Conceptual Channel Design and Erosion Assessment
Bronte River Limited Partnership (BRLP) Property
Town of Oakville, Ontario

Prepared for:

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GEO MORPHIX
Geomorphology
Earth Science
Observations

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1 Introduction

GEO Morphix Ltd. was retained by the Bronte River Limited Partnership (BRLP) to complete a conceptual channel design and erosion assessment for a tributary of Bronte Creek within the proposed Argo/Enns development at 1300 Bronte Road, Oakville Ontario. The BRLP lands, hereon referred to as the subject lands, are located on the western side of Bronte Road between Upper Middle Road West and Highway 403. The western extent of the property is bound by the steep valley formed by Bronte Creek. It is understood that stormwater management practices are required in the study area to meet a set of objectives relating to erosion and water quantity control. Given the sensitivity of the receiving tributary, an erosion assessment was required to determine and address any potential impacts to the watercourse resulting from the development. Additionally, a conceptual channel design was developed to further address stability concerns associated with the receiving watercourse. The erosion assessment and conceptual channel design completed for the receiving watercourse is detailed in this report and included the following activities:

- Review of pertinent background information, including conceptual development plans and previous reporting on the subject watercourse
- Map out erosion issues/concerns, if any
- Detailed geomorphic assessment, the primary objective of which is to support the critical flow or erosion threshold
- Determination of the erosion threshold using an in-house model and empirically derived permissible shear stresses or velocities
- An erosion exceedance modeling exercise comparing pre- to post-development flows with the established erosion threshold for a sensitive reach within the receiving watercourse
- Establishment of monumented cross sections and photograph locations at locations deemed most sensitive to erosion to facilitate a quantitative assessment of stability
- Description of the natural channel design characteristics and features
- Recommendations for design implementation including construction timing, and best management practices
- Description of a post-construction monitoring plan

2 Existing Site Conditions

2.1 Background Review

As part of the assessment, a background review of existing materials, mapping, and reporting related to the subject lands was completed to inform the erosion assessment and conceptual channel design. The material reviewed included the geotechnical investigations (DS Consultants Ltd., March 2023; Terraprobe, March 2023), the amended Phase One ESA for Area 1 and Area 2 (DS Consultants Ltd., 2023), and property mapping provided by Beacon (2023).

The subject lands are approximately 12.12 ha in size, situated on the western side of Bronte Road and is bound by the Greenbelt to the south, west, and partially to the north. The bounding Greenbelt lands support the valleylands, woodlands, and fields that largely form part of the Bronte Creek Provincial Park. The development is generally constrained by a 10 m dripline buffer associated with adjacent woodlots, and 15 m setback from the long-term stable slope crest associated with the Bronte Creek valley. Development plans for the subject lands consist mainly of residential units.

Existing drainage from the site is segmented between the 14-Mile Creek and Bronte Creek watersheds, with approximately two-thirds of the area draining to the latter. Four drainage features exist that direct flows from the property, three of which outlet to Bronte Creek. Two ponds exist within the property and receive drainage internally. The larger pond, referred to as Pond 1, was constructed for recreational purposes. Pond 2, the smaller pond, similarly exists for recreational and aesthetic purposes (DS Consultants Ltd., 2023), but presumably also provides some level of stormwater retention functionality. Both ponds are fed by surface water and intercepting groundwater flow (DS Consultants Ltd., 2023). Pond 1 discharges into Pond 2 through a culvert passing under the existing driveway. A map of the study area is provided in **Appendix A.**

2.2 Surficial 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 appropriate erosion thresholds, as the stability of the channel banks and bed is dependent on the composition of soils, sediment, and underlying parent materials (MNR, 2002).

The subject lands are located within the South Slope physiographic region. This region extends southward from the southern slope of the Oak Ridges Moraine and is characterized by a subdued morainic topography overlying till plains with localized sand and gravel deposits. Drainage is typically controlled by and oriented in the direction of the predominant regional south-facing slope, with exposed red shales of the Queenston Formation being common on valley walls (Chapman and Putnam, 1984).

The local surficial geology varies throughout the subject lands. Most of the subject lands are characterized by coarse textured glaciolacustrine deposits of sand, gravel, silt, and clay. The westernmost portion of the lands contains a patch of clay to silt-textured till derived from either shales or glaciolacustrine deposits. Paleozoic bedrock of the Queenston Shale formation defines the base of the valley and floodplain of Bronte Creek (OGS, 2010).

A preliminary geotechnical investigation completed by DS Consultants Ltd. (2023) indicated a topsoil thickness of up to 150 mm throughout the property. Cohesionless silt, sand, and gravel deposits were noted below the topsoil layer, down to depths of 6 m below ground surface. This was underlain by a later of cohesive silty clay and clayey silt till. Sandy silt till was observed at the terminal end of several boreholes. All the boreholes were found to contain saturated material at the time of drilling on August 18th, 2020. During this date, subsurface water levels were 1.2 to 4.6 m below the ground surface, equating to subsurface water elevations of 129.4 to 125.3 m.

2.3 Field Observations

Field observations were completed during site visits on December 17th and 18th, 2020, to characterize the existing site conditions from a fluvial geomorphological perspective. A total of four (4) drainage features that capture flows from the property were observed during the site visits. A study area map including the approximate locations of these drainage features is provided within **Appendix A**.

The first observed drainage feature (DF-1) was best characterized as roadside ditch that drains a section of the property adjacent to Highway 25. A second drainage feature (DF-2) draining an southern portion of the property was identified. This feature was best characterized as a small gully that has cut a ravine through the valley wall associated with Bronte Creek. A third drainage feature (DF-3) was observed at the western extent of the property with a poorly defined channel and a steep gradient. It was assumed that this steep gradient extended over the valley wall, but due to property access limitations, this was not confirmed. The aforementioned drainage features did not display evidence of excessive erosion that would feasibly pose a threat to any existing infrastructure.

The fourth and final drainage feature identified on the property is a larger gully-type channel that cuts through the valley wall in the southern portion of the property (**Reach BCT-1**). It is understood that this watercourse is proposed to receive outflows from the SWM facility following development. This watercourse is considered the main drainage feature within the subject lands, as it appeared to drain the majority of the subject lands. The upstream extent is connected to the outlet of Pond 2, which was being aerated at the time of assessment.

Reach BCT-1 is best described in three sections, each with distinct geomorphic functionality: the upstream extent or ravine feature (**BCT-1a**), the transfer zone (**BCT-1b**), and the alluvial fan (**BCT-1c**). Together, these zones comprise a typical, complete fluvial system. The upstream ravine feature represents the predominant source of sediment for the system. The sediment produced within the ravine is transported downstream along the transfer zone to the base of the valley slope. As the channel gradient reduces, this sediment is deposited at the base of the valley, dispersing outwards within the Bronte Creek floodplain, and forming an alluvial fan.

Ravine - Reach BCT-1a

Adjacent to the small outbuilding on site, the outlet from Pond 2 directs flows to the ravine feature. Immediately downstream of this, evidence of erosion was observed in the form of fluvial entrainment, valley wall contact, and an exposed building foundation. Erosion in this location is likely attributable to reworking of the pond over time, loss of sediment supply, and concentration of flows from the outlet structure. Flows in the ravine feature pass between valley walls towards the Bronte Creek floodplain in a straight, mixed-load channel with a steep gradient. Bed substrate in the ravine ranges from gravel to large cobbles. The valley walls contain high amounts of gravel and sand material.

Transfer Zone - Reach BCT-1b

Moving downstream, the ravine opens into the transfer zone and the channel gradient became less steep. Cobbles and boulders, gravel deposits, and minor exposures of the shale were observed throughout the channel bed. Evidence of channel erosion was not as severe in this section but was still observed with localized patches of exposed shale, occasional exposed tree roots, and multiple occurrences of large organic debris. Leaning and fallen trees, as well as J-trunk trees were observed throughout this section of the valley, indicating a sustained level of slope adjustment. The slope adjustment in this area is likely partially attributable to the relatively shallow local groundwater table, as evidenced by the seeps and prior borehole observations (DS Consultants Ltd., 2023).

Transfer Zone - Reach BCT-1c

The channel in the transfer zone has a continuous, wide riparian buffer comprised mainly of established trees. The channel lacks diverse velocity and depth conditions and is dominated by riffle-type geomorphologies. Multiple knickpoints created by small woody debris jams were observed. Channel geometry is more defined in this section, with a measured average bankfull width and depth of 2.25 m and 0.51 m.

Immediately below the transfer zone section, the channel enters the floodplain of Bronte Creek, where it eventually outlets. At this location, an active, open alluvial sediment fan was observed. Bed substrate in this section is considerably finer, consisting mostly of sand and gravel. The floodplain is also open, providing good communication with multiple distributary channels within the fan that drain into the main branch of Bronte Creek. Evidence of erosion in this section was not present.

3 Watercourse Characterization

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are divided as such because they are expected to have similar inputs and outputs in terms of sediments and discharge. They are also expected to react similarly throughout to flow events and other stressors. They are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This 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 delineated based on changes in the following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Certain types of channel modifications by humans

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004).

Reaches are first delineated as a desktop exercise using available data and information such as aerial photography, topographic maps, geology information and physiography maps. The results are then verified in the field.

One reach was identified along the receiving watercourse within the property, extending from the existing outlet at Pond 2 until the confluence with Bronte Creek. This reach, named **BCT-1** as a whole, is further characterized by 3 distinct sub-reaches representing the upstream ravine (**BCT-1a**), the transfer zone (**BCT-1b**), and the alluvial fan (**BCT-1c**), as described in section 2.3. The remaining features were best characterized as surficial drainage features and were not classified as stream reaches due to their lack of channel definition, flow inputs, and indiscernible geomorphic activity. A reach map is provided within **Appendix A**.

3.2 Detailed Geomorphological Assessment

Field observations for the main drainage channel and adjacent features on the property were collected during site visits on December 17th and 18th, 2020. **Appendix B** provides a photographic record of the features. Field notes, including a detailed sketch of the feature and property, are also provided as additional background information in **Appendix C**.

The detailed assessment, used to inform the erosion threshold analysis, was completed primarily on reach **BCT-1a** and spanned a small portion of BCT-1b as well. The assessment was completed on December 17th, 2020. Activities completed for the detailed assessment included the following:

- Long-profile survey of the channel centre line
- Eight detailed cross-sectional surveys of the watercourse
- Detailed instream measurements at each cross-section location 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
- Velocity and discharge measurements at select representative cross-sections

The resulting measured channel parameters are outline in **Table 1**, and a summary of the detailed assessment results is provided in **Appendix D**.

4 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 determined from detailed field observations of reach **BCT-1a**. Reach **BCT-1a** was selected for assessment because it is the most erosion-sensitive receiving channel associated with the site. The main channel of Bronte Creek itself was not considered due to the its large drainage area relative to the subject lands. As such, downstream erosion impacts to Bronte Creek would be imperceptible, especially within the context of erosion modelling. 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 was adopted, as it provides the more conservative and limiting estimate.

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.

4.1 Methods

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 is calculated at various depths for a representative cross section until the average velocity in the cross section slightly exceeds the critical velocity 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) or calculated using Limerino's (1970) approach. 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 visual approach (Acrement and Schneider, 1989) was adopted for determining the Manning's roughness coefficient.

For the bank materials, following Chow (1959) in a simplified cross section, 75% of the bed shear stress acts on the channel banks. In a similar approach, the depth of flow is increased until the shear stress acting on the banks exceeds the resisting shear strength of the bank materials.

4.2 Results

Using the data obtained from the detailed geomorphic assessment, an erosion threshold was defined for both the bank and bed material in the form of a critical discharge. The composition of the bed and bank materials were examined and characterized with respect to pertinent literature to inform the appropriate methodology for computing the erosion threshold. Summarized results of the erosion threshold analysis are provided in **Table 1**.

The bed material ranges from silt and sand to large cobbles, with coarser materials being dominant within the reach. The D_{50} of 29.74 mm equates to a permissible velocity of 0.94 m/s using Komar (1987). This represents the velocity required to entrain the median-sized material within the reach and was consequently adopted to compute the critical discharge. The resulting critical discharge required to entrain the median-sized bed material was 0.041 m^3/s.

The bank material was best characterized as a sandy silt loam with trace amounts of fine gravel. A corresponding permissible velocity of 0.76 m/s was obtained from Julien (1998) for ordinary firm loam. From this, a critical discharge of 0.054 m^3/s was computed. The water level at which the flows can feasibly access and erode the banks in an unobstructed manner, as estimated using the D_{84} grain size, was also considered during the analysis, but did not prove to be a limiting factor. Given the limited depth of flow associated with the bed threshold, erosion would occur before substantial inundation of the channel banks.

The limiting critical discharge resulted from the bed materials. Thus, 0.041 m^3/s was selected to define the erosion threshold for reach **BCT-1**.

Table 1: Bankfull conditions and erosion threshold calculation parameters for Bronte Creek Tributary reach BCT-1

Channel parameter	Results by Reach
	BCT-1
Bankfull Conditions	
Average bankfull width (m)	2.16
Average bankfull depth (m)	0.54
Channel gradient (%)	20.84
D_{50} (mm)	29.74
D_{84} (mm)	105.08
Manning's n roughness coefficient	0.055
Bankfull discharge (m^3/s)	2.90
Bankfull velocity (m/s)	4.00
Channel Bed Erosion Threshold	
Bed Material	Graded sand to large cobbles
Apparent shear stress acting on bed (N/m^2)†	66.95
Critical velocity at the bed (m/s)*	0.94
Critical discharge (m^3/s)	0.041
Channel Banks Erosion Threshold	
Bank Material	Firm silty loam, sand and small gravel present
Apparent shear stress acting on banks (N/m^2)†	59.04
Critical velocity at the banks (m/s)**	0.76
Critical discharge (m^3/s)	0.054
Limiting critical discharge (m^3/s)	**0.041**

* Criteria of permissible velocity using Komar (1987) for D50 material
** Criteria of permissible velocity for ordinary firm loam (Julien, 1998)
† Effective shear stresses are expected to be significantly lower than the model suggests

5 Pre- to Post-Development Erosion Exceedance Analysis

A pre- to post-development erosion exceedance analysis was completed for reach **BCT-1**. This analysis was informed by the erosion threshold analysis results and utilized continuous hydrological modelling provided by Urbantech Consulting (2023). Hydrological modelling was provided in 15-minute timesteps in two datasets spanning the years 1960 to 1999, and 2008 to 2017. The erosion exceedance analysis was completed to investigate the impacts of SWM controls on potential erosion within the receiving watercourse. The analysis was completed using our own in-house model with results based on four indices:

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

These indices have been applied elsewhere in CH, TRCA, CVC, and other jurisdictions. They, as a product, provide an evaluation of the number of events, period of transport, and magnitude. We note that the most relevant indicator is the cumulative effective stream power.

Time of exceedance and number of exceedances can be simply calculated from the discharge record. For more relevant indicators, 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 Consulting for two separate time periods. The first flow dataset utilized climate data provided by Conservation Halton (CH) and spanned the years 2008 to 2017. The second dataset spanned the years 1960 to 1999, and were generated using climate data obtained by Urbantech. Flow scenarios were provided for the proposed (post-development) conditions, as well as existing (pre-development) conditions, both excluding ("without pond") and including ("with pond") the effects of the existing pond.

5.1 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:

$$Q_{T=}\sum Q_i \qquad \text{[Eq. 1]}$$

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

$$Q_i = U_i w_i d_i \qquad \text{[Eq. 2]}$$

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:

$$\tau_{o_{\max}} = d_{\max}\rho g S_{\text{bed}} \qquad \text{[Eq. 3]}$$

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, ϖ_{tot} is defined as:

$$\omega_{tot} = \sum \tau_{0_{max}} . U_{avg} . \Delta t \quad \text{[Eq. 4]}$$

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

$$\omega_{eff} = \sum \tau - \tau_{cr} . U . \Delta t, \omega < 0 = 0 \quad \text{[Eq. 5]}$$

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

Time of exceedance t_{ex} defined as:

$$t_{ex} = \sum \Delta t \quad \text{for } (Q_T > Q_{\text{threshold}}) \quad \text{[Eq. 6]}$$

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

5.2 Results

The full series of post- to pre-development hydrographs are included in **Appendix E**, and include the erosion threshold based on discharge, for reference. **Table 2** provides the results of the assessment based on the continuous hydrology provided by Urbantech Consulting (2023).

Table 2: Results of the continuous-hydrology exceedance analysis for the post- to pre-development scenario in Reach BCT-1

Simulation		CED (m^3)	ω_{eff} (N/m^2)	t_{ex} (hrs)	# of Exceedances
(Conservation Halton) 2008-2017 Pre with Pond	**Pre**	32210.10	6784.65	312.75	119
	Post	21267.90	4632.20	132.75	63
	Change (%)	**-33.97**	**-31.73**	**-57.55**	**-47.06**
(Conservation Halton) 2008-2017 Pre w/o Pond	**Pre**	42580.80	8180.10	310.00	172
	Post	21267.90	4632.20	132.75	63
	Change (%)	**-50.05**	**-43.37**	**-57.18**	**-63.37**
(Urbantech) 1960-1999 Pre with Pond	**Pre**	309427.20	59546.03	2052.00	609
	Post	285241.50	57875.58	1463.75	356
	Change (%)	**-7.82**	**-2.81**	**-28.67**	**-41.54**
(Urbantech) 1960-1999 Pre w/o Pond	**Pre**	365496.30	66292.00	1951.00	823
	Post	285241.50	57875.58	1463.75	356
	Change (%)	**-21.96**	**-12.70**	**-24.97**	**-56.74**

We note that the cumulative effective work index (ω_{eff}) is considered the most relevant index with respect to erosion potential, as it reflects both the flow magnitude and exceedance duration of a given erosion event. Of secondary relevance is the cumulative effective discharge (CED) indicator, which is simply the total discharge volume that exceeds the established critical discharge throughout the modelling record.

For the simulation that utilized the CH hydrology record and the pre-development conditions with the existing recreational pond, the rate of long-term erosion is predicted to decrease following development. The CED and ω_{eff} indices decreased by 34% and 32% in the post-development conditions, indicating a reduction in potential erosion relative to the existing state. Cumulative exceedance duration (t_{ex}) and the number of exceedance events are predicted to decrease by 58% and 47%, respectively. Results for the simulation using CH hydrology and the "without pond" pre-development conditions yielded similar results, with each erosion index decreasing by 43% or more.

For the simulation that utilized the Urbantech hydrology record and the pre-development conditions with the existing recreational pond, the CED and ω_{eff} indices decreased by 8% and 3% in the post-development conditions, indicating a relatively minor decrease in erosion potential following development. Cumulative exceedance duration (t_{ex}) and the number of exceedance events are predicted to decrease by 28% and 42%, respectively. The results for the simulation using Urbantech hydrology and the "without pond" pre-development conditions similarly predict a greater increase in erosion potential when excluding the pond effects in the existing conditions. The CED and ω_{eff} indices decreased by 22% and 13%, indicating a moderate level of erosion reduction. Overall, the results from the Urbantech hydrology simulations predict less of a decrease to long-term erosion potential relative to the simulations that utilized the CH hydrology.

The relative difference between the "with pond" and "without pond" scenarios for both hydrology data sources may indicate a minor potential level of erosion mitigation stemming from the recreational pond. Considering the existing erosion concerns, a decrease in the long-term erosion potential would likely serve to enhance and stabilize the watercourse from a geomorphic context. All simulations, regardless of hydrology data source or existing condition characteristics, predicted a minor to moderate reduction in the long-term rates of erosion following development. As such, the proposed stormwater management plan adequately addresses concerns relating to erosion mitigation and is expected to enhance the stability of the feature going forward. We note that these results can be further refined during detailed design stages.

6 Conceptual Channel Design

6.1 Design Objectives

To receive outflows from the proposed SWM facility following development, an existing online pond (Pond 2) is proposed to be removed and the associated drainage feature to be restored and enhanced. This provides an opportunity to replace the previously modified and morphologically-limited system with a dynamically stable treatment train to receive and convey flows.

The proposed design provides a treatment train that aims to provide channel invert control, erosion protection, and energy dissipation, while also enhancing channel form and function, and providing habitat variability.

Overall, given the limited channel form and previous impacts from land use practices, the proposed realignment and naturalization provides opportunities for improved riparian conditions and treatments with morphological variability, that will provide additional erosion protection. Improvements in morphology and function also provide benefits to sediment balance, storage, vegetation communities, and water quality. The proposed conceptual designs are included in **Appendix F** and described in further detail below.

6.2 Design Elements

The outfall for the bio-filtration swale / LID located within the BRLP lands is proposed to consist of a stone core pocket wetland, low flow channel, pocket wetland, and an alternating cascade. The outfall channel design has been proposed to maintain the existing length of **Reach BCT-1**.

The stone core pocket wetland feature serves to accept flows from the bio-filtration swale and associated headwall and will release flows into the low flow channel. The wetland stone core refers to hydraulically sized rounded stone, which is the subsurface material used to ensure wetland stability. A layer of topsoil will be installed on top of the stone mix within the wetlands to improve vegetation establishment. Benefits of the proposed wetlands include organic inputs, temperature regulation, polishing, energy dissipation, and dispersion of flows. Additionally, by retaining flows, the wetland can provide opportunities for infiltration, evapotranspiration, and detention.

The restoration design proposes a provide a self-maintaining low-flow channel with a riffle-pool channel system. When it is assessed to be an appropriate channel type, a riffle-pool system offers numerous benefits, namely:

- Channel bed relief for flow variability
- Water aeration in riffle sections
- Relatively quiescent flows in pool sections
- Instream energy dissipation

During the detailed design stages, geometries and dimensions will be determined for the proposed low flow channel using a simple Manning's approach to iteratively back-calculate bankfull dimensions from the proposed bankfull discharge, as this represents what is generally considered the channel-forming discharge or the dominant discharge.

An alternating cascade, consisting of hydraulically sized keystones, is proposed within the existing gully feature to provide invert control, erosion protection, and energy dissipation. The series of cascades will reduce erosion along the channel banks by concentrating flow towards the centre of the channel and dissipating energy by creating turbulence. A layer of sacrificial sediments is proposed on top of the keystones. This layer will consist of fine native material or granular 'b' type I (from naturally formed deposits, containing no deleterious materials) and will fill pore spaces during the first few flooding events and help prevent water from piping beneath the keystones. It is understood a portion of this sediment may get transported downstream, but it is required to help prevent water from piping beneath the keystones. A series of photographs depicting examples of an alternating cascade design and gully erosion mitigation treatment that were installed in channels with similar characteristics to **BCT-1** is provided in **Appendix G**, for reference. Note an optional bed treatment is shown on the design drawings in **Appendix F**. The optional wood reinforced check dam is included for its relative ease of construction and limited footprint of disturbance and would complement the alternating cascade treatment. The treatment would be installed solely using hand labour and would be field fit during construction, if required. The treatment would consist of 150 mm diameter untreated cedar logs that are embedded and layered in the exiting gully bed and banks and help to anchor the proposed hydraulically sized substrates.

Vegetated rock buttress is proposed along the banks of the alternating cascade. The vegetated rock buttress will consist of hydraulically sized stones with container grown plants staggered between the stones, spaced horizontally 1 m apart. The strength of the vegetated buttress will be augmented through vegetation establishment, and it will reduce the potential for erosion. Additionally, the plantings will provide additional thermal mitigation through shade, but will also provide a source of organic matter, to enhance semi-aquatic habitat.

Brush mattress is proposed along the outside meander bend of the low flow channel and along the banks of the alternating cascade. This treatment consists of a toe stone and live brush cuttings installed parallel to the banks and tied in with coir twine and stakes. The brush mattress will provide bank stability and improve aquatic habitat through shading.

Hydraulic sizing will be completed for all stone required within the proposed treatments during the detailed design phase. A range of techniques will be utilized to determine the appropriate stone size, as summarized in the National Engineering Handbook (NRCS, 2007). These techniques include the Isbash method (Isbash, 1936), the USBR Method (Peterka, 1958), and Maynord's Method (Maynord, 1988). The stone will be hydraulically sized to limit entrainment at the regional event and sizing will include a factor of safety to provide additional stability. The hydraulically sized stone will provide increased stability during the regional event, while allowing for storage and infiltration at lower flows.

6.3 Outfall Location Recommendations

To support the development of SWM outfall concepts, observations were collected in the vicinity of the potential outfall locations. Potential outfall locations were identified at the top and at the base of the Bronte Creek valley, adjacent to the BRLP lands. Photographs of the potential outfall locations are included in **Appendix B**.

The first option ("Option A") is an outfall and restored outfall channel located at the upstream extent of **BCT-1**, immediately downstream of the proposed LID treatment train. With this option, channel form and function are enhanced using natural channel design principles within the restored portion of the outfall, and flows through the existing ravine channel are maintained. Localized erosion protection will mitigate impacts, and any future erosion issues are simpler to address, if required, due to the proximity of the outfall to the property. As this outfall option resides outside of the Bronte Creek floodplain, there are no concerns relating to associated flooding and erosion hazards.

The alternative option ("Option B") is a piped outfall, using a drop structure, at the base of the Bronte Creek valley. Adopting the alternative option will cause a significant reduction of flows to the ravine channel, consequently removing most associated geomorphic form and function. Localized erosion protection would be required within the receiving portion of the channel within the floodplain. As this outfall would reside within the floodplain of Bronte Creek, significant hazards relating to erosion and flooding are present. Further, these hazards will be harder to address, both initially and in the longer-term, due to difficult access to the base of the forested valley and the fact that the outfall would be located on non-Town owned property (i.e. Bronte Creek Provincial Park lands).

Fluvial impacts were one consideration when selecting the preferred stormwater outfall location. For additional information, please refer to the EIA (Beacon, 2023) and the FSR (Urbantech, 2023).

6.4 Site Restoration Recommendations

Newly constructed features can be vulnerable to erosion. This is particularly true before vegetation has established along the channel banks. While low-flow events should not intensify erosion, the concern for erosion occurs when there are high flows or precipitation events during construction.

For immediate erosion protection, mechanical stabilization in the form of biodegradable erosion control blankets (i.e., coir cloth, jute mat, etc.) should be used. As the blankets will biodegrade over time, this serves as a short-term stabilization measure.

For long-term stability, implementation of a planting plan is recommended. This should include deep rooting native grasses and/or shade tolerant herbaceous species seeded along and within channel sections, prescription of flood tolerant native shrub and tree species, and use of seed banks within the local soil. Shrubs should be planted close to the channel margins to provided maximum benefit with respect to stabilization and channel cover.

Potential erosion locations (i.e., along the outside meander bends, immediately downstream of wetland features, etc.) should be anticipated, and should be reflected in the planting plans. Live staking and shrub stock should be used adjacent to the channel bank to provide immediate benefit as well as long-term infilling. If appropriate live staking methods are followed, this method should provide greater benefits than simple potted or bare root shrub plating. This is because of the potential for higher densities with live staking.

6.5 Recommendations for Construction and Implementation

The proposed design elements are unique and as such, the designer or representative should be part of construction supervision to ensure proper installation and function of the design elements. The designer should confirm materials are appropriate prior to installation. This will ensure the feature functions as intended. On-site supervision will ensure a rapid response to construction issues. The constructed feature should be deemed stable by the designer, prior to flow introduction.

The limits of construction will be delineated to prevent unanticipated impacts to natural surroundings, including trees and the watercourse. All isolated work areas will be dewatered to perform work under dry conditions. Water will be pumped to a sediment filtration system located at least 30 m from existing creeks and be allowed to naturally flow over a well-vegetated surface and ultimately return to the channel downstream of the work area. This will allow particles to settle before reaching the watercourse.

All materials and equipment will be stored and operated in such a manner that prevents any deleterious substances from entering the water. Vehicle and equipment refuelling and/or maintenance will be conducted away from the watercourse and be free of fluid leaks and externally cleaned/degreased to prevent the release of deleterious substances. Machinery should arrive on site in a clean condition (including free of mud/soil/dirt from other locations; including clean wheels/tires/tracks) and should be maintained free of fluid leaks. In order to reduce the spread of invasive species, equipment should be cleaned before being brought on-site and before leaving site. For guidance in this regard, please refer to the Clean Equipment Protocol for Industry available online: (https://www.ontarioinvasiveplants.ca/wp-content/uploads/2016/07/Clean-Equipment-Protocol_June2016_D3_WEB-1.pdf).

Regarding construction of the enhancements to the upper reach of the ravine/gully (**BCT-1a**) (i.e., below the location of the existing berm, within the existing footprint of the ravine/gully feature), we note that we have experience installing similar works with either the installation of stone, or in one case, the installation of sediment traps across the channel for channels that are confined. In these cases, equipment and materials were "crabbed" down the channel after pumping flows around the site and installing appropriate ESC measures. Materials are brought down by hand or by excavator. Usually blast mats or timber mats are installed to facilitate movement of materials. We have also been involved in projects where materials have been slung or cabled down into the ravine. The channel is then constructed from its downstream to upstream extent.

6.6 Recommendations for Maintenance

Given the keystones in the alternating cascades and vortex rock weirs are to be hydraulically sized to withstand the regional event, it is unlikely any regular maintenance will be required. The proposed biofiltration swale has been designed to outlet flow rates below the calculated erosion threshold, which mitigates potential erosion. Individual stones may adjust over time to a more natural form without compromising the intended function.

In the unlikely case maintenance is required; it would simply involve rearranging the existing materials. We note that there is sufficient maintenance access to both the channel proposed within the original pond footprint and the channel that will be installed in the footprint of the current berm (i.e., the upstream extent of **BCT-1a**). These sections of the channel are where the most significant alterations are proposed and, as such, would be the most likely location where future maintenance may be required. In the post development condition, there would be access into the restored areas from the upstream section of the meandering channel, if required. Access could be gained through the Town owned LID feature. Notwithstanding that access will be available to this portion of **BCT-1**, the proposed alternating cascade section has been designed to be stable and to evolve and adjust within the provided footprint and as such should be maintenance free.

In the unlikely case that future works are required within the ravine, a similar method of phasing and access would be proposed. Flow would be diverted around the gully through a pumping system installed by hand labour. Appropriate ESC measures would be installed also by hand labour. The materials would then be either moved down the ravine by hand or with a small vehicle. Staging and hoarding of materials would occur adjacent to the footprint of the proposed LID feature, and then materials and equipment would be walked down the ravine.

We do not anticipate future channel works will be required beyond the warranty period. The proposed alternating cascade channel has been designed to be stable and to evolve and adjust within the provided footprint and should therefore be maintenance free. As such, we do not recommend installation of a road or other access into, or adjacent to, the ravine given the spatial constraints and substantive environmental impacts that would be required to both install and maintain the access route. We also note that the erosion setback requirements and geotechnical requirements associated with Bronte Creek itself provide for a significant buffer with regards to erosion around the gully feature.

6.7 Post-Construction Monitoring

Monitoring of the proposed restoration will allow issues to be identified and addressed promptly. The features should be monitored for a period of five years after construction. Monitoring should include general observations, identification of any erosion issues, monumented cross sections within the feature to measure potential changes to the feature's geometries, monumented photographs and a yearly survey of prescribed plant materials. General observations should also be completed after construction and after the first large flooding event to identify any areas of potential erosion. The proposed monitoring plan will be finalized during the detailed design phase.

7 Summary and Recommendations

The objective of this study was to determine an appropriate erosion threshold for a small tributary of Bronte Creek in support of the development of an erosion mitigation plan to address post-development impacts downstream of the proposed SWM facility for the BRLP lands in Oakville, ON. Additionally, a conceptual outfall channel design was developed for the receiving watercourse to provide further channel invert control, erosion protection, and energy dissipation.

Reach delineation and reconnaissance-level assessments were completed to identify areas of potential erosion sensitivity downstream of the proposed SWM facility. A detailed assessment was completed thereafter along the sensitive areas of the receiving watercourse (**Reach BCT-1**) and was used to inform the erosion threshold analysis.

A permissible velocity using Komar (1987) for the D_{50} bed material was adopted as the limiting criteria for the erosion threshold. The resulting erosion threshold for **Reach BCT-1** was given as critical discharge of 0.041 m^3/s.

An erosion exceedance assessment was subsequently completed, which applied the pre- and post-development hydrographs prepared by Urbantech Consulting (2023) to the erosion threshold of the receiving watercourse. Results indicate that no exacerbated rates of erosion are expected within the receiving watercourse following development. We therefore support the proposed storm water management strategy and suggest that no significant changes to the sensitive reaches will occur as a result of development.

A conceptual channel design, including post-construction monitoring and maintenance recommendations, was developed to support the removal and naturalization of Pond 2. The proposed conceptual designs provide channel invert control and erosion protection, while also enhancing channel form, function, and aquatic habitat. Proposed channel features include a low-flow channel, an alternating keystone cascade, a stone core pocket wetland, and a vegetated rock buttress.

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

Respectfully submitted,

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

John Tweedie, M.Sc.
Watershed Scientist

Benjamin Miller, B.Sc., CAN-CISEC
River Scientist, Project Manager

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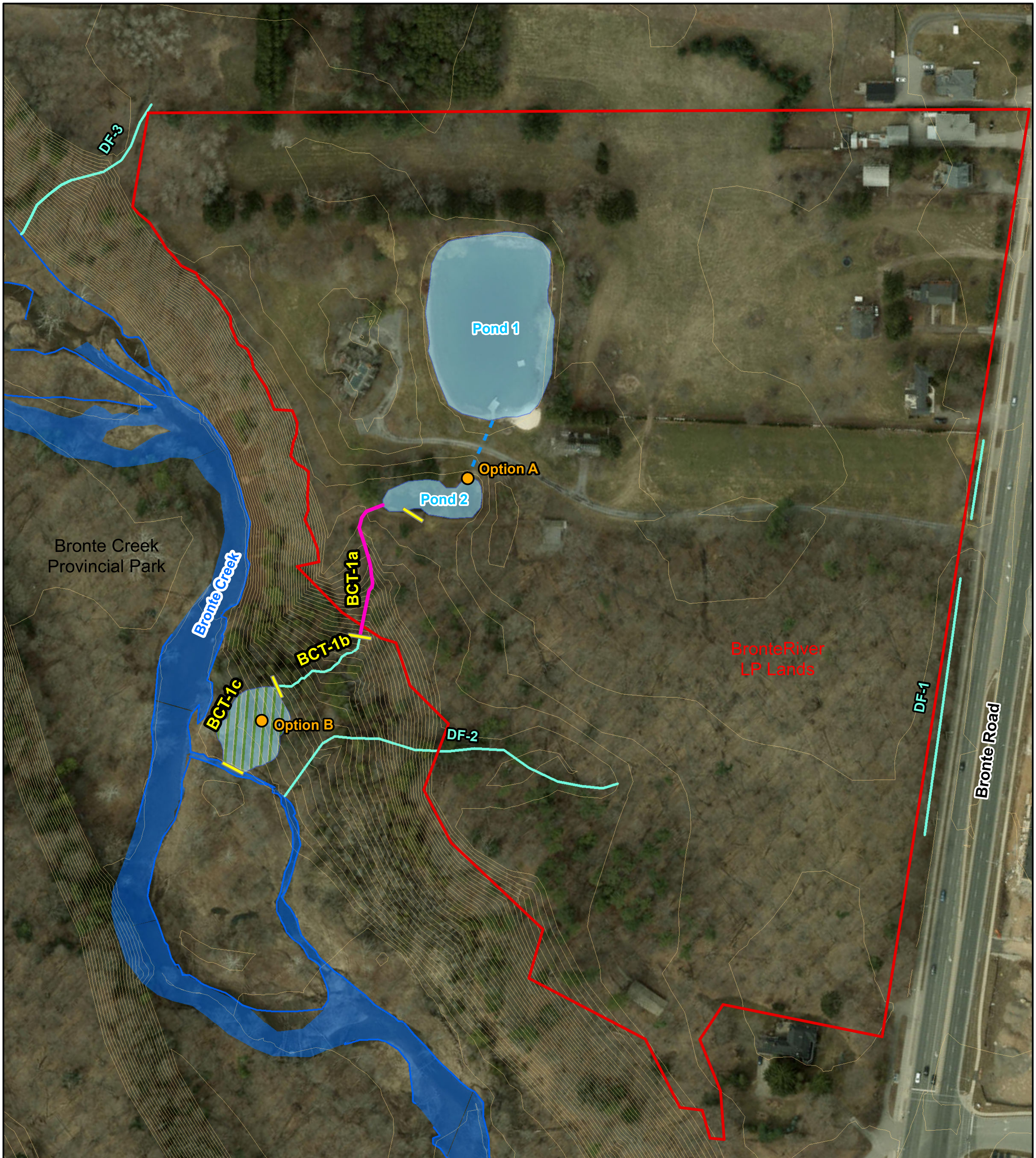
Appendix A
Study Area Mapping



Bronte River Limited Partnership Development

Conceptual Channel Design and Erosion Assessment

Oakville, Ontario

Imagery: Google Earth Imagery, 2017.
Reach Break and Label, Alluvial Fan, Pond, Detailed Assessment: GEO Morphix Ltd., 2022. Study Site: Argo, 2021.
Watercourse: MNRF and GEO Morphix Ltd., 2021.
Drainage Feature, Proposed Outlet: GEO Morphix Ltd., 2023.
1 m Contour: Conservation Halton, 2016.
Printed: April 2023. PN20117. Drawn by: J.T., M.O.

