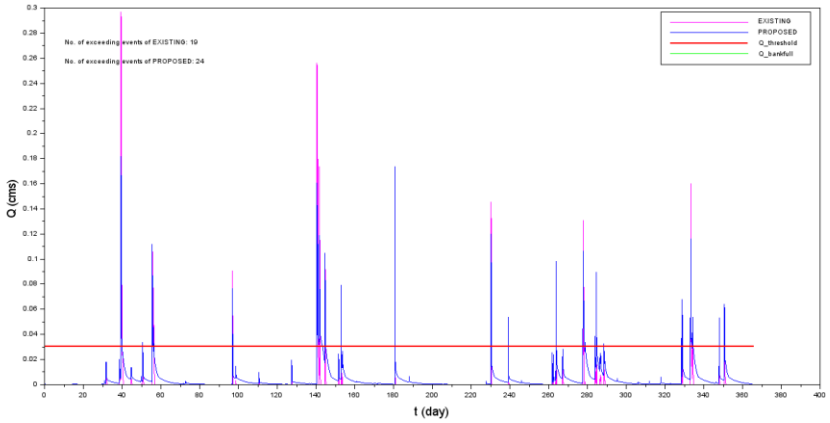
Flows to Critical Reach TFC4-1 1990	
Flows to Critical Reach TFC4-1 1991	

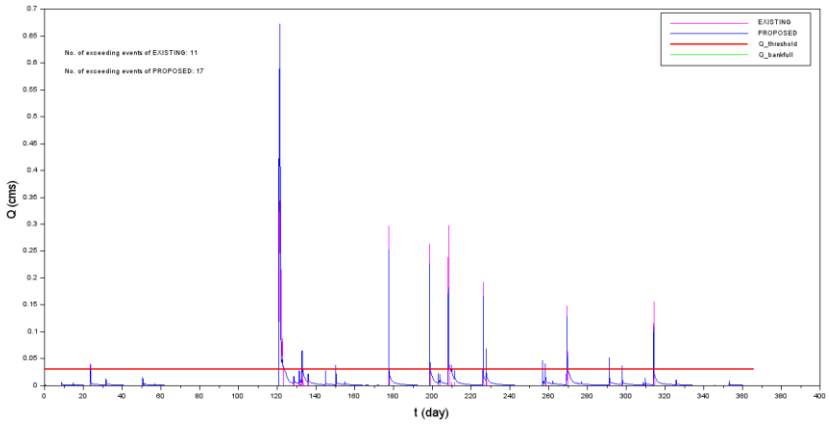
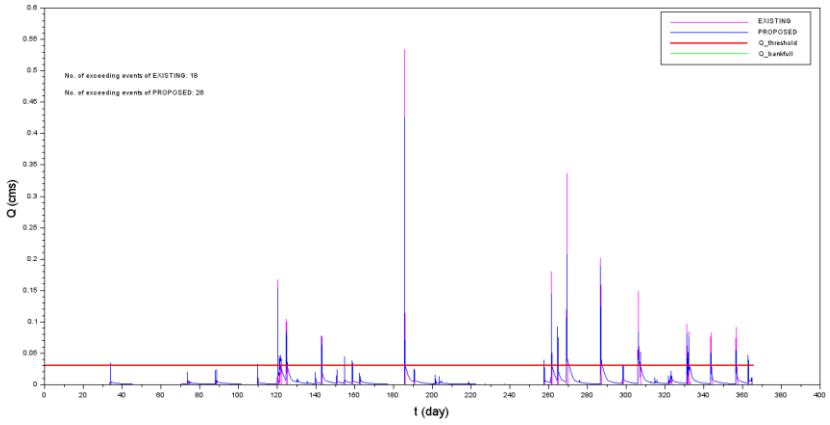
Flows to Critical Reach TFC4-1 1992	
Flows to Critical Reach TFC4-1 1993	

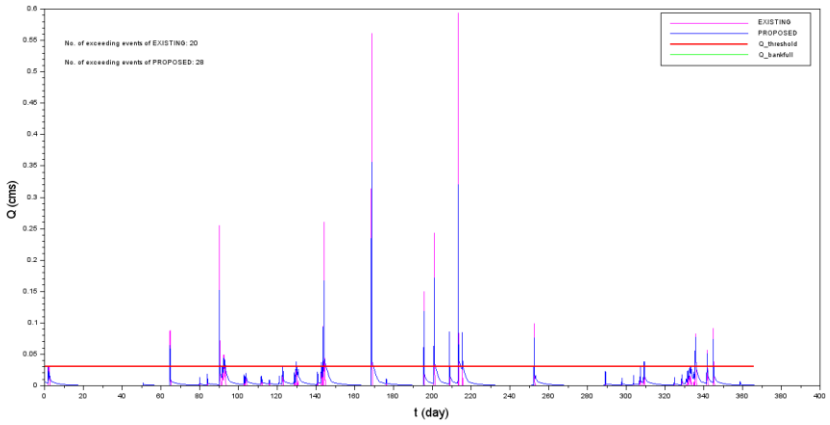
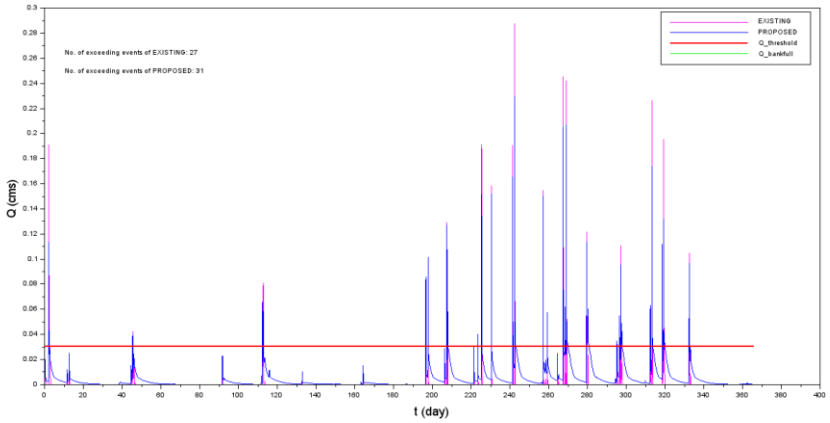
Flows to Critical Reach TFC4-1 1994	
Flows to Critical Reach TFC4-1 1995	

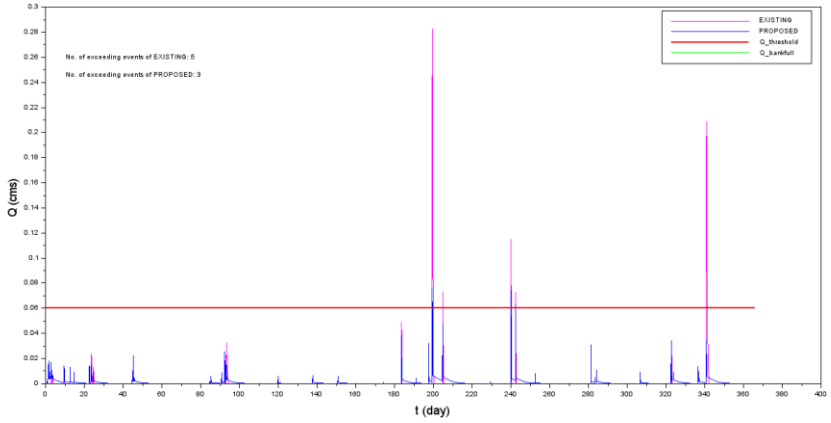
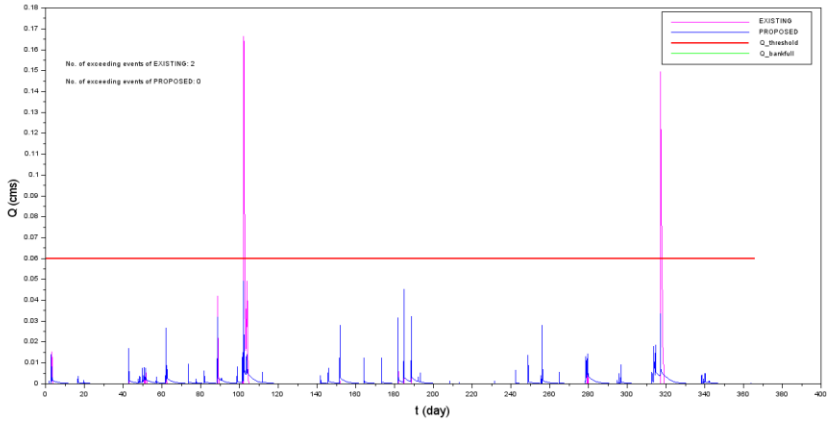
Flows to Critical Reach TFC4-1 1996	
Flows to Critical Reach TFC4-1 1997	

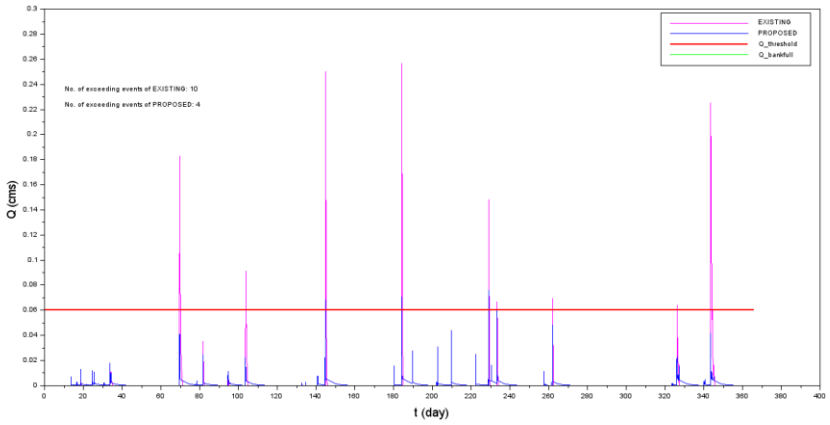
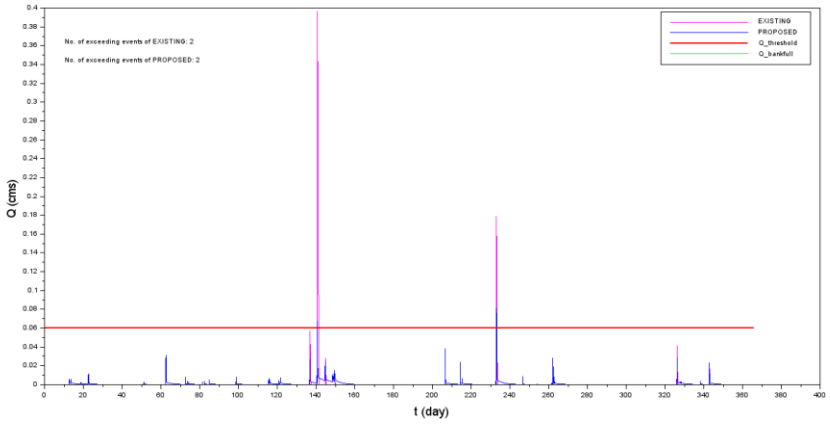
Flows to Critical Reach TFC4-1 1998	
Flows to Critical Reach TFC4-1 1999	

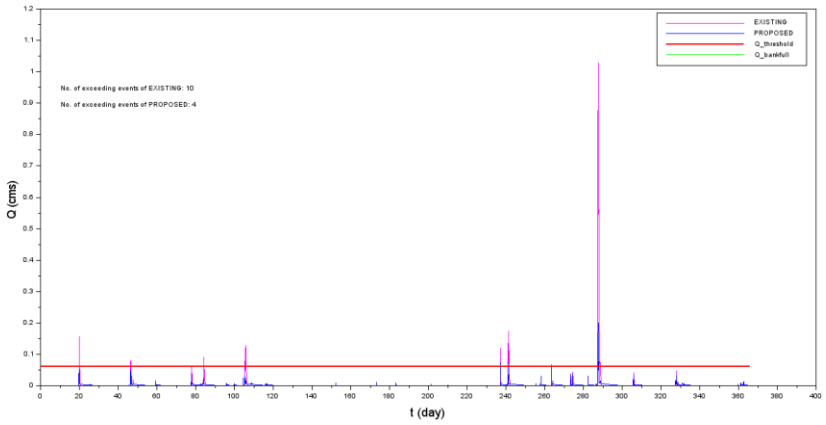
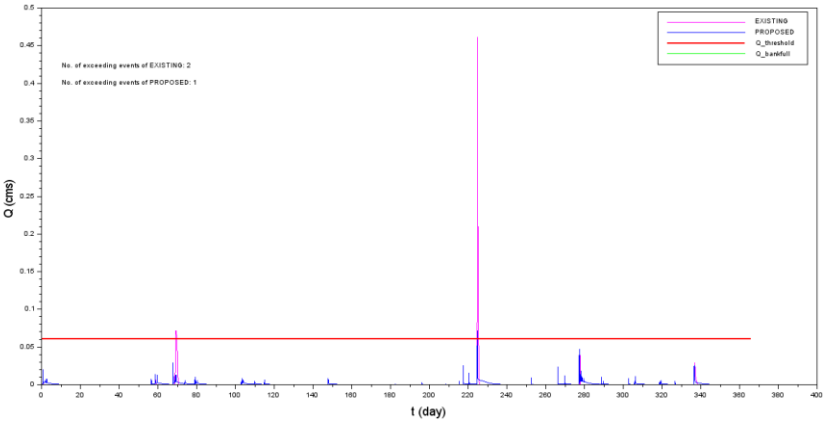
Flows to Critical Reach TFC4-1 2000	
Flows to Critical Reach TFC4-1 2001	

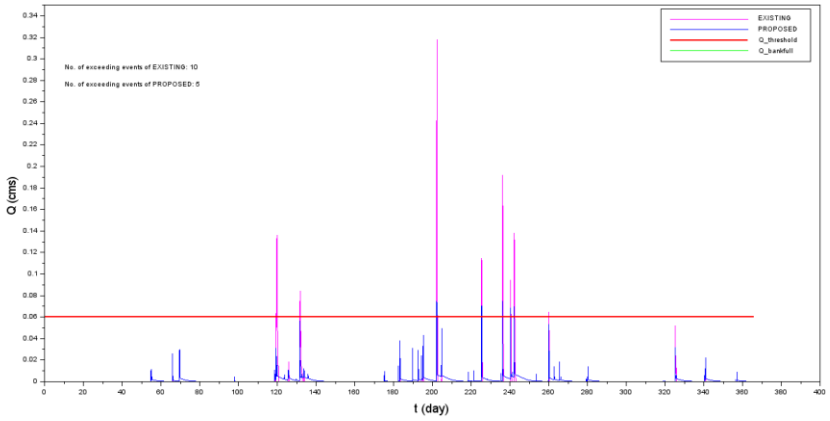
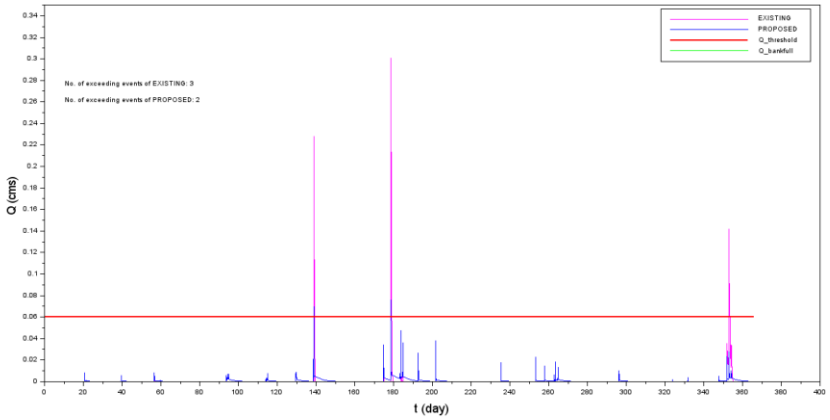
Flows to Critical Reach TFC4-1 2002	
Flows to Critical Reach TFC4-1 2003	

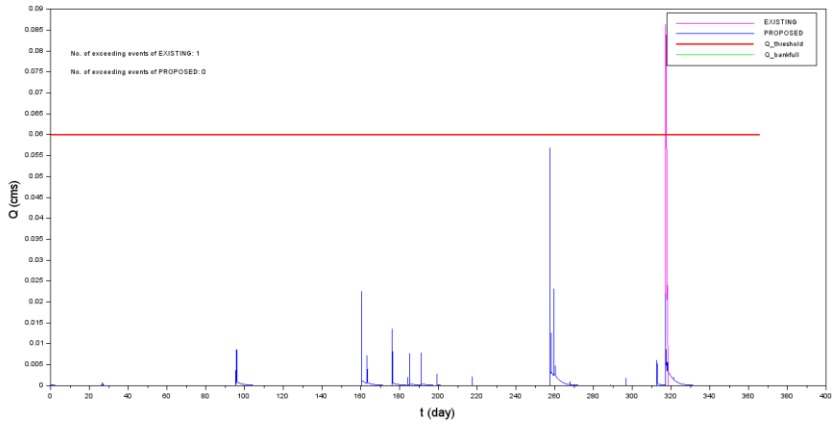
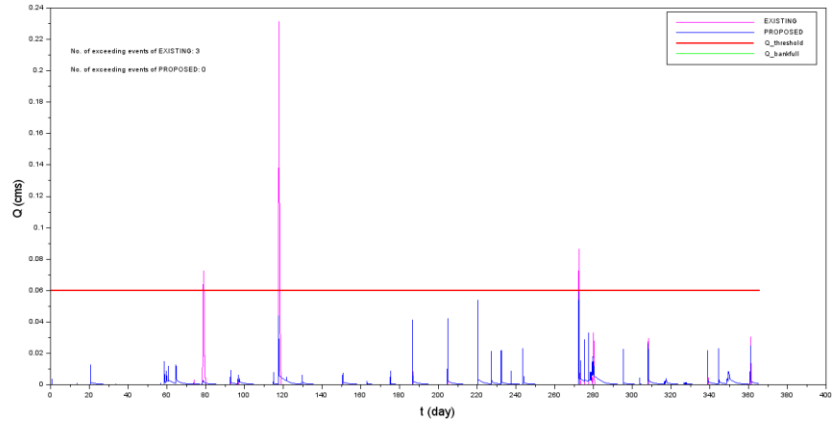
Flows to Critical Reach TFC4-1 2004	
Flows to Critical Reach TFC4-1 2005	