Appendix B
Photo Record

Photo 1
Main Ravine Feature: View Right Bank

Photo taken from the south bank of pond and berm feature. Note location of pond (right), berm, and small outbuilding. Arrow depicts flow direction from pond outfall.

Photo 2
Main Ravine Feature: View Upstream

Photo facing north towards pond outfall.

Photo 3
Main Ravine Feature: View Downstream

Photo taken from the pond outfall facing the small outbuilding on site.

Photo 4
Main Ravine Feature: View Downstream

Ravine flows south between valley walls. Note exposed building foundation.

Photo 5 Main Ravine Feature: Downstream	 Erosion evidence in the form of fluvial entrainment and exposed tree roots.
Photo 6 Main Ravine Feature: View Downstream	 Valley wall contact on both banks of the channel. Bed substrate ranged from gravel to large cobble.

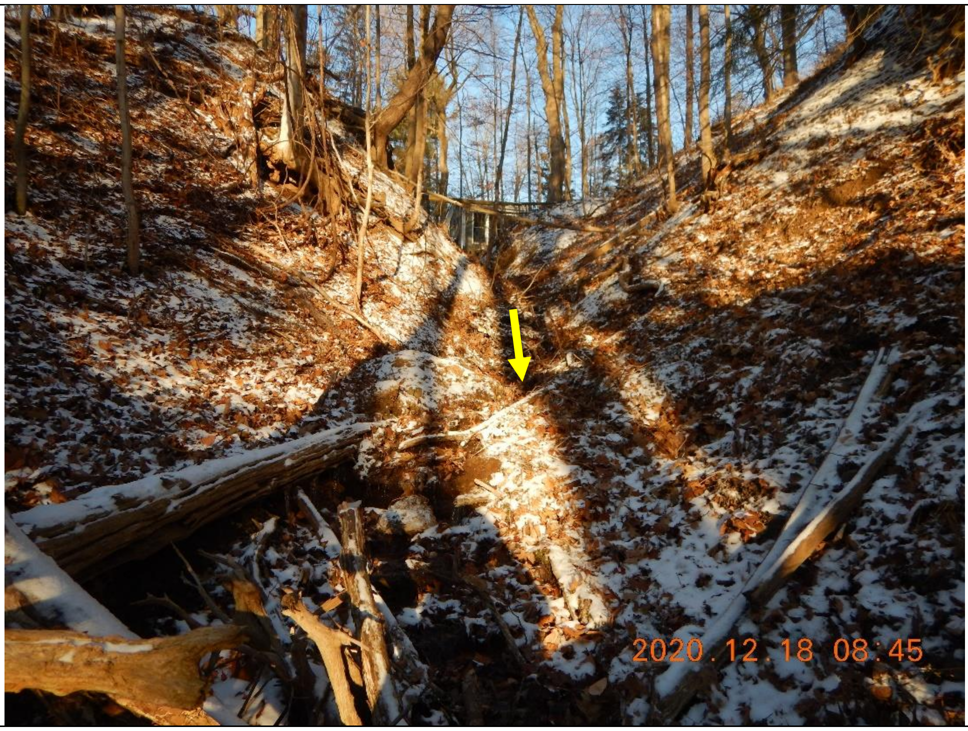
Photo 7 Main Ravine Feature: View Left Bank	 Bank material consisted of mainly sand and gravel. Groundwater seepage was also evident in the banks.
Photo 8 Main Ravine Feature: View Upstream	 Ravine feature was straight with a steep gradient. Note small outbuilding at the top of slope.

Photo 9
Transfer Zone: View Downstream

The transfer zone had a less steep gradient compared to the main ully.

Photo 10
Transfer Zone: View Downstream

As the channel moved away from the valley walls, more defined bankfull conditions were evident.

Photo 11 Transfer Zone: View Upstream	 Multiple knickpoints created by small woody debris jams were present throughout the transfer zone section of the channel.
Photo 12 Transfer Zone: View Downstream/Right Bank	 Evidence of erosion in the form of fluvial entrainment. Bank materials in the channel consisted of mainly sand and gravel with some silt.

Photo 13 Transfer Zone: View Right Bank		Overland ice formation shows evidence of groundwater seeps throughout the channel.
Photo 14 Transfer Zone: View Upstream		Riffle-like characteristics present throughout the entirety of the transfer zone. Bed substrate ranged from gravel to small boulders.

Photo 15 Alluvial Fan: View Downstream	 Photograph taken from the right bank at the upstream extent of the alluvial fan section of the channel.
Photo 16 Alluvial Fan: View Downstream	 Channel splits into multiple flow paths. Photo taken viewing left side of alluvial fan.

Photo 17 Alluvial Fan: View Downstream	 Channel splits into multiple flow paths. Photo taken viewing right side of alluvial fan.
Photo 18 Alluvial Fan: View Upstream	 Photo taken from left bank of Bronte Creek facing the alluvial fan.

Photo 19 Proposed Outlet Location A	 Approximate outlet location at the downstream extent of the proposed LID features, at the top of the Bronte Creek Valley.
Photo 20 Proposed Outlet Location B	 Secondary outlet location option at the upper extent of the alluvial fan. Bank protection is reduced and less stable, and impact to tree cover impact is increased. Significant flooding and erosion hazards are also presented from Bronte Creek.

Appendix C
Field Observations

General Site Characteristics

Project Code: 20117

Date:	2020-12-18	**Stream/Reach:**	
Weather:	sun -10°C	**Location:**	1300 Bronte Rd
Field Staff:	TR	**Watershed/Subwatershed:**	Bronte Crk

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

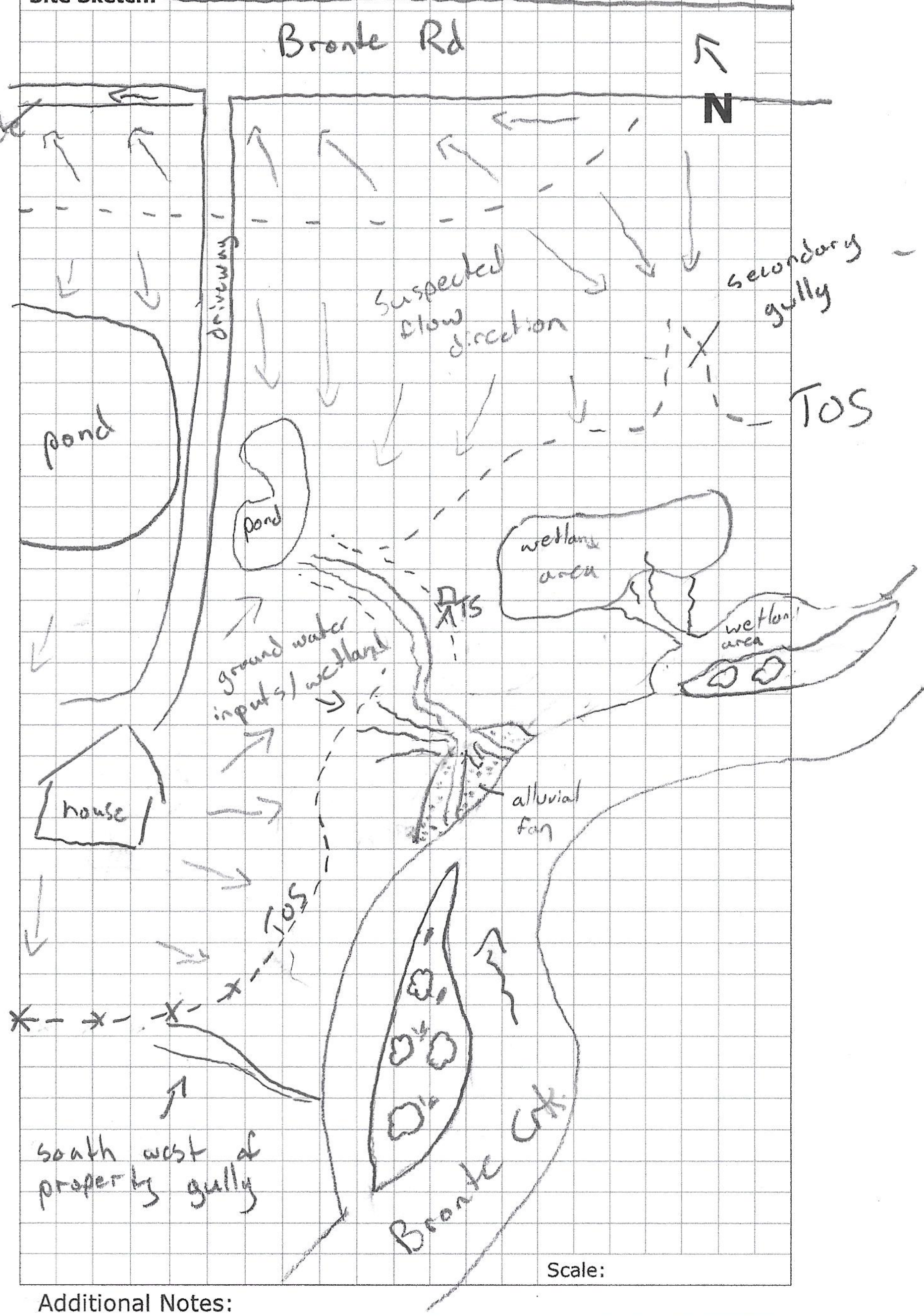
Substrate

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:

Completed by: TR   Checked by: ________

GEO | MORPHIX
Geomorphology
Earth Science
Observations

General Site Characteristics

Project Code: 20117

Date:	2020-12-17	**Stream/Reach:**	
Weather:	SUNNY -4°C	**Location:**	Bronte Green
Field Staff:	CVM TR	**Watershed/Subwatershed:**	Bronte 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

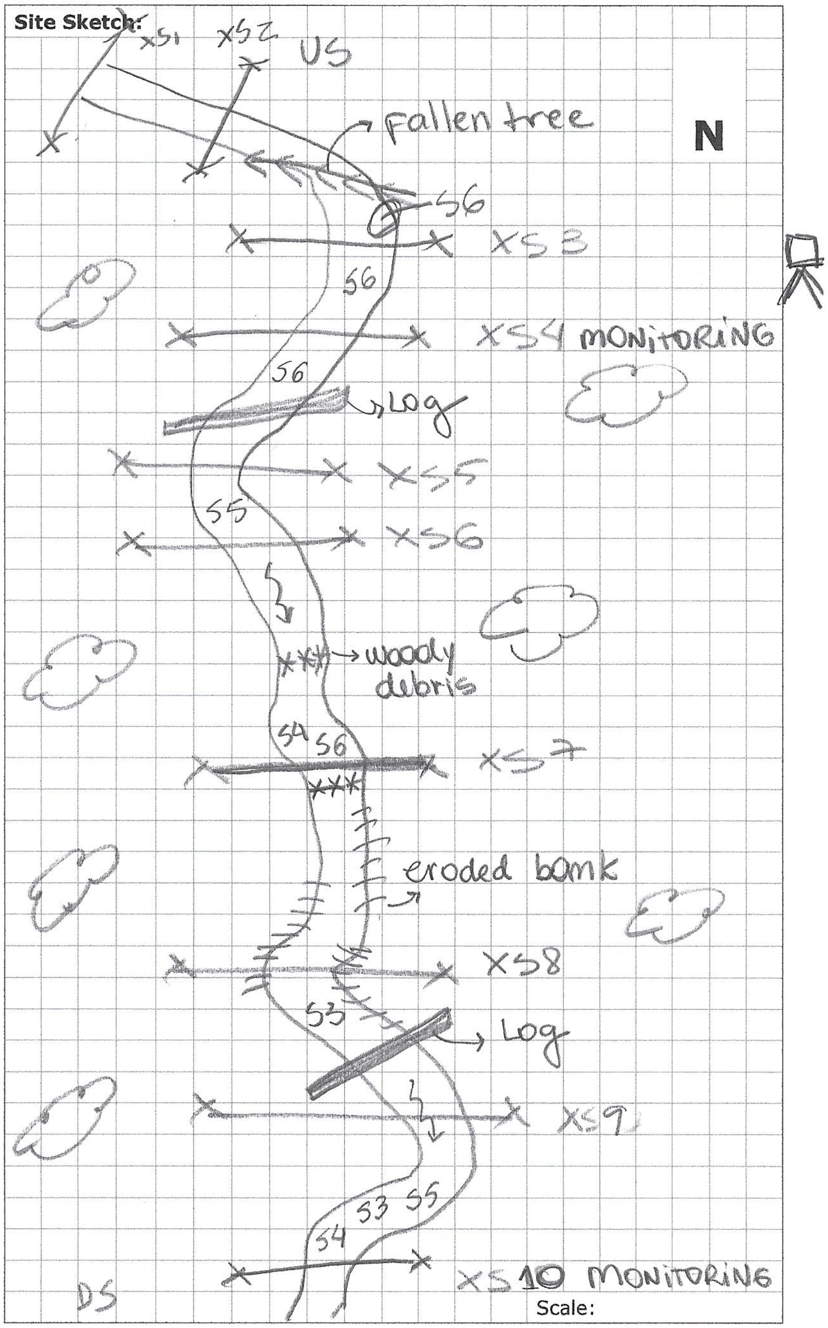
Substrate

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:

Completed by: CVM Checked by: ________

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Observations

Detailed Assessment (Level)

Project Code: 20117

Date:	2020-12-17	**Reach:**	gully/ravine
Weather:	overcast -10°C	**Location:**	
Field Staff:	TR CVM	**Watershed/Subwatershed:**	

Top	Middle	Bottom	Angle	Water	XS	Notes
	TS					
	File	20117	F2020			
	Long	Profile				
	-points	100	- 197			
	point	192 =	WL			
	XS1	points	1100 →	1117		
	XS2	points	1200 →	1220		
	XS3	points	1300 →	1315		
M	XS4	points	1400 →	1421		
	XS5	points	1500 →	1520		
	XS6	points	1600 →	1620		
	XS7	points	1700 →	1717		
	XS8	points	1800 →	1820		
	XS9	points	1900 →	1921		
	XS10	points	2000 →	2019		

Survey Direction

- ☑ Upstream to Downstream
- ☐ Downstream to Upstream

Cross-sections

No. of Cross-sections: 10

Monitoring Cross-sections:

- ☐ None
- ☑ Yes

If yes, which ones: 4 & 10

Rain in last 24 hours

- ☑ None
- ☐ Yes: Amount _____ mm

Valley Type:
Confined Partially Unconfined

Channel Zone:
Headwater Transfer Deposition

Land Use: residential/forest

Aquatic Vegetation: N/A

Coverage of Reach: – %

Riparian Vegetation: trees

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

XS 1+2 not a part of detailed survey.
-additional data

Completed by: TR Checked By: ________

Page ____ of ____

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Cross-Section Characteristics

Project Code: PN 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS1
Weather:	Overcast	**Location:**	Bronte
Field Staff:	TR CVM	**Watershed/Subwatershed:**	Bronte Creek

					Notes
			total	Station	

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 4.5	11. 1.0	21. 0.2	31. 0.9
2. 9.0	12. 3.4	22. 0.4	32. 1.1
3. 2.5	13. 2.8	23. 1.2	33. 1.3
4. 0.3	14. 0.8	24. 6.5	34. 0.4
5. 0.2	15. 0.6	25. 2.4	35. 1.2
6. 1.4	16. 0.3	26. 1.2	36. 0.5
7. 4.2	17. 0.3	27. 1.0	37. 0.4
8. 3.4	18. 0.3	28. 0.6	38. 0.5
9. 1.5	19. 0.5	29. 0.4	39. 0.6
10. 1.8	20. 0.4	30. 0.5	40. 0.5

Particle Shape:

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

Embededness: 80 %

Subpavement: ____________

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: CVM Checked by: ________

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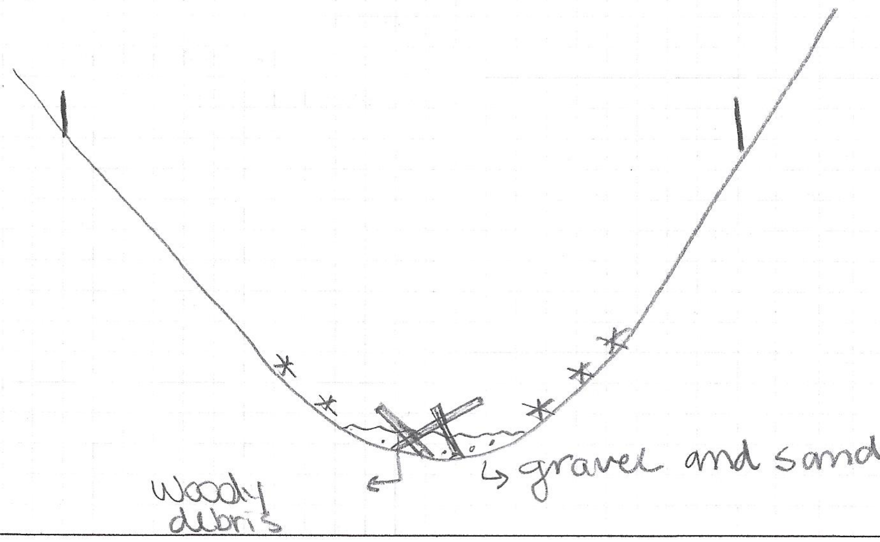
Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS1

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

Left Bank **Right Bank**



Left Bank Materials

- [ ] Bedrock
- [ ] Till
- [ ] Clay
- [ ] Silt
- [x] Sand
- [x] Gravel
- [ ] Small Cobble
- [ ] Large Cobble
- [ ] Small Boulder
- [ ] Large Boulder

Bank Height:	VWC	m
Bank Angle:	70	°
Root Depth:	3.0	m
Root Density:	5	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm²

Foot Used: ☐ Yes ☐ No

Right Bank Materials

- [ ] Bedrock
- [ ] Till
- [ ] Clay
- [ ] Silt
- [x] Sand
- [x] Gravel
- [ ] Small Cobble
- [ ] Large Cobble
- [ ] Small Boulder
- [ ] Large Boulder

Bank Height:	VWC	m
Bank Angle:	80	°
Root Depth:	3.0	m
Root Density:	5	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm²

Foot Used: ☐ Yes ☐ No

Additional Notes

Photo Order:

Completed by: ________ Checked by: __________

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Earth Science
Observations

Cross-Section Characteristics **Project Code:** PN 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS 2
Weather:	overcast	**Location:**	Bronte
Field Staff:	TR CNM	**Watershed/Subwatershed:**	

					Notes
				total	station

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 7.8	11. 0.4	21. 2.3	31. Sand
2. 7.5	12. 0.5	22. 1.6	32.
3. 0.9	13. 2.2	23. 5.4	33.
4. 0.4	14. 1.1	24. 0.8	34.
5. 0.5	15. 2.2	25. 1.6	35.
6. 0.4	16. 0.2	26. 1.0	36.
7. 0.5	17. 0.4	27. 7.7	37.
8. 0.3	18. 3.3	28. 6.6	38.
9. 0.2	19. 8.4	29. 2.0	39.
10. 1.1	20. 5.2	30. 0.9	40.

Particle Shape:

☐ Platy ☑ Sub-angular ☐ Well Rounded

☐ Very Angular ☐ Angular ☑ Sub-Rounded

☐ Rounded

Embededness: 80 %

Subpavement: ____________

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: __________ Checked by: __________

GEO | MORPHIX
Geomorphology
Earth Science
Observations

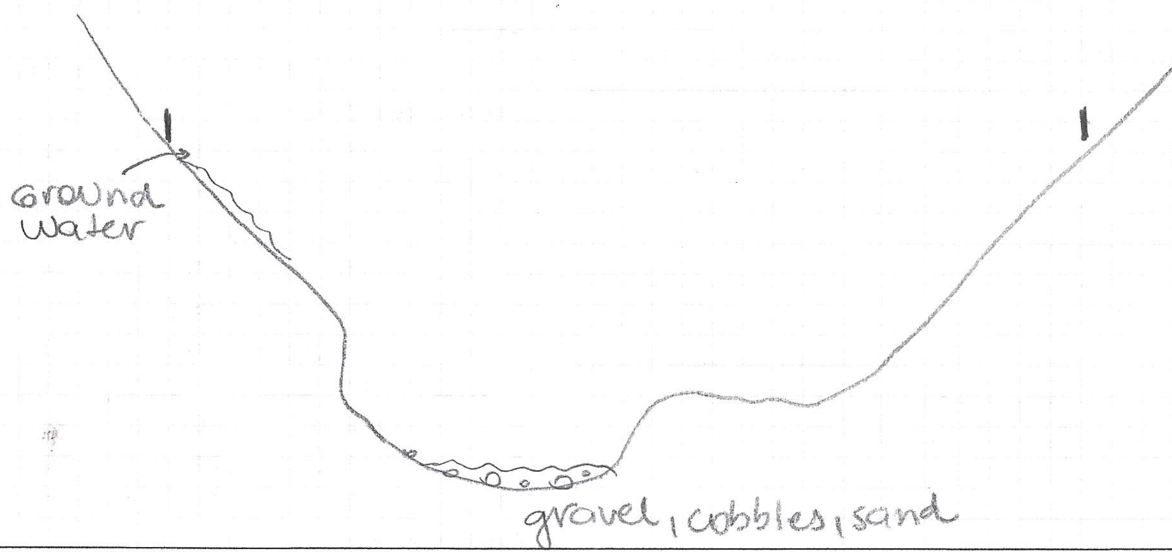
Bank Characteristics

Project Code: PN 20117

Date:	2020-12-17	**Reach/XS:**	XS 2

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

Left Bank **Right Bank**



Left Bank Materials

- ☐ Bedrock
- ☐ Till
- ☐ Clay
- ☐ Silt
- ☑ Sand
- ☑ Gravel
- ☐ Small Cobble
- ☐ Large Cobble
- ☐ Small Boulder
- ☐ Large Boulder

Bank Height:	VWC	m
Bank Angle:	70	°
Root Depth:	3.0	m
Root Density:	5	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm²

Foot Used: ☐ Yes ☐ No

Right Bank Materials

- ☐ Bedrock
- ☐ Till
- ☐ Clay
- ☐ Silt
- ☑ Sand
- ☑ Gravel
- ☐ Small Cobble
- ☐ Large Cobble
- ☐ Small Boulder
- ☐ Large Boulder

Bank Height:	VWC	m
Bank Angle:	70	°
Root Depth:	3.0	m
Root Density:	10	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm²

Foot Used: ☐ Yes ☐ No

Additional Notes

Photo Order:

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GEO | MORPHIX
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Cross-Section Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS3
Weather:	Overcast	**Location:**	Bronte Green
Field Staff:	TR. CVM	**Watershed/Subwatershed:**	Bronte Creek

					Notes
			total	station	

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 4.5	11. 1.2	21. 1.6	31. 3.8
2. 19	12. 2.0	22. 1.3	32. 2.8
3. 4.0	13. 1.5	23. 7.0	33. 7.5
4. 35	14. 1.6	24. 14.0	34. 2.4
5. 1.0	15. 3.8	25. 16.5	35. 1.4
6. 2.2	16. 2.5	26. 22.0	36. 10.5
7. 2.0	17. 1.0	27. 7.5	37. 8.3
8. 3.2	18. 1.5	28. 4.2	38. 2.4
9. 3.4	19. 1.2	29. 7.8	39. 2.6
10. 0.5	20. 1.2	30. 7.4	40. 1.7

Particle Shape:

☐ Platy ☑ Sub-angular ☐ Well Rounded

☐ Very Angular ☑ Angular ☐ Sub-Rounded

☐ Rounded

Embededness: 80 %

Subpavement: ____________

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: __________ Checked by: __________

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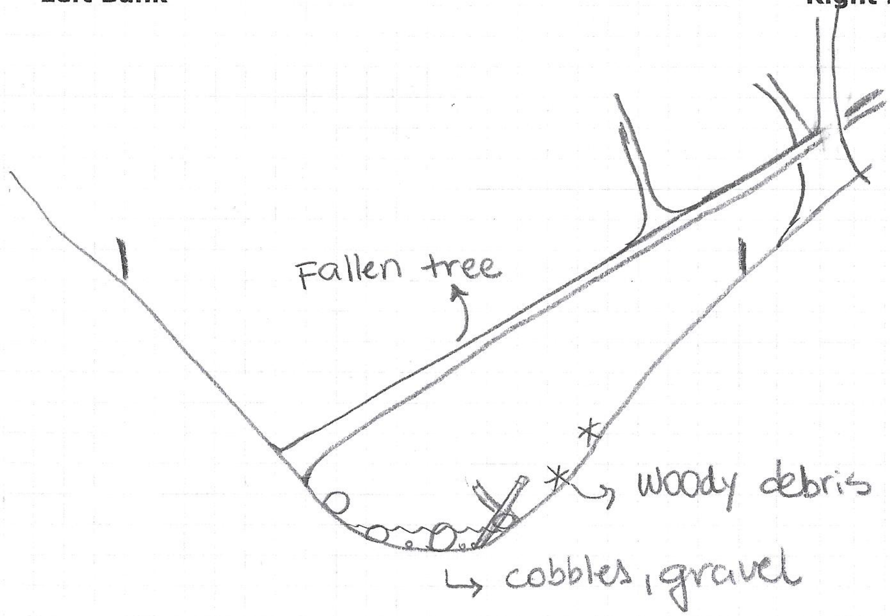
Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS3

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

Left Bank **Right Bank**



Left Bank Materials

☐ Bedrock	☒ Gravel
☐ Till	☐ Small Cobble
☐ Clay	☐ Large Cobble
☐ Silt	☐ Small Boulder
☒ Sand	☐ Large Boulder

Bank Height:	VWC	m
Bank Angle:	80	°
Root Depth:	3.0	m
Root Density:	5	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm^2

Foot Used: ☐ Yes ☐ No

Right Bank Materials

☐ Bedrock	☒ Gravel
☐ Till	☐ Small Cobble
☐ Clay	☐ Large Cobble
☐ Silt	☐ Small Boulder
☒ Sand	☐ Large Boulder

Bank Height:	VWC	m
Bank Angle:	70	°
Root Depth:	3.0	m
Root Density:	5	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm^2

Foot Used: ☐ Yes ☐ No

Additional Notes

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Cross-Section Characteristics

Project Code: PN 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS4- monitoring
Weather:	Overcast	**Location:**	Bronte Green
Field Staff:	TR CVM	**Watershed/Subwatershed:**	Bronte Creek

					Notes
		total	station		

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 14.0	11. 25.0	21. 1.7	31. 2.6
2. 12.5	12. 11.0	22. 2.8	32. 9.5
3. 10.5	13. 7.2	23. 6.8	33. 2.5
4. 22.0	14. 1.1	24. 9.4	34. 5.8
5. 17.5	15. 1.4	25. 5.2	35. 9.5
6. 13.5	16. 0.5	26. 5.5	36. 4.4
7. 6.8	17. 2.3	27. 3.2	37. 3.7
8. 18.0	18. 6.2	28. 1.3	38. 3.5
9. 29.5	19. 3.3	29. 4.8	39. 7.0
10. 19.0	20. 1.6	30. 5.2	40. 13.0

Particle Shape:

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

Embededness: 60 %

Subpavement: ____________

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: __________ Checked by: __________

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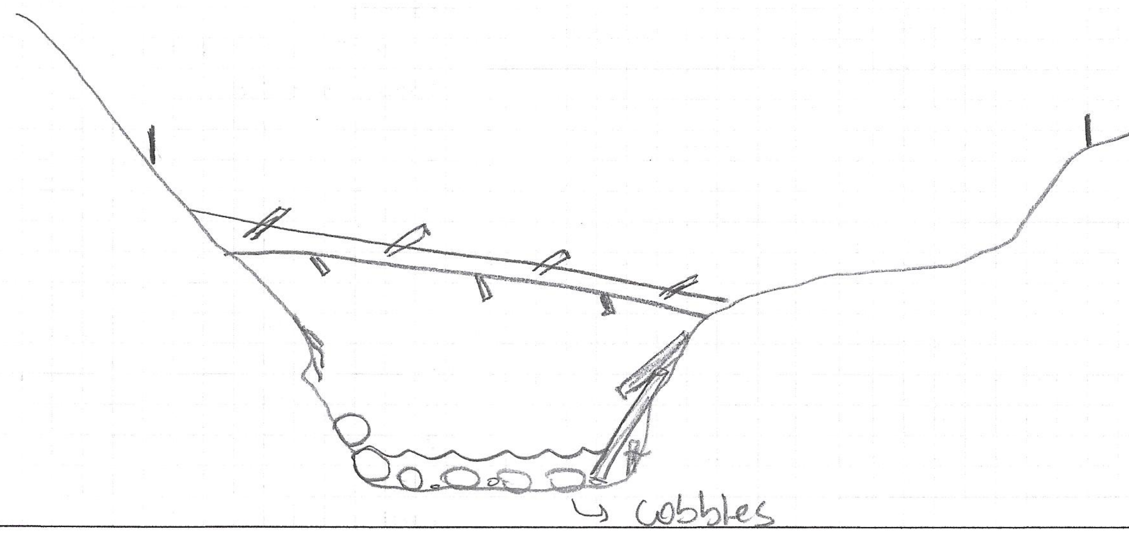
Bank Characteristics **Project Code:** PN 20117

Date:	2020-12-17	Reach/XS:	XS4 Monitoring

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:	VWC	m	
Bank Angle:	70	°	
Root Depth:	3.0	m	
Root Density:	10	%	
Undercut:	0.08	m	
Erosion Pin:	0.20	m	installed
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:	0.55	m	
Bank Angle:	80	°	
Root Depth:	0.40	m	
Root Density:	10	%	
Undercut:	0	m	
Erosion Pin:	0.20	m	installed
Penetrometer:		kg/cm²	
Foot Used:	☐ Yes	☐ No	

Additional Notes

Photo Order:

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Cross-Section Characteristics

Project Code: PN 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS5
Weather:	overcast	**Location:**	Bronte
Field Staff:	CVM TR	**Watershed/Subwatershed:**	Bronte Creek

					Notes
			total station		

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 25.0	11. 10.5	21. 0.5	31. 1.1
2. 11.5	12. 14.0	22. 0.3	32. 1.6
3. 8.5	13. 1.2	23. 0.4	33. 1.5
4. 10.2	14. 1.4	24. 0.2	34. 0.5
5. 6.4	15. 1.1	25. 0.2	35. 0.7
6. 4.8	16. 1.8	26. 0.5	36. 0.6
7. 7.0	17. 1.2	27. 0.4	37. 0.6
8. 6.0	18. 1.5	28. 17.8	38. 0.4
9. 16.0	19. 0.5	29. 3.5	39. 0.5
10. 5.5	20. 0.6	30. 1.5	40. 0.5

Particle Shape:

☐ Platy ☑ Sub-angular ☐ Well Rounded

☐ Very Angular ☐ Angular ☐ Sub-Rounded

☐ Rounded

Embededness: 40 %

Subpavement: ____

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: ____ Checked by: ____

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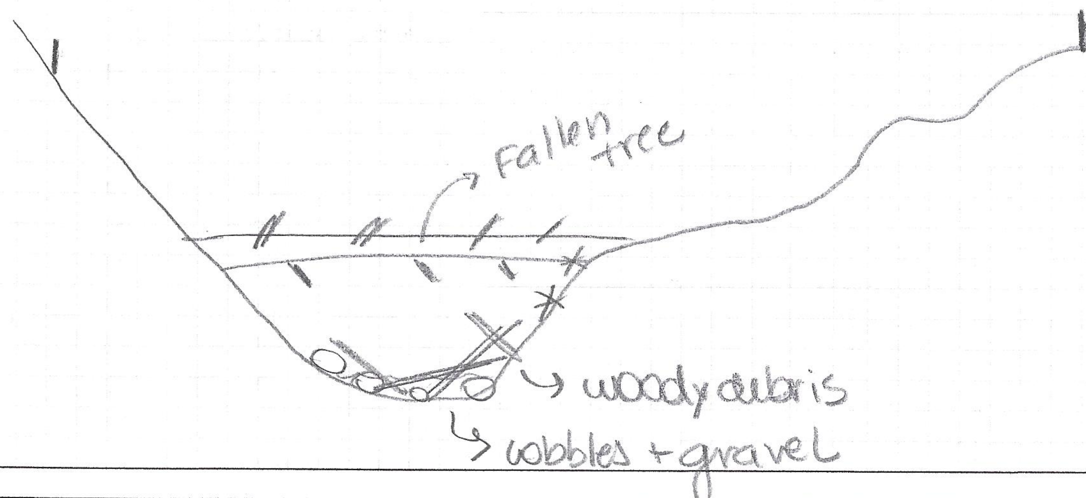
Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS5

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

Left Bank **Right Bank**



Left Bank Materials

- ☐ Bedrock
- ☐ Till
- ☐ Clay
- ☐ Silt
- ☒ Sand
- ☒ Gravel
- ☐ Small Cobble
- ☐ Large Cobble
- ☐ Small Boulder
- ☐ Large Boulder

Bank Height:	VWC	m
Bank Angle:	70	°
Root Depth:	3.0	m
Root Density:	20	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm²

Foot Used: ☐ Yes ☐ No

Right Bank Materials

- ☐ Bedrock
- ☐ Till
- ☐ Clay
- ☐ Silt
- ☒ Sand
- ☒ Gravel
- ☐ Small Cobble
- ☐ Large Cobble
- ☐ Small Boulder
- ☐ Large Boulder

Bank Height:	0.65	m
Bank Angle:	80	°
Root Depth:	0.20	m
Root Density:	10	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm²

Foot Used: ☐ Yes ☐ No

Additional Notes

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Cross-Section Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS6
Weather:	overcast	**Location:**	Bronte
Field Staff:	TR CVM	**Watershed/Subwatershed:**	Bronte Creek

					Notes
			total station		

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 20.5	11. 1.2	21. 0.2	31. 0.7
2. 6.0	12. 1.4	22. ↓	32. 1.3
3. 7.8	13. 1.2	23.	33. 1.2
4. 22.6	14. 1.2	24.	34. 7.5
5. 14.5	15. 7.5	25.	35. 2.6
6. 8.2	16. 1.6	26.	36. 2.8
7. 1.5	17. 0.8	27.	37. 2.5
8. 1.5	18. 1.6	28.	38. 0.4
9. 1.2	19. 2.2	29.	39. 6.5
10. 1.1	20. 0.5	30.	40. 4.2

Particle Shape:

☐ Platy ☑ Sub-angular ☐ Well Rounded

☐ Very Angular ☐ Angular ☑ Sub-Rounded

☐ Rounded

Embededness: 80 %

Subpavement: ____

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: ____ Checked by: ____

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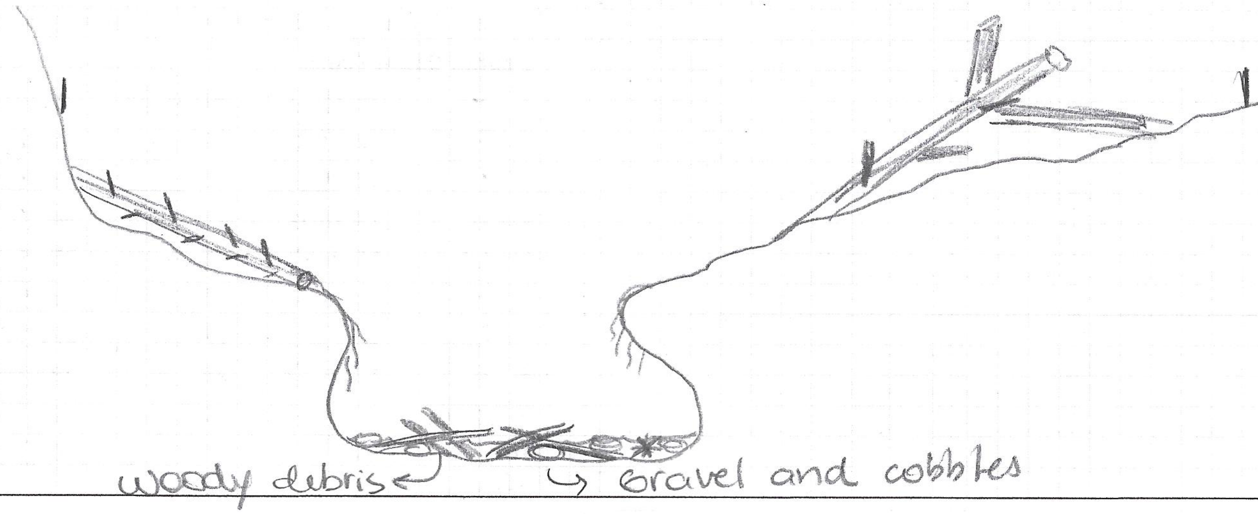
Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS6

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

Left Bank | **Right Bank**



Left Bank Materials

☐ Bedrock ☐ Gravel
☐ Till ☐ Small Cobble
☐ Clay ☐ Large Cobble
☐ Silt ☐ Small Boulder
☐ Sand ☐ Large Boulder

Bank Height: 0.72 m
Bank Angle: 90 °
Root Depth: 0.40 m
Root Density: 15 %
Undercut: 0.21 m
Erosion Pin: N/A 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: 0.90 m
Bank Angle: 90 °
Root Depth: 0.70 m
Root Density: 25 %
Undercut: 0.44 m
Erosion Pin: N/A m

Penetrometer: ______ kg/cm²
Foot Used: ☐ Yes ☐ No

Additional Notes

Photo Order:

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Cross-Section Characteristics

Project Code: PN 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS7
Weather:	SUNNY -4°C	**Location:**	Bronte
Field Staff:	TR CVM	**Watershed/Subwatershed:**	Bronte Creek

					Notes

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 21.5	11. 1.7	21. 0.2	31. 18.7
2. 5.2	12. 4.3	22.	32. 8.6
3. 16.0	13. 7.2	23.	33. 5.6
4. 4.8	14. 5.2	24.	34. 4.5
5. 2.4	15. 6.5	25.	35. 3.5
6. 2.0	16. 13.0	26.	36. 6.0
7. 1.6	17. 1.0	27.	37. 9.5
8. 2.6	18. 0.6	28.	38. 7.0
9. 1.8	19. 1.4	29.	39. 0.4
10. 1.5	20. 13.0	30.	40. 4.5

Particle Shape:

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

Embededness: 50 %

Subpavement: ____________

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: __________ Checked by: __________

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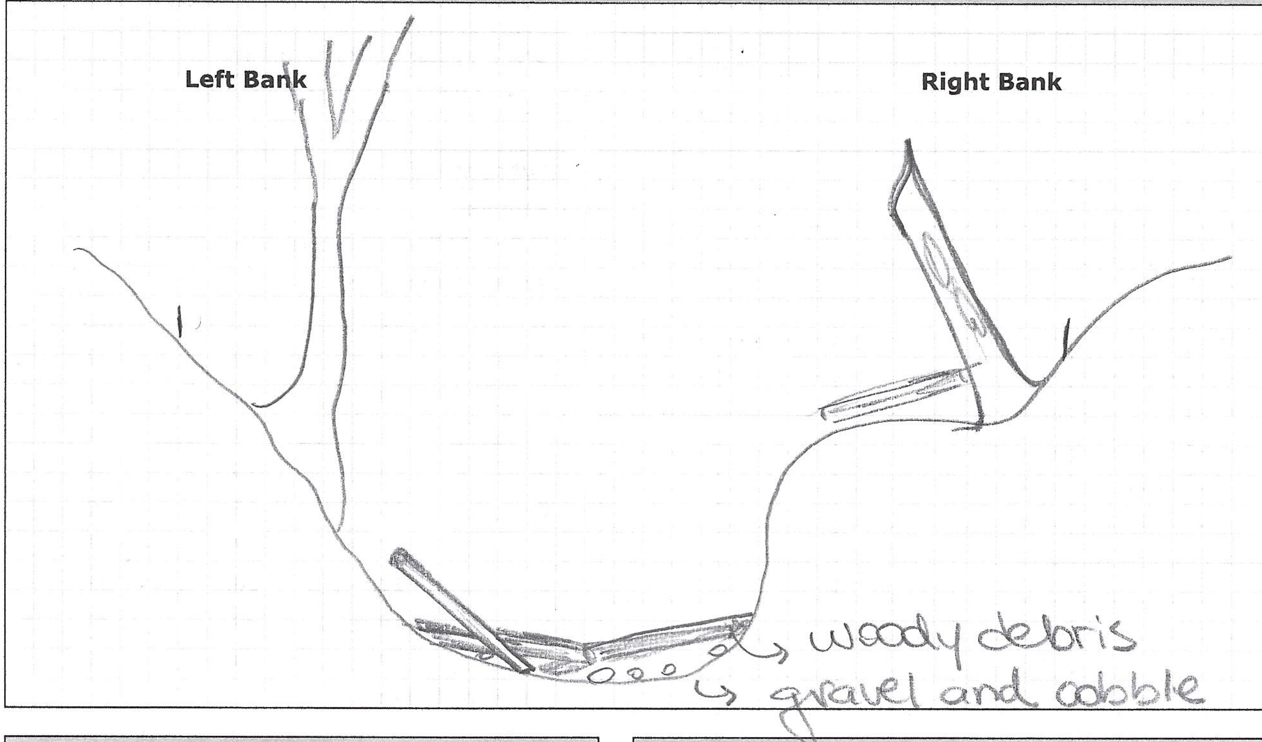
Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS7

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: 1.7 m
Bank Angle: 70 °
Root Depth: 1.0 m
Root Density: 15 %
Undercut: 0 m
Erosion Pin: N/A 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: 1.3 m
Bank Angle: 60 °
Root Depth: 1.0 m
Root Density: 10 %
Undercut: 0 m
Erosion Pin: N/A m

Penetrometer: ________ kg/cm²
Foot Used: ☐ Yes ☐ No

Additional Notes

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Cross-Section Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS8
Weather:	SUNNY	**Location:**	Bronte
Field Staff:	TR CNM	**Watershed/Subwatershed:**	Bronte Creek

					Notes
			total	Station	

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 8.0	11. 7.6	21. 4.3	31. 17.0
2. 13.0	12. 12.5	22. 4.8	32. 0.2
3. 12.0	13. 7.8	23. 7.8	33.
4. 19.0	14. 9.5	24. 3.5	34.
5. 10.5	15. 12.5	25. 3.2	35.
6. 18.0	16. 10.0	26. 4.8	36.
7. 7.0	17. 11.5	27. 4.1	37. 6.5
8. 11.5	18. 12.2	28. 15.0	38. 6.5
9. 8.5	19. 16.0	29. 10.0	39. 6.8
10. 7.2	20. 6.0	30. 11.5	40. 6.9

Particle Shape:

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

Embededness: 40 %

Subpavement: ______

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: ______ Checked by: ______

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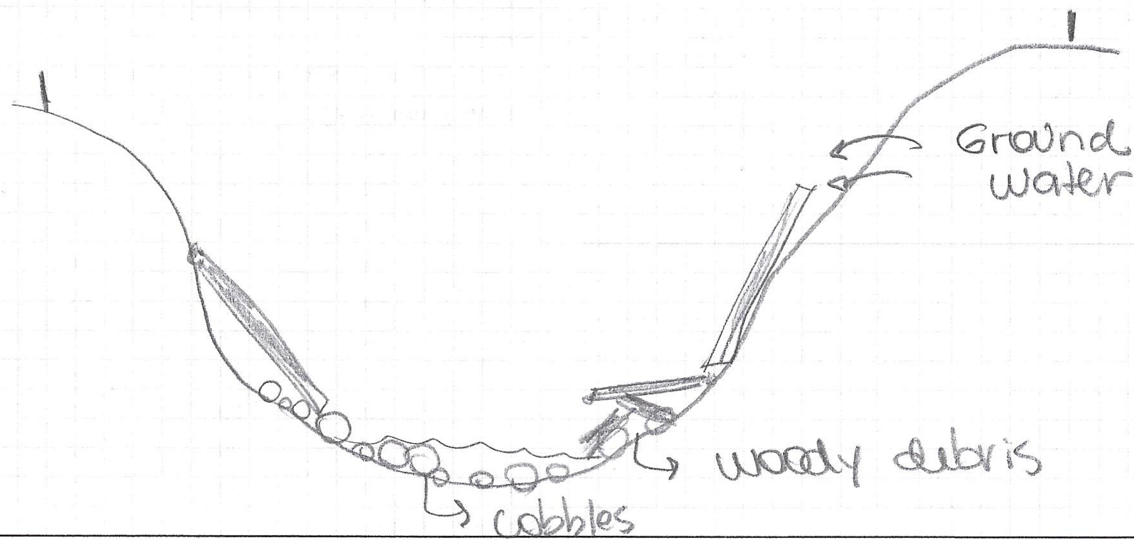
Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS8

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

Left Bank **Right Bank**



Left Bank Materials

☐ Bedrock	☒ Gravel
☐ Till	☐ Small Cobble
☐ Clay	☐ Large Cobble
☐ Silt	☐ Small Boulder
☒ Sand	☐ Large Boulder

Bank Height:	1.8	m
Bank Angle:	45	°
Root Depth:	1.0	m
Root Density:	10	%
Undercut:	0	m
Erosion Pin:	N/A	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:	1.9	m
Bank Angle:	35	°
Root Depth:	80	m
Root Density:	10	%
Undercut:	0	m
Erosion Pin:	N/A	m
Penetrometer:		kg/cm²
Foot Used:	☐ Yes	☐ No

Additional Notes

Photo Order:

Completed by: ________ Checked by: ________

GEO | M O R P H I X

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Cross-Section Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS9
Weather:	SUNNY -4°C	**Location:**	Bronte Green
Field Staff:	CNM TR	**Watershed/Subwatershed:**	Bronte Creek

					Notes

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 10.4	11. 6.0	21. 3.2	31. 0.2
2. 13.5	12. 24.0	22. 2.0	32. 0.6
3. 9.5	13. 11.0	23. 4.4	33. 0.3
4. 7.5	14. 5.8	24. 6.9	34. 0.4
5. 4.0	15. 9.2	25. 8.0	35. 0.3
6. 8.8	16. 7.0	26. 10.0	36. 1.6
7. 11.3	17. 6.2	27. 2.5	37. 1.5
8. 8.1	18. 4.5	28. 1.1	38. 1.7
9. 9.4	19. 10.5	29. 0.4	39. 3.3
10. 5.5	20. 7.2	30. 0.2	40. 3.5

Particle Shape:

☐ Platy ☐ Sub-angular ☐ Well Rounded

☐ Very Angular ☐ Angular ☐ Sub-Rounded

☐ Rounded

Embededness: __________ %

Subpavement: __________

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: ______ Checked by: ______

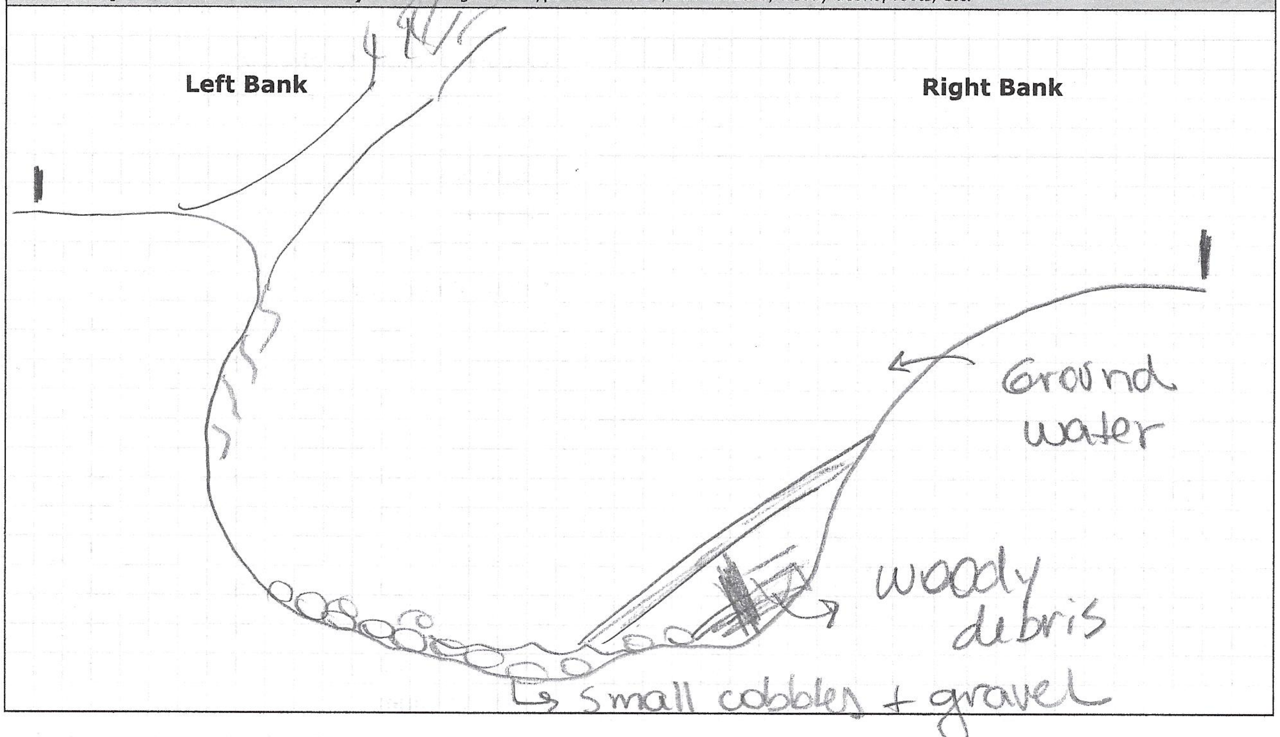
GEO | MORPHIX
Geomorphology
Earth Science
Observations

Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS9

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: 1.95 m
Bank Angle: 75 °
Root Depth: 1.2 m
Root Density: 20 %
Undercut: 0 m
Erosion Pin: N/A 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: 1.7 m
Bank Angle: 60 °
Root Depth: 1.6 m
Root Density: 20 %
Undercut: 0 m
Erosion Pin: N/A m

Penetrometer: ________ kg/cm²
Foot Used: ☐ Yes ☐ No

Additional Notes

Photo Order:

Completed by: ________ Checked by: ________

GEO | MORPHIX
Geomorphology
Earth Science
Observations

Cross-Section Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/Cross-section:**	XS10 MONITORING
Weather:	Cloudy	**Location:**	Bronte
Field Staff:	TR CVM	**Watershed/Subwatershed:**	Bronte Creek

					Notes

Cross-sectional Morphology

☐ Riffle ☐ Pool ☐ Run ☐ Other

Substrate

Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count (cm):

1. 43.0	11. 6.9	21. 18.0	31. 0.6
2. 35.0	12. 9.5	22. 12.0	32. 0.3
3. 9.0	13. 9.4	23. 11.5	33. 0.5
4. 7.5	14. 4.5	24. 17.5	34. 0.6
5. 3.3	15. 6.1	25. 29.0	35. 6.2
6. 5.4	16. 4.2	26. 19.0	36. 2.4
7. 8.0	17. 6.2	27. 16.5	37. 3.4
8. 8.4	18. 5.5	28. 22.0	38. 2.4
9. 28.0	19. 7.7	29. 0.5	39. 5.6
10. 7.2	20. 11.1	30. 0.4	40. 11.3

Particle Shape:

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

Embededness: 30 %

Subpavement: ____________

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: ________ Checked by: ________

GEO | MORPHIX
Geomorphology
Earth Science
Observations

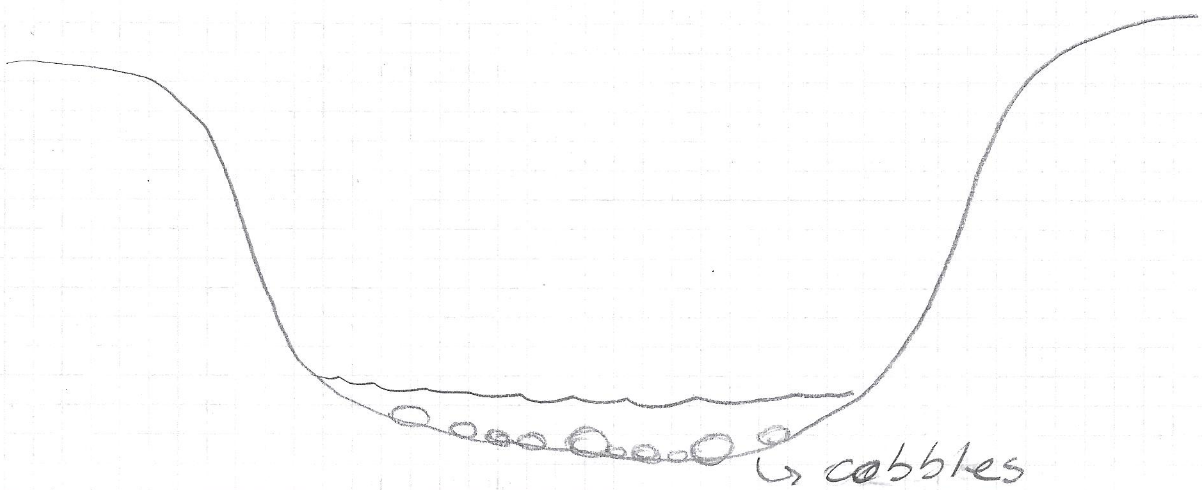
Bank Characteristics

Project Code: 20117

Date:	2020-12-17	**Reach/XS:**	XS 10 - MONITORING

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

Left Bank **Right Bank**



Left Bank Materials

- ☐ Bedrock
- ☐ Till
- ☐ Clay
- ☐ Silt
- ☒ Sand
- ☒ Gravel
- ☐ Small Cobble
- ☐ Large Cobble
- ☐ Small Boulder
- ☐ Large Boulder

Bank Height: 1.75 m
Bank Angle: 50 °
Root Depth: 1.5 m
Root Density: 20 %
Undercut: 0 m
Erosion Pin: 0.20 m

Penetrometer: ______ kg/cm²
Foot Used: ☐ Yes ☐ No

Right Bank Materials

- ☐ Bedrock
- ☐ Till
- ☐ Clay
- ☐ Silt
- ☒ Sand
- ☒ Gravel
- ☐ Small Cobble
- ☐ Large Cobble
- ☐ Small Boulder
- ☐ Large Boulder

Bank Height: 1.65 m
Bank Angle: 65 °
Root Depth: 1.20 m
Root Density: 20 %
Undercut: 0 m
Erosion Pin: 0.20 m

Penetrometer: ______ kg/cm²
Foot Used: ☐ Yes ☐ No

Additional Notes

Photo Order:

Completed by: ______ Checked by: ______

Page ____ of ____

Appendix D
Detailed Assessment Summary

Detailed Geomorphological Assessment Summary

Reach BCT-1

Project Number:	PN20117	**Date:**	2020-12-17
Client:	Argo Bronte River Corporation	**Length Surveyed (m):**	46.2
Location:	Oakville	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	n/a	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forested, residential	**Width of Riparian Cover:**	>10 Channel Widths
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	Mature
Dominant Instream Vegetation Type:	n/a	**Extent of Encroachment into Channel:**	None
Portion of Reach with Vegetation:	0%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	Not measured	**Calculated Bankfull Discharge (m^3/s):**	2.90
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	4.00
Modelled 2-year Velocity (m/s):	Not modelled		

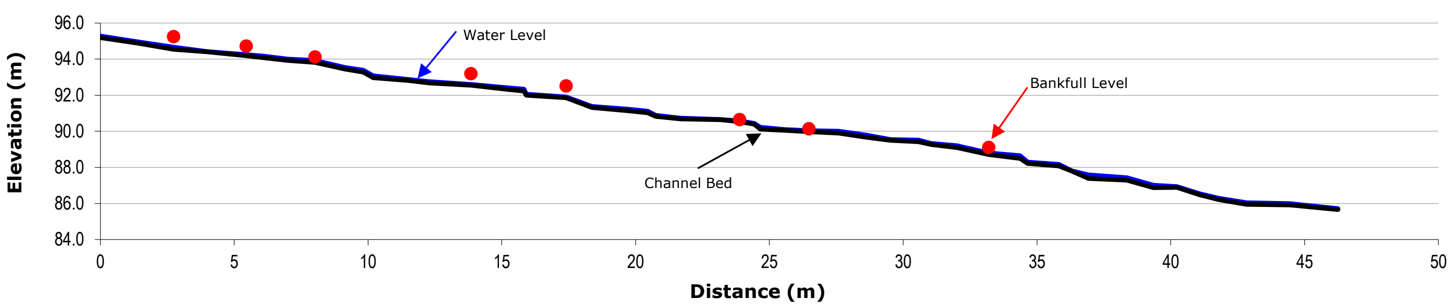
Profile Characteristics

Bankfull Gradient (%):	20.84
Channel Bed Gradient (%):	20.78
Riffle Gradient (%):	27.91
Riffle Length (m):	7.59
Riffle-Pool Spacing (m):	15.24

Planform Characteristics

Sinuosity:	1.10
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):	0.55	1.90	1.19
Bank Angle (deg):	35	90	71
Root Depth (m):	0.20	80.00	6.79
Root Density (%):	5	25	11
Bank Undercut (m):	0.08	0.44	0.24

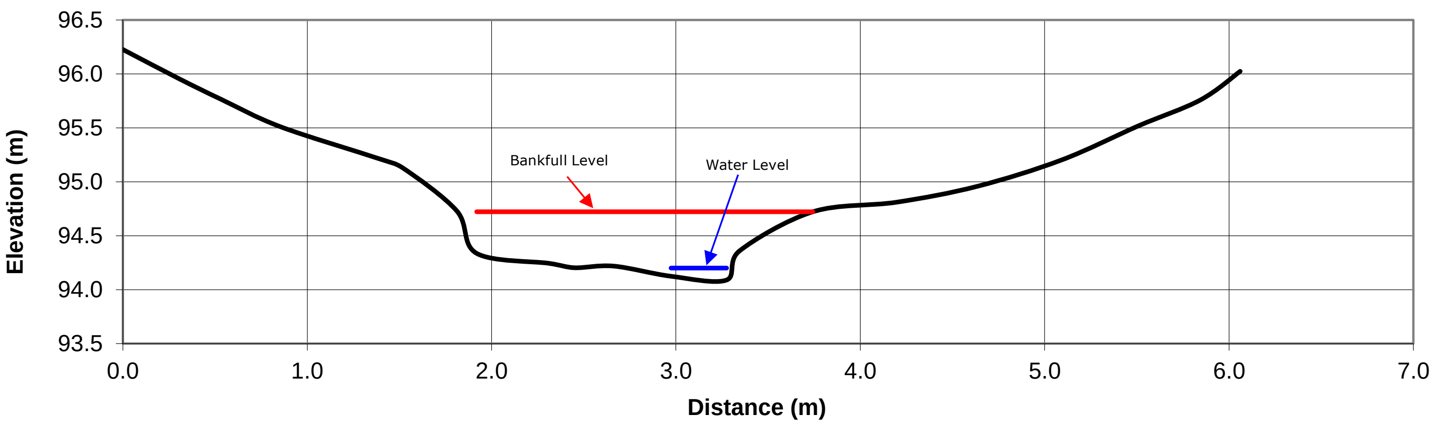
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):			

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.22	3.11	2.16
Average Bankfull Depth (m):	0.19	0.44	0.34
Bankfull Width/Depth (m/m):	3	17	7
Wetted Width (m):	0.00	0.73	0.42
Average Water Depth (m):	0.00	0.09	0.05
Wetted Width/Depth (m/m):	0	32	10
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.00	0.11	0.07
Manning's *n*:		0.055	

Photograph at cross section 4 (looking upstream)

Representative Cross-Section #4



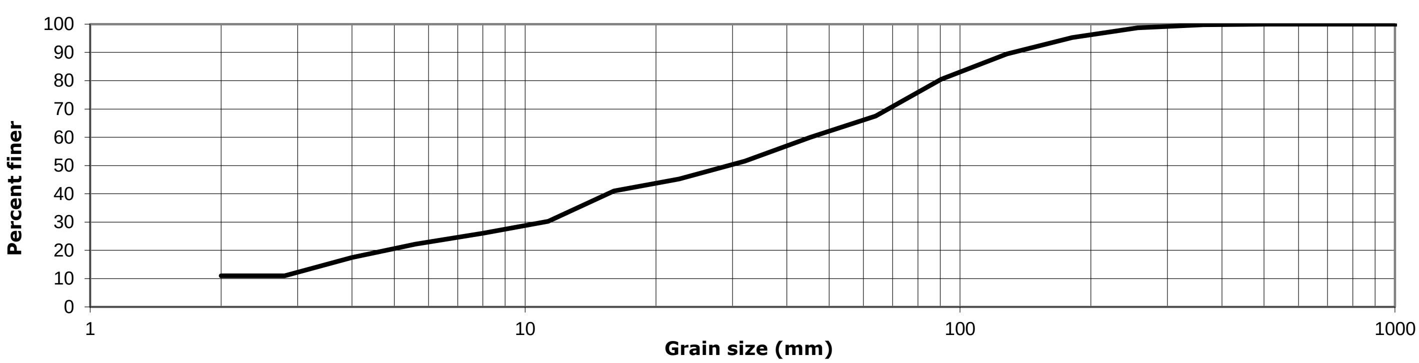
Substrate Characteristics

Particle Size (mm)

D_{10} :	<2
D_{50} :	29.7
D_{84} :	105.1

Subpavement:	Shale
Particle shape:	Sub-angular, sub-rounded
Embeddedness (%):	50-80
Particle range (riffle):	Sand to large cobble
Particle Range (pool):	Sand to cobble

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	684.99
for D_{50}:	0.94	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	1.68	**Critical Shear Stress (D_{50}) (N/m^2):**	21.67
Unit Stream Power at Bankfull (W/m^2):	2741.58		

General Field Observations

Channel Description

Reach BCT-1 is a steep, confined channel that flows down along the valley associated with Bronte Creek. The channel is fed by a small pond at the top of the valley. Valley wall contact at the banks is nearly constant throughout the upstream portion of the reach. The downstream portion opens into the Bronte Creek floodplain, where the channel begins to exhibit a more meandering planform. Substrate is characterized by sand, gravel, and cobbles. Large woody debris is fairly common throughout and exposed mature tree roots are observable in many banks. Evidence of groundwater seepage in the banks was noted during the assessment. Average bankfull width and depth are 2.16 m and 0.34 m, respectively.

Cross Section 6 - Facing Upstream

Appendix E
Erosion Modelling Hydrograph

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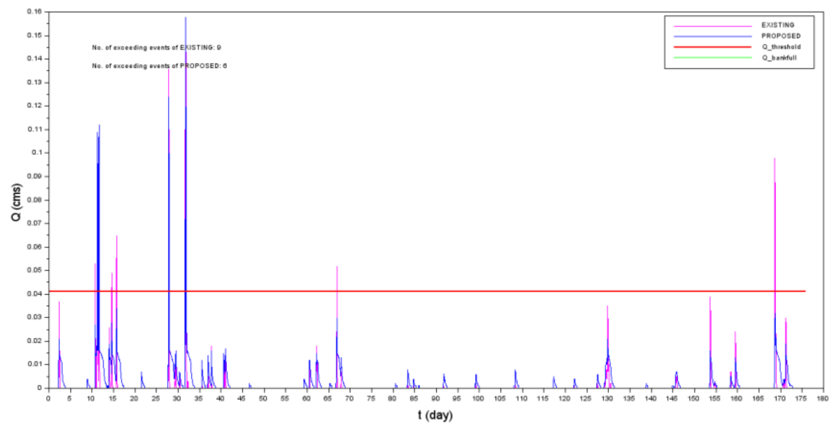
BCT-1a

CH Data -
Pre with
Pond

2008</td>
<td>
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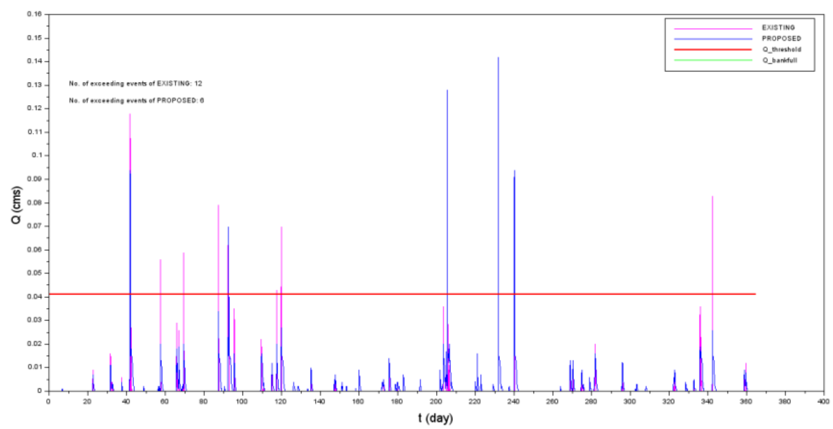
BCT-1a

CH Data -
Pre with
Pond

2009</td>
<td>
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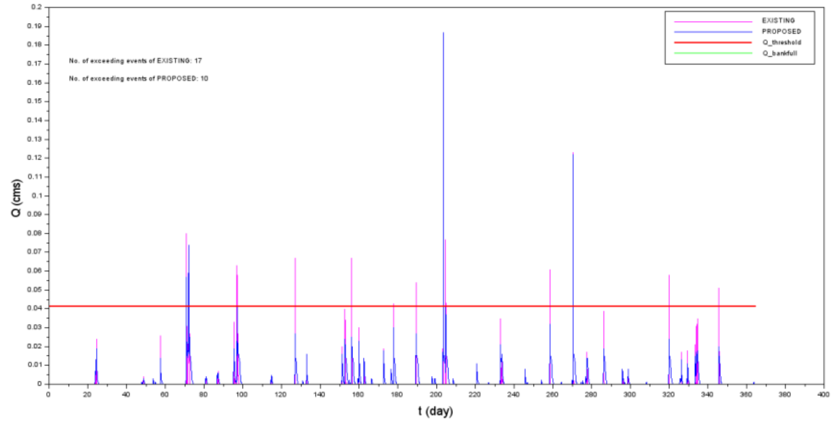
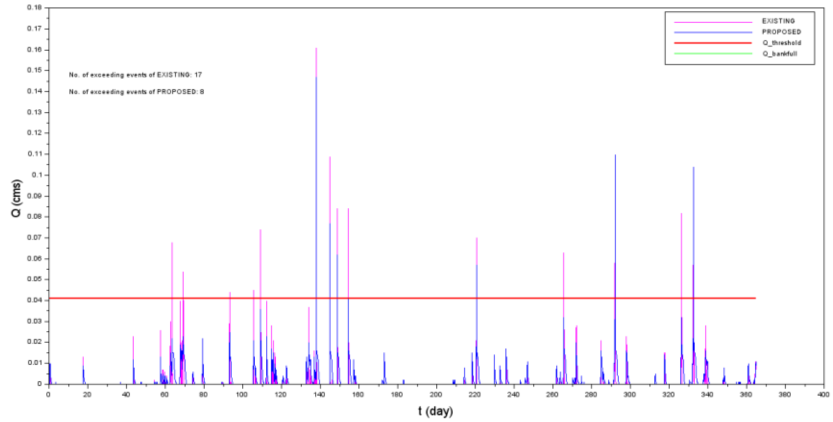
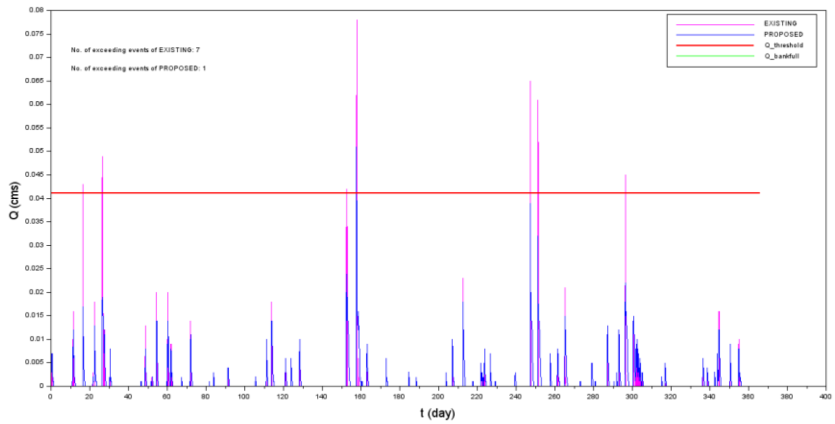
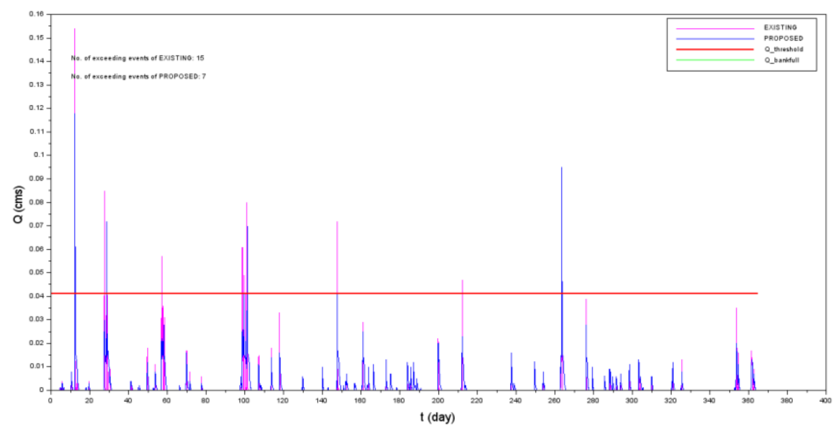
Reach **BCT-1a** CH Data - Pre with Pond 2010	
Reach **BCT-1a** CH Data - Pre with Pond 2011	