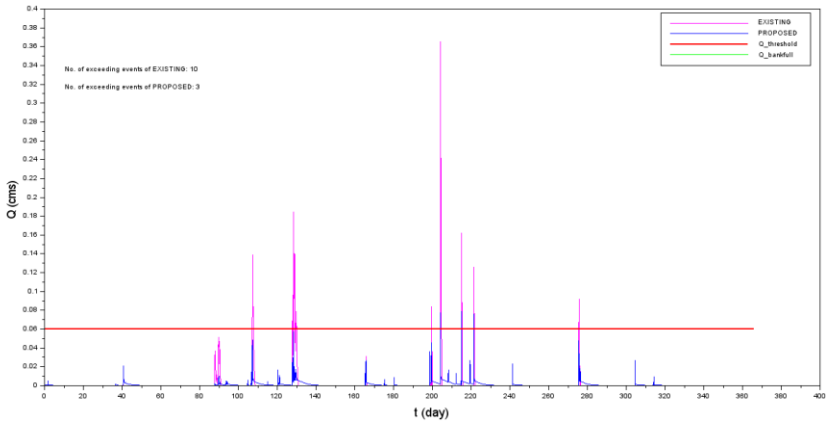
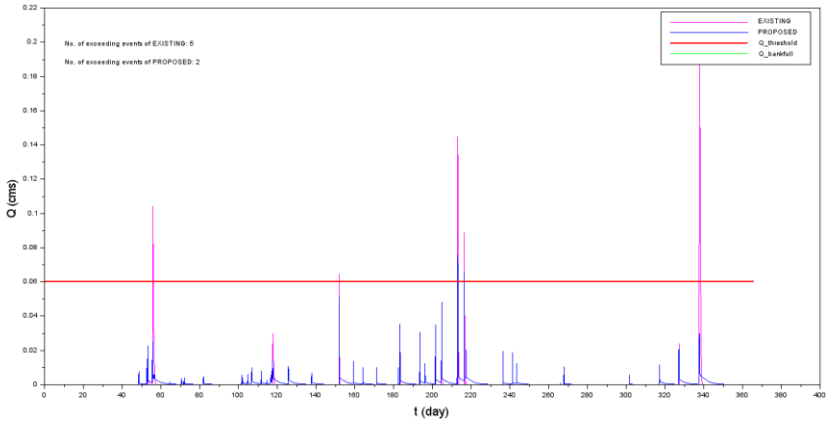
Flows to Critical Reach SC-A-5 1950	
Flows to Critical Reach SC-A-5 1951	

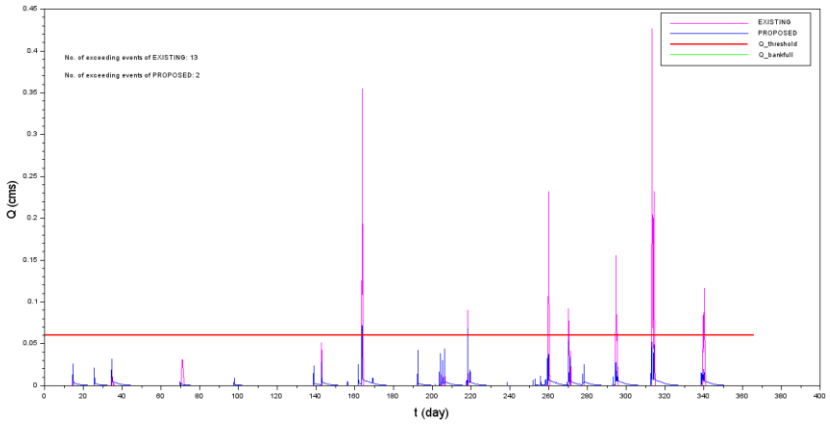
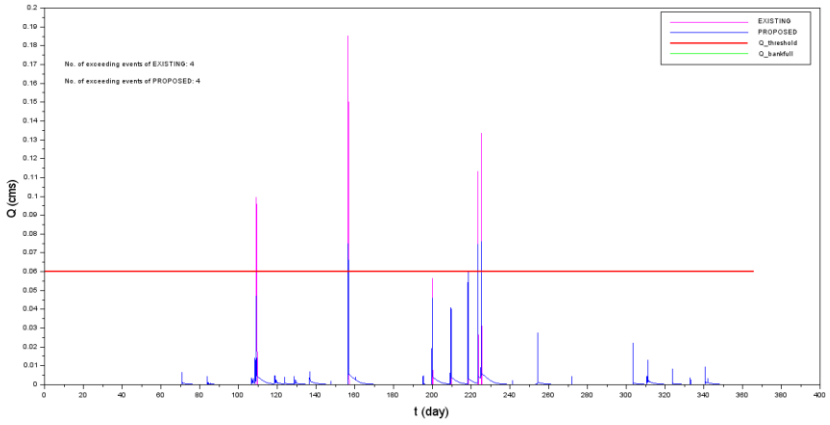
Flows to Critical Reach SC-A-5 1952	
Flows to Critical Reach SC-A-5 1953	

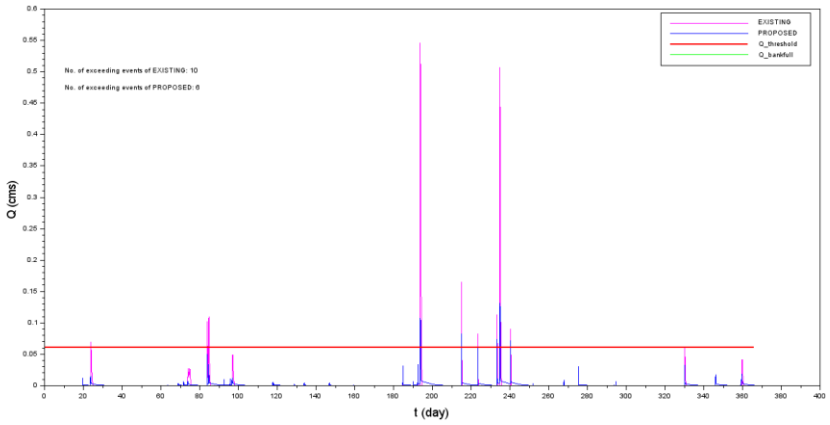
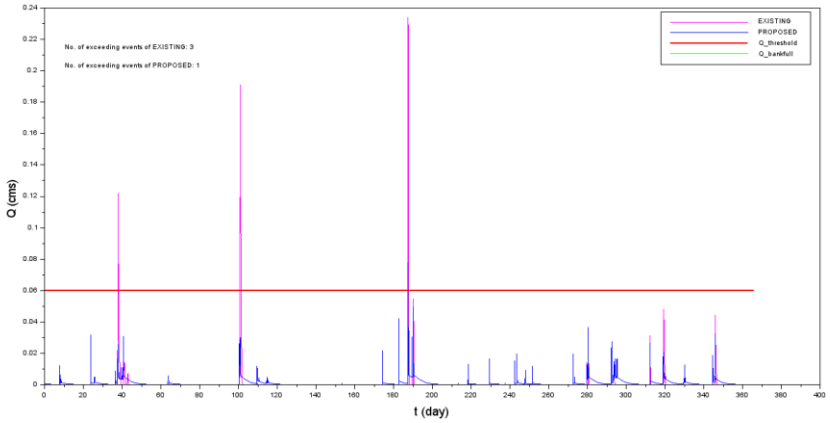
Flows to Critical Reach SC-A-5 1954	
Flows to Critical Reach SC-A-5 1955	

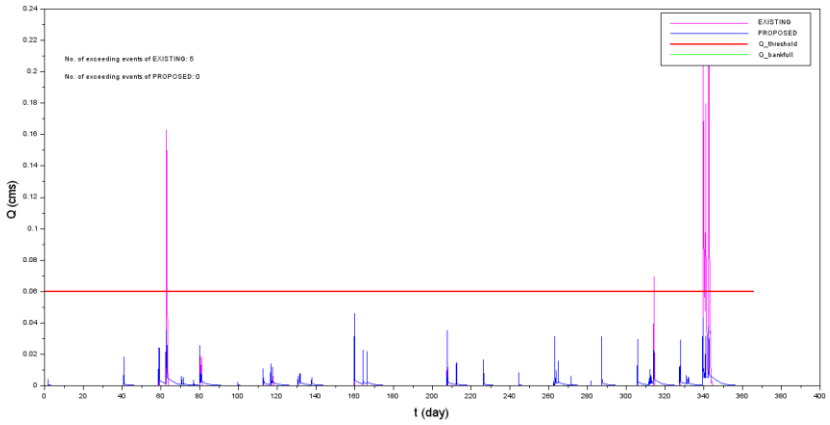
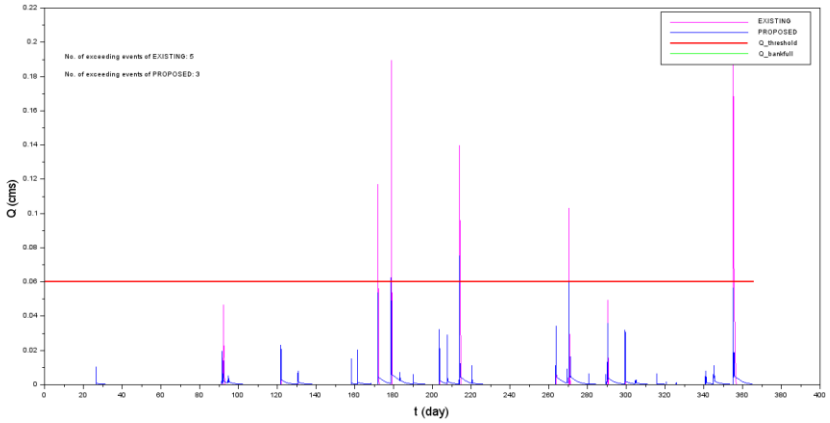
Flows to Critical Reach SC-A-5 1956	
Flows to Critical Reach SC-A-5 1957	

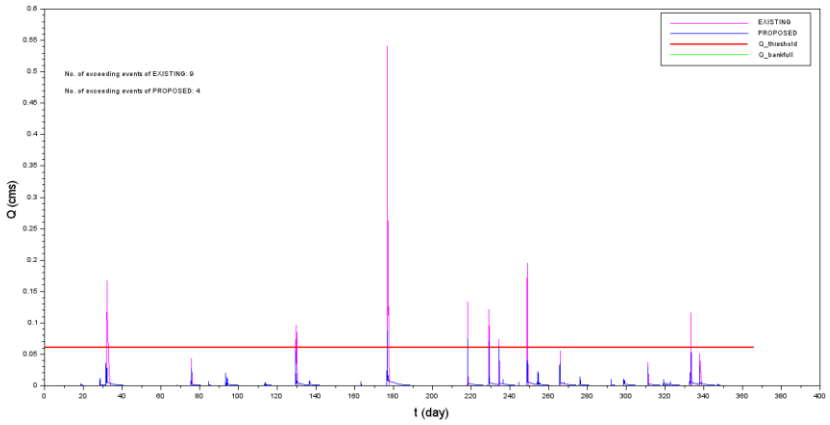
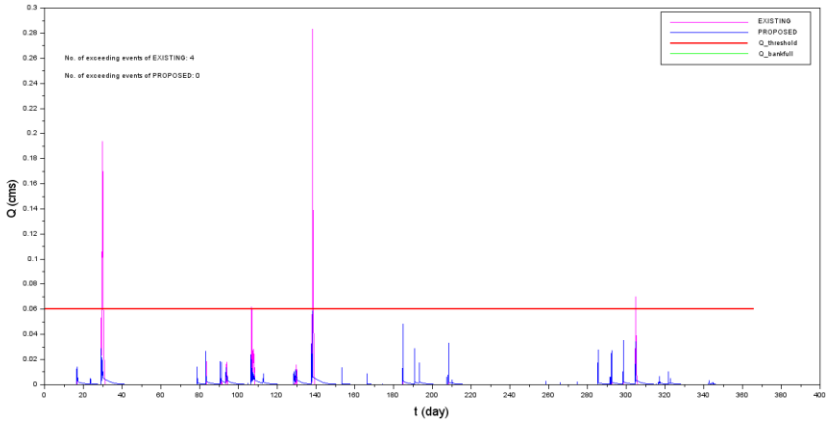
Flows to Critical Reach SC-A-5 1958	
Flows to Critical Reach SC-A-5 1959	

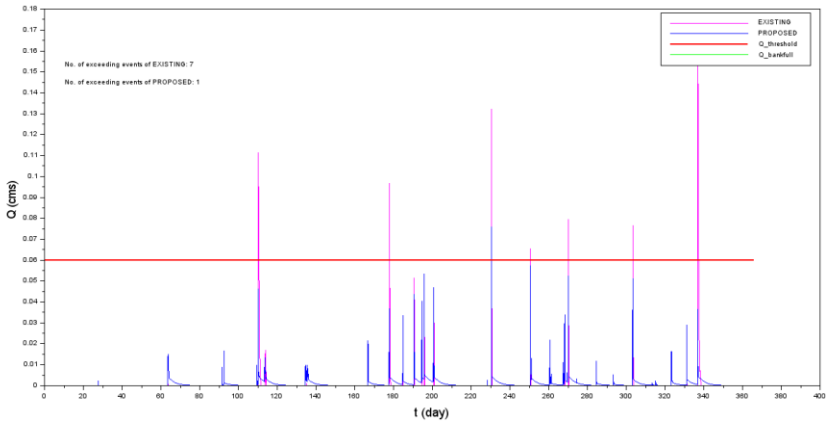
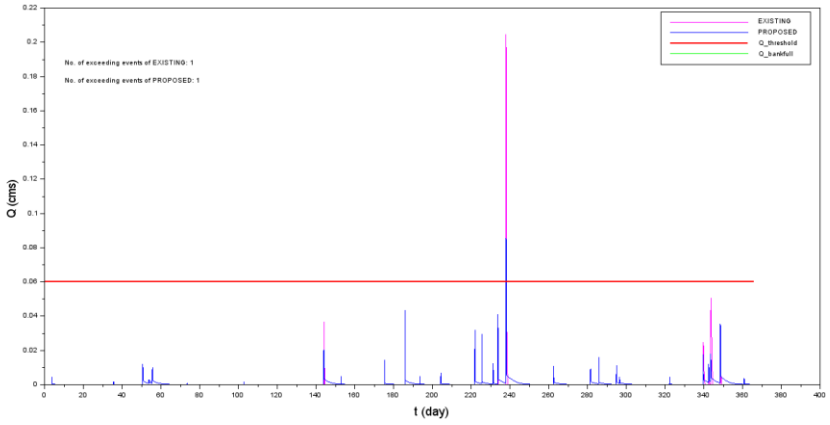
Flows to Critical Reach SC-A-5 1960	
Flows to Critical Reach SC-A-5 1961	

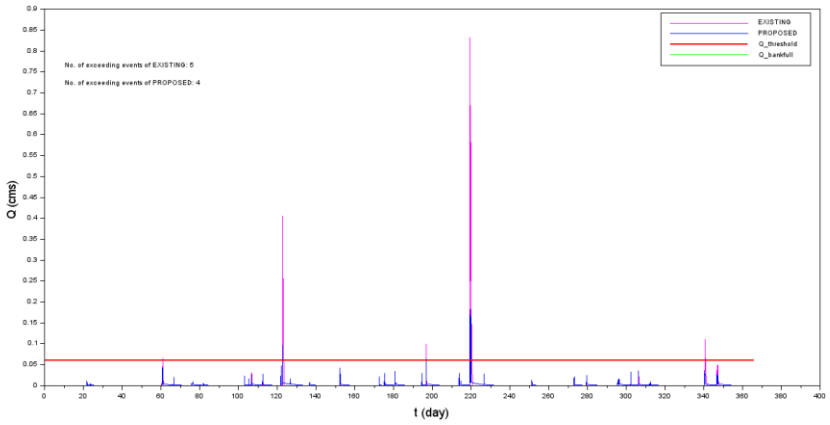
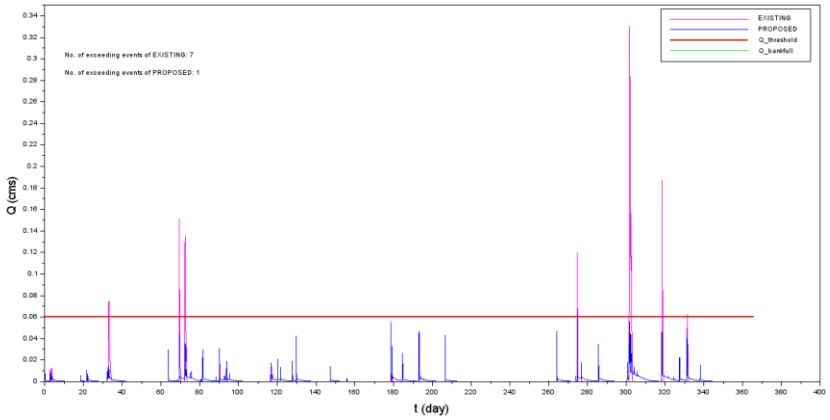
Flows to Critical Reach SC-A-5 1962	
Flows to Critical Reach SC-A-5 1963	