Reach **BCT-1a** CH Data - Pre with Pond 2012	
Reach **BCT-1a** CH Data - Pre with Pond 2013	

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CH Data - Pre with Pond

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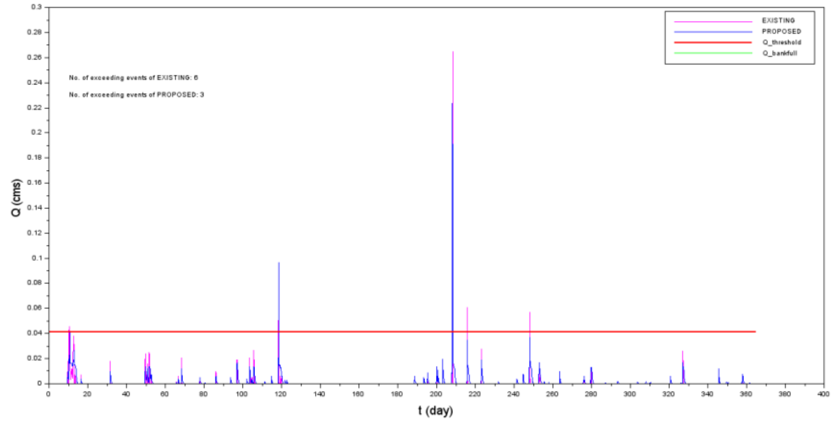
<td>
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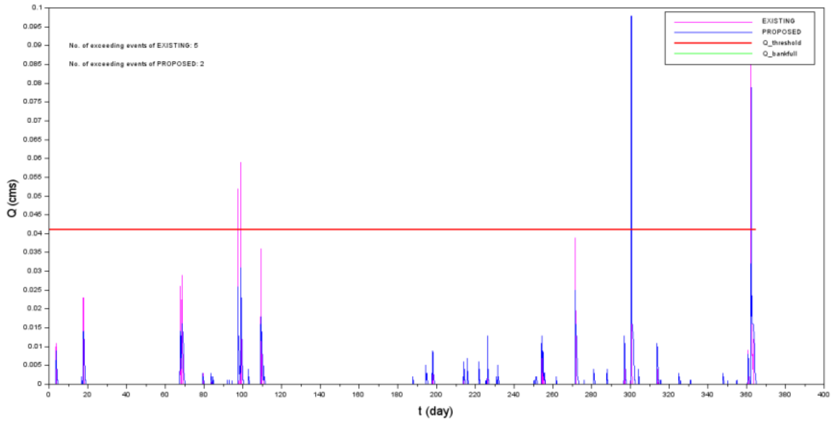
CH Data - Pre with Pond

2015</td>
<td>
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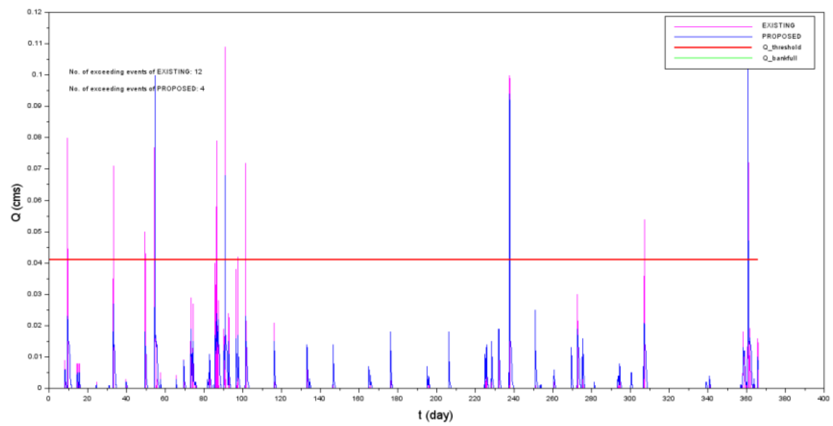
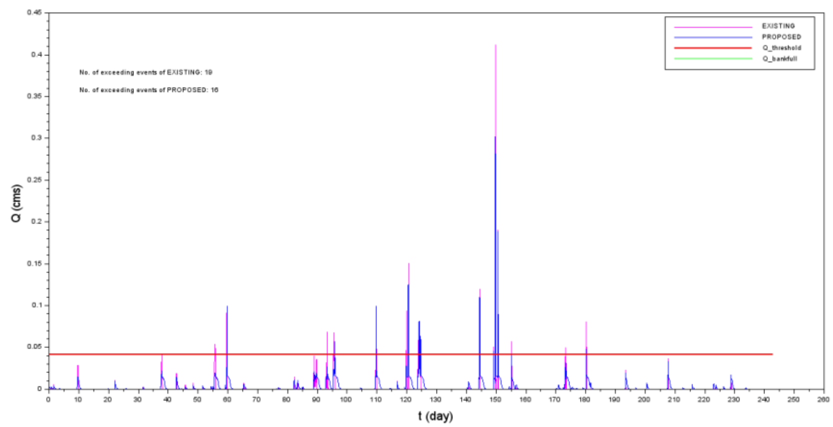
Reach **BCT-1a** CH Data - Pre with Pond 2016	
Reach **BCT-1a** CH Data - Pre with Pond 2017	

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CH Data -
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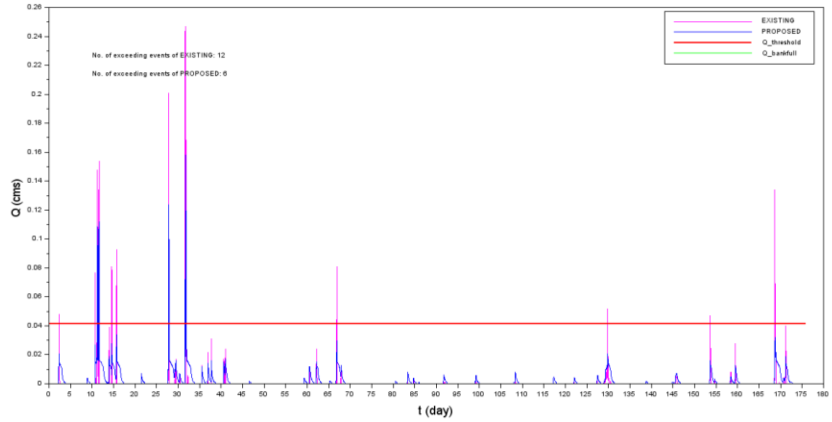
<td>
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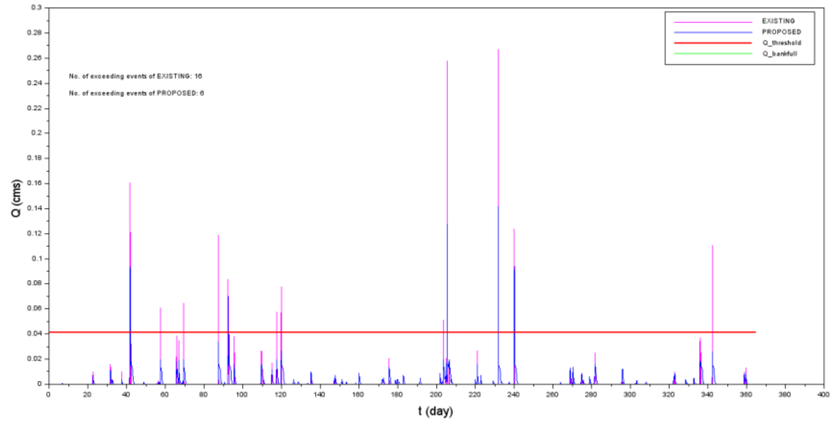
2009</td>
<td>
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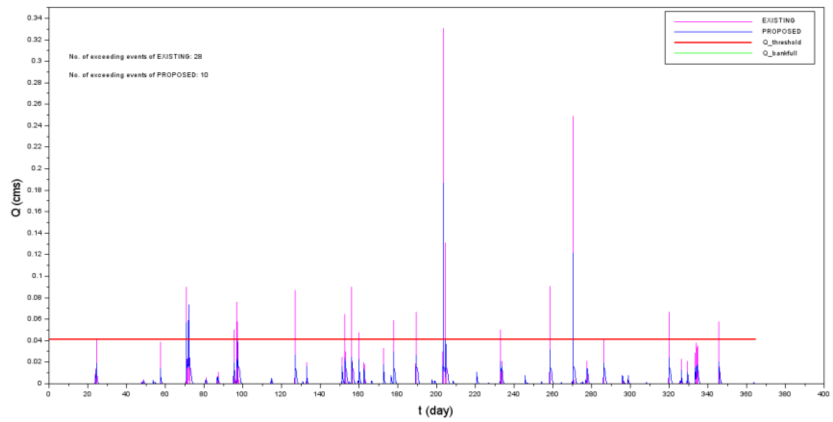
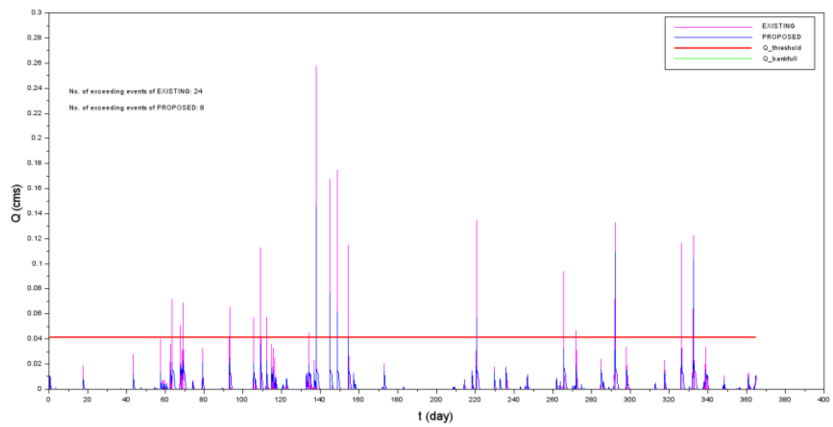
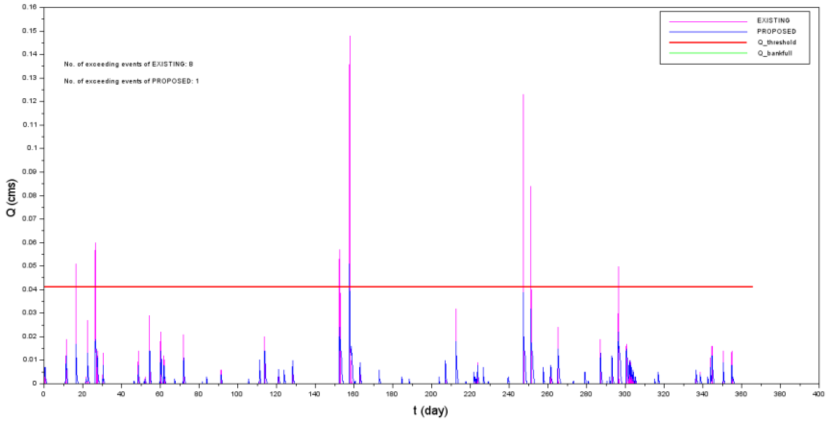
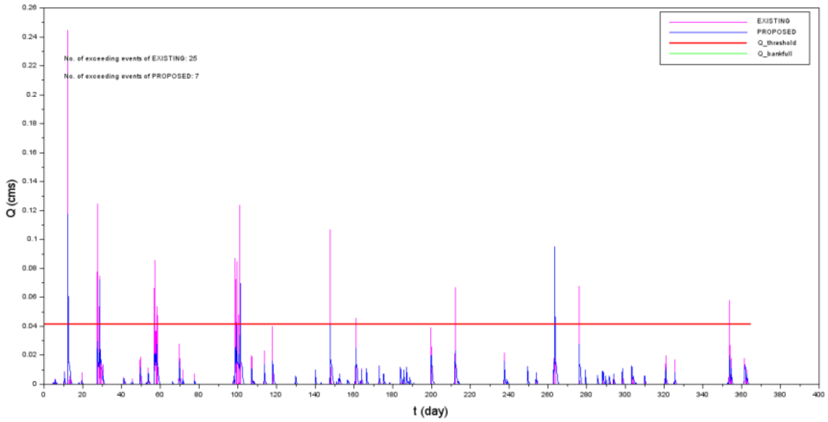
Reach **BCT-1a** CH Data - Pre without Pond 2010	
Reach **BCT-1a** CH Data - Pre without Pond 2011	

Reach **BCT-1a** CH Data - Pre without Pond 2012	
Reach **BCT-1a** CH Data - Pre without Pond 2013	

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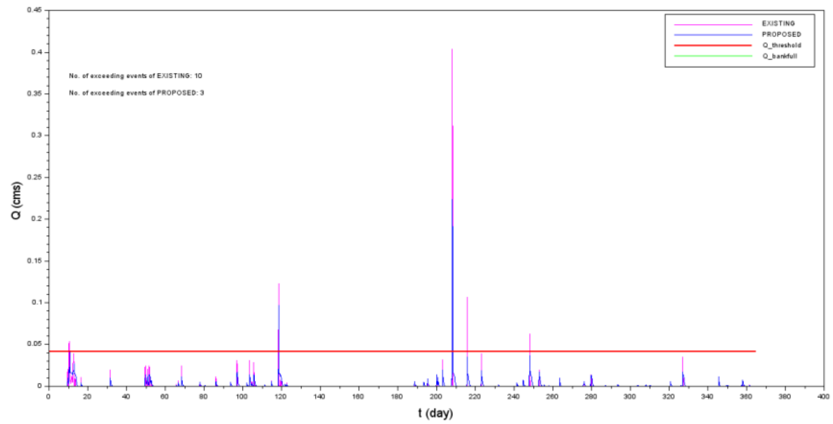
<td>
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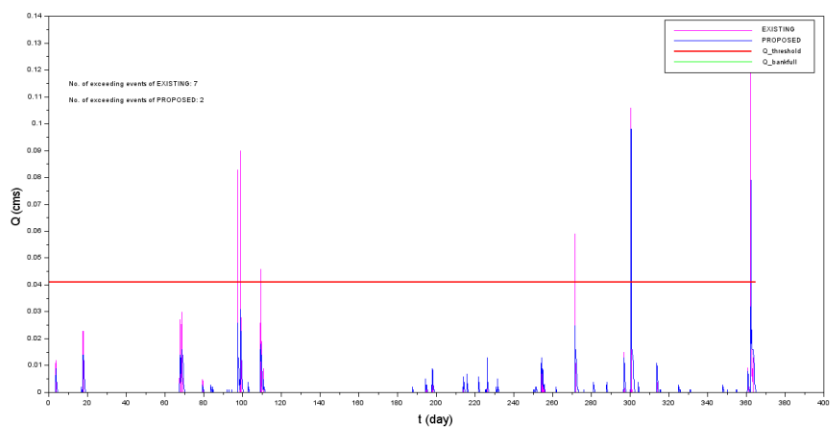
<td>
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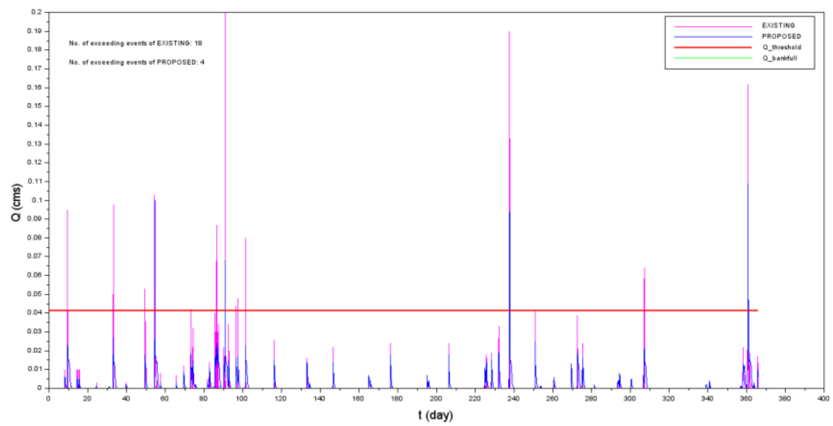
<td>
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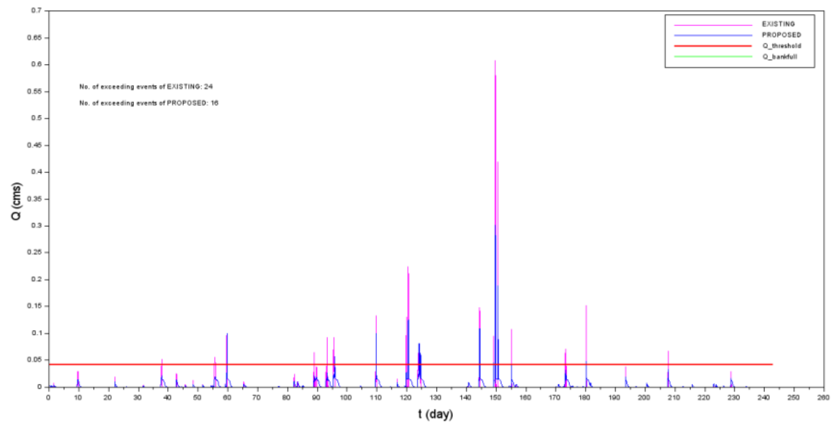
<td>
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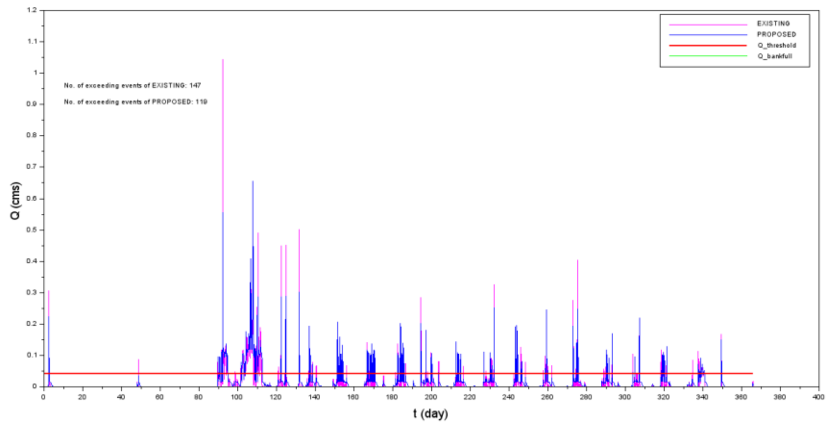
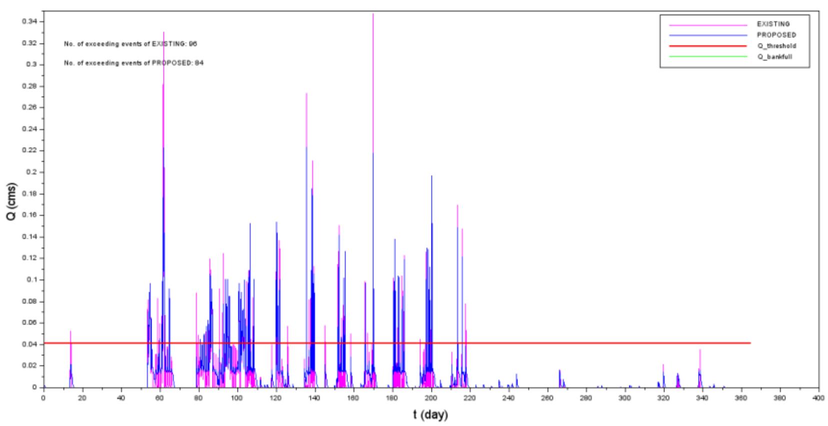
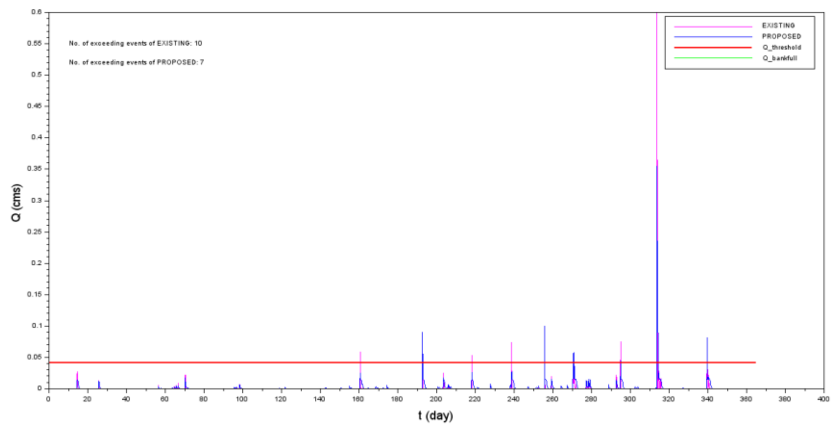
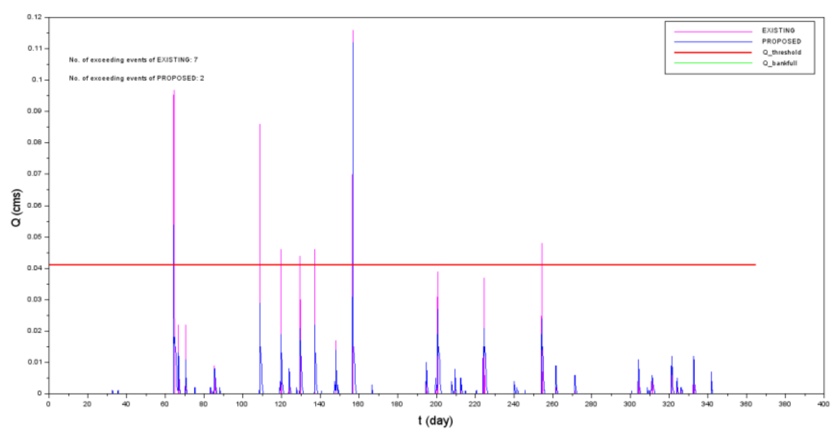
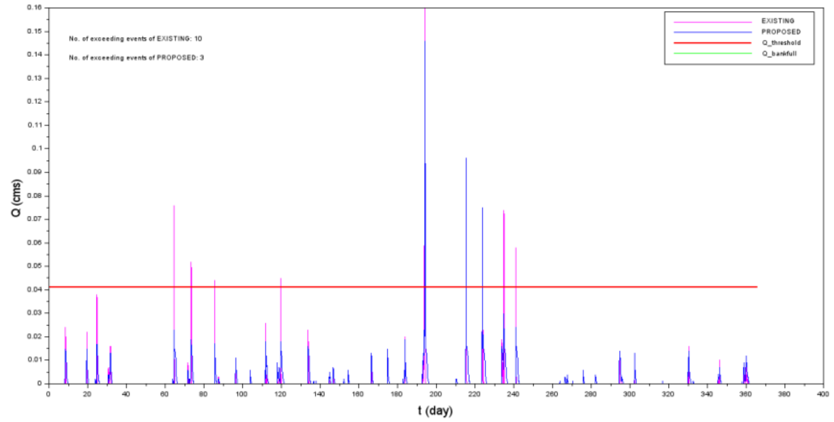
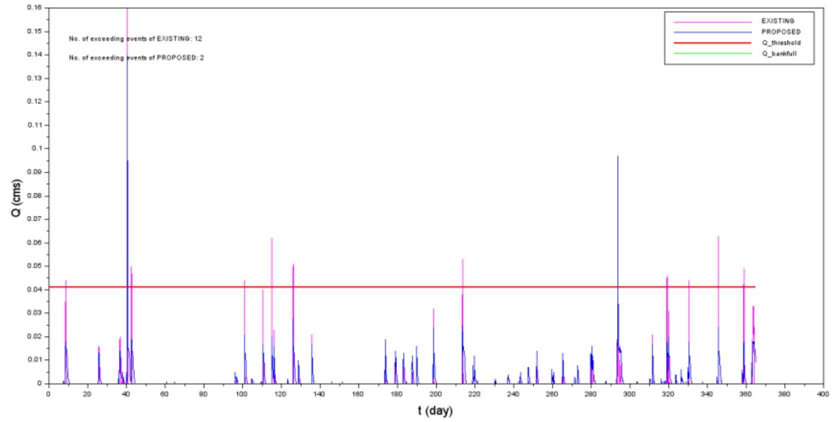
Reach **BCT-1a** UT Data - Pre with Pond 1960	
Reach **BCT-1a** UT Data - Pre with Pond 1961	

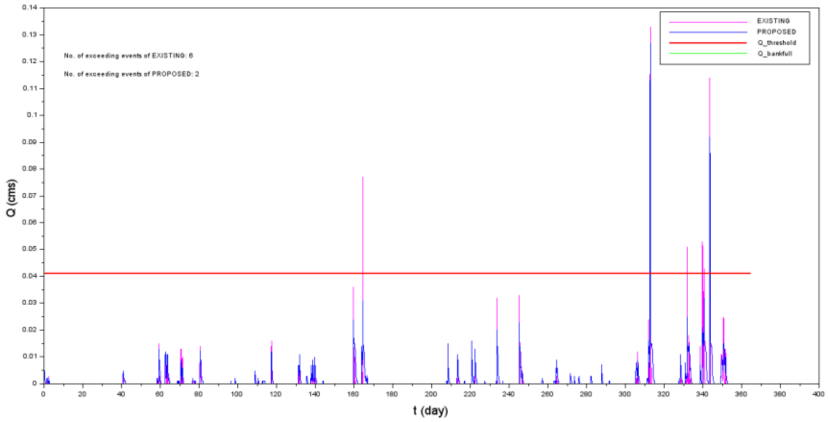
Reach **BCT-1a** UT Data - Pre with Pond 1962	
Reach **BCT-1a** UT Data - Pre with Pond 1963	

Reach **BCT-1a** UT Data - Pre with Pond 1964	
Reach **BCT-1a** UT Data - Pre with Pond 1965	

Reach
BCT-1a

UT Data - Pre with Pond

1966



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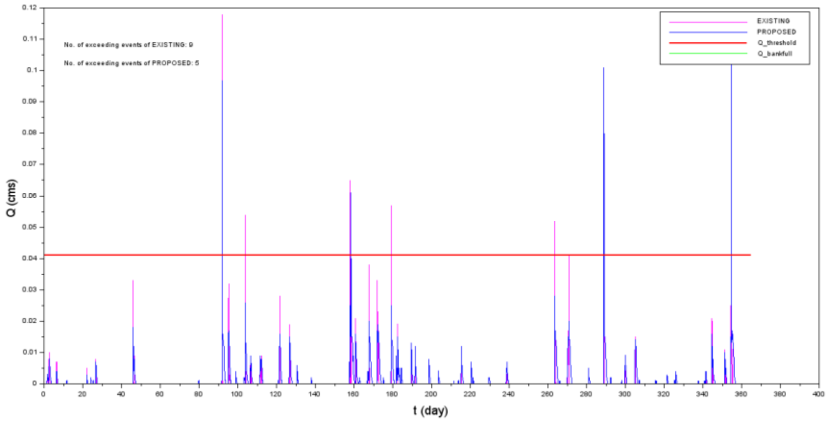
UT Data - Pre with Pond

1967



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Pre with
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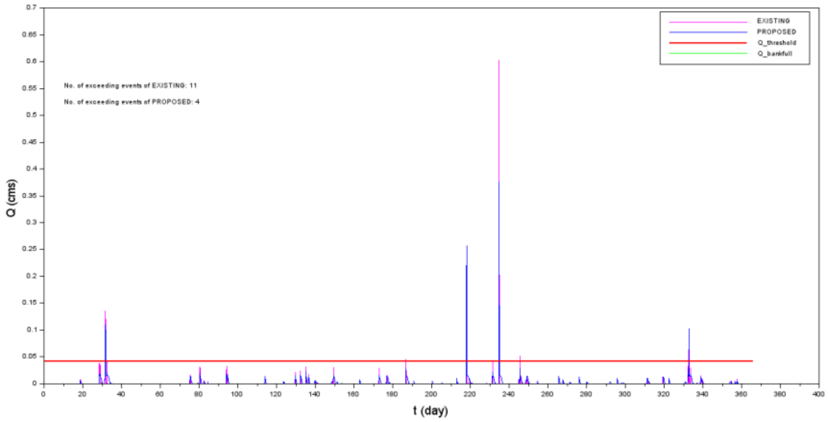
<td>
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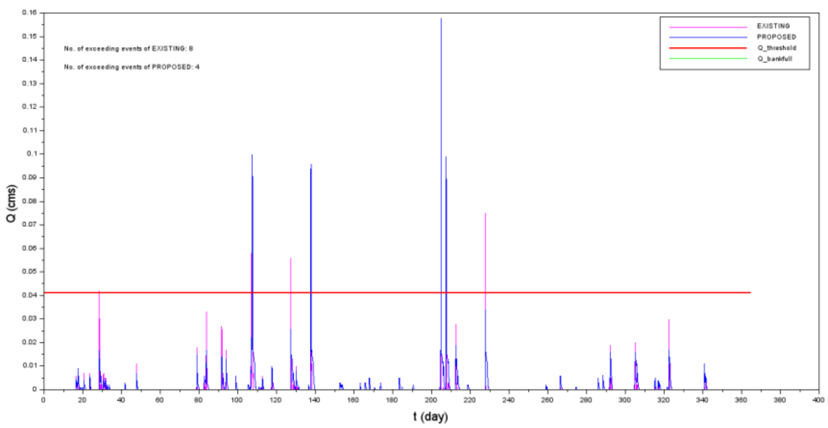
<td>
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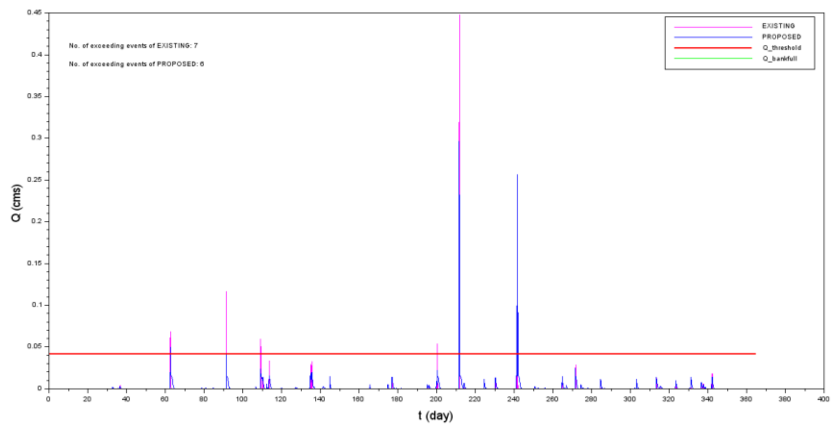
<td>
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UT Data - Pre with Pond

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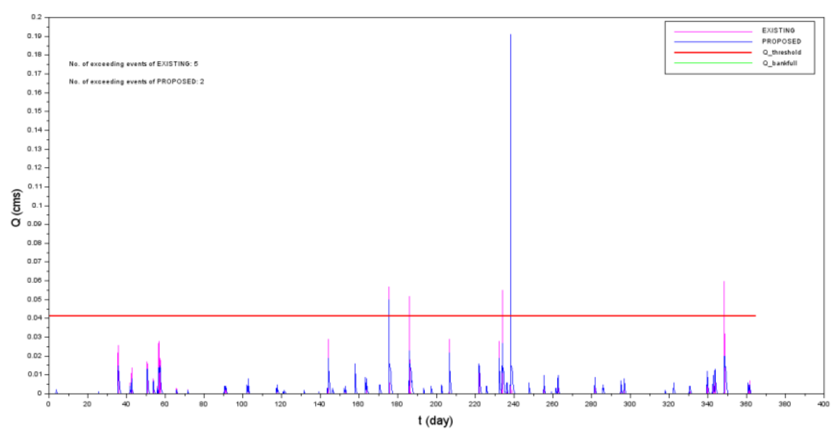
<td>
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Pre with
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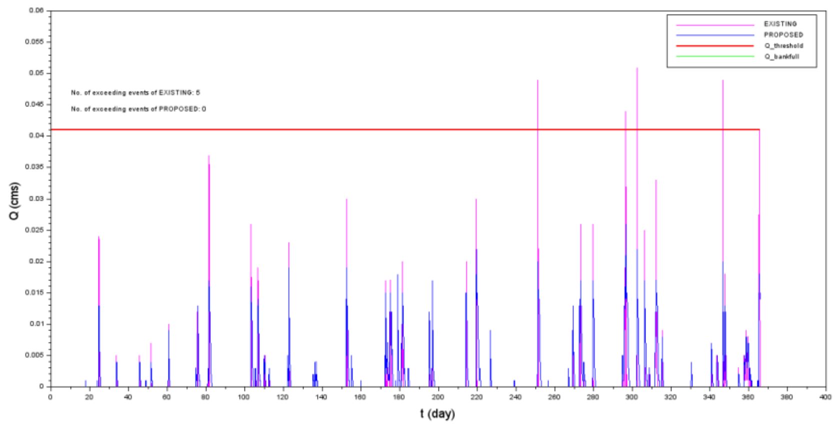
<td>
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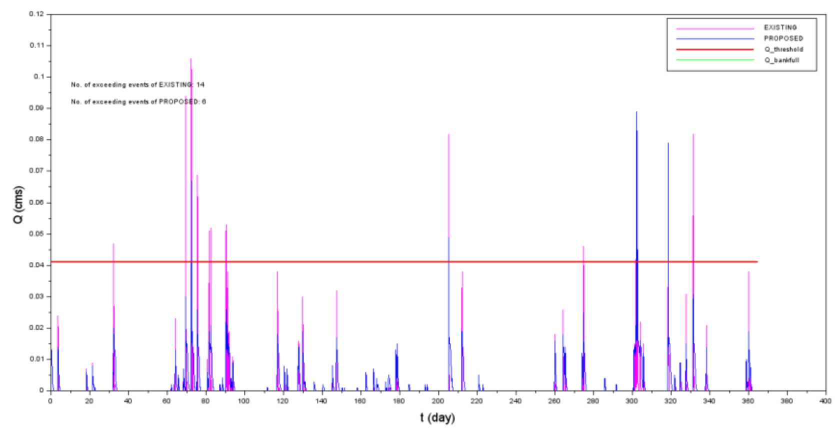
<td>
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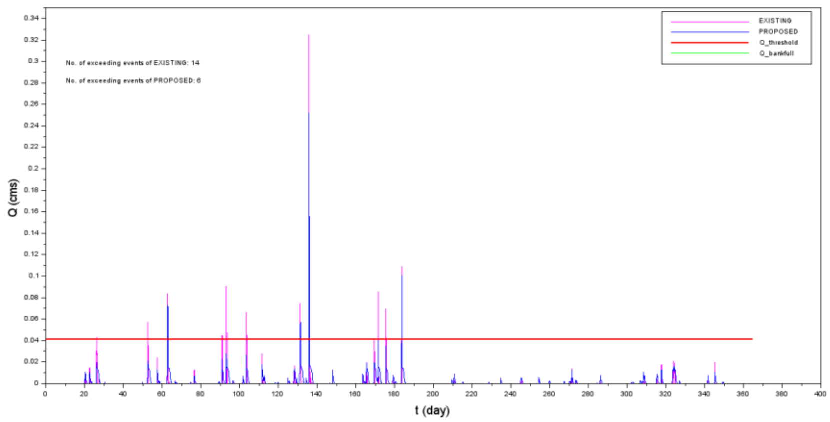
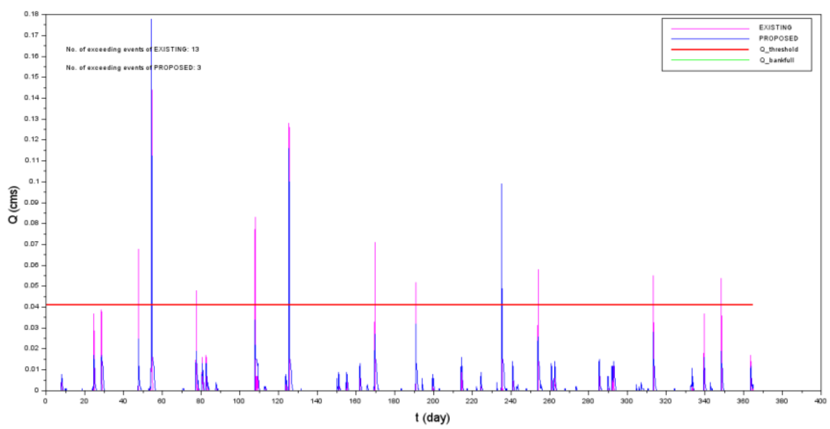
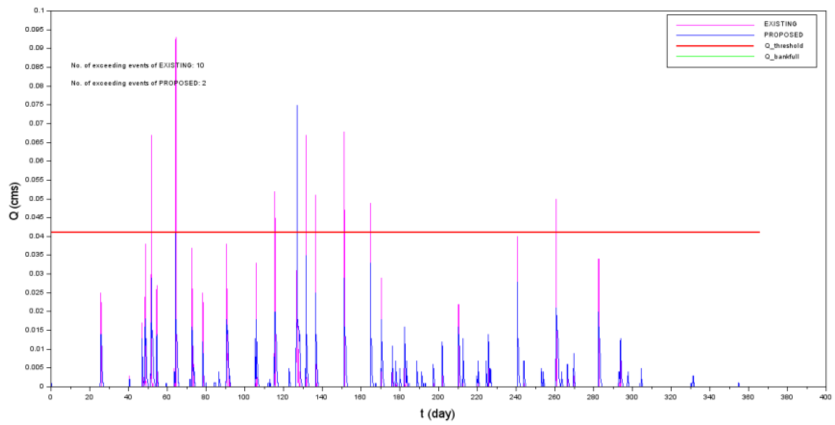
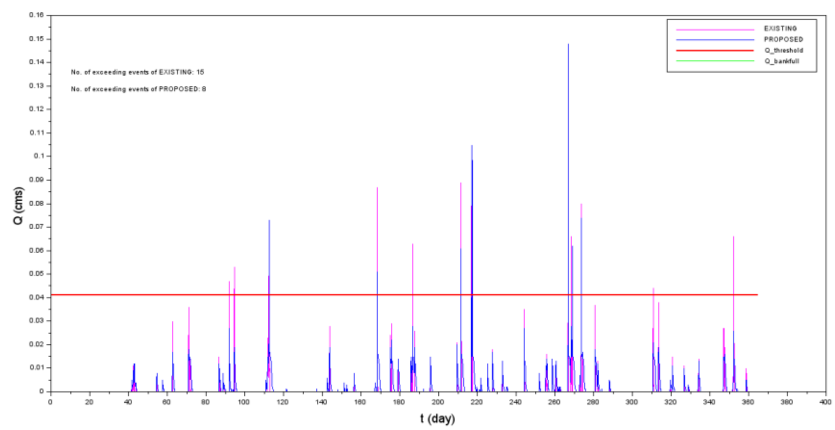
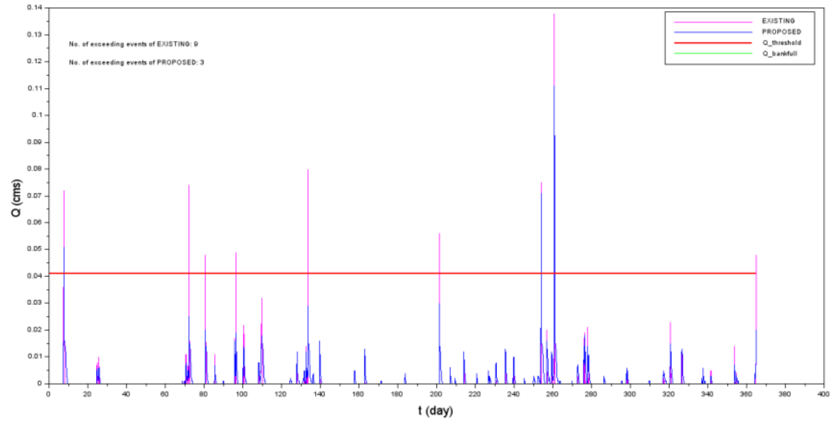
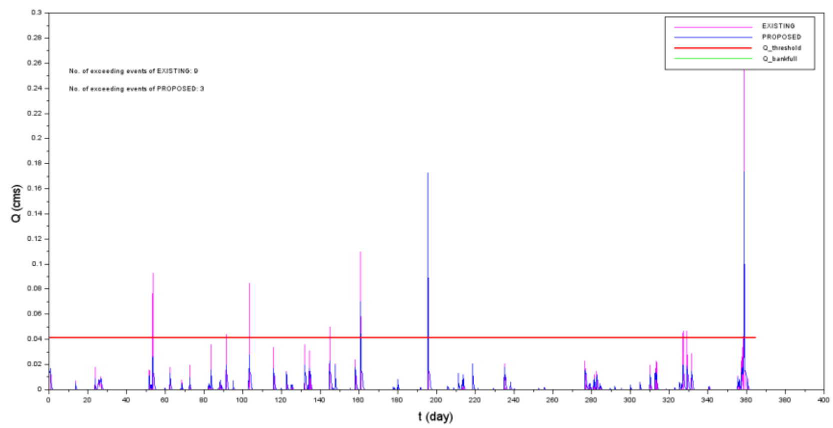
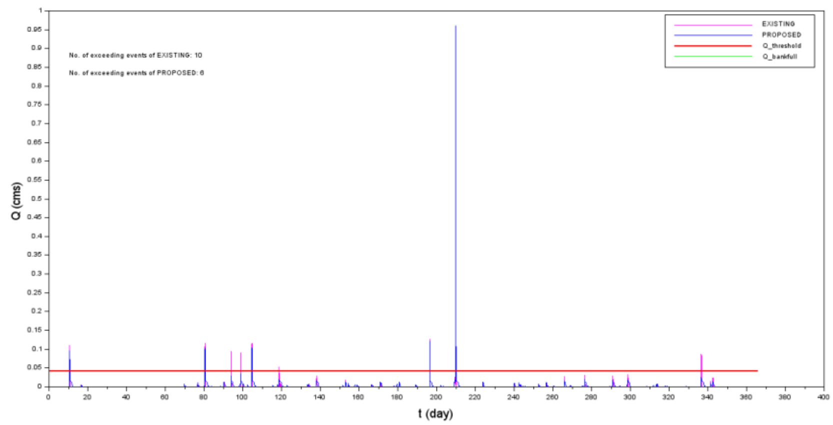
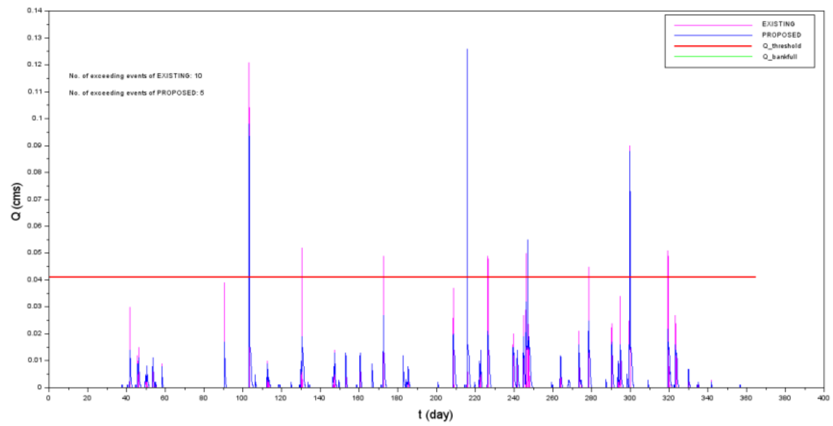
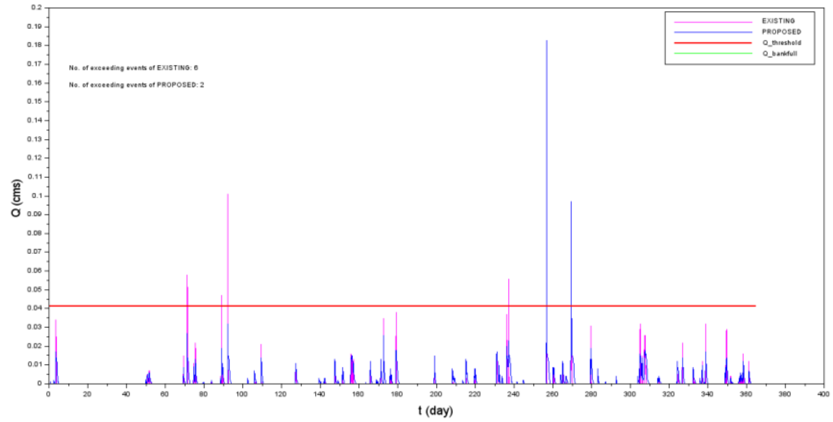
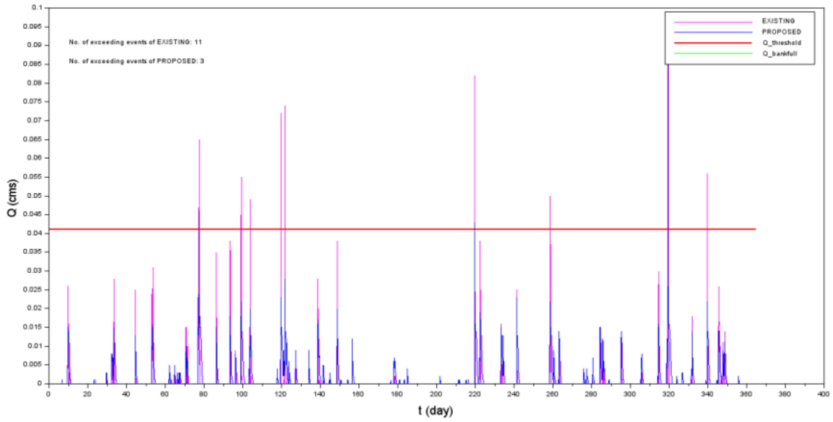
Reach **BCT-1a** UT Data - Pre with Pond 1974	
Reach **BCT-1a** UT Data - Pre with Pond 1975	

Reach **BCT-1a** UT Data - Pre with Pond 1976	
Reach **BCT-1a** UT Data - Pre with Pond 1977	

Reach **BCT-1a** UT Data - Pre with Pond 1978	
Reach **BCT-1a** UT Data - Pre with Pond 1979	

Reach **BCT-1a** UT Data - Pre with Pond 1980	
Reach **BCT-1a** UT Data - Pre with Pond 1981	

Reach **BCT-1a** UT Data - Pre with Pond 1982	
Reach **BCT-1a** UT Data - Pre with Pond 1983	

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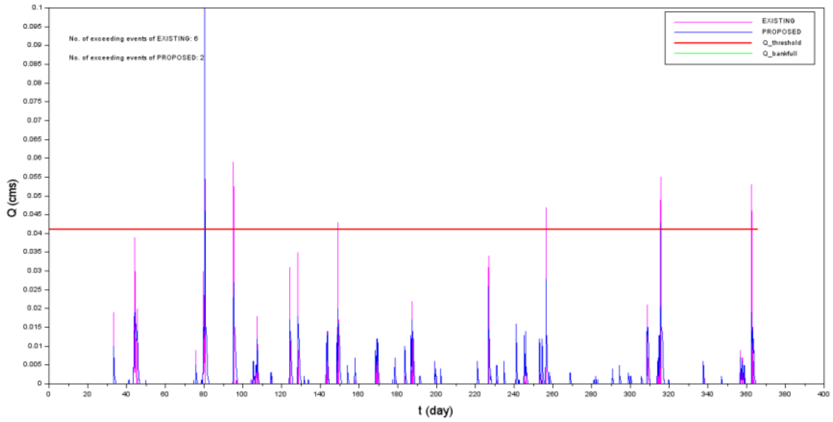
<td>
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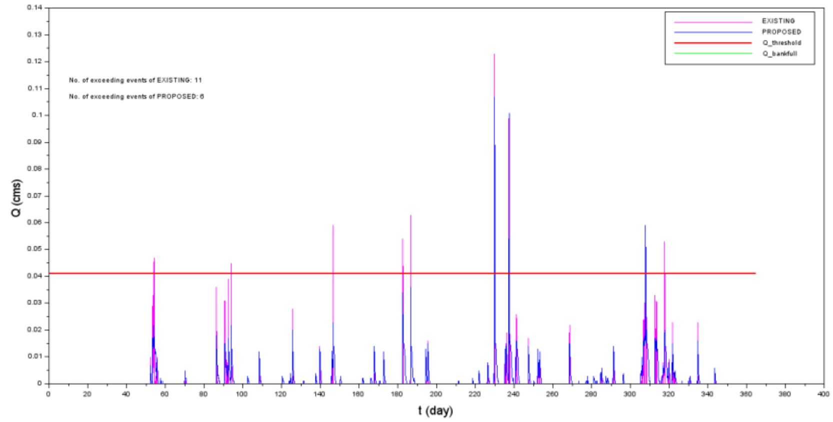
<td>
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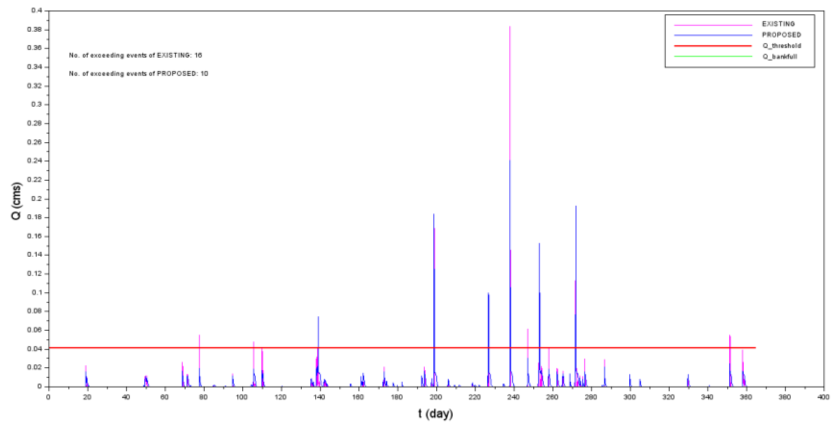
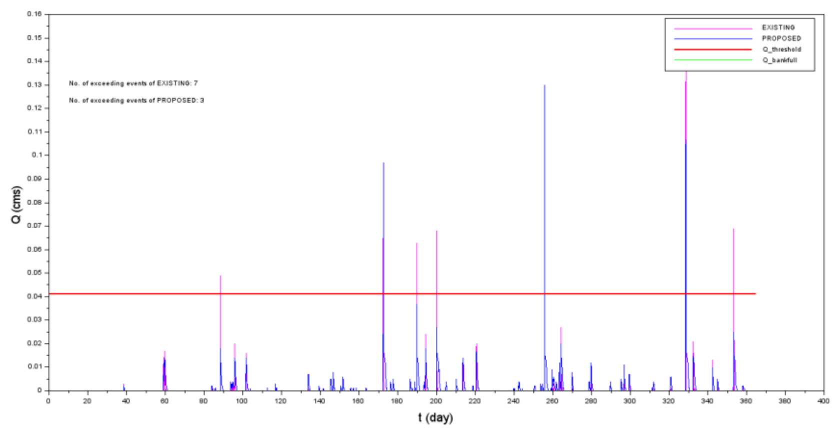
Reach **BCT-1a** UT Data - Pre with Pond 1986	
Reach **BCT-1a** UT Data - Pre with Pond 1987	

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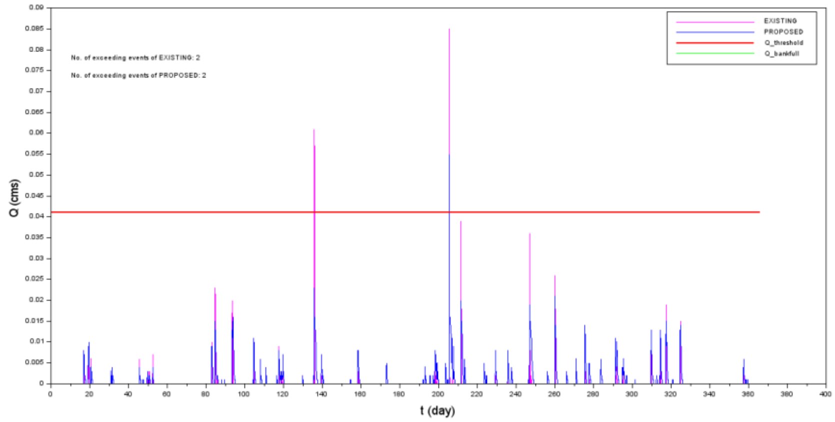
<td>
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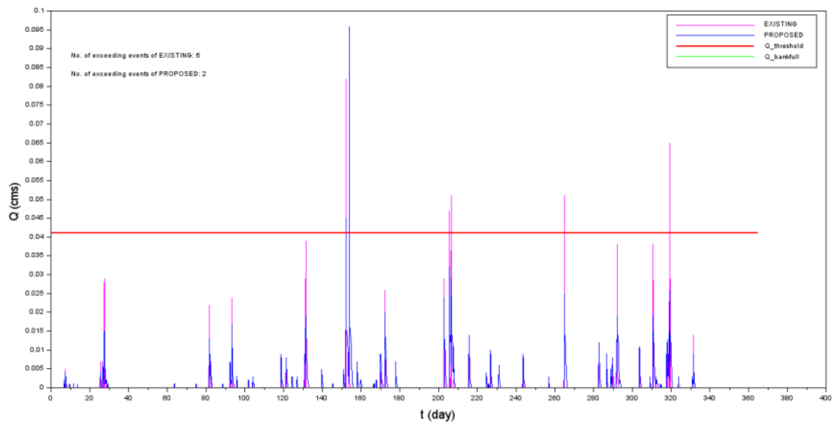
<td>
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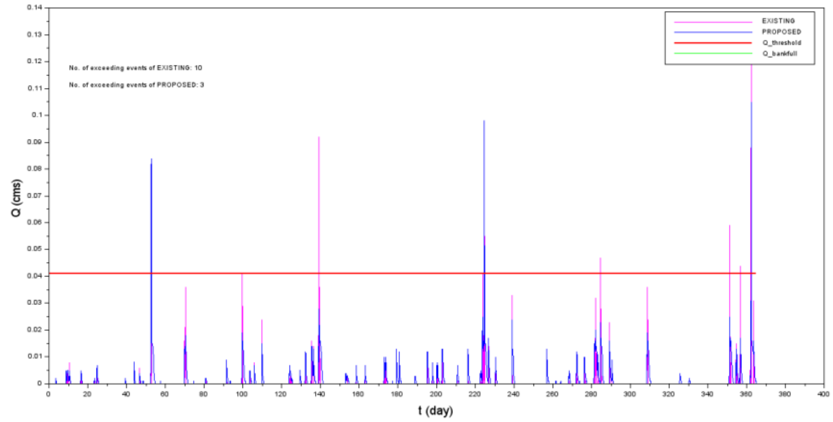
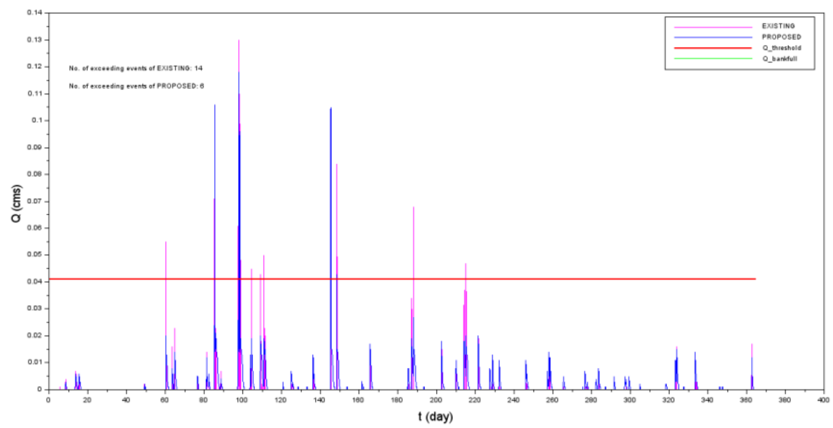
Reach **BCT-1a** UT Data - Pre with Pond 1990	
Reach **BCT-1a** UT Data - Pre with Pond 1991	

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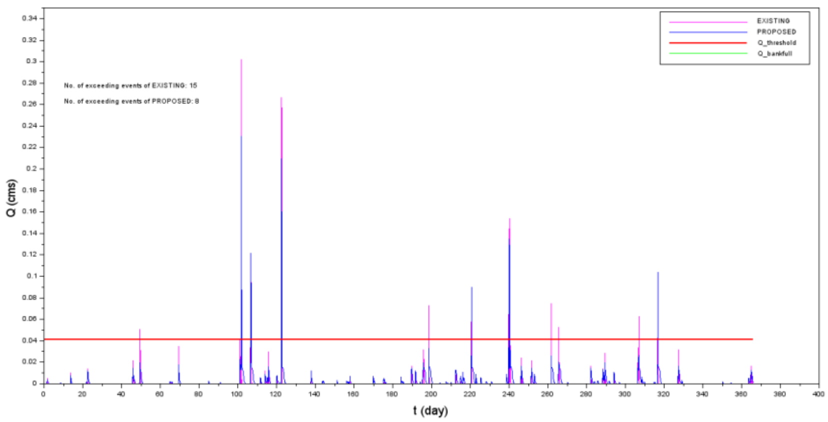
<td>
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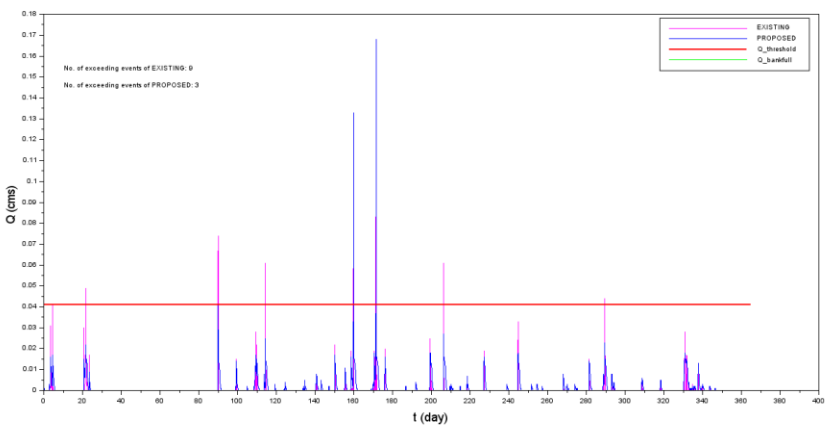
<td>
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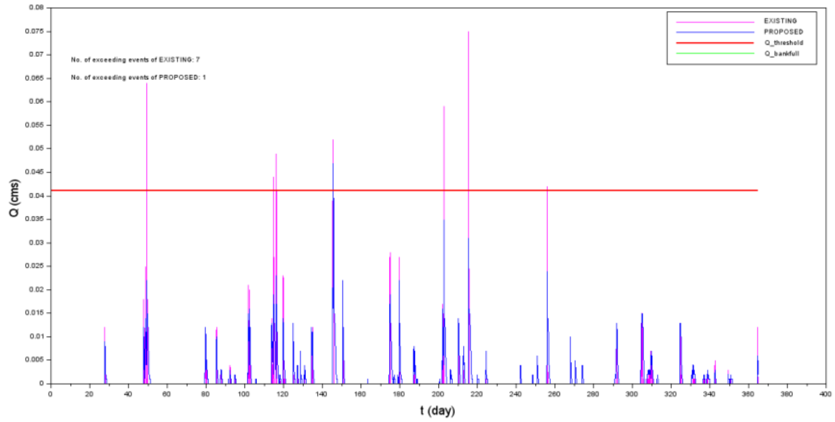
1994</td><td>
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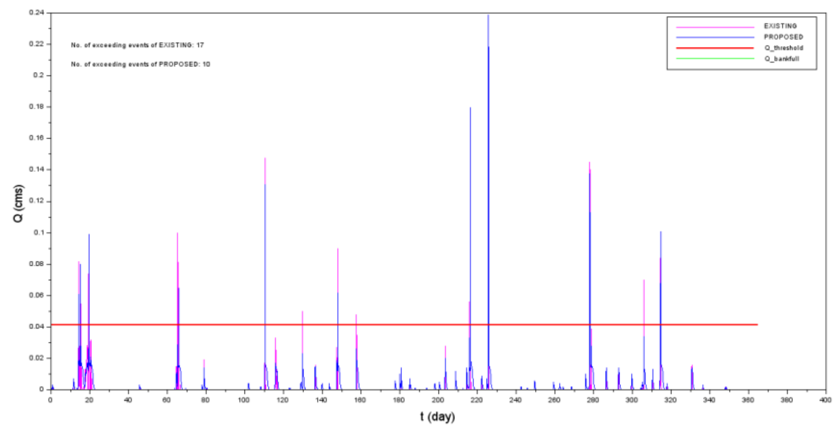
1995</td><td>
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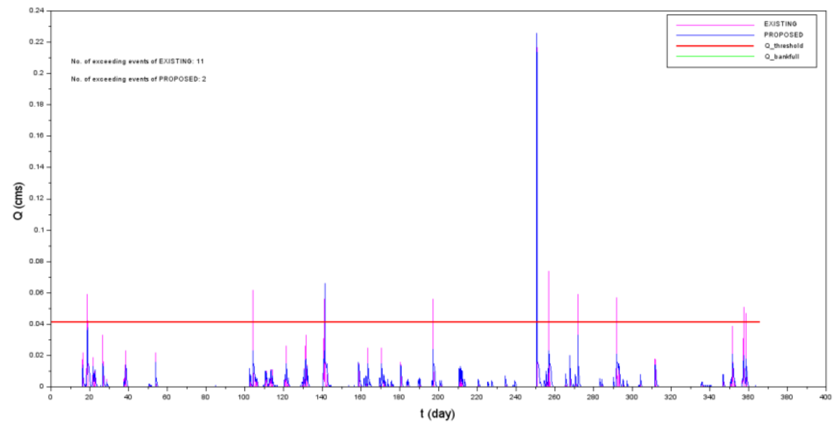
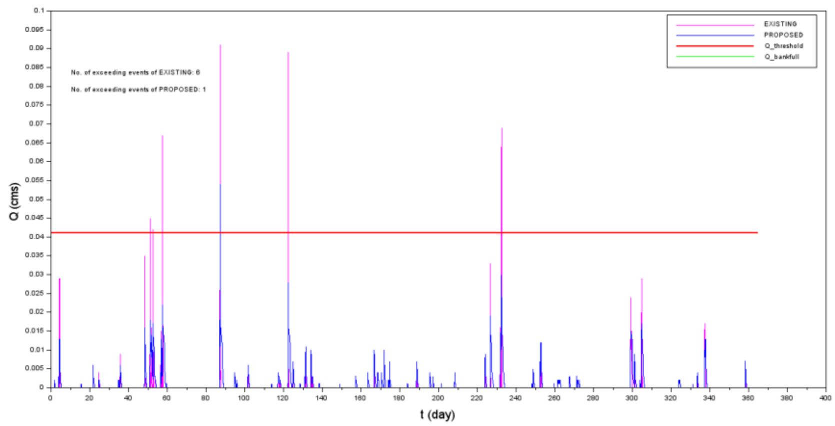
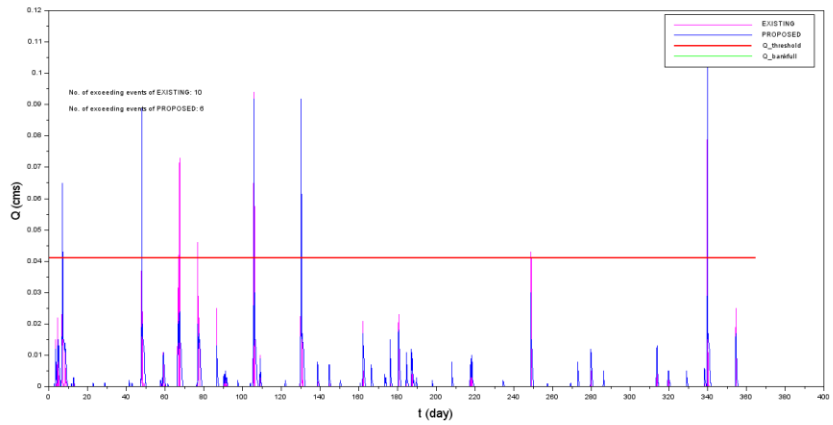
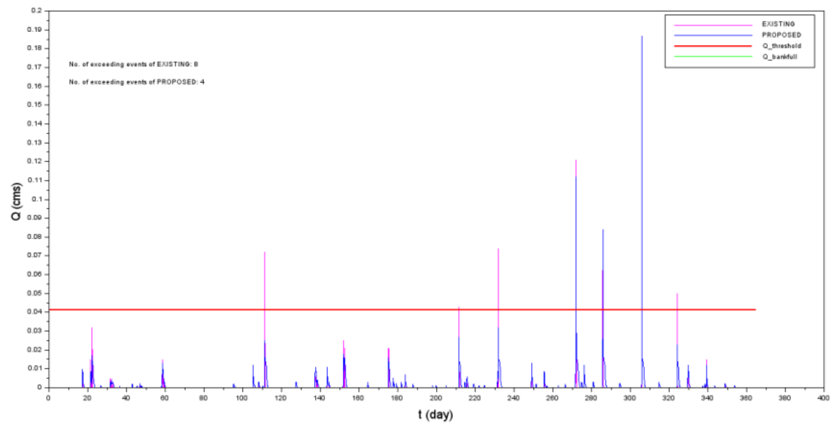
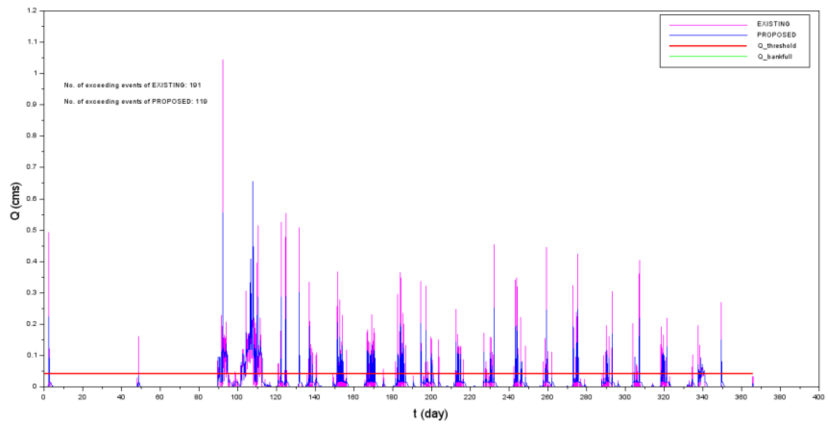
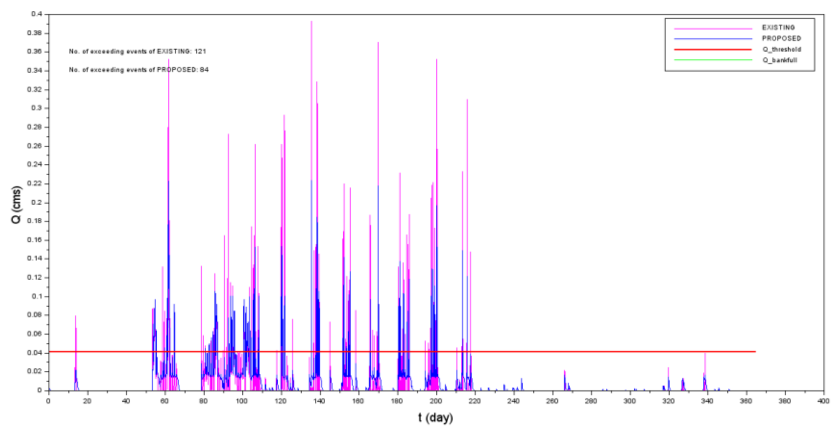
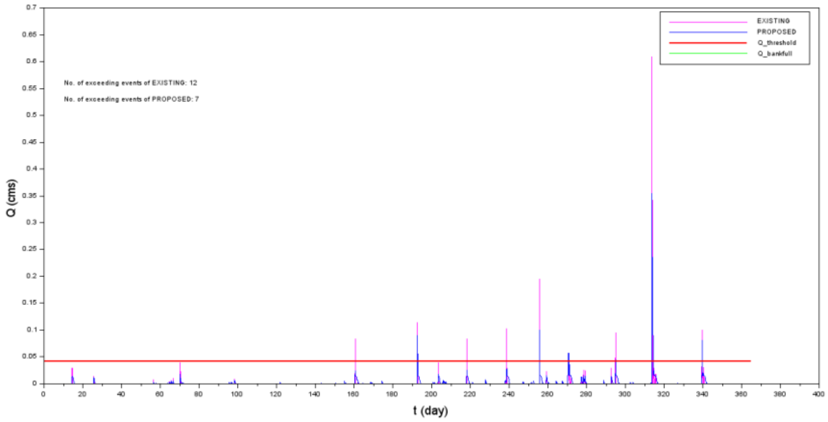
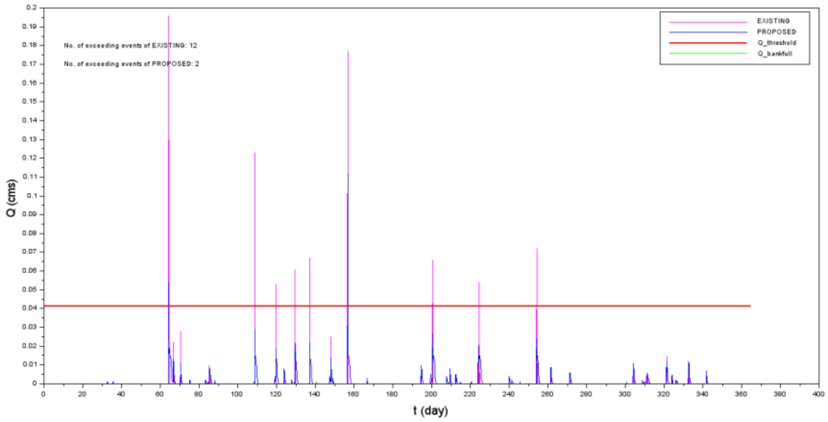
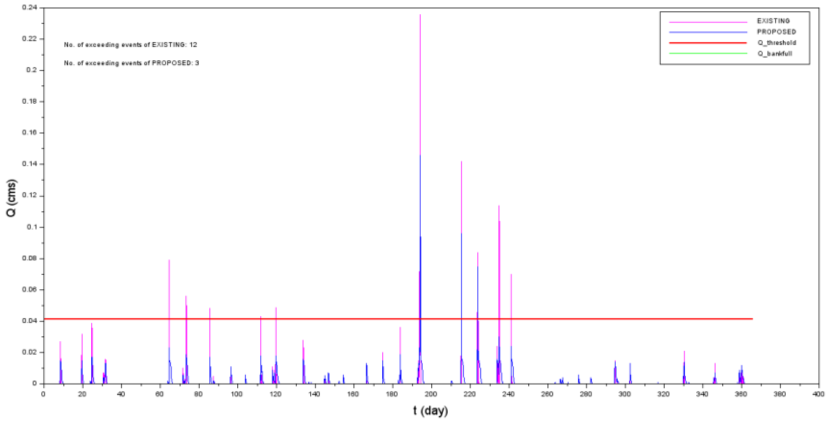
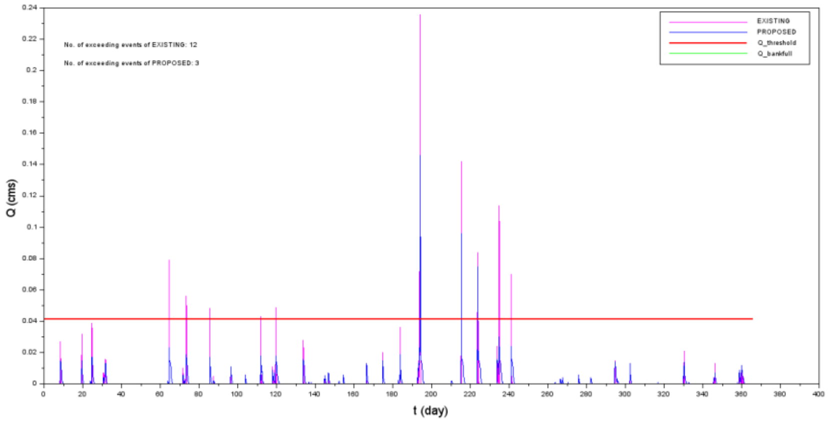
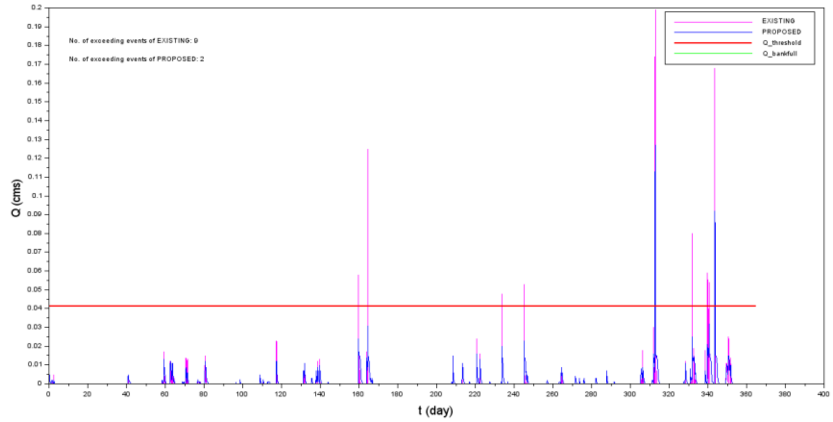
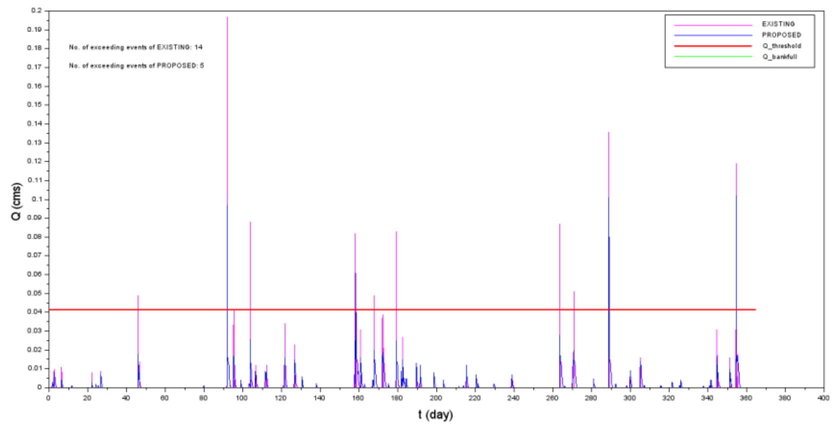
Reach **BCT-1a** UT Data - Pre with Pond 1996	
Reach **BCT-1a** UT Data - Pre with Pond 1997	