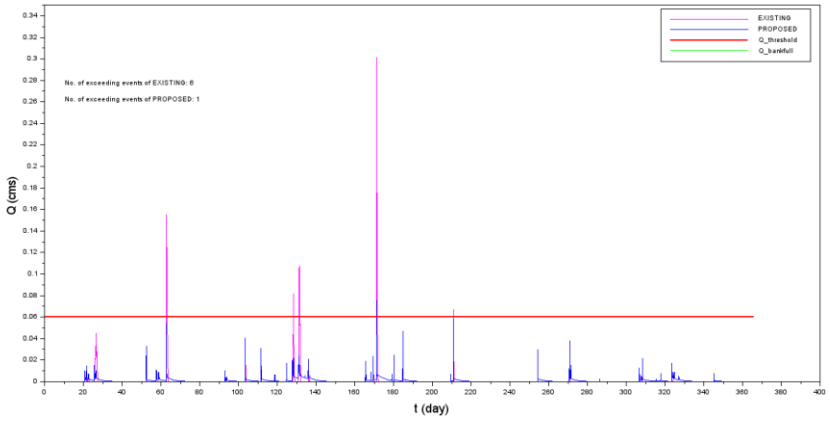
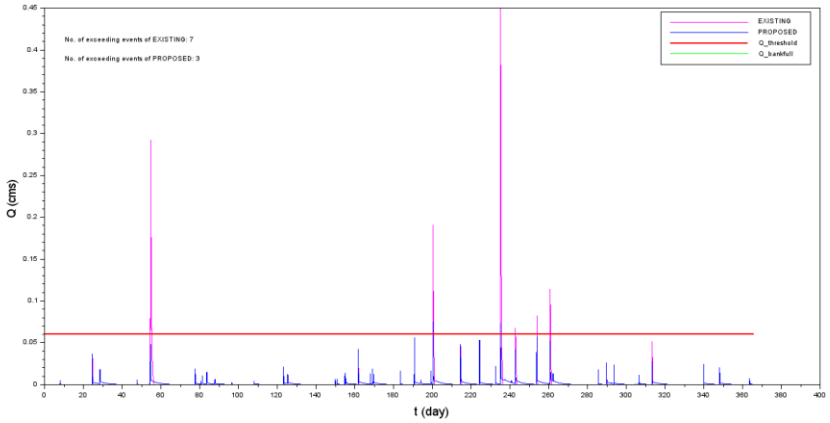
Flows to Critical Reach SC-A-5 1964	
Flows to Critical Reach SC-A-5 1965	

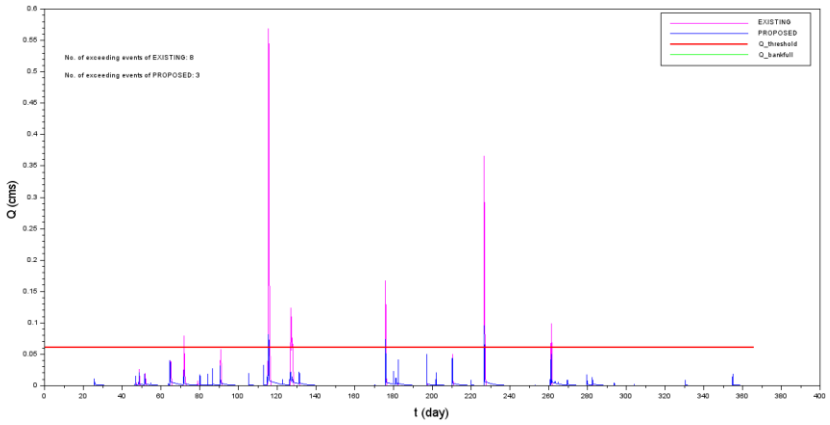
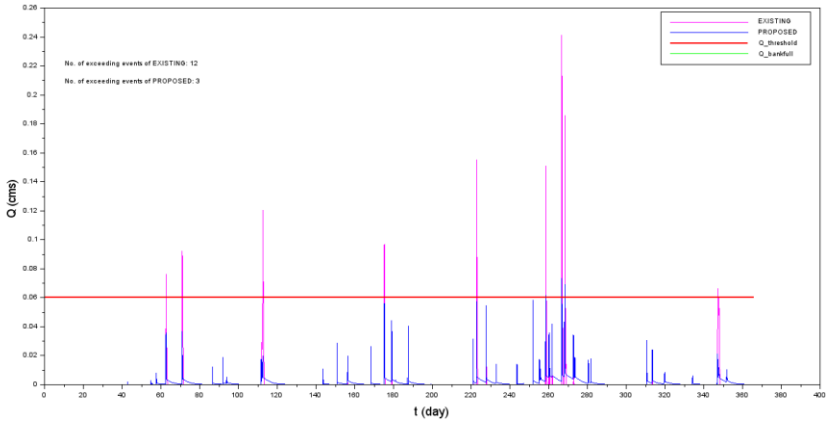
Flows to Critical Reach SC-A-5 1966	
Flows to Critical Reach SC-A-5 1967	

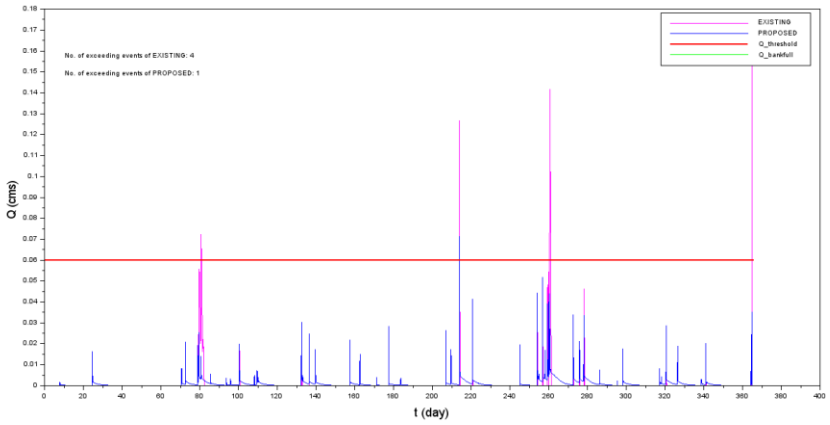
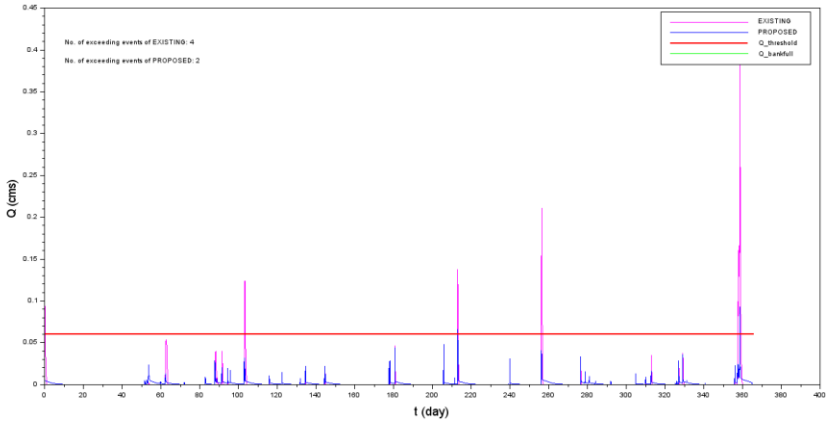
Flows to Critical Reach SC-A-5 1968	
Flows to Critical Reach SC-A-5 1969	

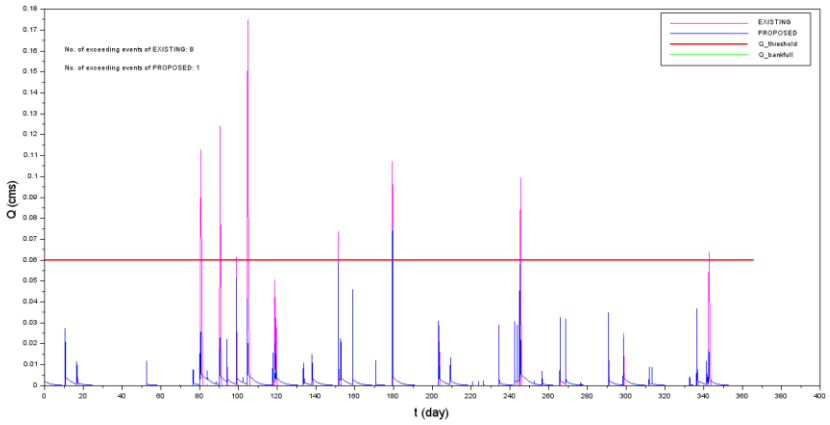
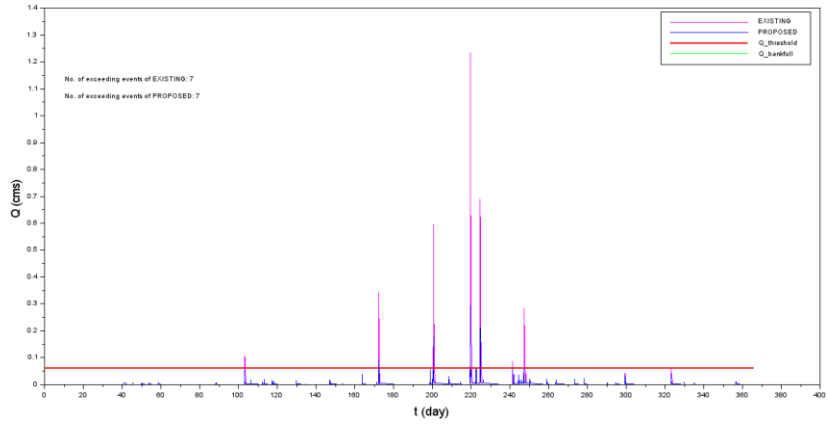
Flows to Critical Reach SC-A-5 1970	
Flows to Critical Reach SC-A-5 1971	

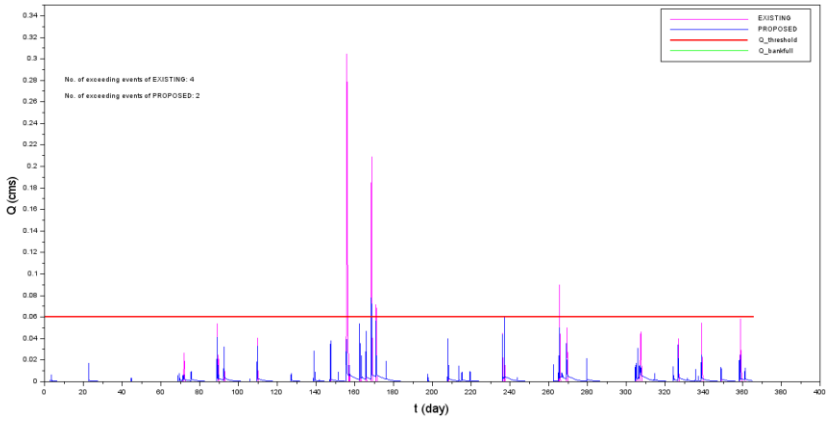
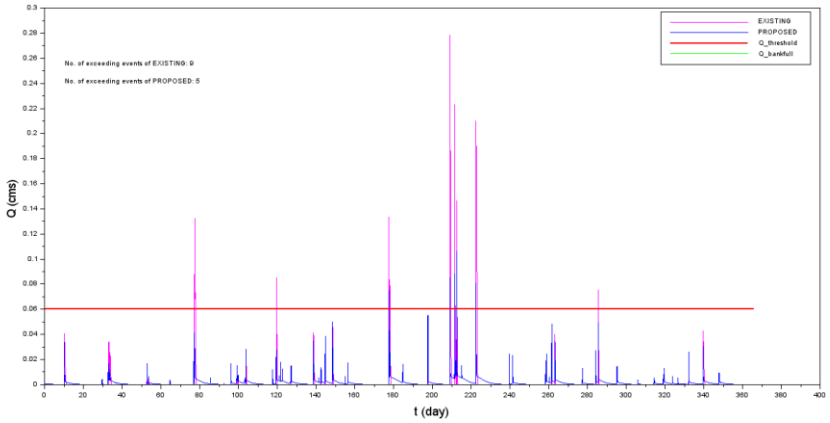
Flows to Critical Reach SC-A-5 1972	
Flows to Critical Reach SC-A-5 1973	

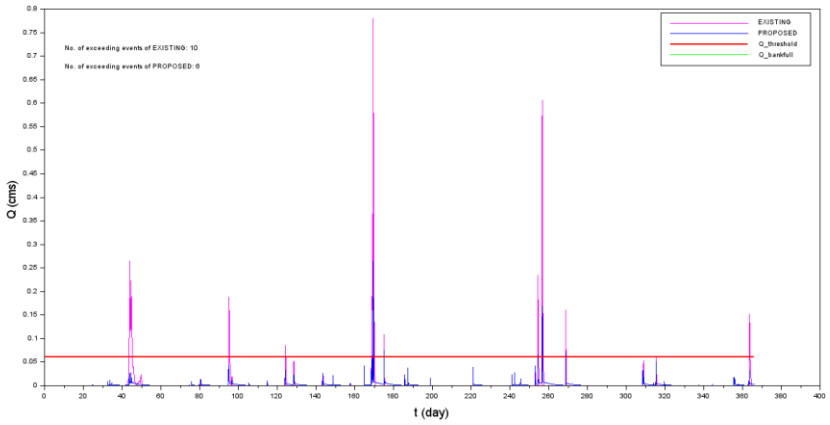
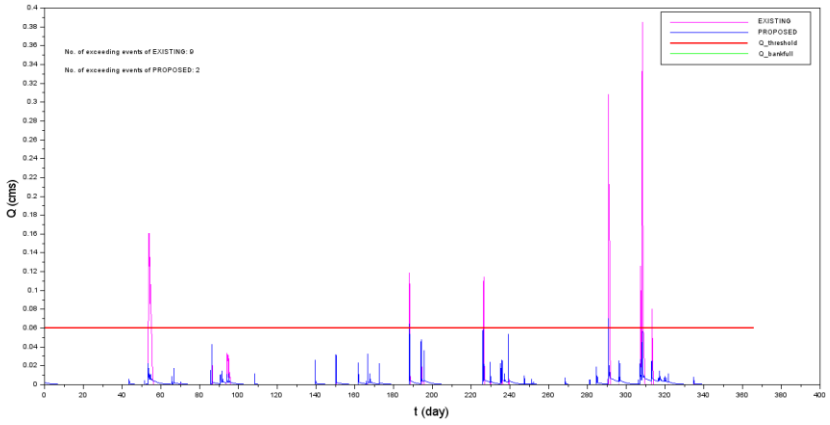
Flows to Critical Reach SC-A-5 1974	
Flows to Critical Reach SC-A-5 1975	

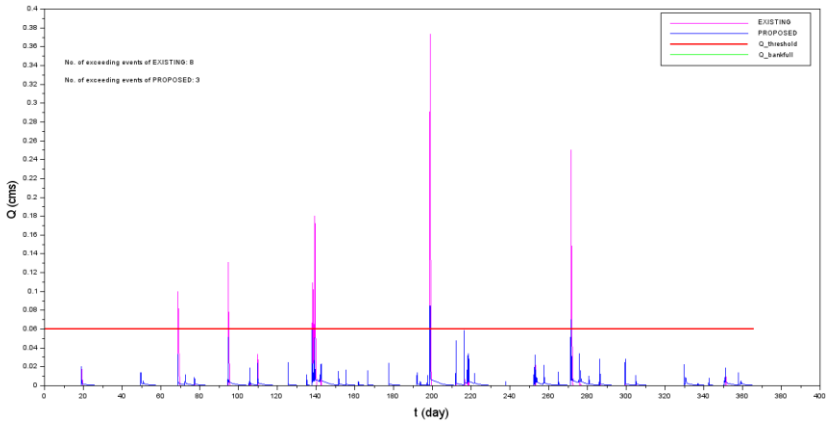
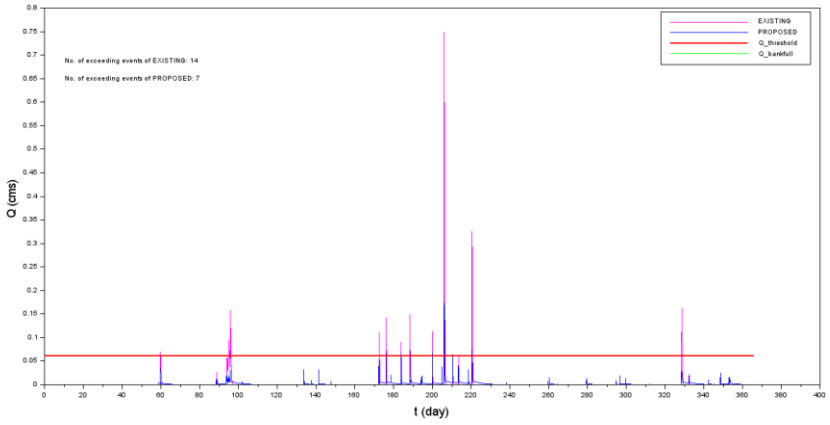
Flows to Critical Reach SC-A-5 1976	
Flows to Critical Reach SC-A-5 1977	