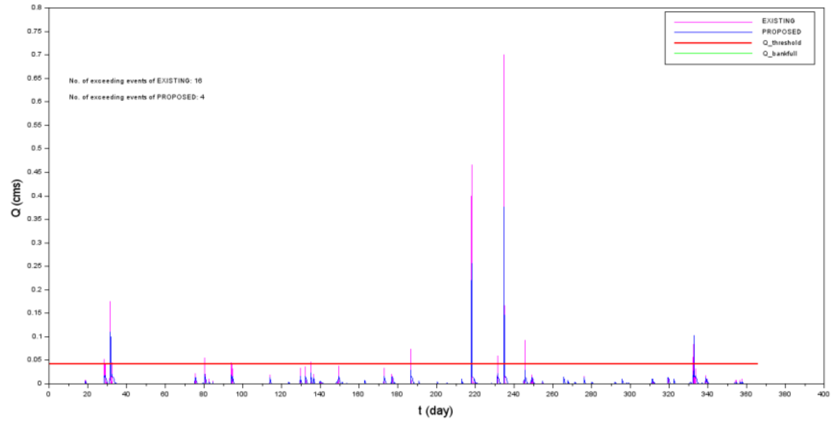
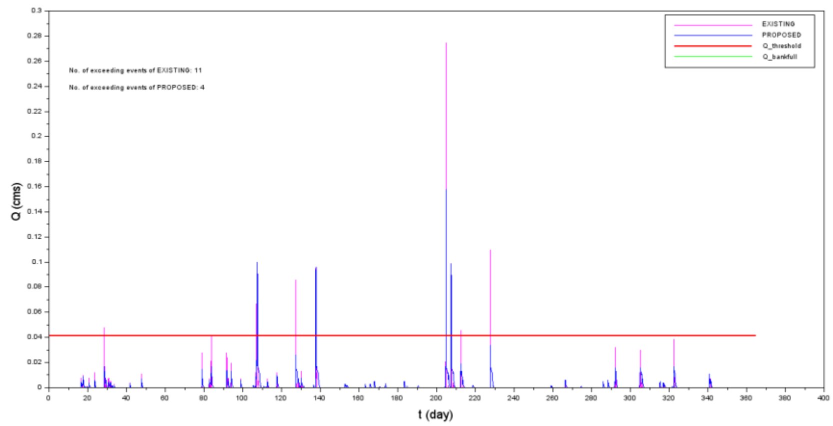
Reach **BCT-1a** UT Data - Pre with Pond 1998	
Reach **BCT-1a** UT Data - Pre with Pond 1999	

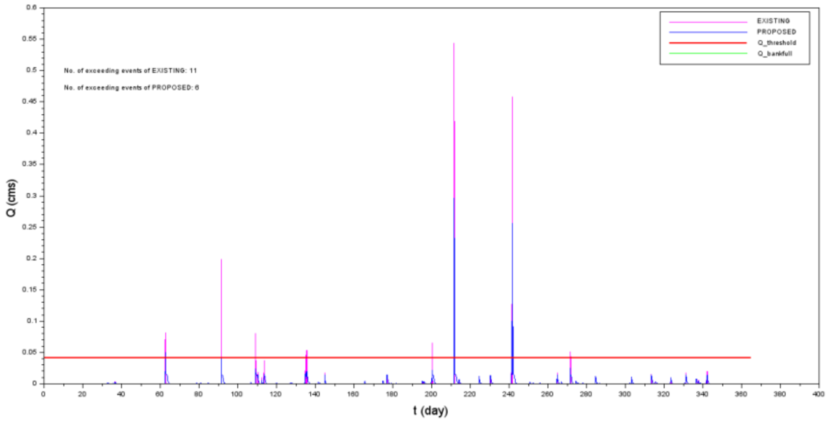
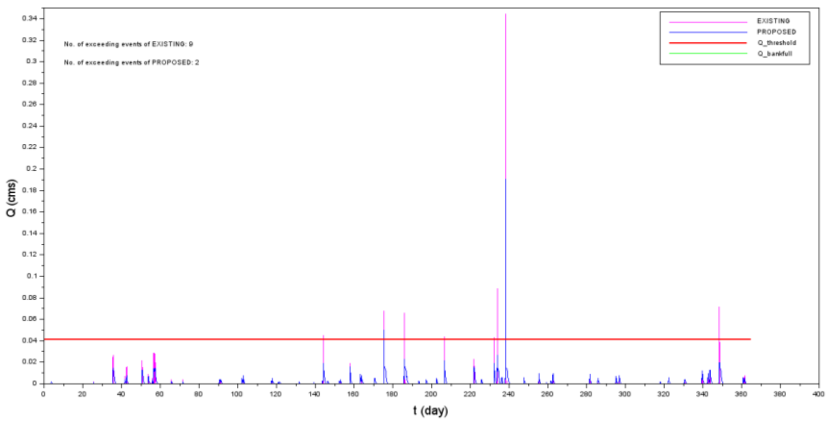
Reach **BCT-1a** UT Data - Pre without Pond 1960	
Reach **BCT-1a** UT Data - Pre without Pond 1961	

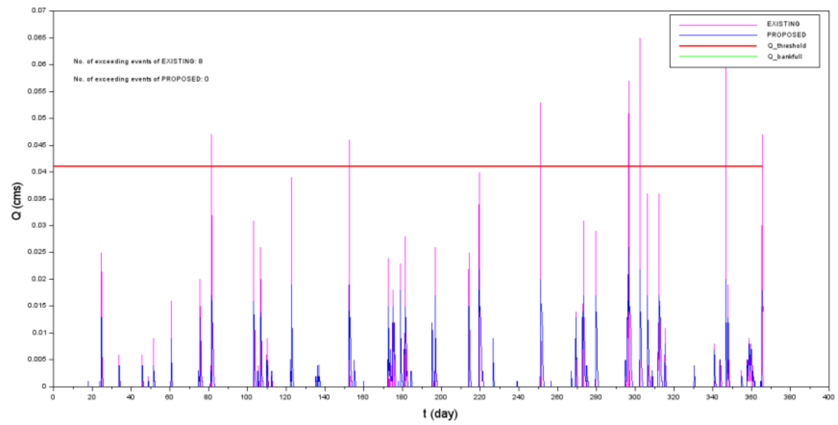
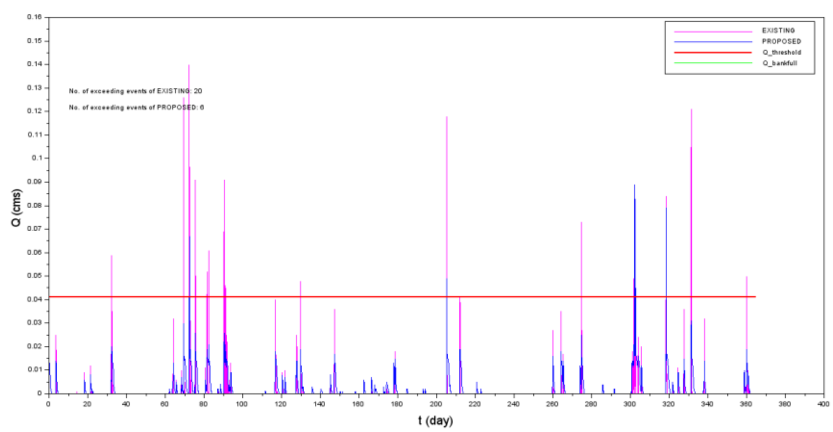
Reach **BCT-1a** UT Data - Pre with Pond 1962	
Reach **BCT-1a** UT Data - Pre without Pond 1963	

Reach **BCT-1a** UT Data - Pre without Pond 1964	
Reach **BCT-1a** UT Data - Pre without Pond 1965	

Reach **BCT-1a** UT Data - Pre without Pond 1966	
Reach **BCT-1a** UT Data - Pre without Pond 1967	

Reach **BCT-1a** UT Data - Pre without Pond 1968	
Reach **BCT-1a** UT Data - Pre without Pond 1969	

Reach **BCT-1a** UT Data - Pre without Pond 1970	
Reach **BCT-1a** UT Data - Pre without Pond 1971	

Reach **BCT-1a** UT Data - Pre without Pond 1972	
Reach **BCT-1a** UT Data - Pre without Pond 1973	

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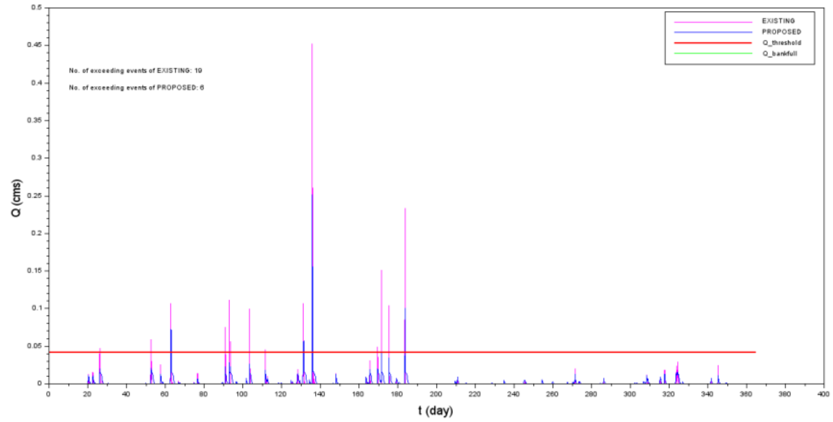
<td>
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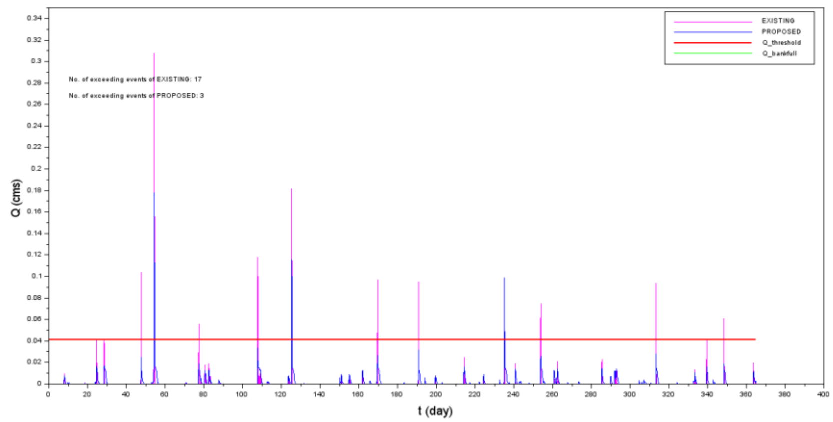
<td>
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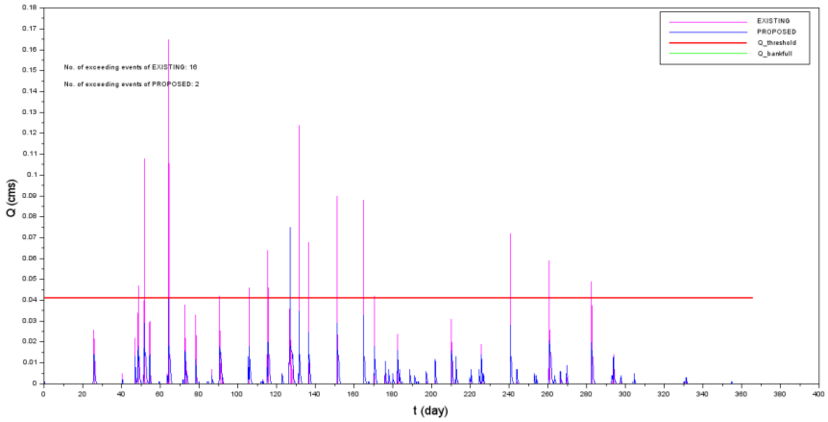
<td>
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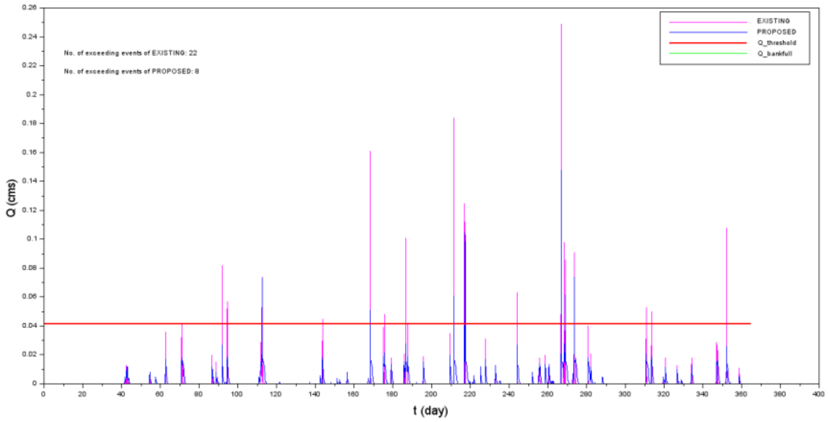
<td>
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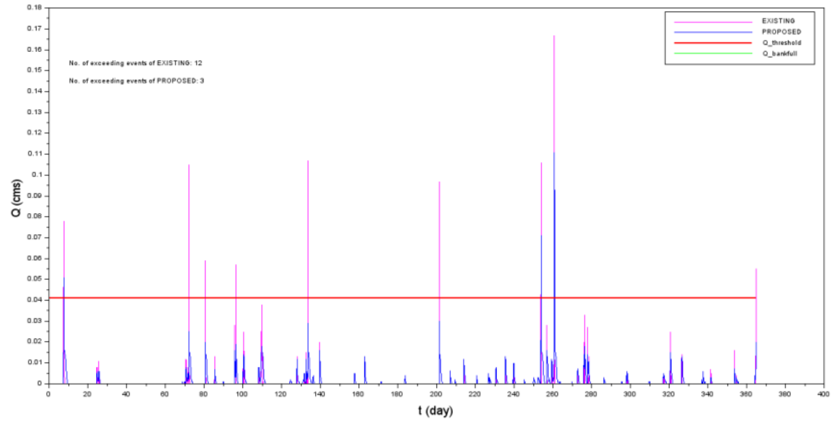
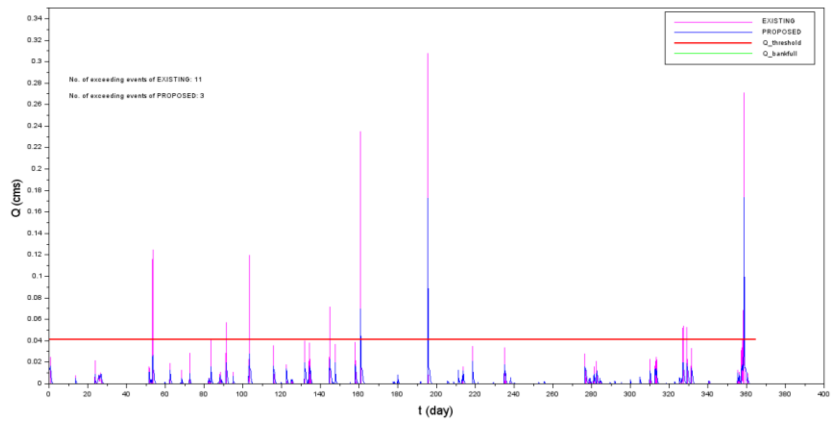
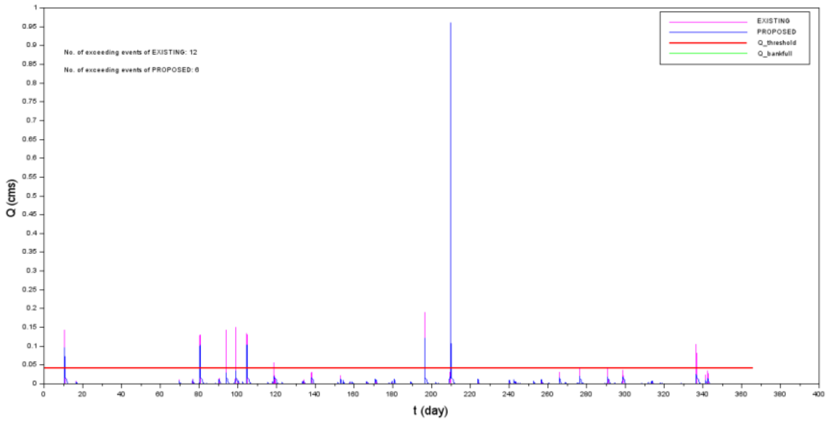
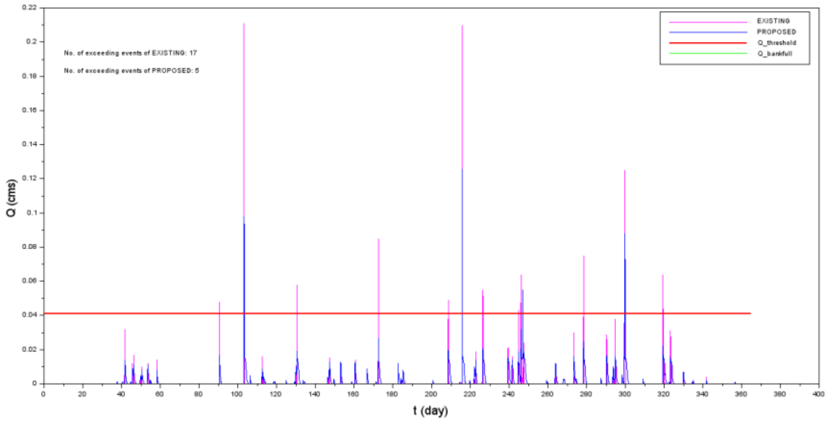
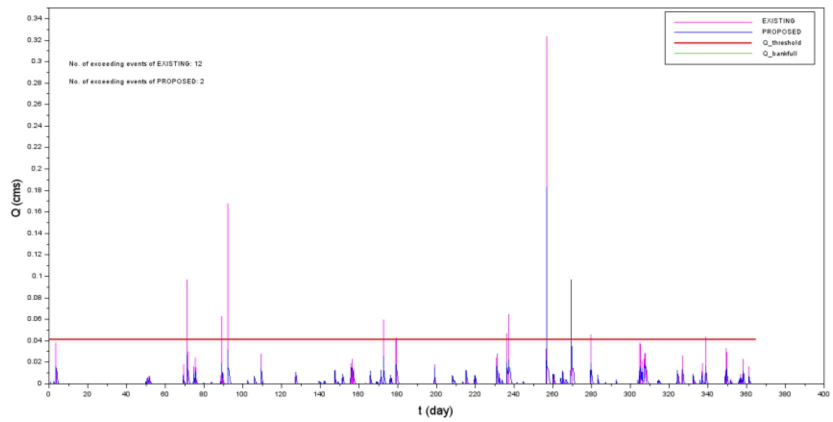
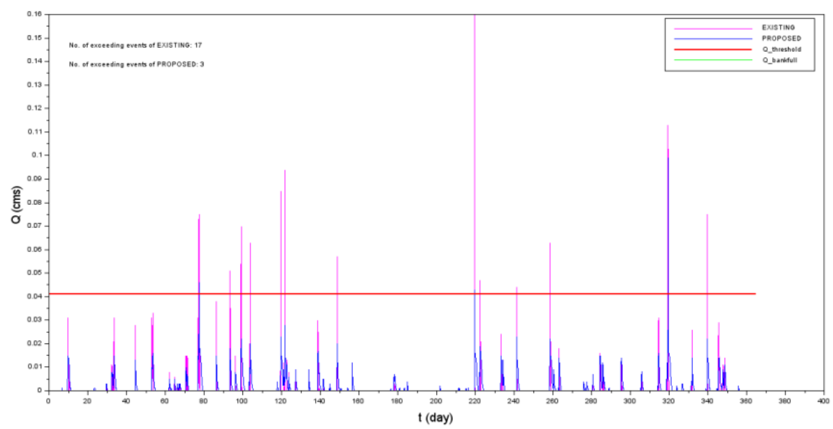
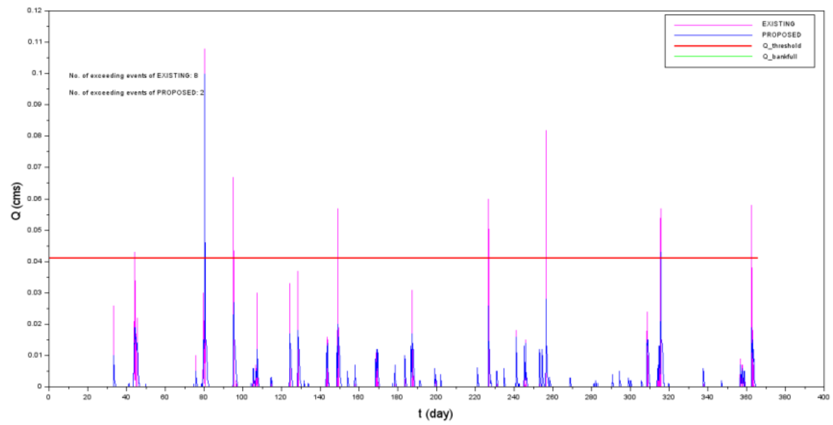
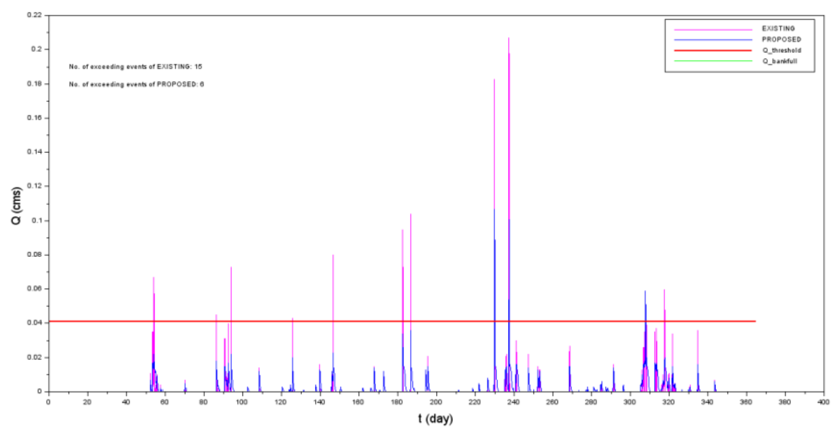
Reach **BCT-1a** UT Data - Pre without Pond 1978	
Reach **BCT-1a** UT Data - Pre without Pond 1979	

Reach **BCT-1a** UT Data - Pre without Pond 1980	
Reach **BCT-1a** UT Data - Pre without Pond 1981	

Reach **BCT-1a** UT Data - Pre without Pond 1982	
Reach **BCT-1a** UT Data - Pre without Pond 1983	

Reach **BCT-1a** UT Data - Pre without Pond 1984	
Reach **BCT-1a** UT Data - Pre without Pond 1985	

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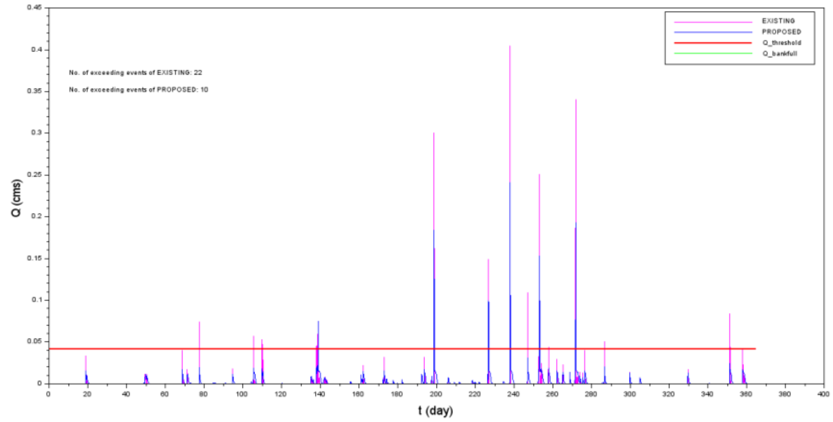
<td>
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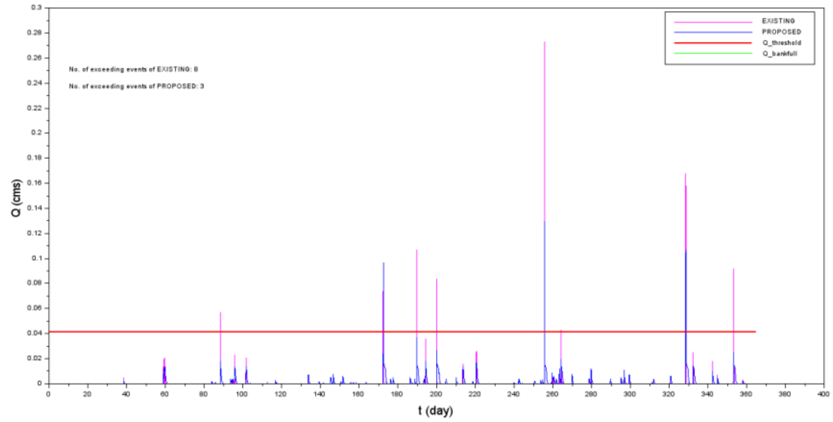
<td>
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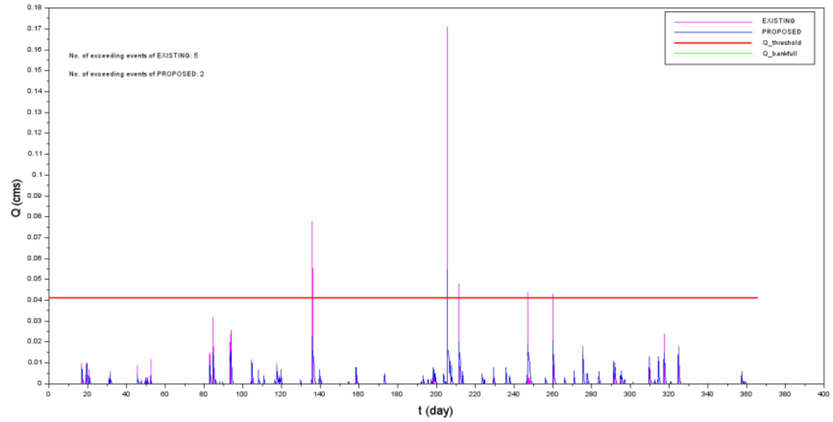
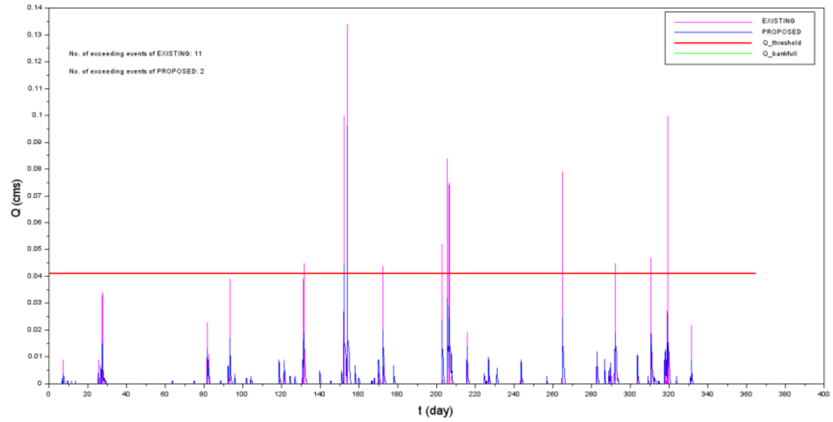
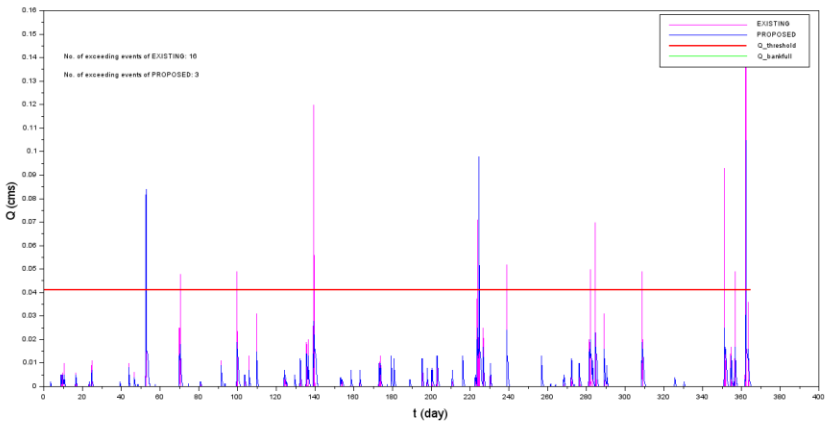
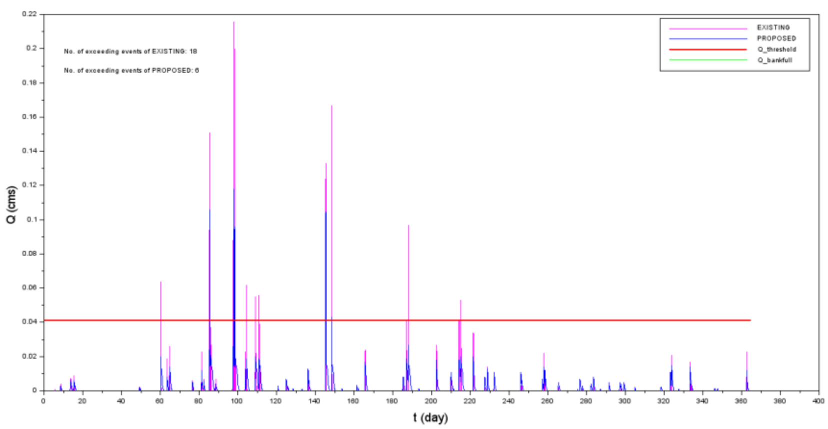
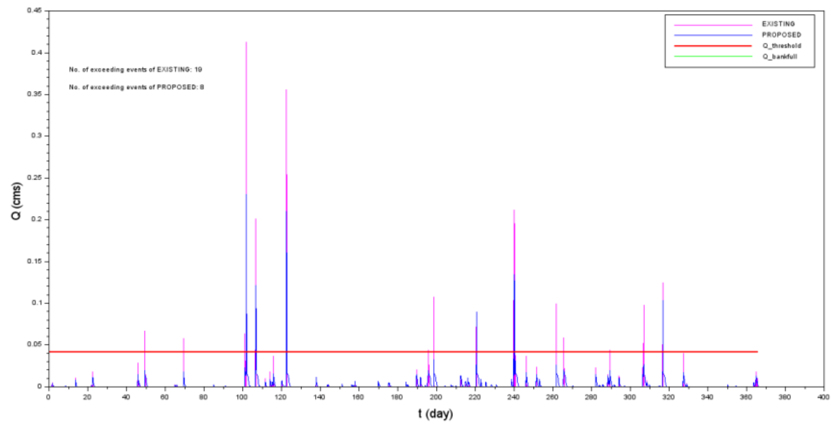
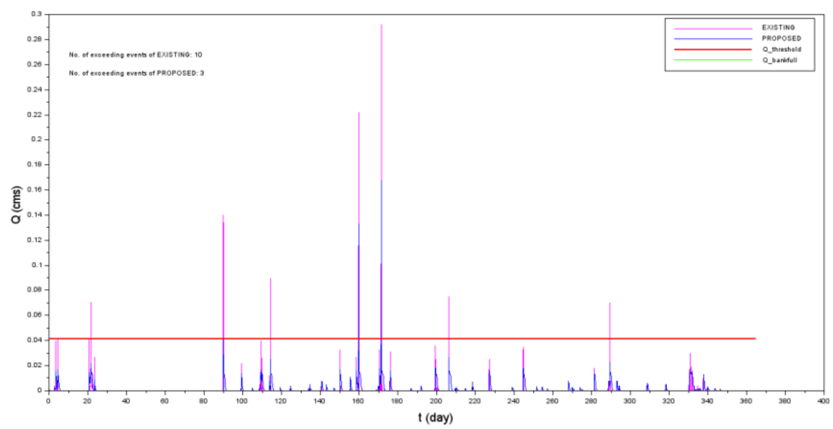
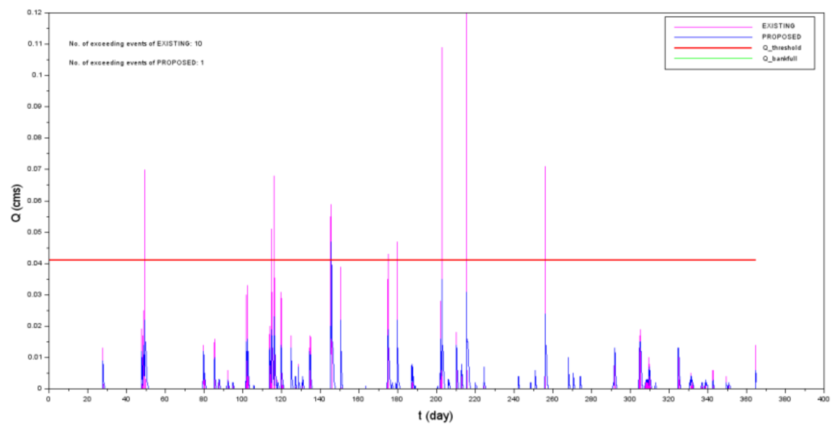
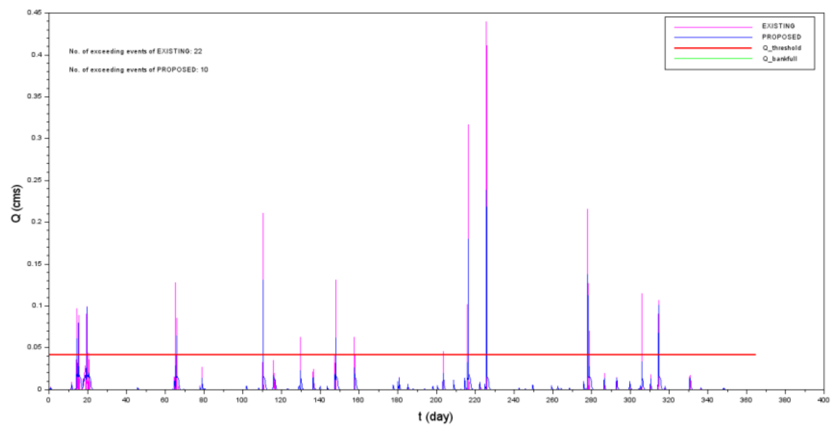
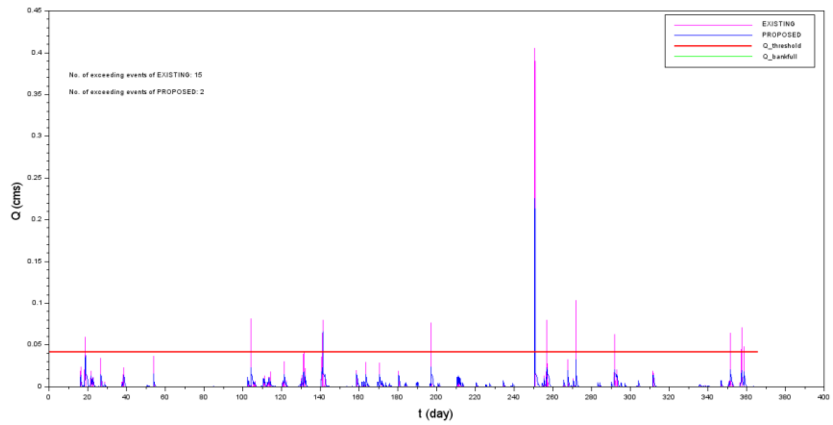
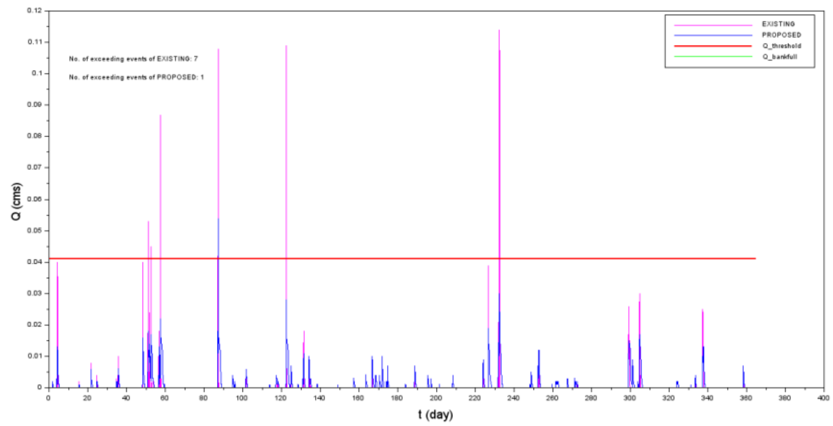
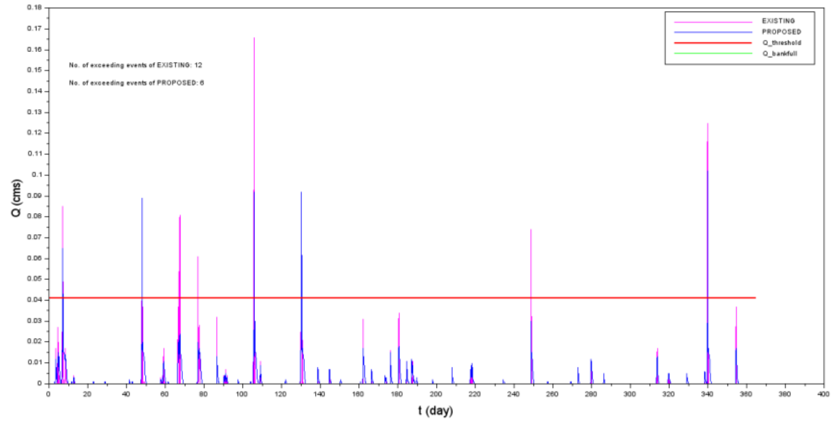
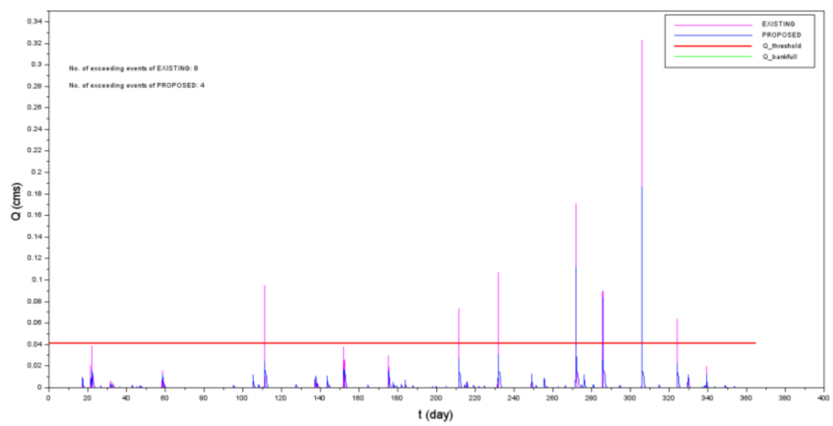
Reach **BCT-1a** UT Data - Pre without Pond 1988	
Reach **BCT-1a** UT Data - Pre without Pond 1989	

Reach **BCT-1a** UT Data - Pre without Pond 1990	
Reach **BCT-1a** UT Data - Pre without Pond 1991	

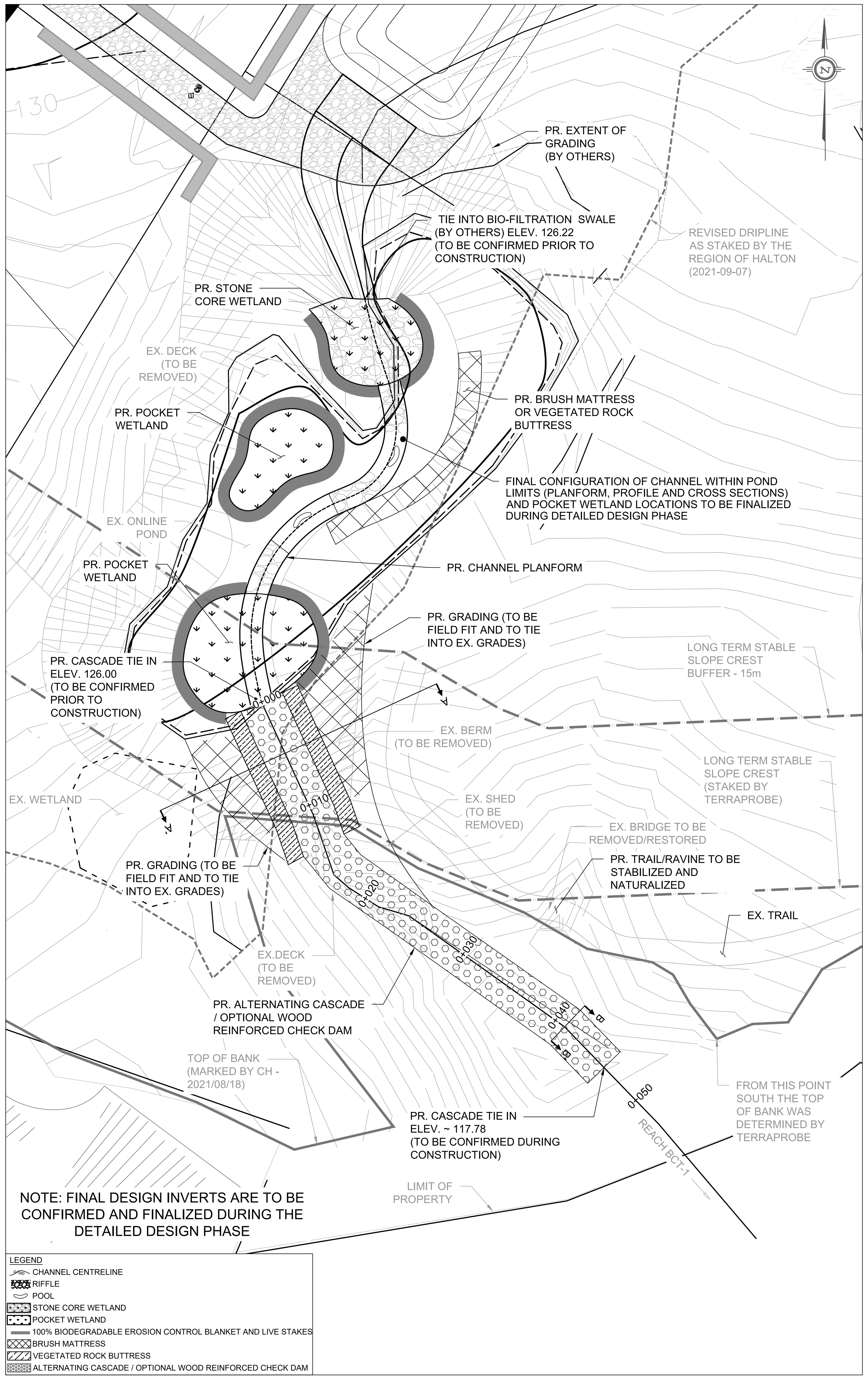
Reach **BCT-1a** UT Data - Pre without Pond 1992	
Reach **BCT-1a** UT Data - Pre without Pond 1993	

Reach **BCT-1a** UT Data - Pre without Pond 1994	
Reach **BCT-1a** UT Data - Pre without Pond 1995	

Reach **BCT-1a** UT Data - Pre without Pond 1996	
Reach **BCT-1a** UT Data - Pre without Pond 1997	

Reach **BCT-1a** UT Data - Pre without Pond 1998	
Reach **BCT-1a** UT Data - Pre without Pond 1999	

Appendix F
Conceptual Design Drawings



PLANFORM
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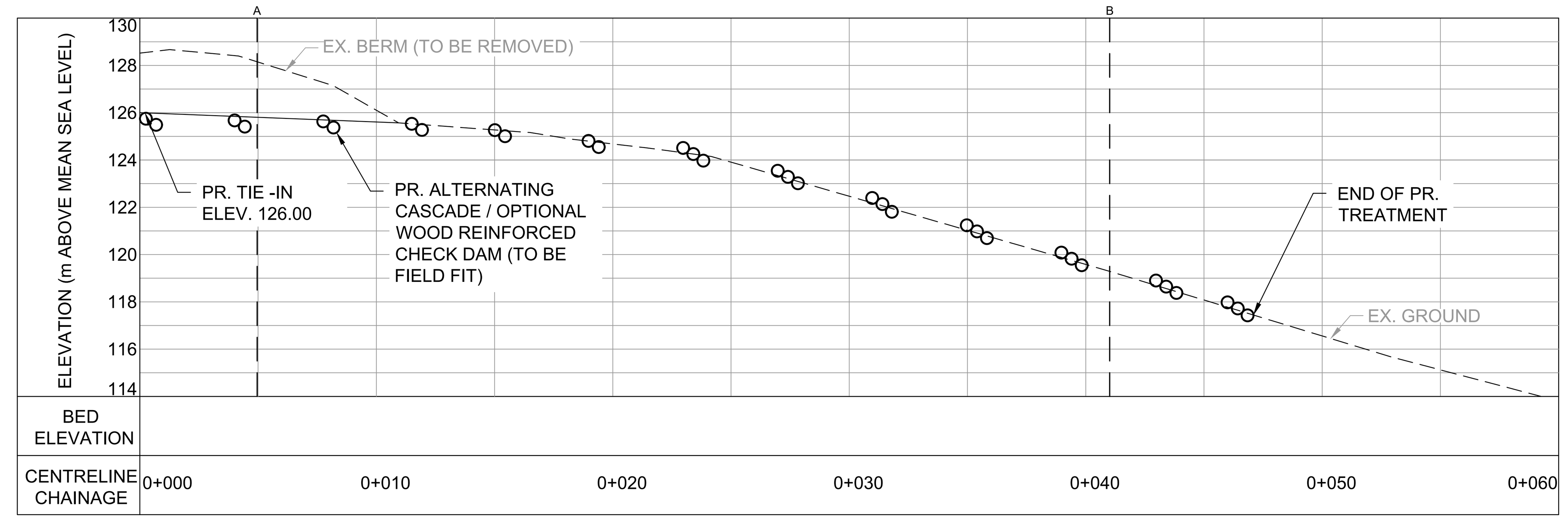

PROFILE
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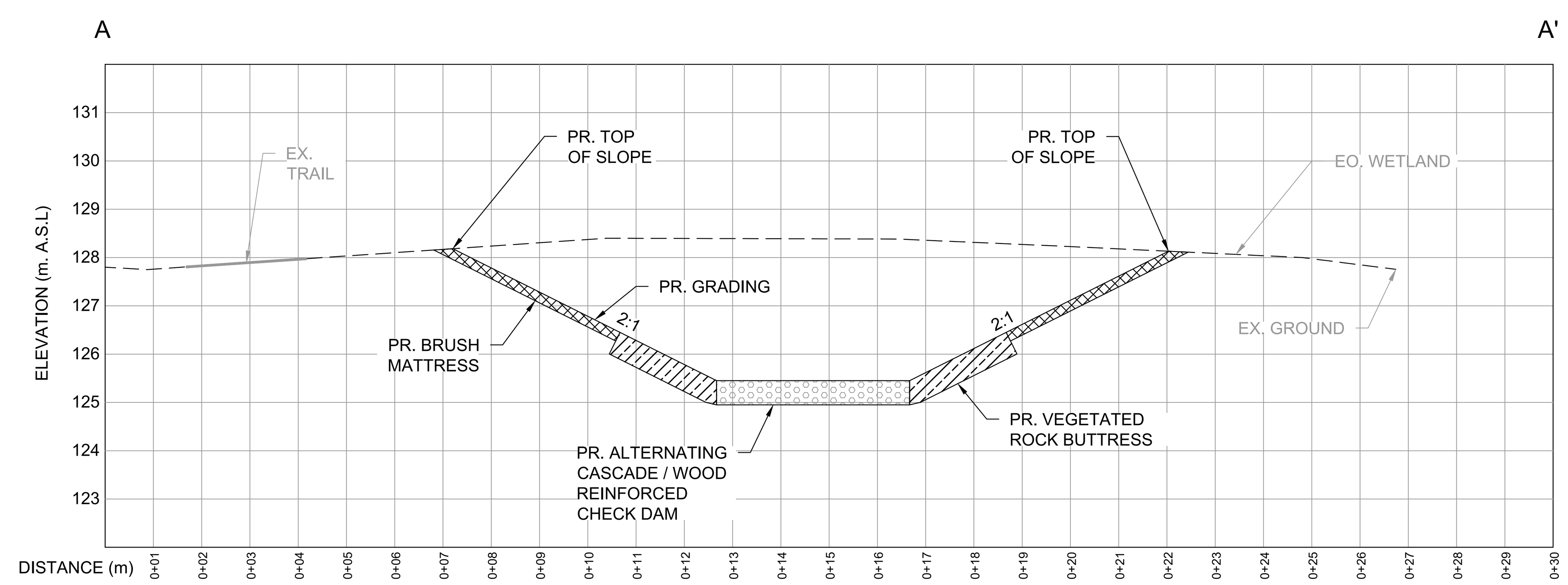

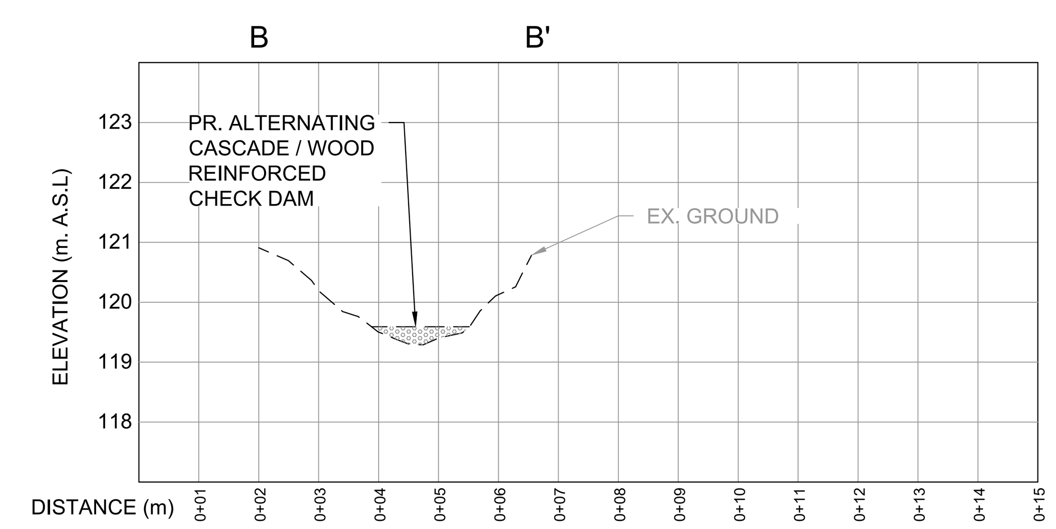

CROSS SECTIONS
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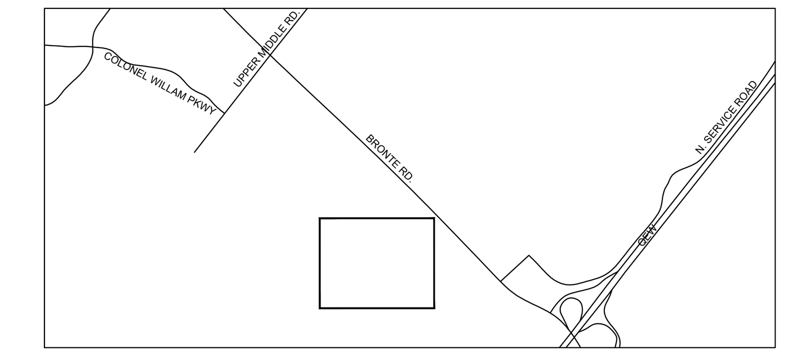

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CONCEPTUAL DRAFT (NOT FOR CONSTRUCTION)

DATE	BY	REVISIONS

DESIGNED BY: P.V.	CHECKED BY: P.V.
DRAWN BY: B.W.M.	DATE: APRIL 2023

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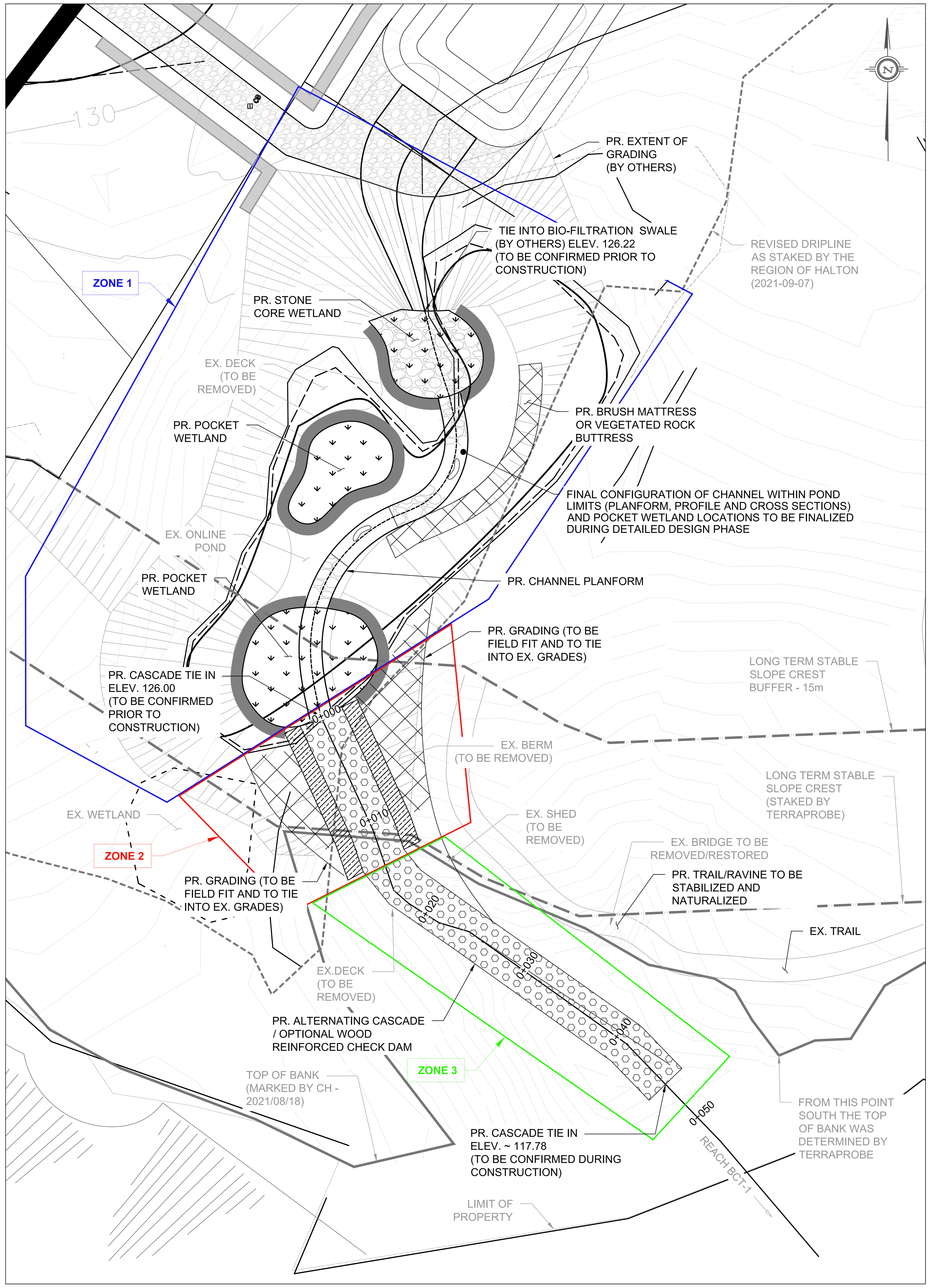
BRONTE RIVER LIMITED PARTNERSHIP
TOWN OF OAKVILLE

RESTORATION DESIGN
PLANFORM, PROFILE, AND CROSS SECTIONS

PROJECT No.: 23026	DRAWING No.: GEO-1
SCALE: AS NOTED	SHEET 1 OF 5

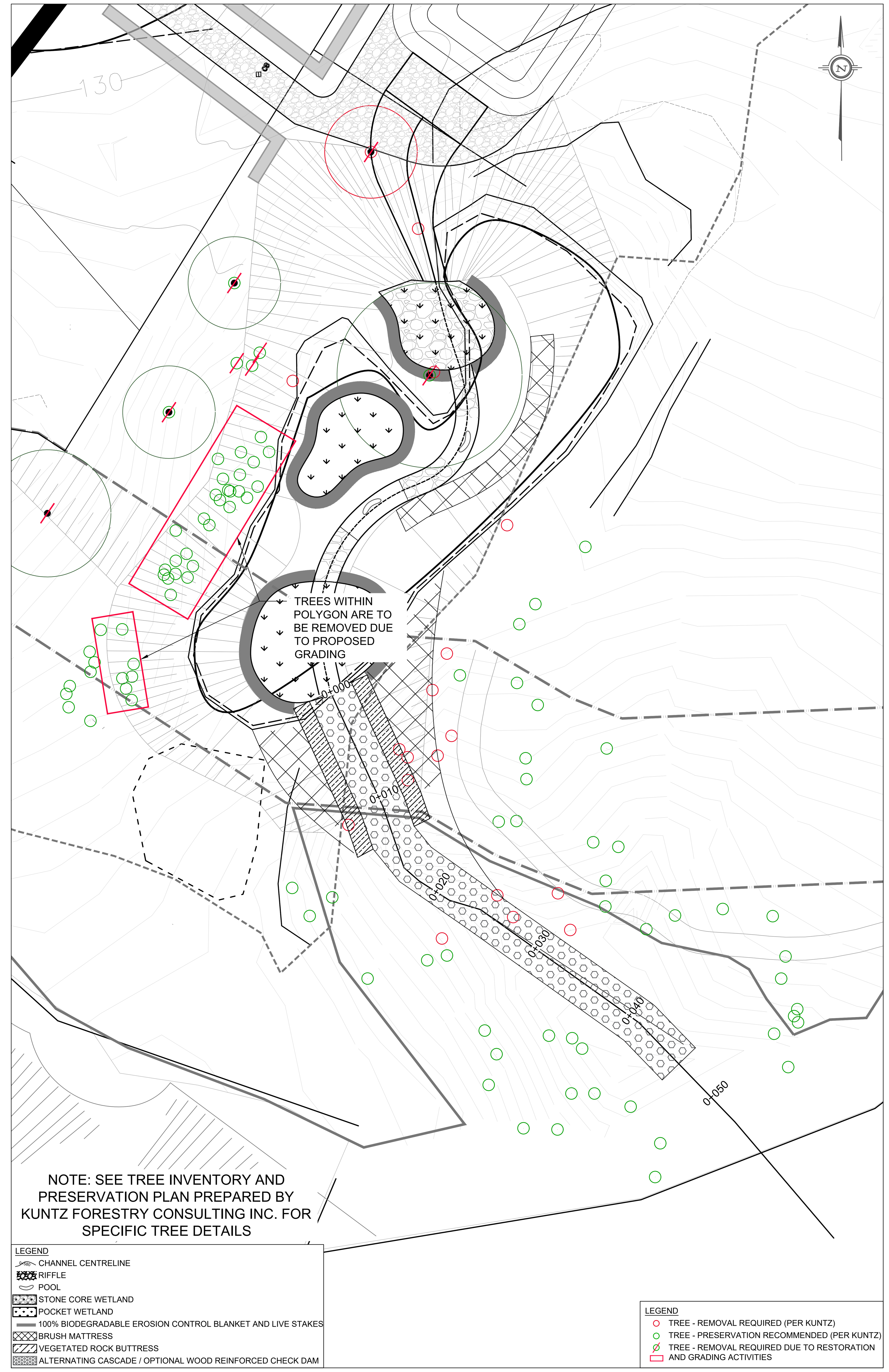
SCALED FOR PLOT ON 'ARCH D'



PLANFORM - CONCEPTUAL PHASING
1:250

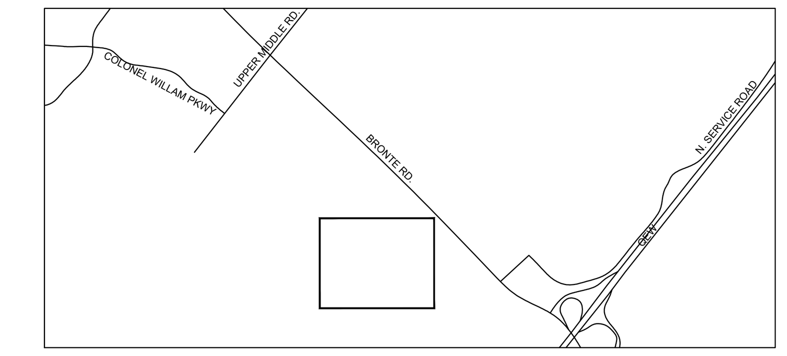
CONCEPTUAL PHASING / SEQUENCE OF CONSTRUCTION

1. CONSTRUCTION CONTRACT ADMINISTRATOR TO REVIEW SITE CONDITIONS PRIOR TO COMMENCEMENT OF WORK.
2. MONITOR WEATHER TO ENSURE IN-WATER WORKS ARE COMPLETED UNDER LOW-FLOW CONDITIONS.
3. INSTALL PERIMETER CONTROL ESC MEASURES AROUND WORK AREA (AS DEEMED NECESSARY BY THE CONTRACT ADMINISTRATOR).
4. INSTALL COFFERDAMS, AS REQUIREED, ENSURING COMPLETE ISOLATION OF WORK AREA (SEE PLAN).
5. CONDUCT FISH AND AMPHIBIAN RESCUE FROM ISOLATED WORK AREAS. FISH RESCUE MUST BE COMPLETED BY A QUALIFIED TECHNICIAN WITH A LICENSE FROM THE ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY.
6. BYPASS PUMPING / UNWATER WORK AREAS TO UNWATERING DISCHARGE FILTRATION SYSTEM AS REQUIRED TO CONDUCT WORK UNDER 'DRY' CONDITIONS.
7. GRADE ACCESS PATH THOUGH ZONE 1.
8. REMOVE BERM IN ZONE 2.
9. CONSTRUCT PROPOSED TREATMENTS IN ZONE 3.
10. CONSTRUCT PROPOSED TREATMENTS IN ZONE 2.
11. CONSTRUCT PROPOSED TREATMENTS IN ZONE 1.
13. STABILIZE AREAS DISTURBED FROM CONSTRUCTION ACTIVITIES WITH SEED AND BIODEGRADABLE EROSION CONTROL BLANKET. TO BE COMPLETED WITHIN IN EACH ZONE PRIOR TO MOVING ON TO NEXT ZONE.
14. REMOVE COFFERDAMS AND INTRODUCE FLOWS TO THE RESTORED CHANNEL ONCE THE SITE HAS BEEN DEEMED STABLE BY THE DESIGNER.
15. RESTORE SURFACES DISTURBED BY THE CONSTRUCTION WORK OR STAGING AREA(S) TO ORIGINAL CONDITION.