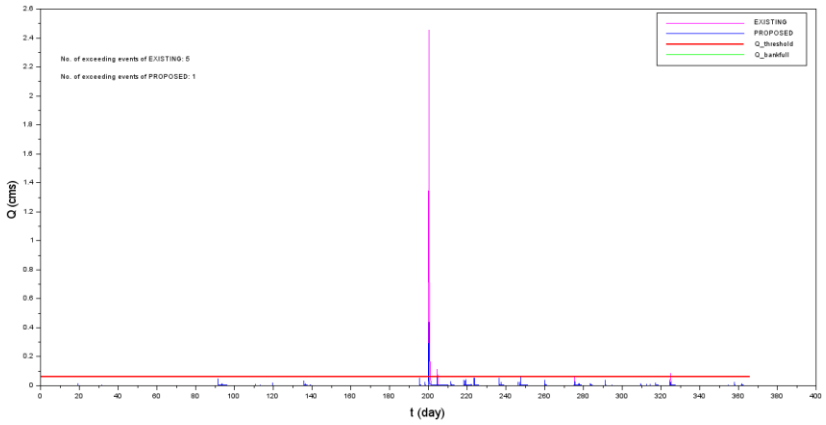
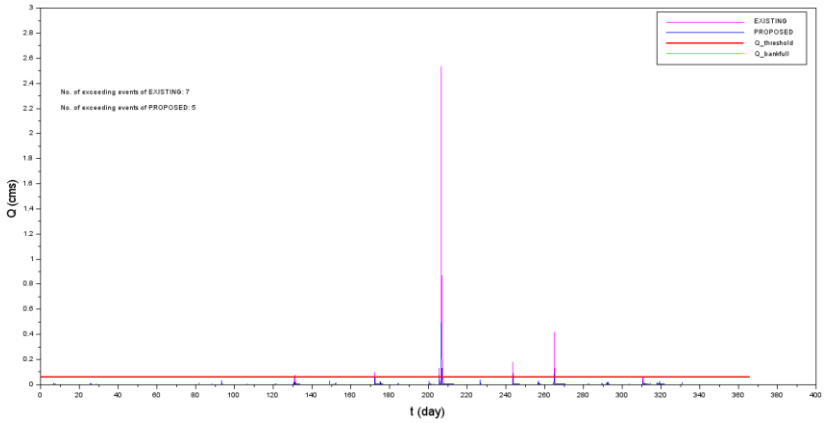
Flows to Critical Reach SC-A-5 1978	
Flows to Critical Reach SC-A-5 1979	

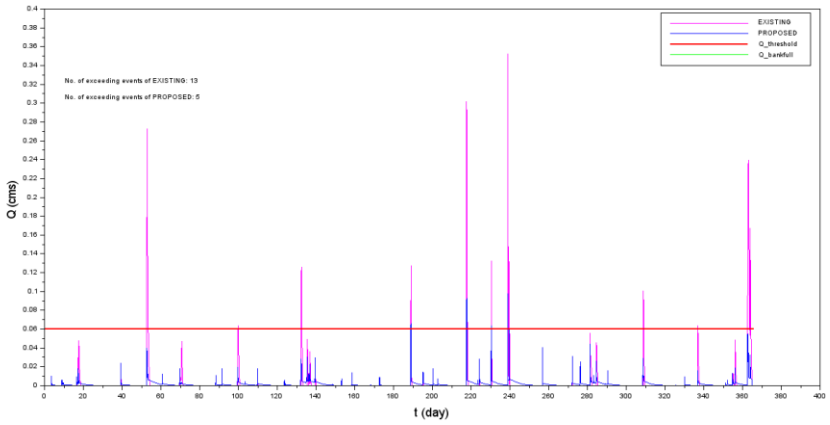
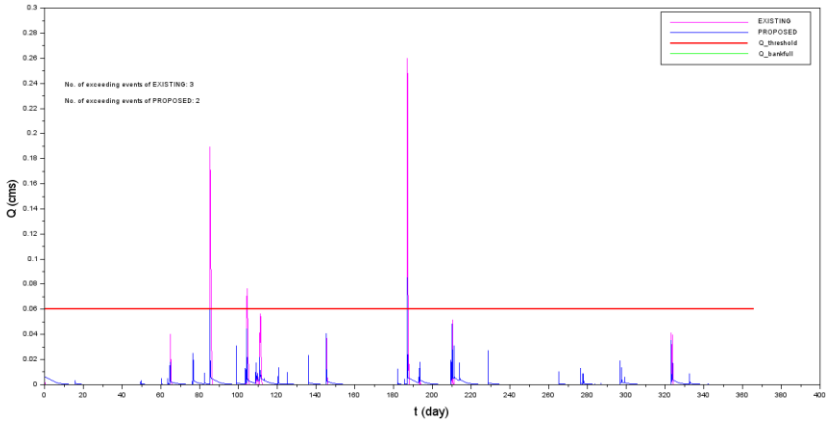
Flows to Critical Reach SC-A-5 1980	
Flows to Critical Reach SC-A-5 1981	

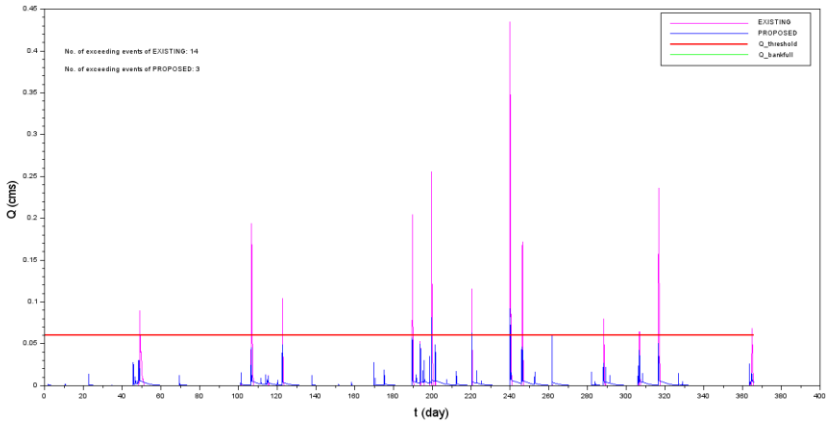
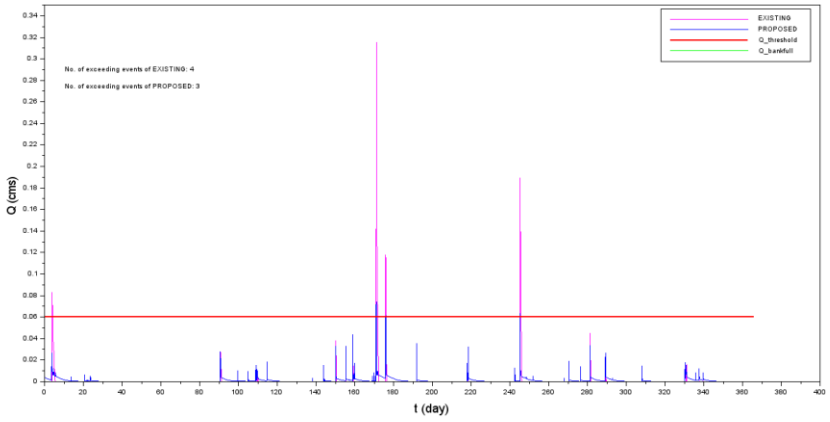
Flows to Critical Reach SC-A-5 1982	
Flows to Critical Reach SC-A-5 1983	

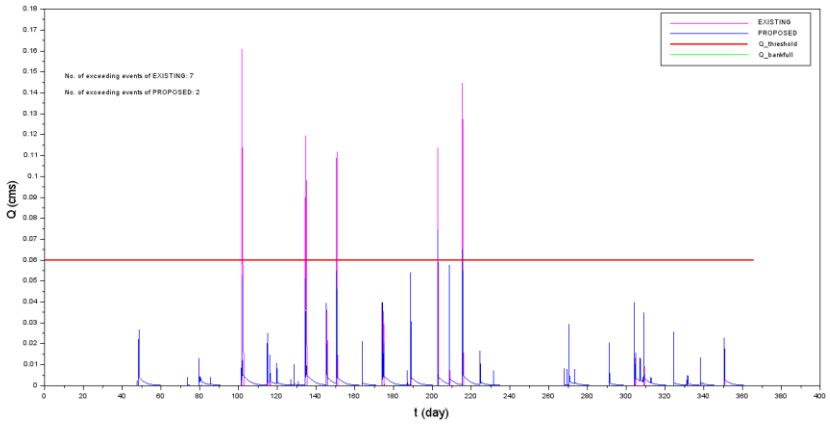
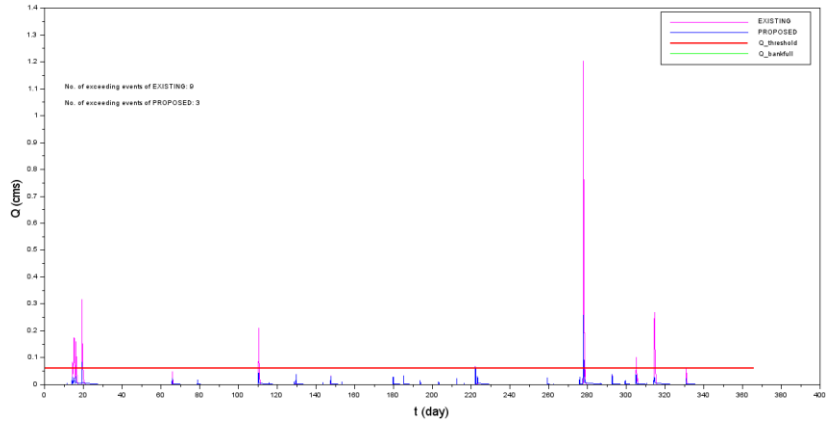
Flows to Critical Reach SC-A-5 1984	
Flows to Critical Reach SC-A-5 1985	

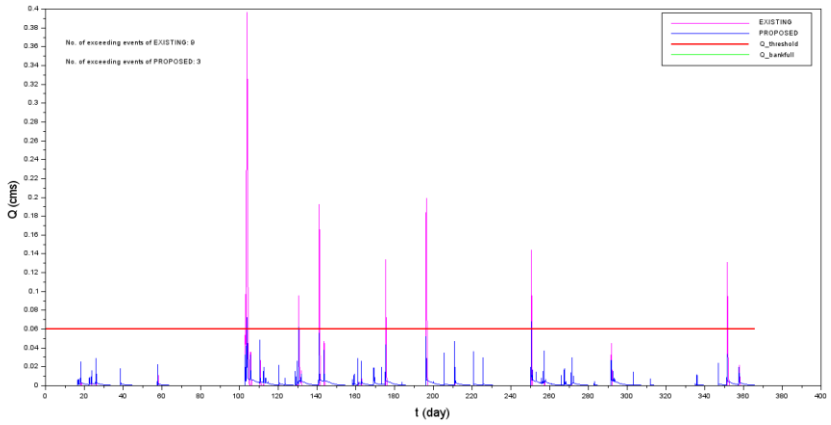
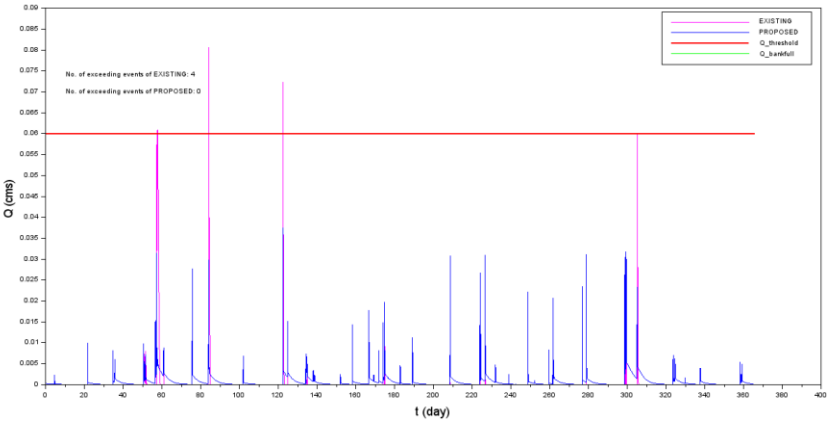
Flows to Critical Reach SC-A-5 1986	
Flows to Critical Reach SC-A-5 1987	

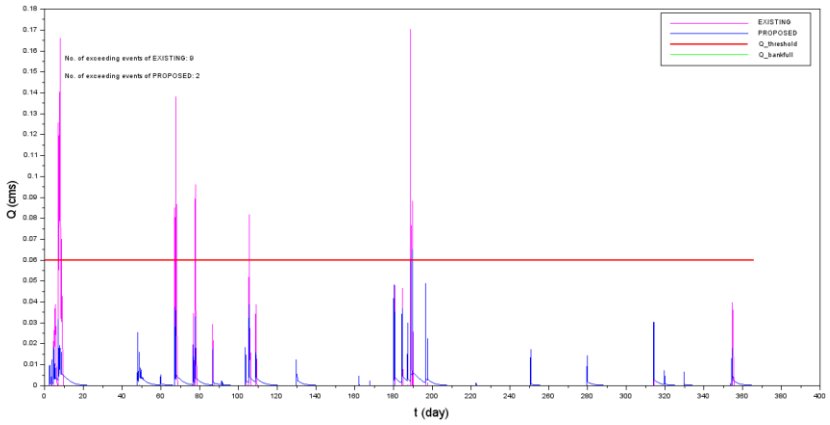
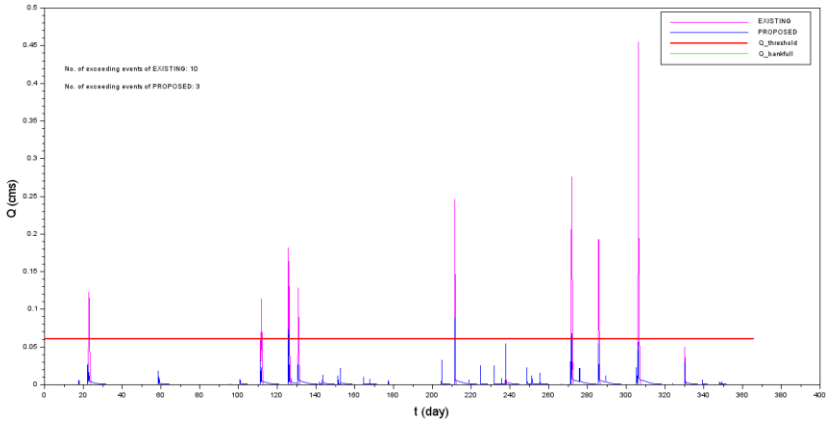
Flows to Critical Reach SC-A-5 1988	
Flows to Critical Reach SC-A-5 1989	

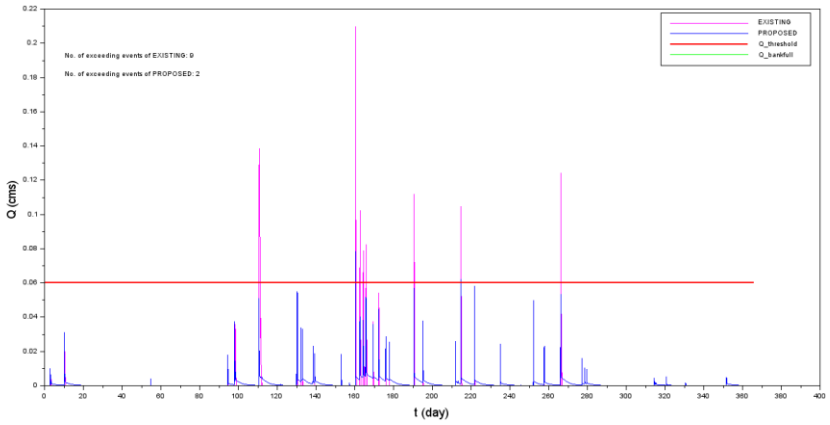
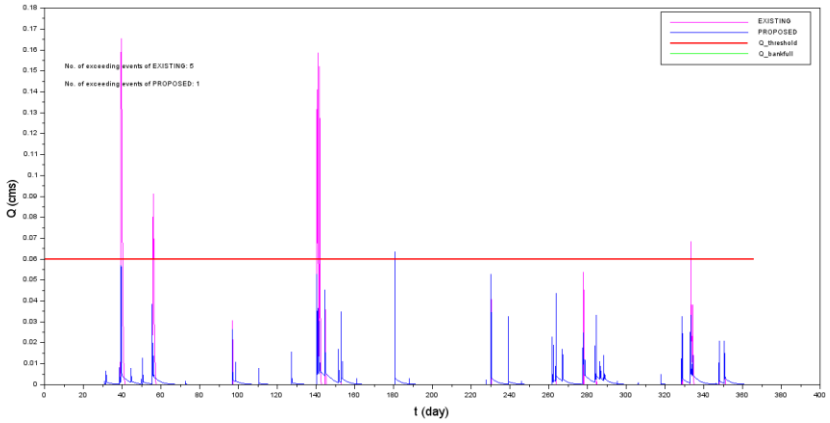
Flows to Critical Reach SC-A-5 1990	
Flows to Critical Reach SC-A-5 1991	

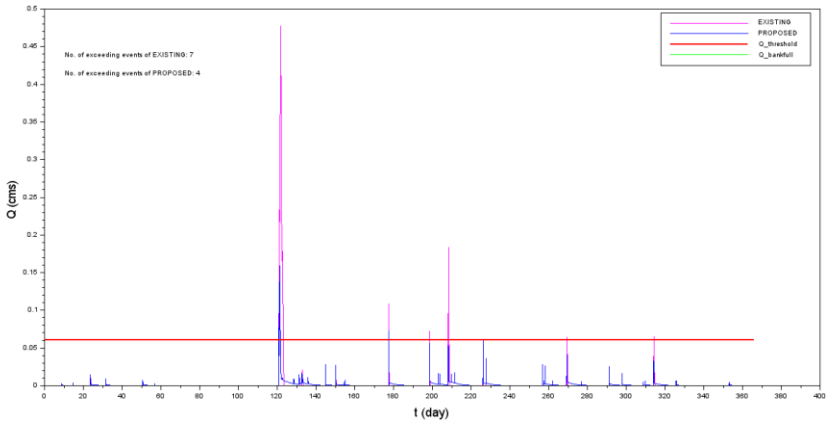
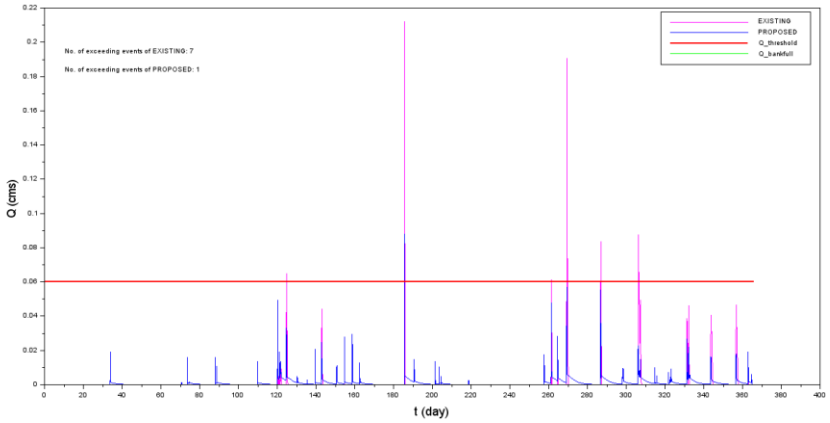
Flows to Critical Reach SC-A-5 1992	
Flows to Critical Reach SC-A-5 1993	

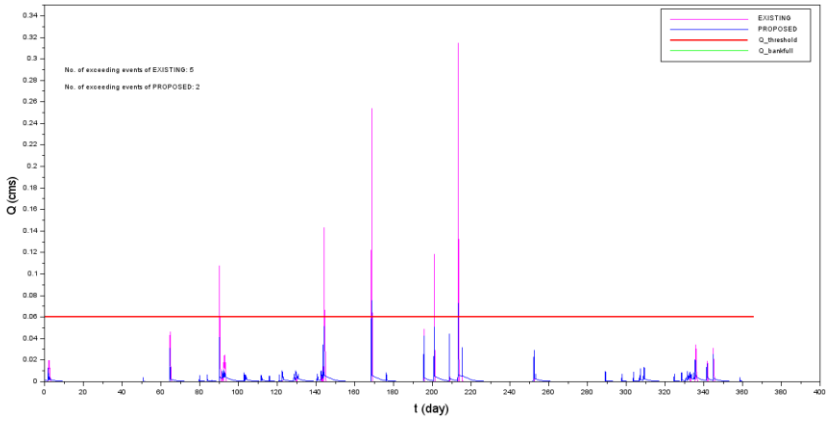
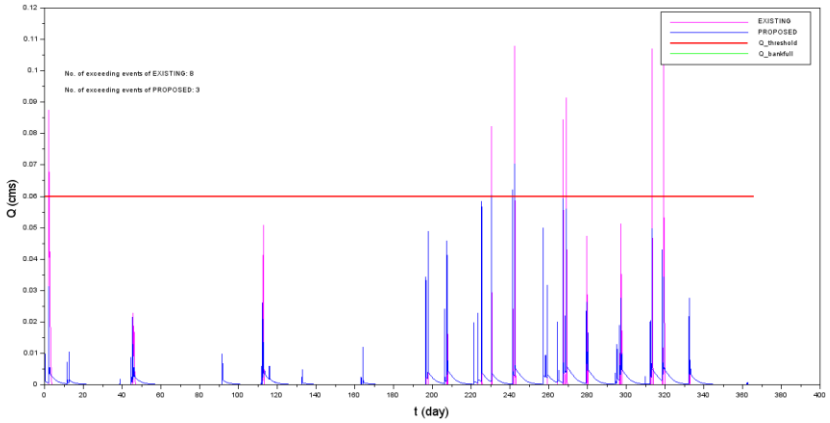
Flows to Critical Reach SC-A-5 1994	
Flows to Critical Reach SC-A-5 1995	

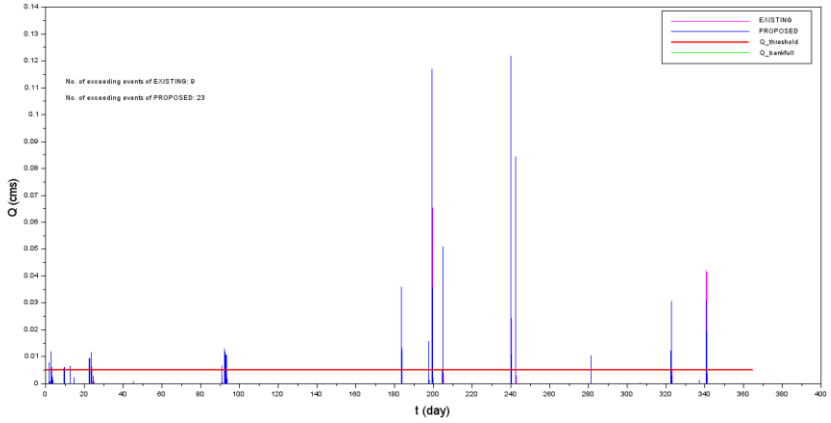
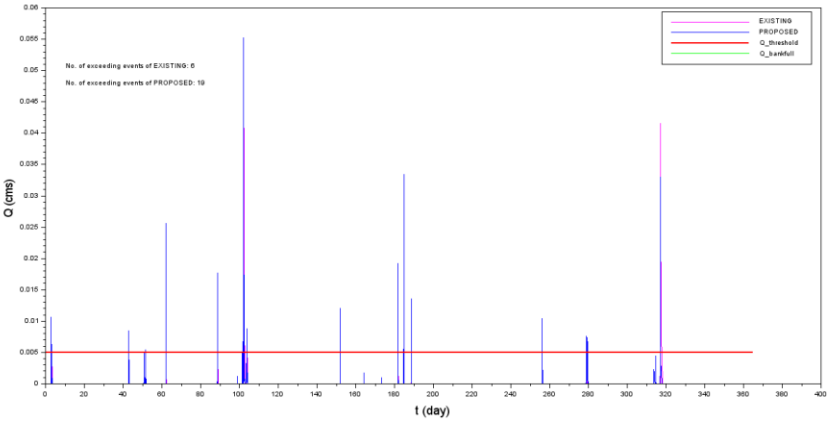
Flows to Critical Reach SC-A-5 1996	
Flows to Critical Reach SC-A-5 1997	

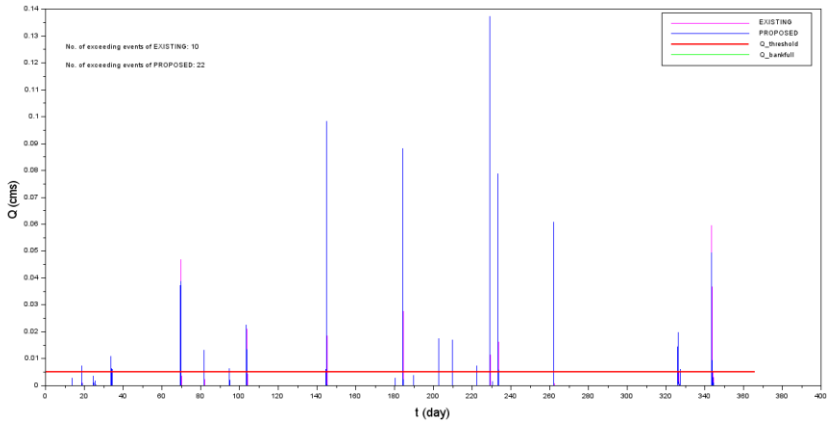
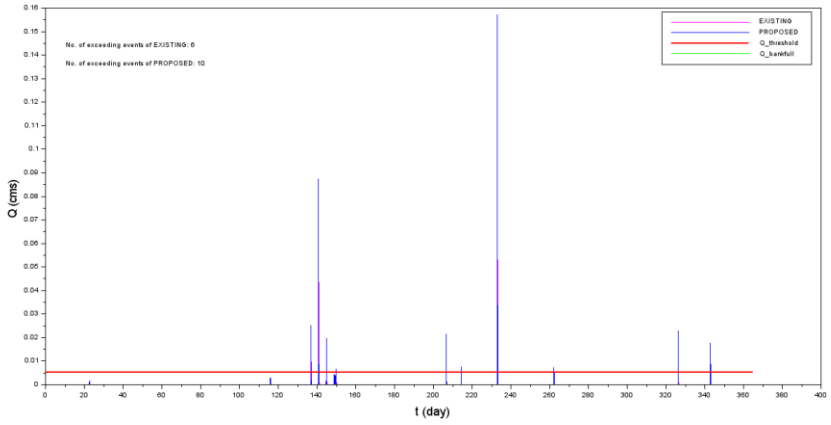
Flows to Critical Reach SC-A-5 1998	
Flows to Critical Reach SC-A-5 1999	

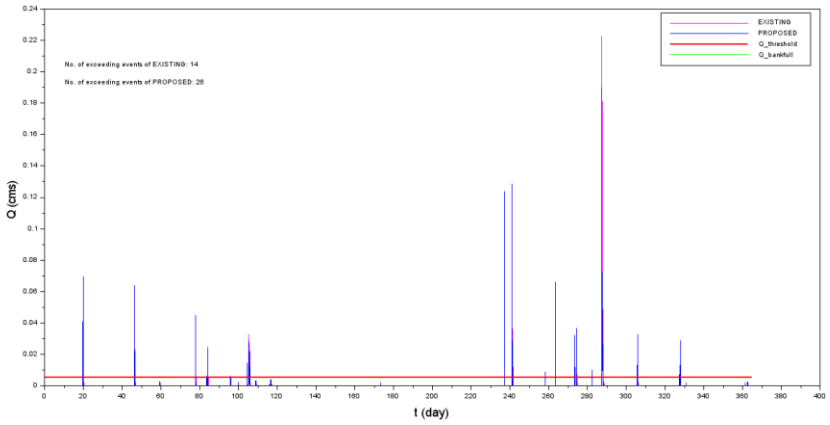
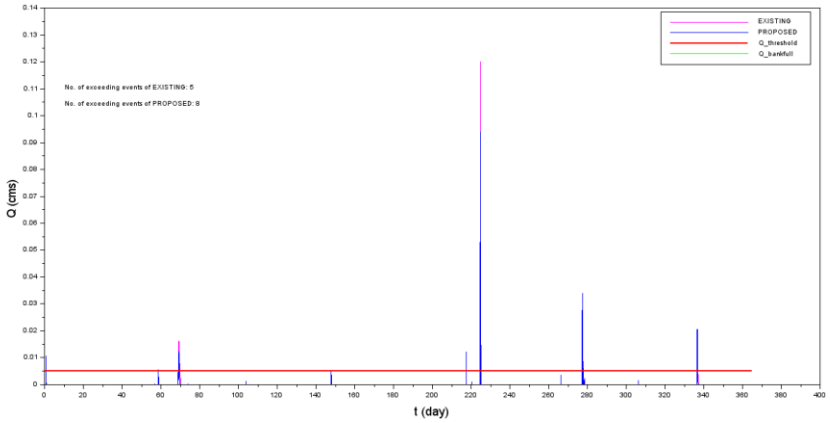
Flows to Critical Reach SC-A-5 2000	
Flows to Critical Reach SC-A-5 2001	

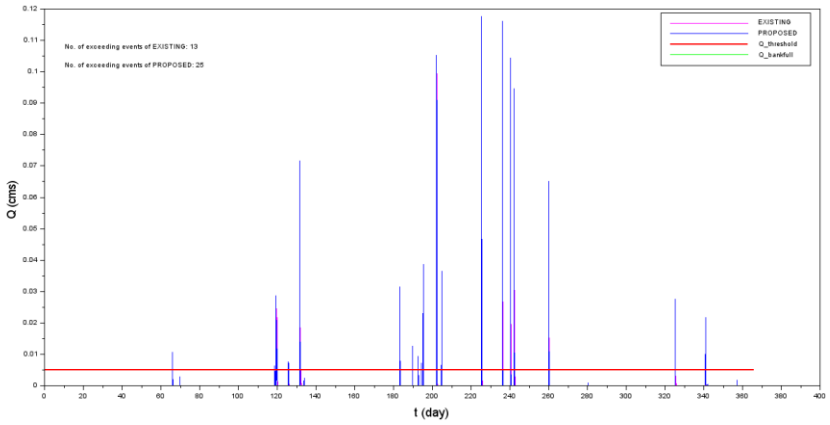
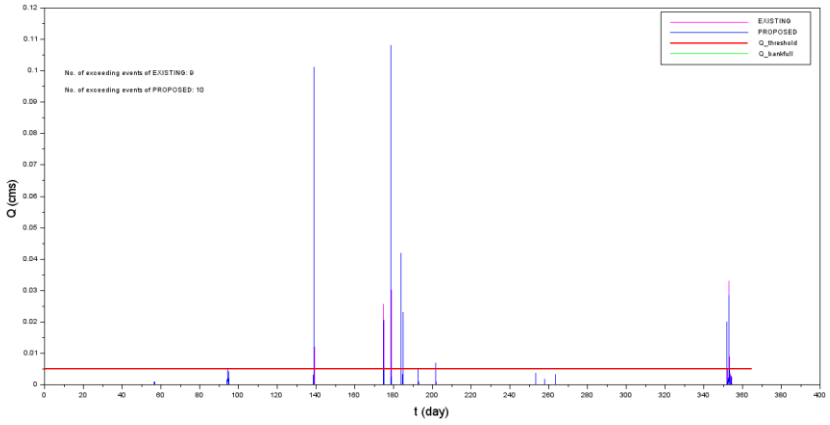
Flows to Critical Reach SC-A-5 2002	
Flows to Critical Reach SC-A-5 2003	

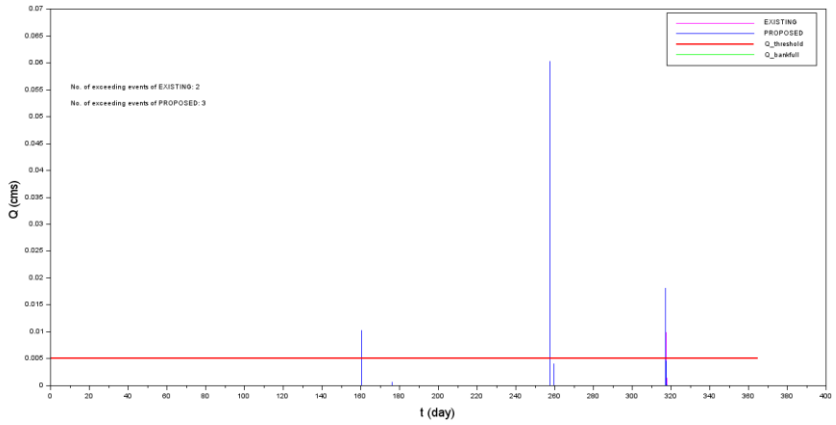
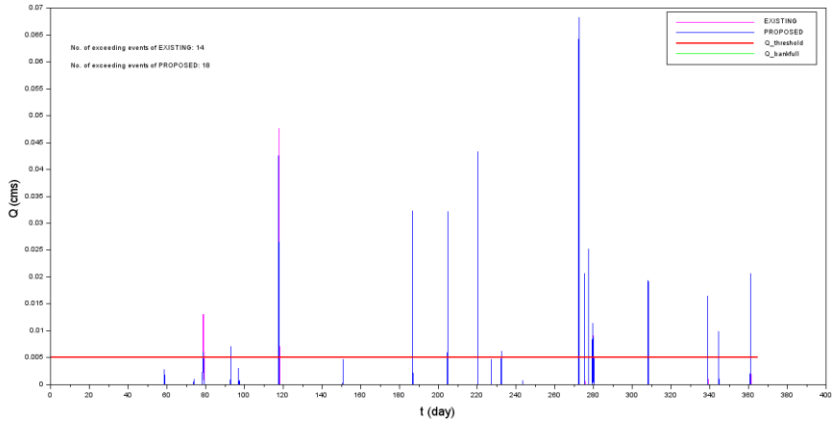
Flows to Critical Reach SC-A-5 2004	
Flows to Critical Reach SC-A-5 2005	

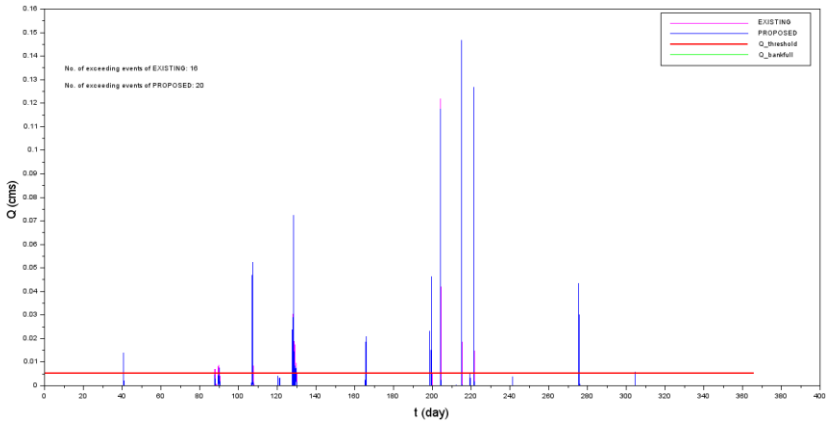
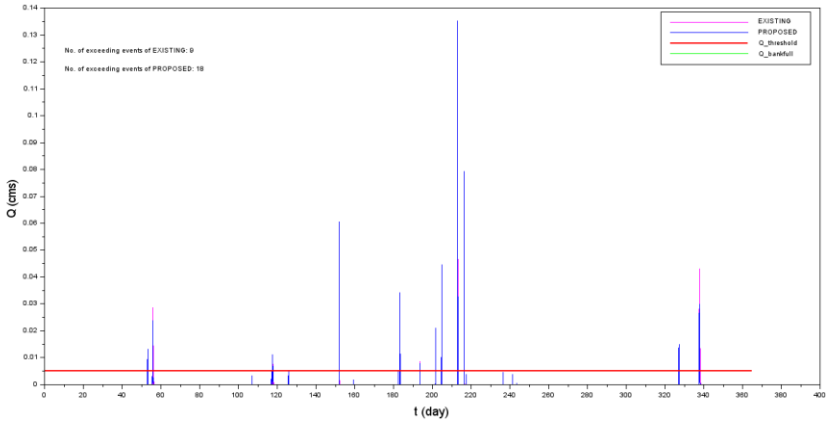
Flows to POI2 1950	
Flows to POI2 1951	

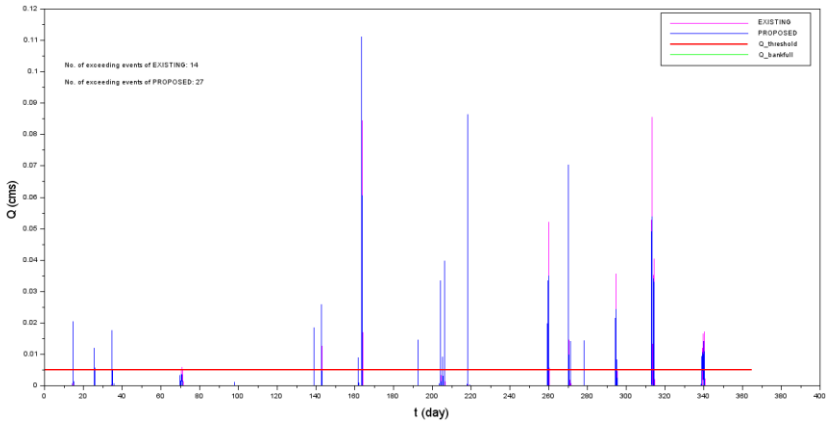
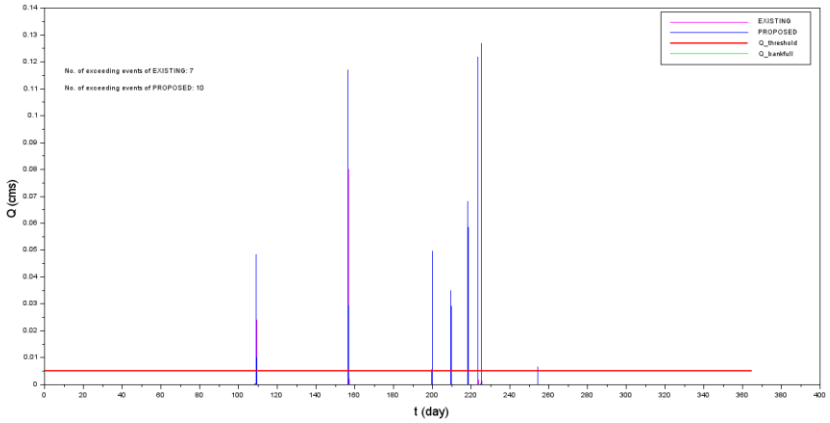
Flows to POI2 1952	
Flows to POI2 1953	

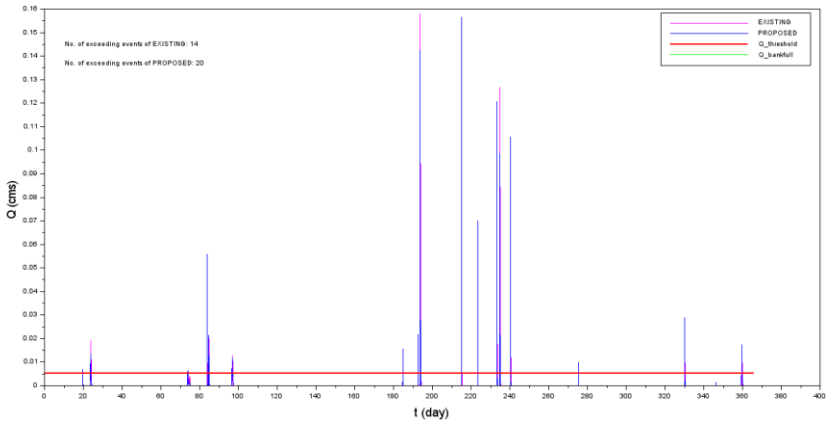
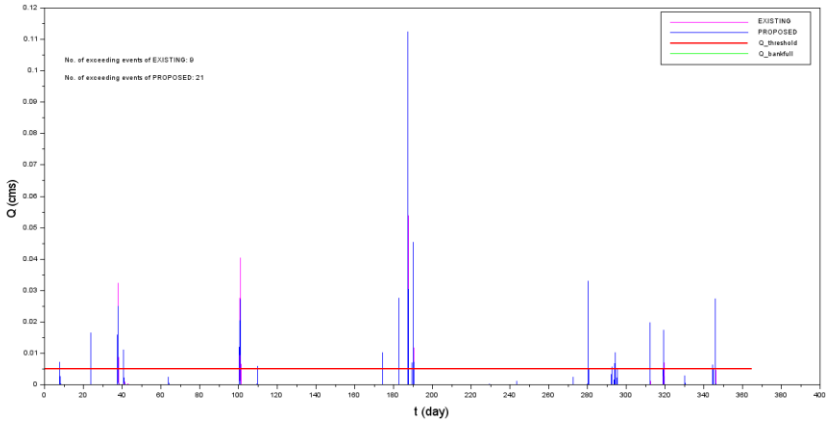
Flows to POI2 1954	
Flows to POI2 1955	

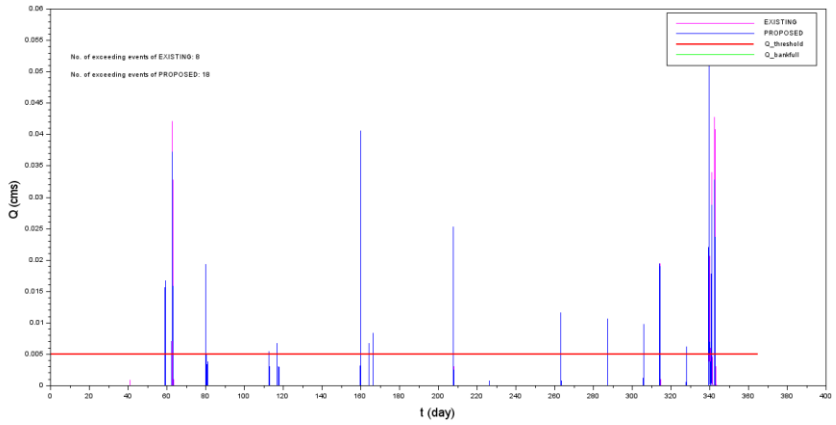
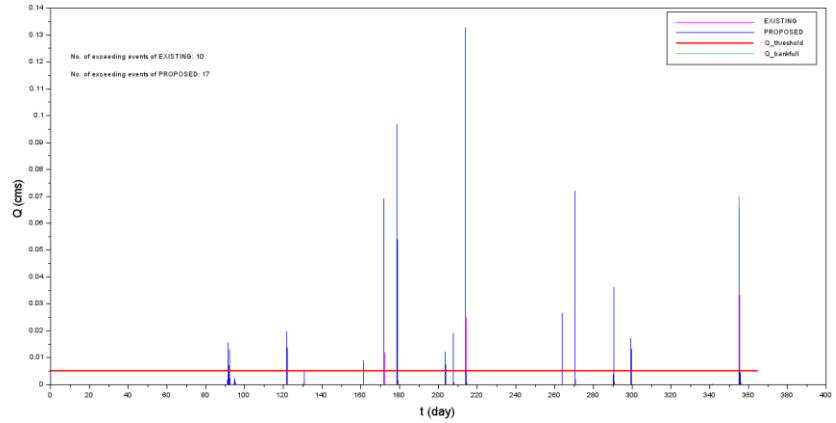
Flows to POI2 1956	
Flows to POI2 1957	

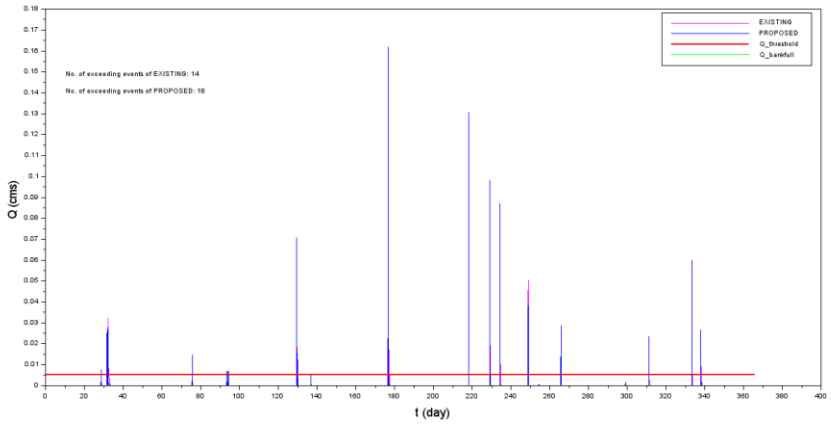
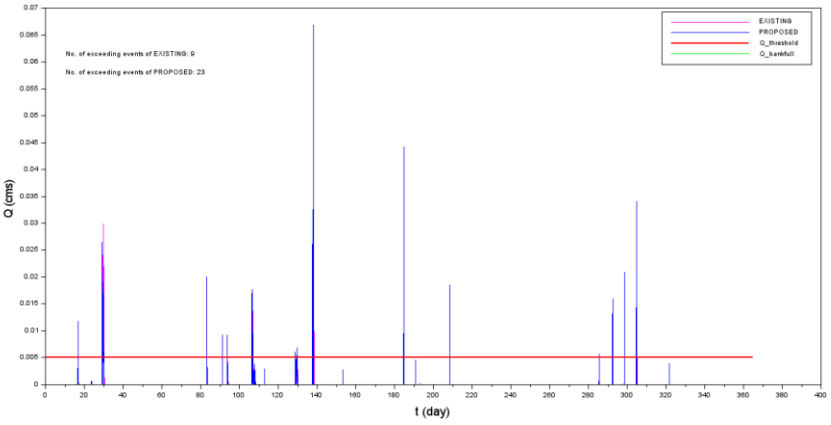
Flows to POI2 1958	
Flows to POI2 1959	

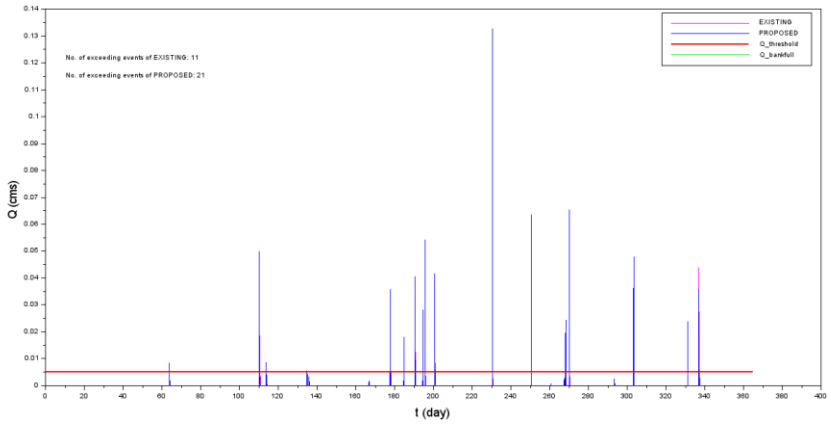
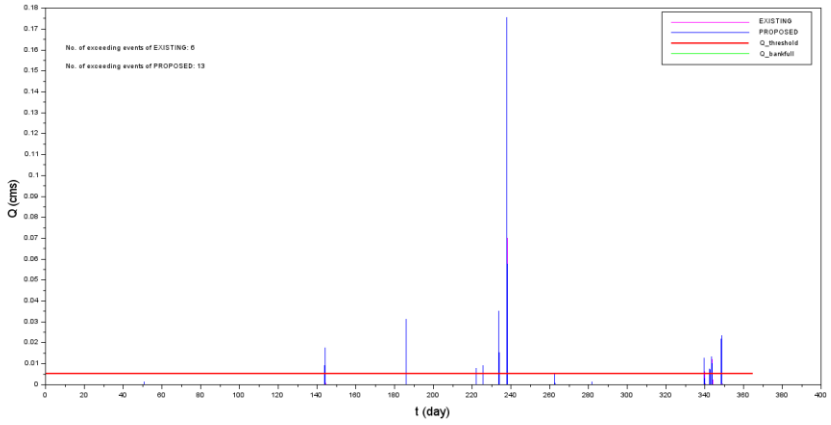
Flows to POI2 1960	
Flows to POI2 1961	

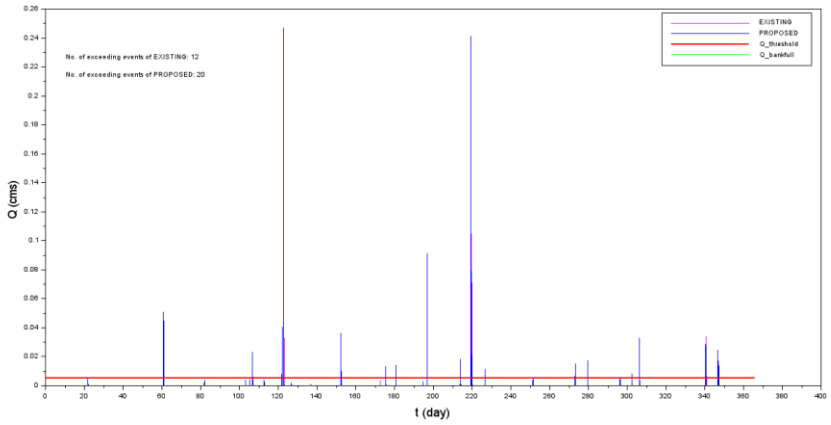
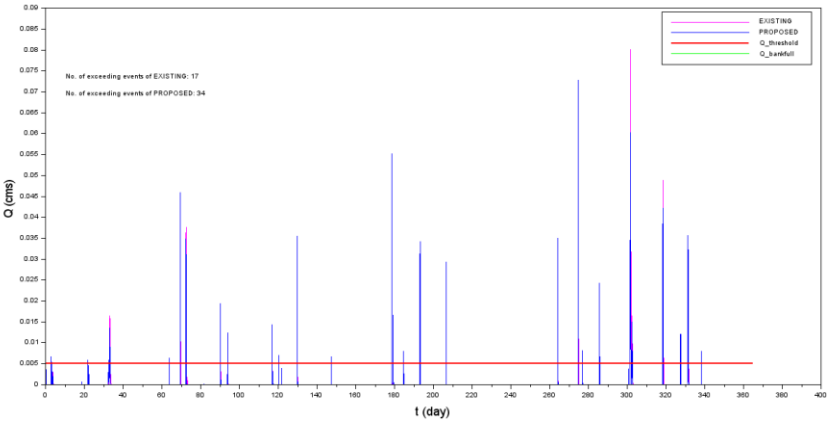
Flows to POI2 1962	
Flows to POI2 1963	

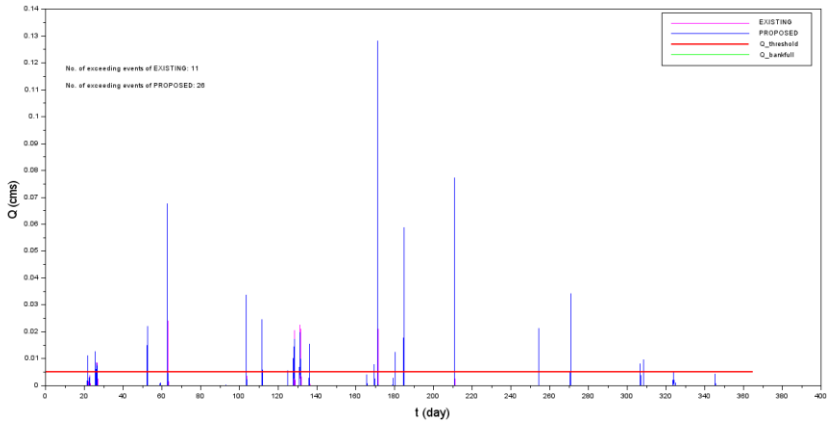
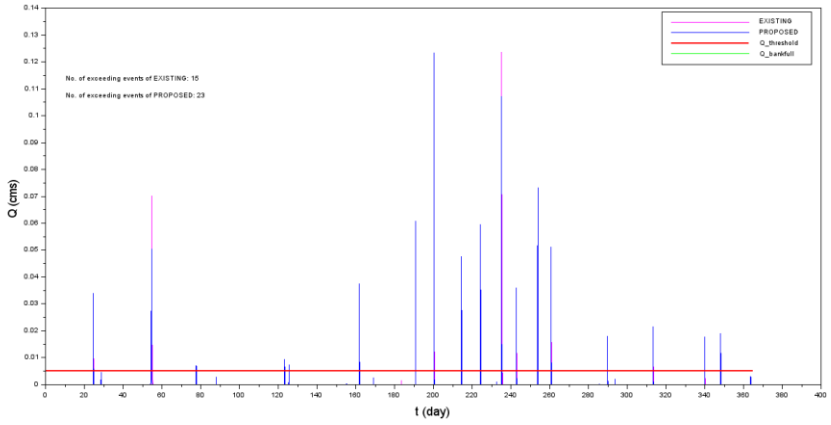
Flows to POI2 1964	
Flows to POI2 1965	

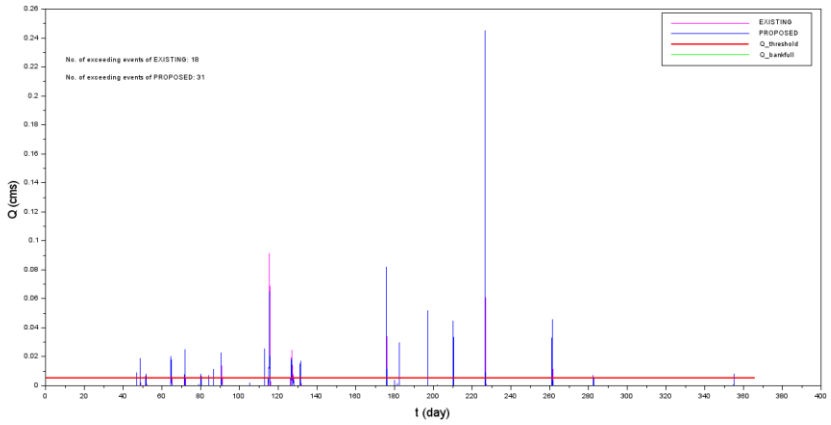
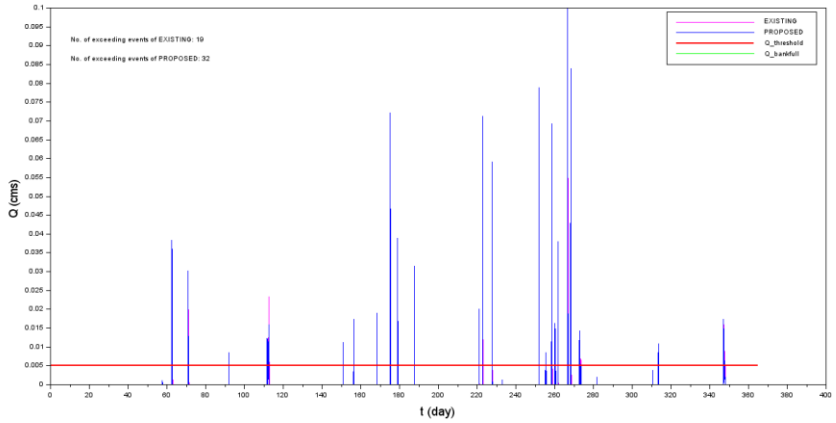
Flows to POI2 1966	
Flows to POI2 1967	

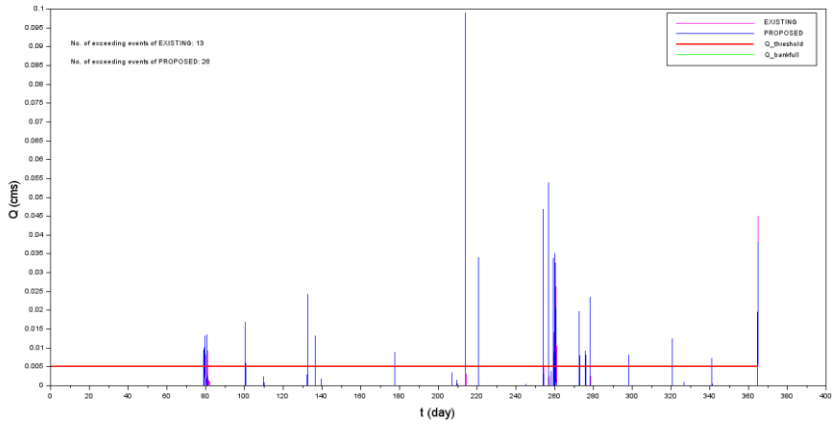
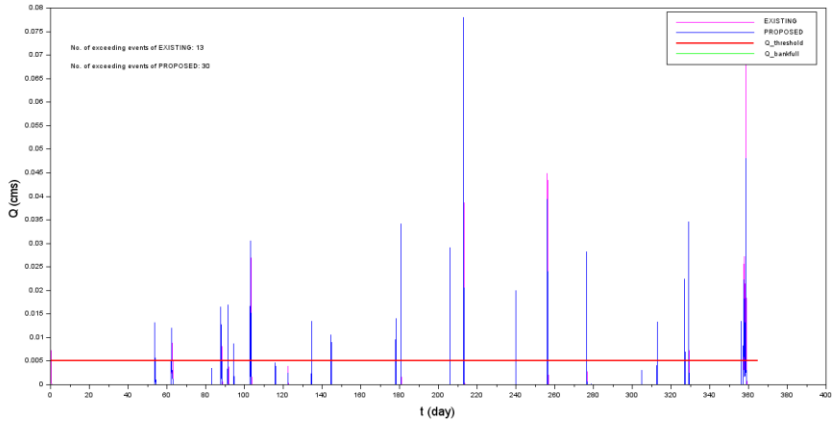
Flows to POI2 1968	
Flows to POI2 1969	

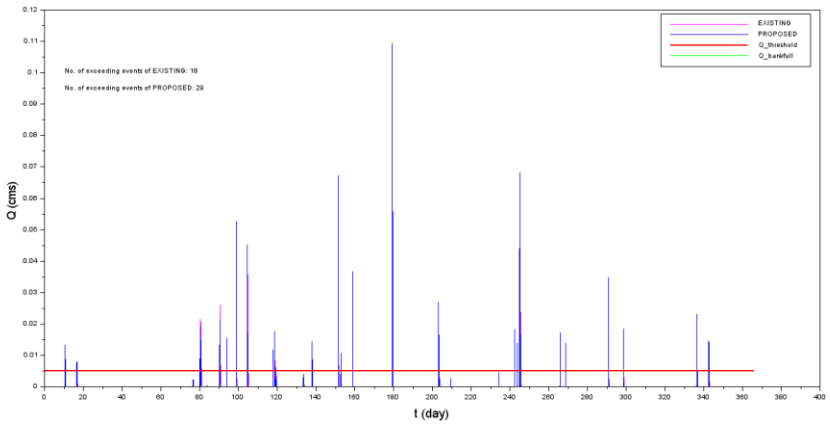
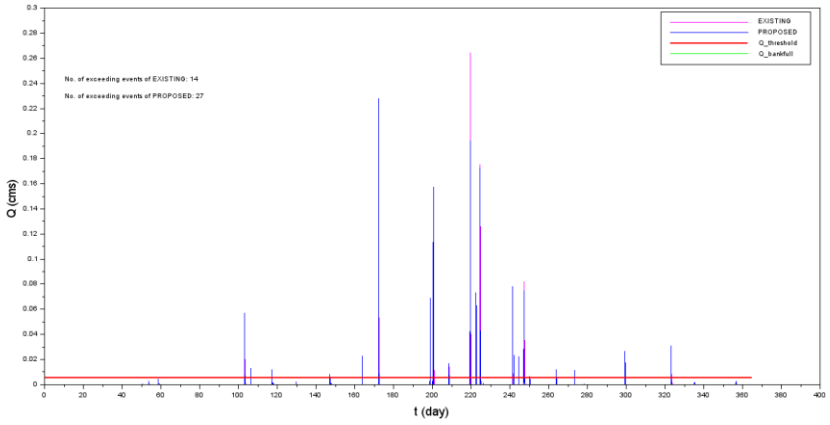
Flows to POI2 1970	
Flows to POI2 1971	

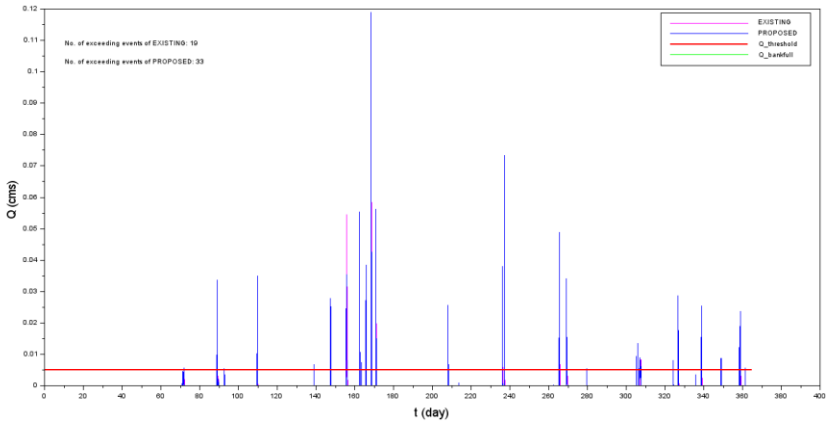
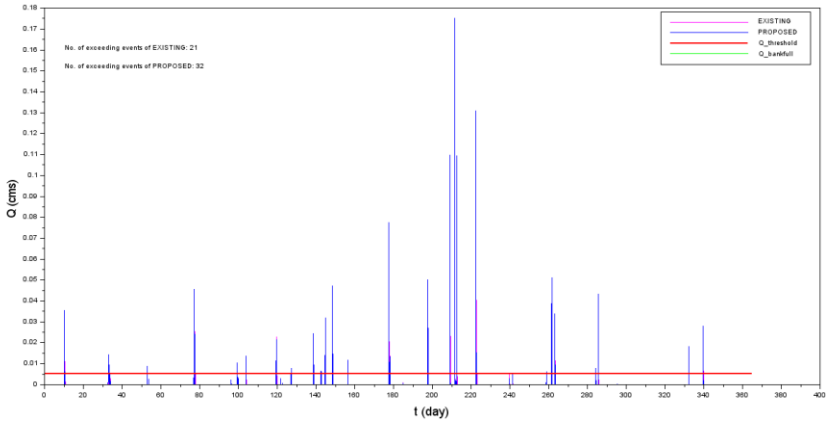
Flows to POI2 1972	
Flows to POI2 1973	

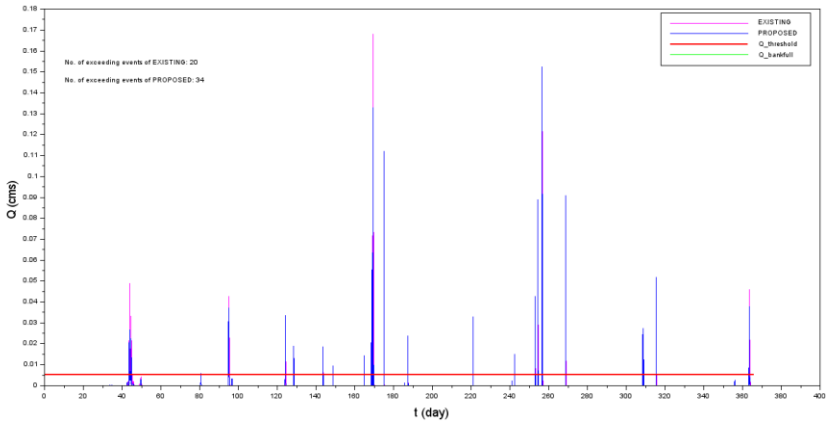
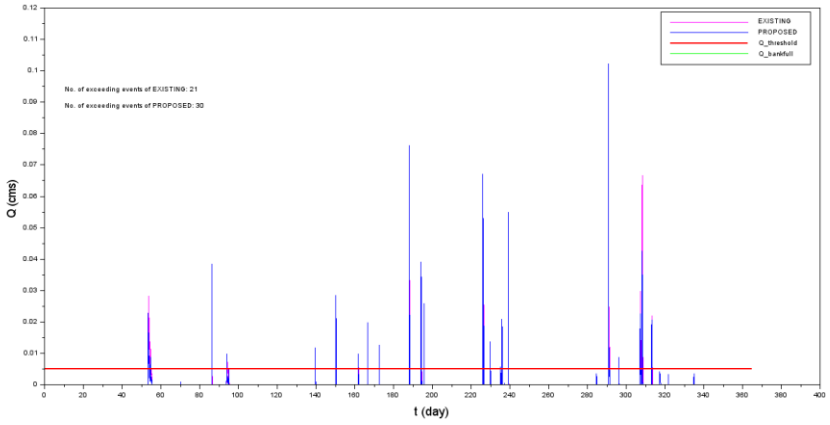
Flows to POI2 1974	
Flows to POI2 1975	

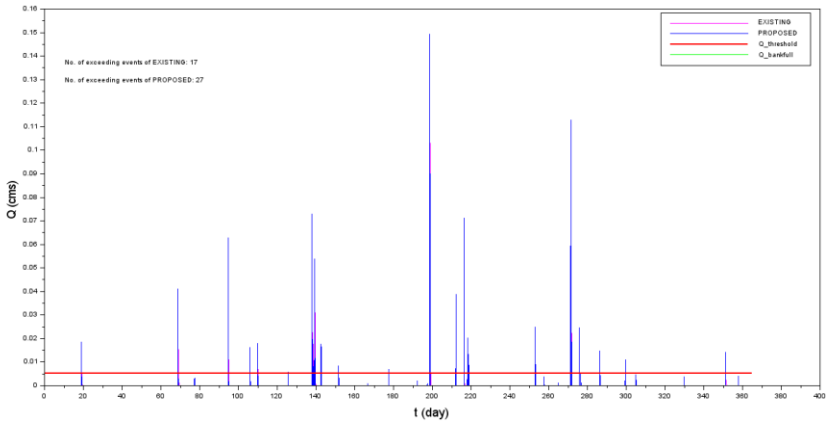
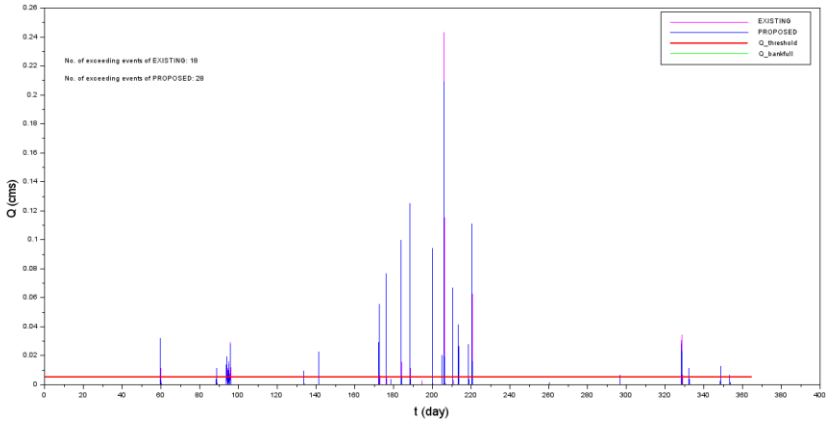
Flows to POI2 1976	
Flows to POI2 1977	

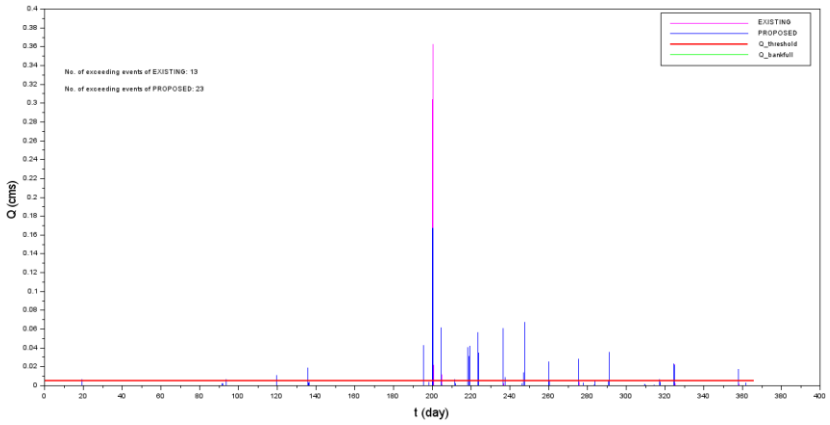
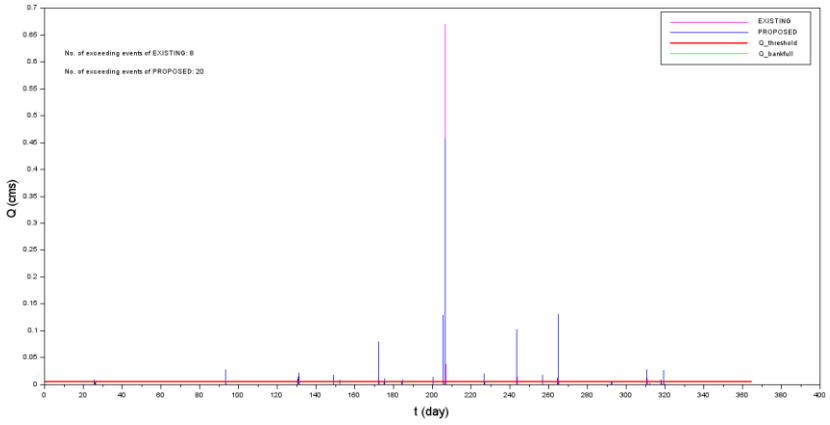
Flows to POI2 1978	
Flows to POI2 1979	

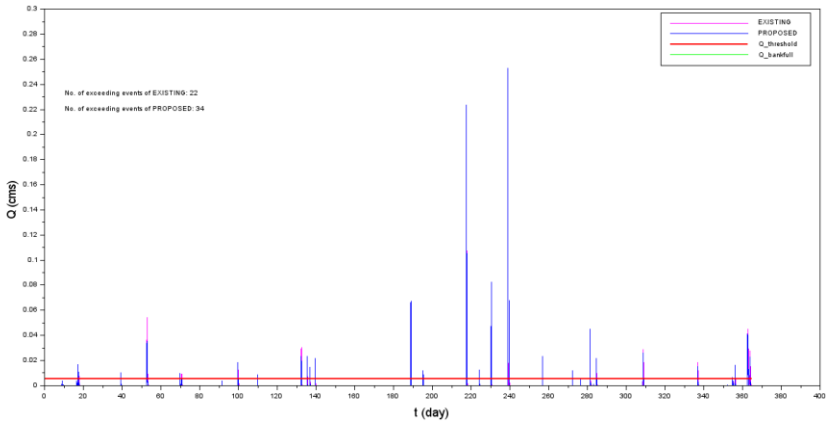
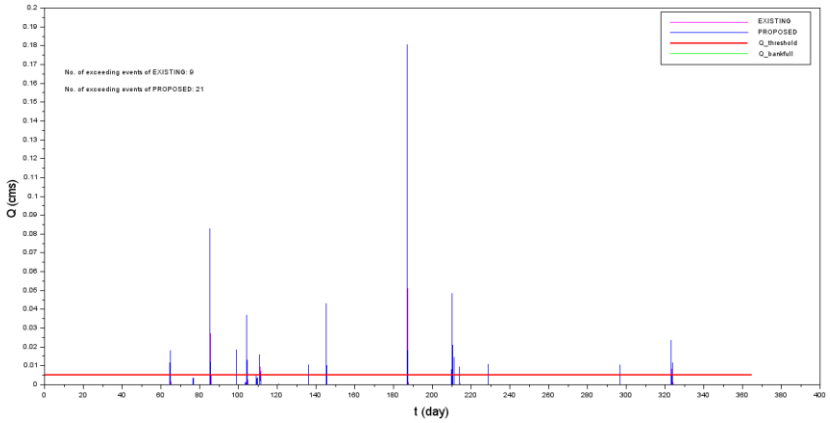
Flows to POI2 1980	
Flows to POI2 1981	

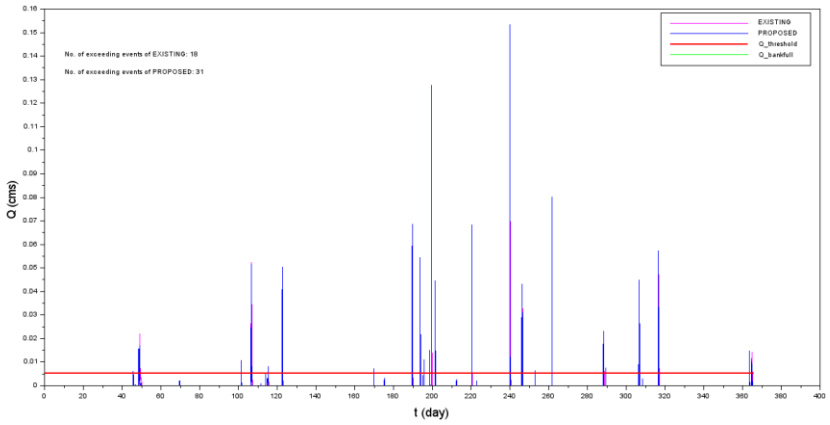
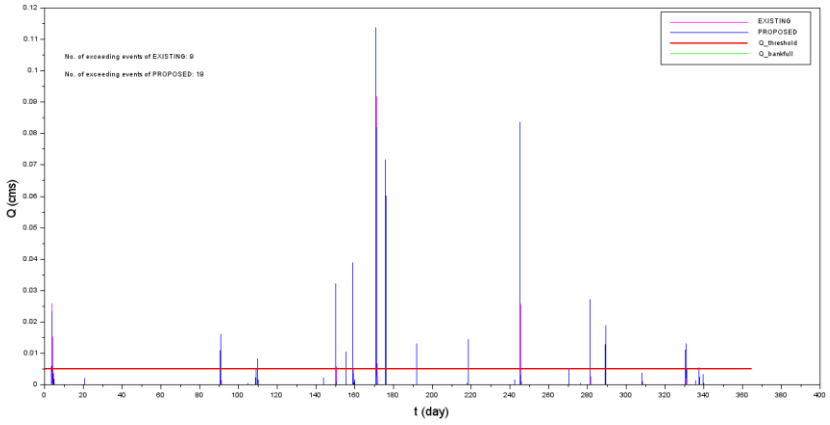
Flows to POI2 1982	
Flows to POI2 1983	

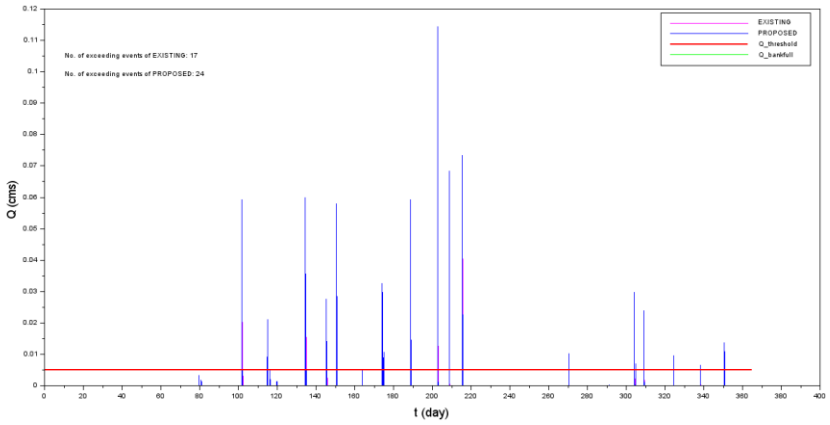
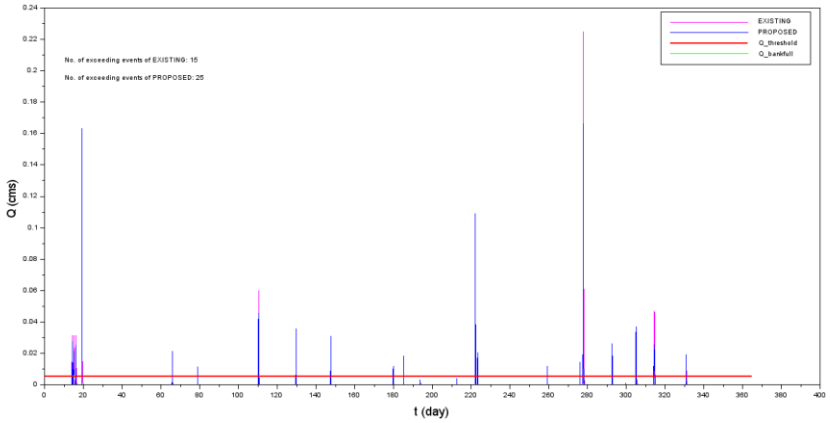
Flows to POI2 1984	
Flows to POI2 1985	

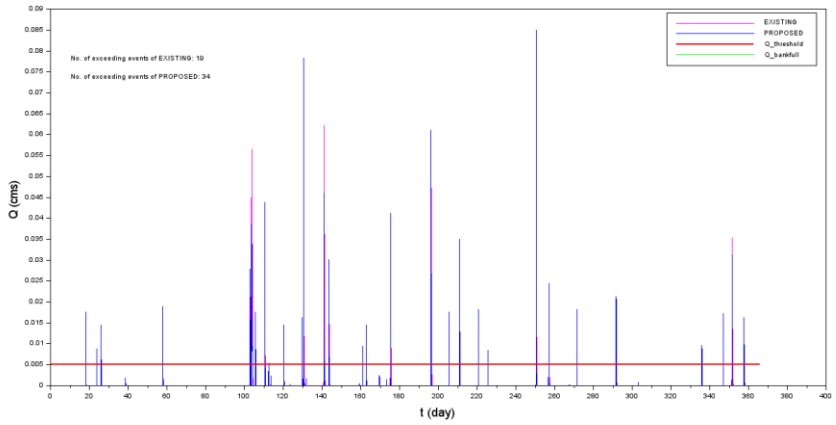
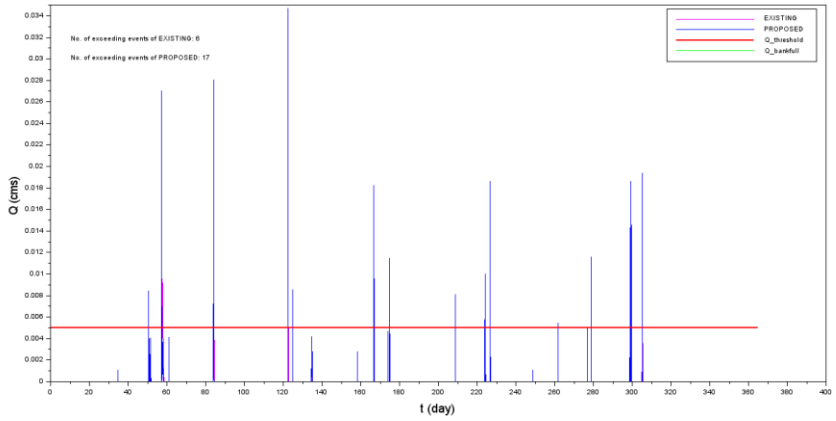
Flows to POI2 1986	
Flows to POI2 1987	

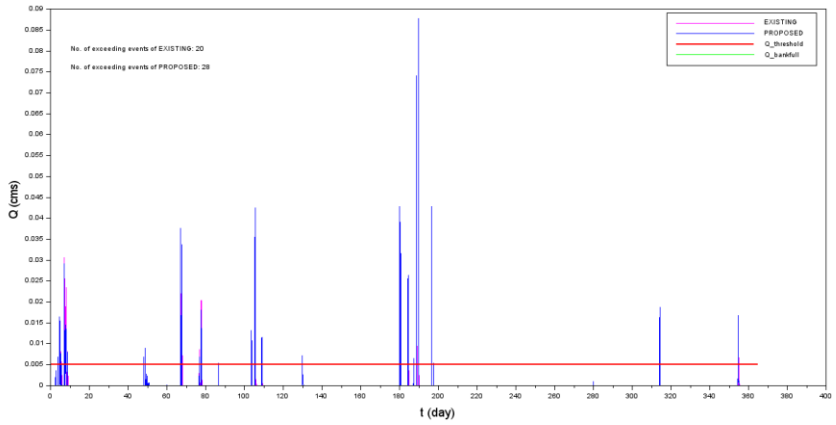
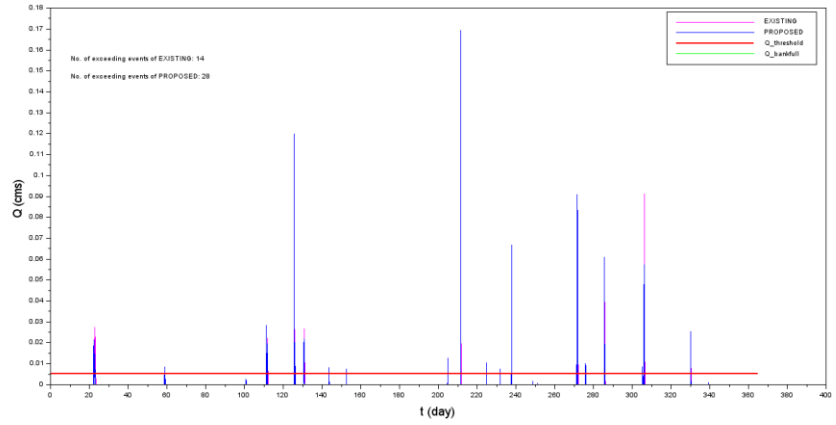
Flows to POI2 1988	
Flows to POI2 1989	

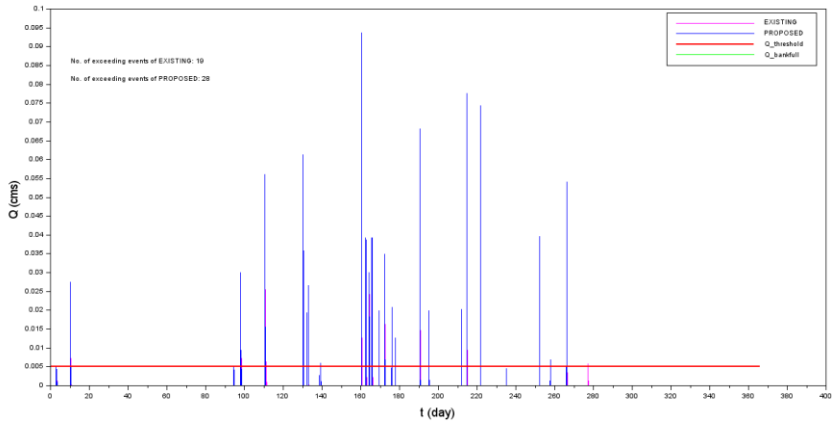
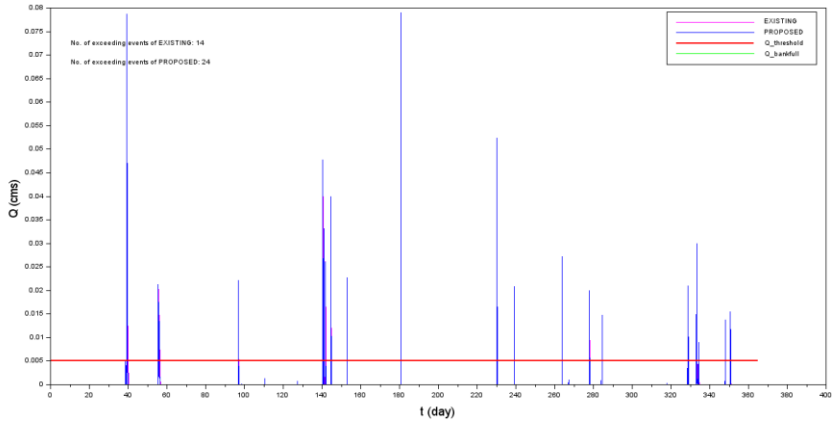
Flows to POI2 1990	
Flows to POI2 1991	

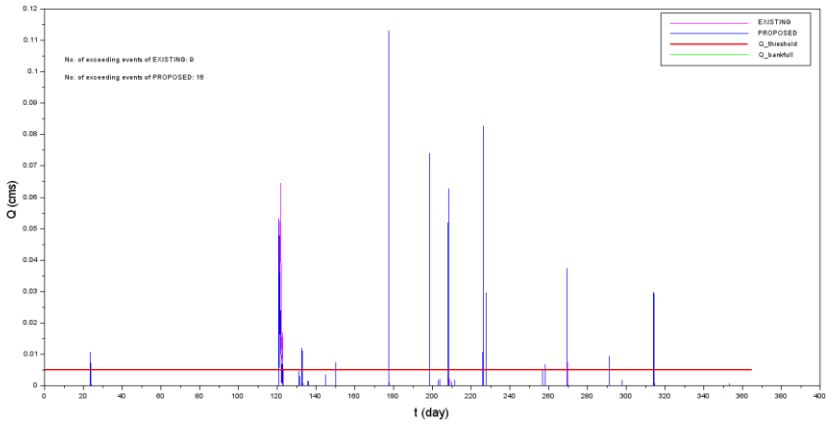
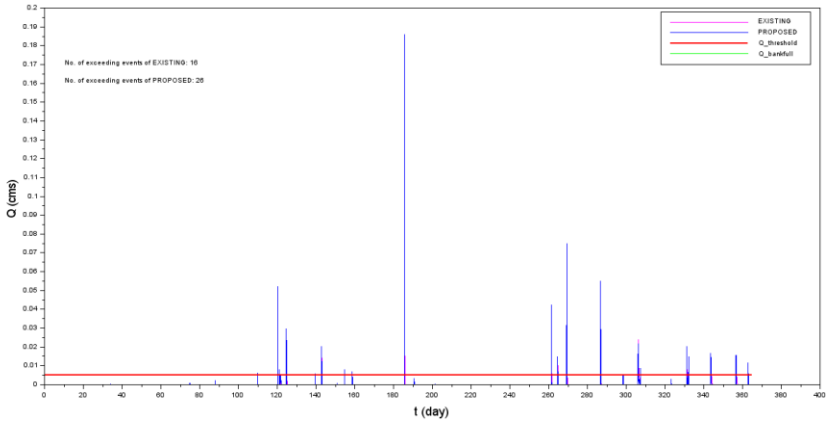
Flows to POI2 1992	
Flows to POI2 1993	

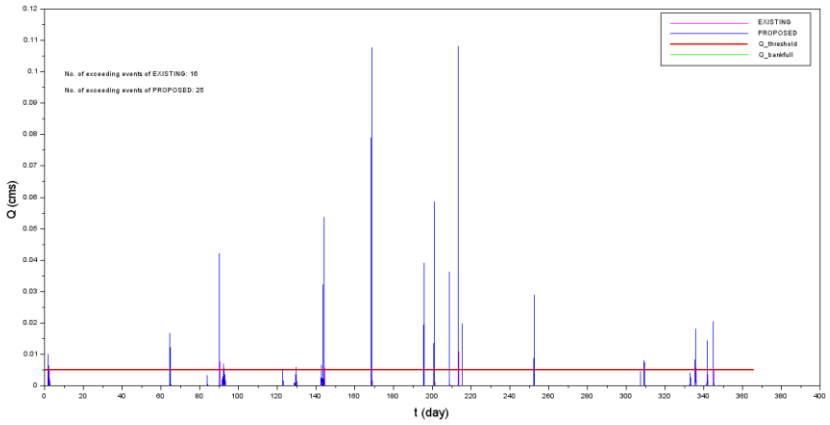
Flows to POI2 1994	
Flows to POI2 1995	

Flows to POI2 1996	
Flows to POI2 1997	

Flows to POI2 1998	
Flows to POI2 1999	

Flows to POI2 2000	
Flows to POI2 2001	

Flows to POI2 2002	
Flows to POI2 2003	

Flows to POI2 2004	
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