PLANFORM - TREE INVENTORY AND REMOVALS ASSOCIATED WITH CHANNEL RESTORATION
1:250

SCALED FOR PLOT ON 'ARCH D'



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DATE	BY	REVISIONS

DESIGNED BY: P.V. | CHECKED BY: P.V.
DRAWN BY: B.W.M. | DATE: APRIL 2023

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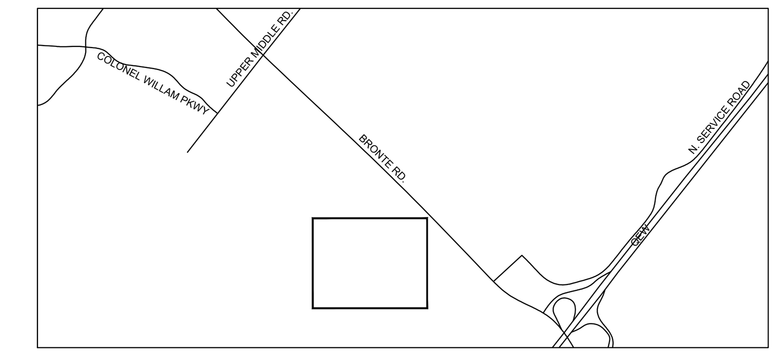
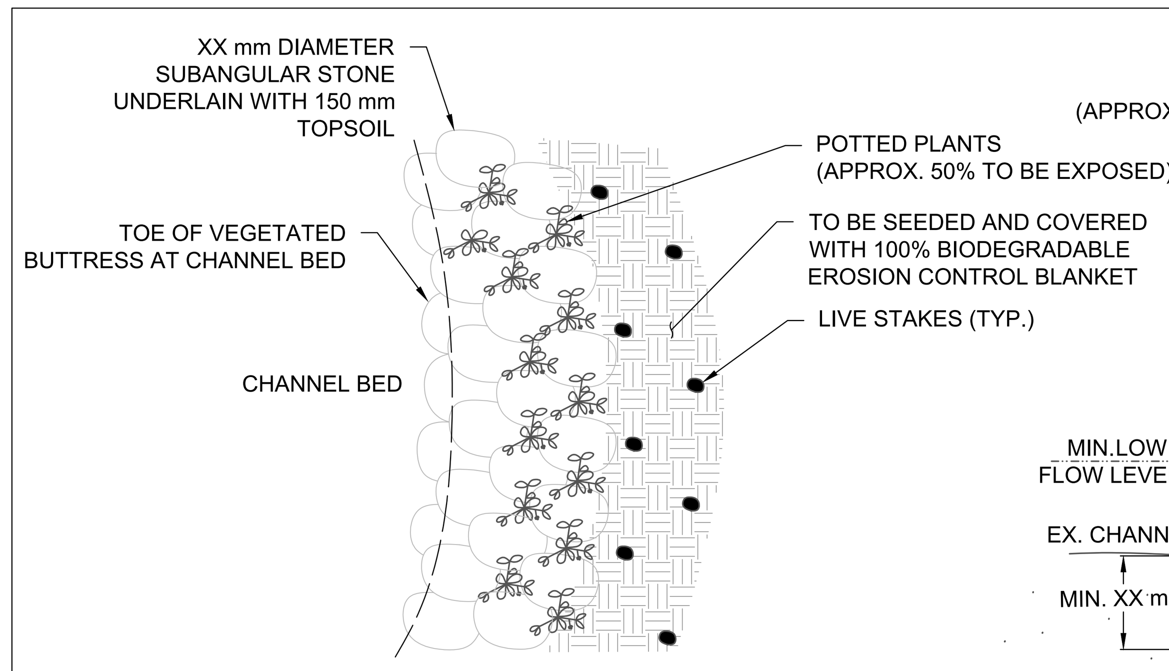
TOWN OF OAKVILLE

RESTORATION DESIGN
CONCEPTUAL PHASING & TREE INVENTORY PLANFORM

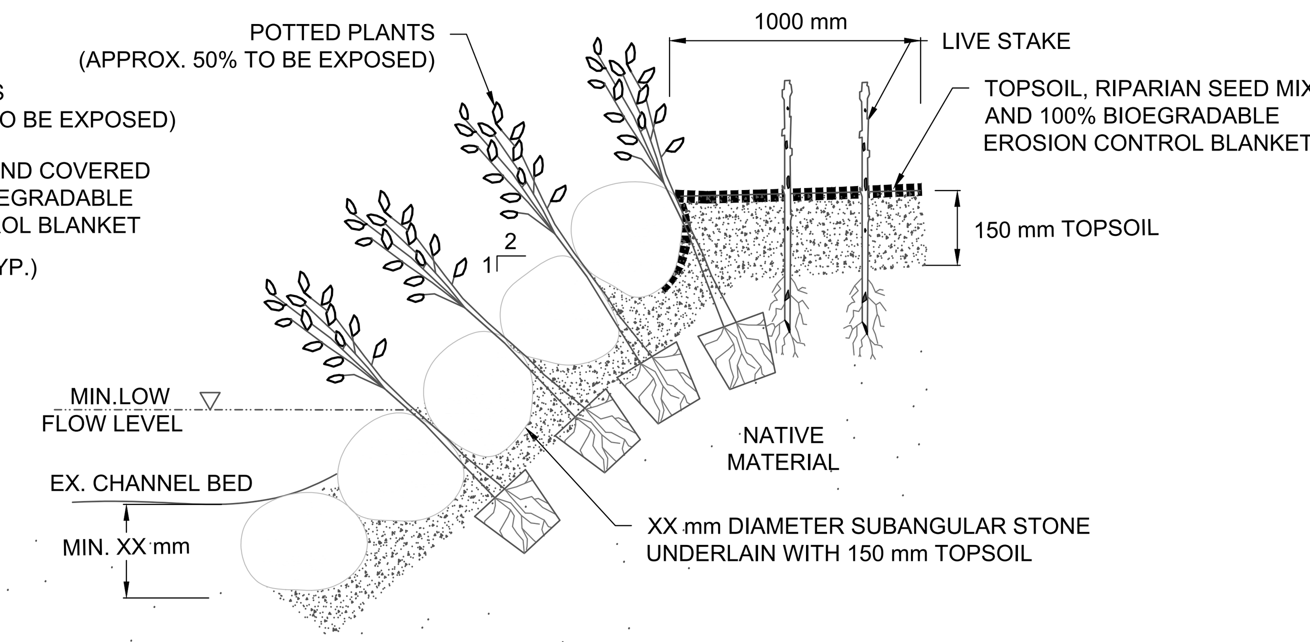
PROJECT No.: 23026 | DRAWING No.: GEO-2
SCALE: AS NOTED | SHEET 2 OF 5



VEGETATED ROCK BUTTRESS



PLAN



CROSS SECTION

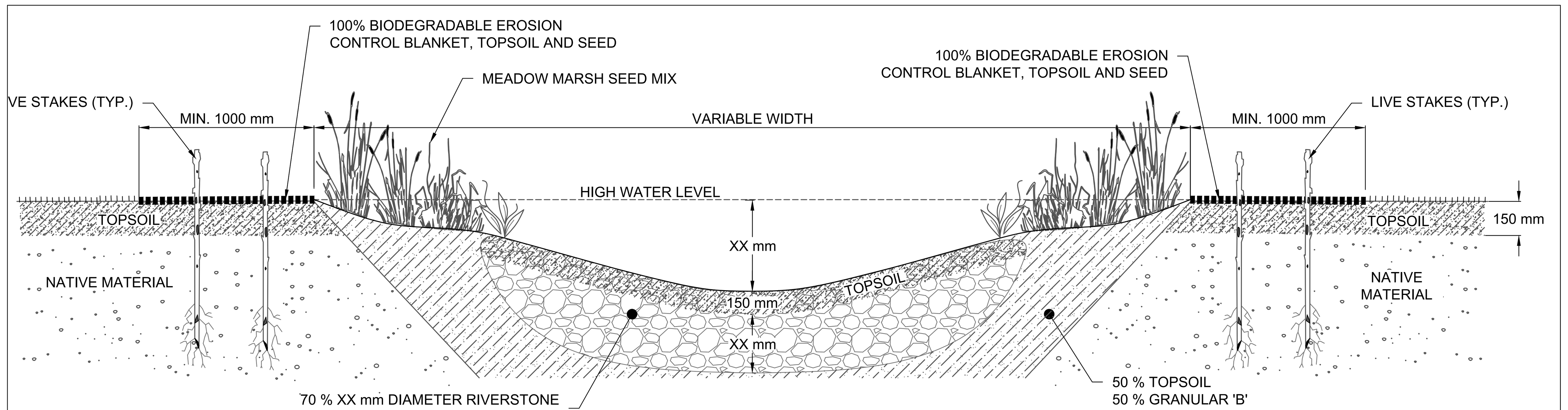
CONSTRUCTION NOTES

1. VEGETATED ROCK BUTTRESS TO BE INSTALLED IN LIFTS.
2. TOE STONES TO BE EMBEDDED INTO CHANNEL BED.
3. INSTALL PLANTS 1 m O/C IN EACH LAYER.
4. LATERALLY STAGGER EACH SUCCESSIVE LAYER OF PLANTS TO AVOID VERTICAL STACKING.
5. PLANTING SPECIES PLACEMENT SHOULD BE RANDOM.

POTTED PLANTINGS SPECIES AND QUANTITIES

COMMON NAME	SPECIES	QUANTITY	CONDITION
RED OSIER DOGWOOD	*Salix discolor*	XX	1 m ht. POTTED
SANDBAR WILLOW	*Salix exigua*	XX	1 m ht. POTTED
SHINING WILLOW	*Salix lucida*	XX	1 m ht. POTTED

VEGETATED ROCK BUTTRESS
N.T.S



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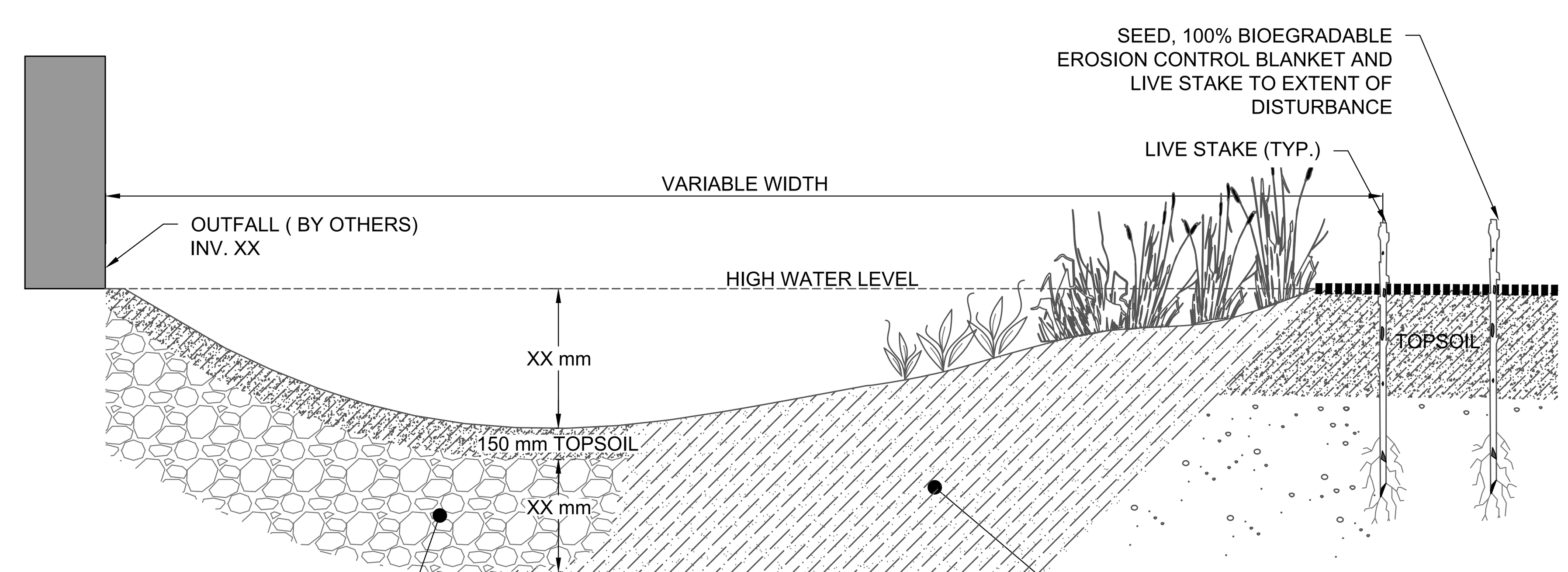

PROFILE

STONE CORE WETLAND
N.T.S

SCALED FOR PLOT ON 'ARCH D'

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3. FISH MUST BE REMOVED FROM THE WORK AREA ONCE ISOLATED. FISH SALVAGE MUST BE COMPLETED BY A QUALIFIED TECHNICIAN WITH A LICENSE FROM THE ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY.

CONCEPTUAL DRAFT (NOT FOR CONSTRUCTION)

	DATE	BY	REVISIONS

DESIGNED BY: P.V.	CHECKED BY: P.V.
DRAWN BY: B.W.M.	DATE: APRIL 2023

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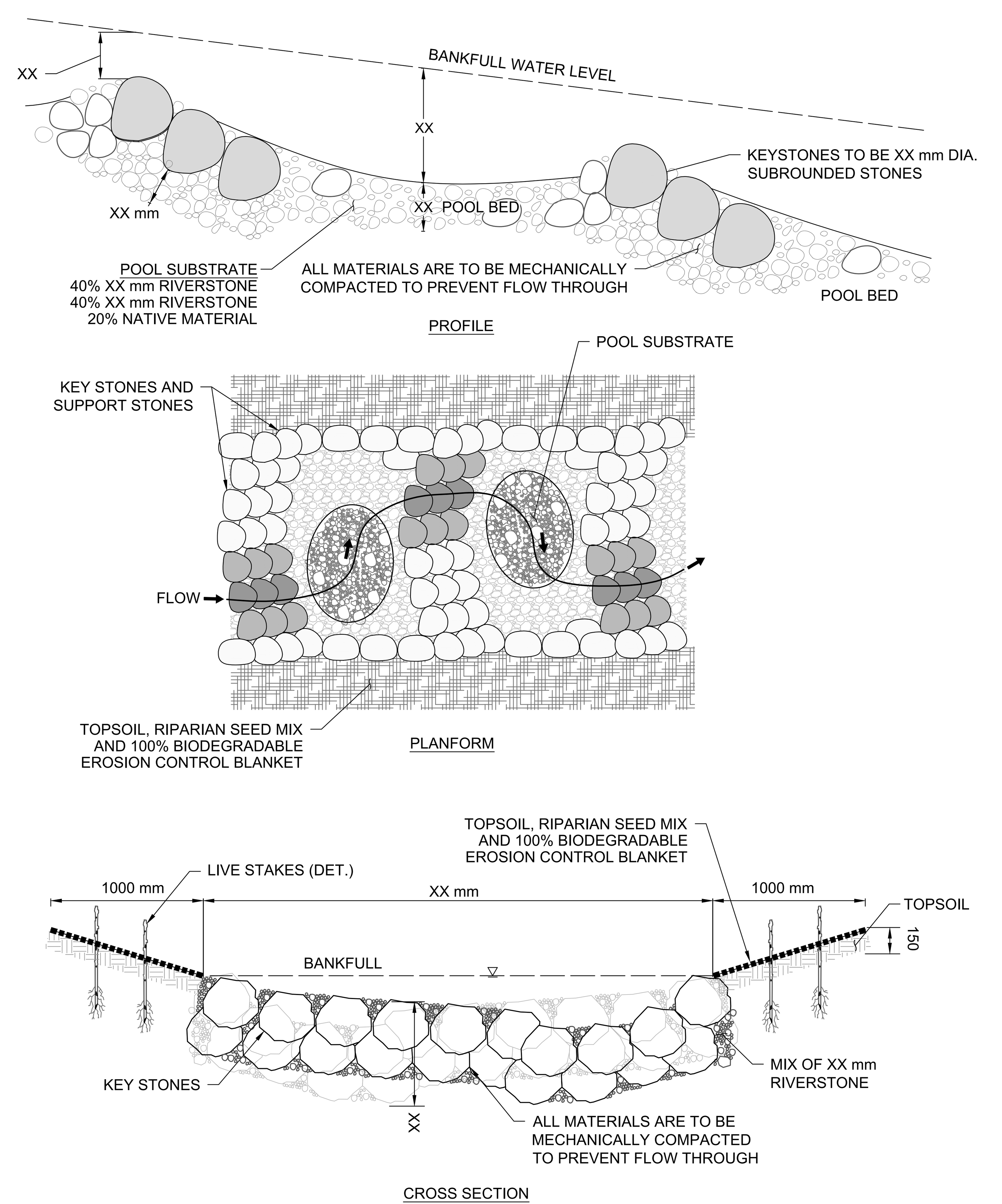
BRONTE RIVER LIMITED PARTNERSHIP
TOWN OF OAKVILLE

RESTORATION DESIGN
DETAILS

PROJECT No.: 23026	DRAWING No.: DET-1
SCALE: AS NOTED	SHEET 3 OF 5



ALTERNATING CASCADE
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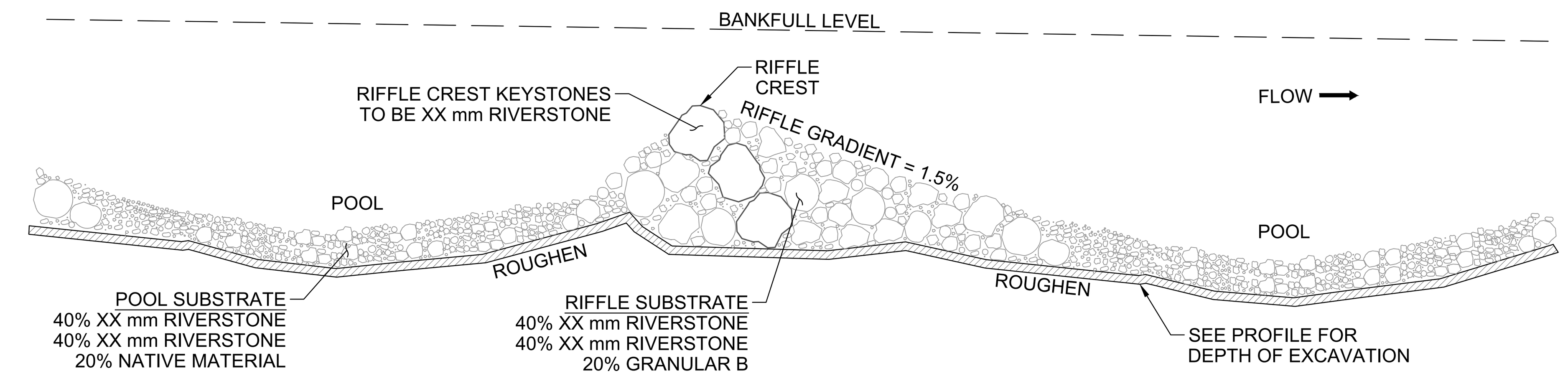

TYPICAL RIFFLE-POOL SEQUENCE
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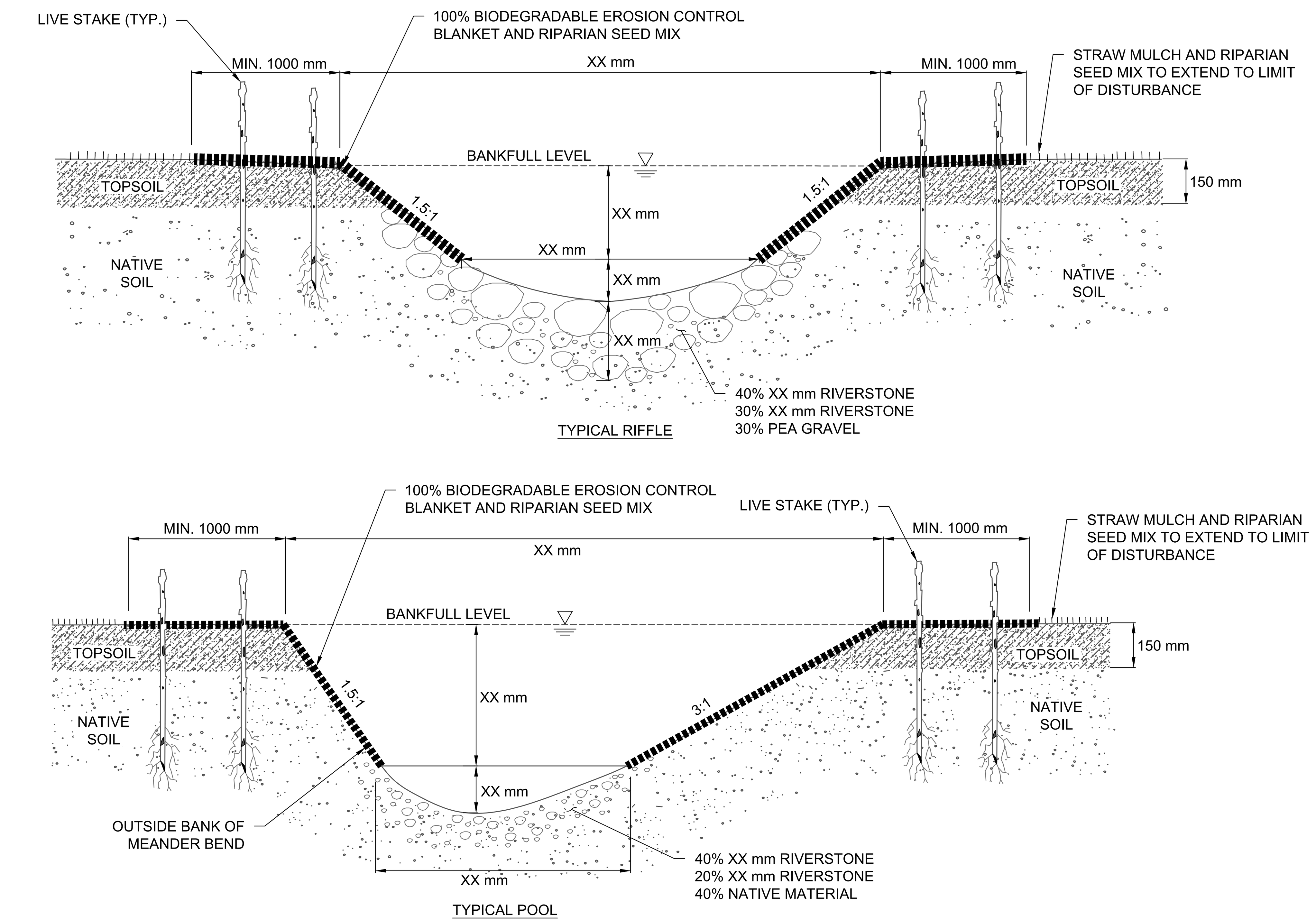

CHANNEL CROSS SECTIONS
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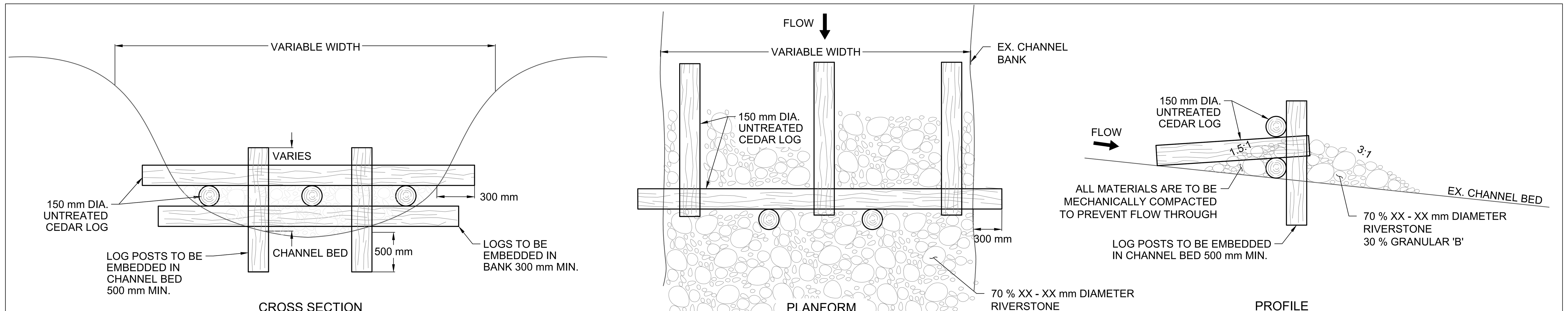

INSTALLATION NOTES
1. TO BE INSTALLED USING HAND LABOUR.
2. USE ONLY UNTREATED CEDAR LOGS WITH A DIAMETER OF 150 mm.
3. SECURE EACH COURSE OF CHECK DAM TO THE PRECEDING COURSE WITH LARGE SPIKES OR REBARS.
4. ENDS OF CHECK DAM LOGS ARE TO EMBEDDED INTO THE EXISTING CHANNEL BANKS A MINIMUM OF 300mm.

NOTE: POTENTIAL BED TREATMENT OPTION AS AN ALTERNATIVE TO THE ALTERNATING CASCADE TREATMENT (SEE SHEET GEO-1 PLANFORM FOR LOCATION). CHECK DAM LOCATIONS TO BE FIELD FIT.

WOOD REINFORCED CHECK DAM - OPTIONAL TREATMENT
N.T.S

SCALED FOR PLOT ON 'ARCH D'

N
N.T.S.

KEY MAP
N.T.S.

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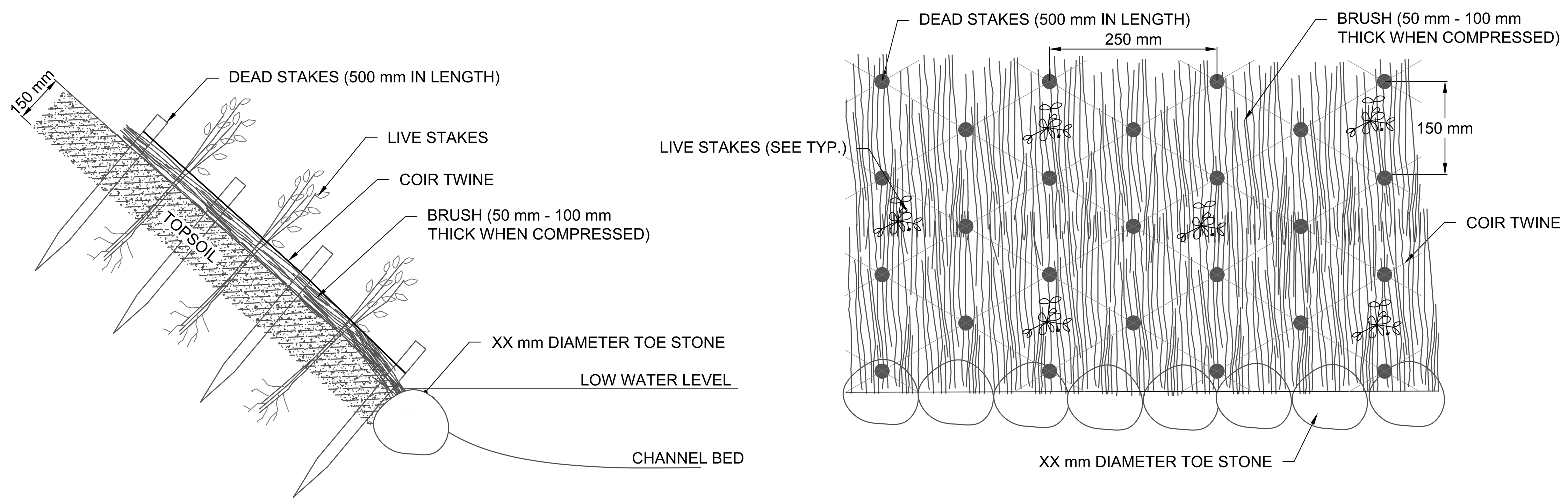
RESTORATION DESIGN DETAILS

PROJECT No.: 23026	DRAWING No.: DET-2
SCALE: AS NOTED	SHEET 4 OF 5



NOTES
1. LIVE BRANCHES TO CONSIST OF WILLOW AND DOGWOOD SPECIES, APPROXIMATELY 1 m IN LENGTH AND 50 mm - 100 mm IN WIDTH.
2. BRANCHES TO BE KEPT IN MOIST AND COLD UNTIL INSTALLATION.
3. BRUSH MATTRESS TO BE INSTALLED WHILE BRANCHES ARE DORMANT.
4. BRANCHES TO BE PLACED ON SLOPE WITH BUTT END TOWARDS VALLEY FLOOR AND PUSHED INTO SOIL.
5. BRANCHES MUST BE FLEXIBLE ENOUGH TO CONFORM TO THE SLOPE SURFACE IRREGULARITIES.
6. POUND DEAD STAKES TO HALF THEIR LENGTH INTO SOIL BETWEEN BRANCHES. TIE COIR TWINE AROUND DEAD STAKES AND TIGHTLY OVER BRANCHES. USE A CLOVE HITCH TO SECURE STAKES. POUND STAKES INTO SLOPE TO COMPRESS BRANCHES AGAINST GROUND.
7. TAMP LIVE STAKES BETWEEN DEAD STAKES.
8. FILL VOIDS BETWEEN BRANCHES OF THE BRUSH MATTRESS WITH SOIL TO PROMOTE ROOTING.

BRUSH MATTRESS
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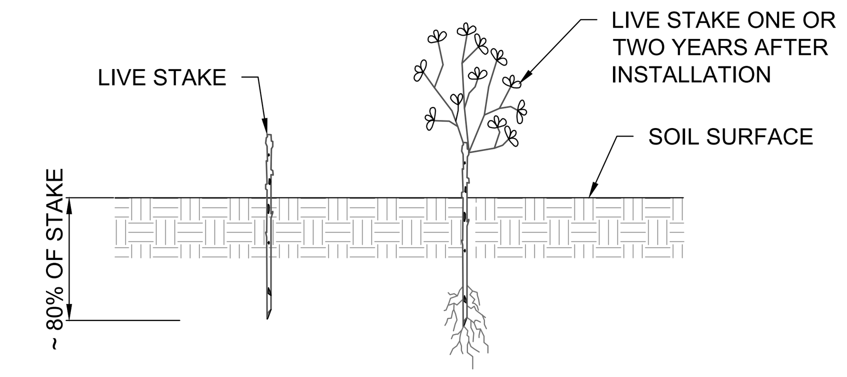

SPECIES AND QUANTITIES

COMMON NAME	SCIENTIFIC NAME	QTY	CONDITION
RED OSIER DOGWOOD	*Cornus stolonifera*	XX	1 m, BARE ROOT
PUSSY WILLOW	*Salix discolor*	XX	1 m, BARE ROOT
SANDBAR WILLOW	*Salix exigua*	XX	1 m, BARE ROOT

NOTES
1. QUANTITY TO BE DETERMINED BASED ON AREA OF DISTURBANCE TO BE RESTORED
2. LIVE STAKES SHOULD BE FROM AT MINIMUM 2-YEAR OLD STOCK.
3. LIVE STAKES ARE TO BE INSTALLED AT A DENSITY OF 3 STAKES PER SQUARE METRE.
4. LIVE STAKES SHOULD BE PRE-SOAKED (SUBMERGED IN WATER) FOR AT LEAST 24 HOURS AFTER HARVESTING AND IMMEDIATELY BEFORE INSTALLATION.
5. LIVE STAKES SHOULD NOT BE STORED FOR A PERIOD LONGER THAN 2 DAYS, UNLESS THEY ARE BEING SOAKED.
6. THE CONTRACTOR SHALL PROTECT PLANT MATERIALS FROM DRYING FROM THE TIME OF HARVEST UNTIL INSTALLED.
7. LIVE STAKES ARE TO BE A MINIMUM OF 25 mm IN DIAMETER AND CUT TO A LENGTH OF 1000 mm.
8. CUT ANGLE AT THE BOTTOM OF THE STAKE AND FLAT ON THE TOP.
9. TRIM ALL SIDE BRANCHES WHILE TAKING CARE NOT TO DAMAGE THE BARK.
10. INSTALL STAKES WITH BUDS POINTING UPWARDS AND THICKER STEM IN THE BED.
11. LIVE STAKES SHOULD BE INSTALLED USING A LARGE RUBBER MALLET.
12. 80% OF THE STAKE IS TO BE BELOW SURFACE.
13. TAMP THE LIVE STAKE INTO THE GROUND AT RIGHT ANGLE TO THE SURFACE.
14. IN COMPACT SOIL A PILOT HOLE SHOULD BE USED TO LIMIT DAMAGE TO THE STAKES.
15. IF USING A PILOT HOLE REPACK SOIL AROUND THE LIVE STAKE.
16. LIVE STAKES SHOULD STAND FIRM FROM THE SOIL FOLLOWING INSTALLATION.
17. ALL STAKES NOT PLANTED TO THE SPECIFICATIONS ABOVE WILL BE REPLACED AT THE CONTRACTOR'S EXPENSE.

LIVE STAKE
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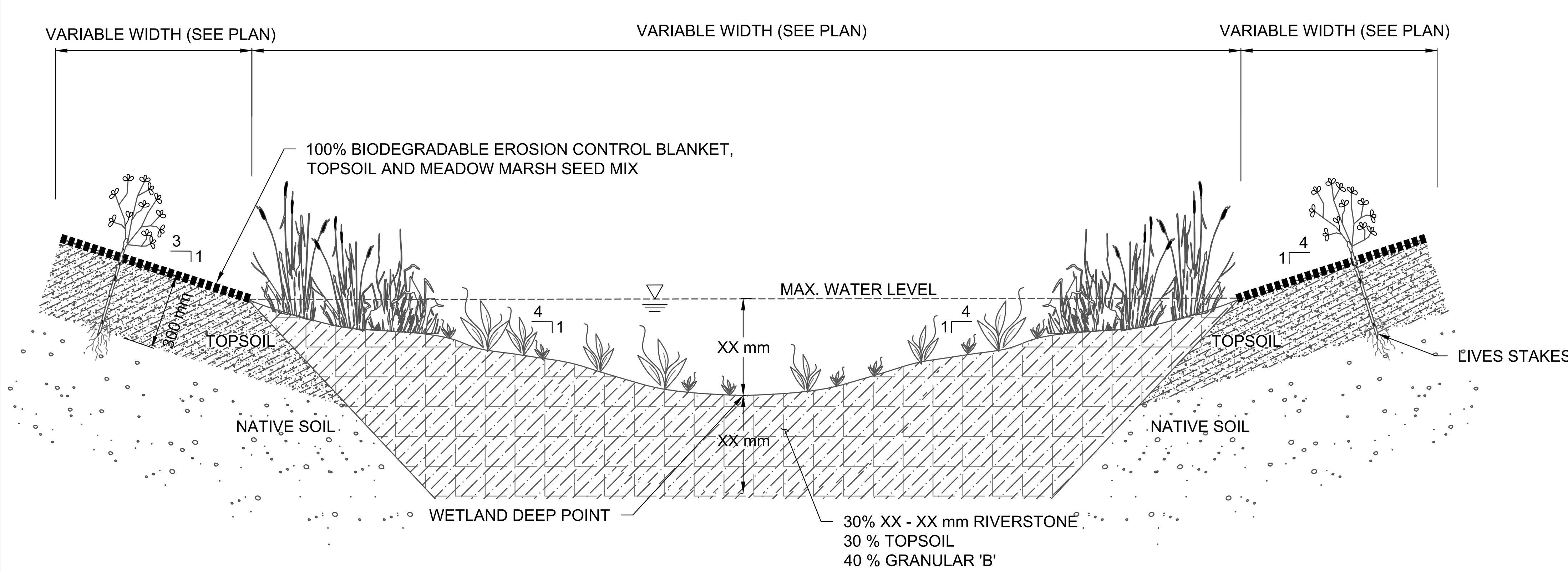

POCKET WETLAND
N.T.S.

CONSERVATION HALTON EARLY SUCCESSION / RIPARIAN MIX

COMMON NAME	SPECIES	% OF MIX
BLACK EYED SUSAN	*Rudbeckia hirta*	5
BLUE VERVAIN	*Verbena hastata*	10
CANADA ANEMONE	*Anemone canadensis*	1
CANADA GOLDENROD	*Solidago canadensis*	4
LITTLE BLUESTEM	*Schizachyrium scoparium*	10
COMMON MILKWEED	*Asclepias syriaca*	5
FOWL BLUEGRASS	*Poa palustris*	25
MEADOW/OPEN FIELD SEDGE	*Carex granularis*	20
NEW ENGLAND ASTER	*Symphyotrichum novae-angliae*	1
PATH RUSH	*Juncus tenuis*	10
PURPLE STEMMED ASTER	*Symphyotrichum puniceum*	1
VIRGINS BOWER	*Clematis virginiana*	4
WILD BERGAMOT	*Elymus virginicus*	4

NOTES
1. APPLY SEED MIX AT A RATE OF 25 kg PER HECTARE.
2. SEEDING SHALL OVERLAP ADJACENT GROUND COVER BY 300 mm.
3. APPLY NURSE CROP AT A RATE OF 25 kg PER HECTARE.
4. WATER SOIL AFTER SEED APPLICATION.

CONSERVATION HALTON MEADOW MARSH MIX

COMMON NAME	SPECIES	% OF MIX
BEBBS SEDGE	*Carex bebbi*	1
BLUE LOBELIA	*Lobelia siphilitica*	1
BLUE VERVAIN	*Verbana hastata*	15
BONESET	*Eupatorium perfoliatum*	2
DARK GREEN BULRUSH	*Scirpus atrovirens*	5
FOX SEDGE	*Carex vulpinoidea*	25
GRASS LEAVED GOLDENROD	*Euthamia graminifolia*	1
MEADOW / OPEN FIELD SEDGE	*Carex granularis*	10
PURPLE STEMMED ASTER	Symphyotrichum puniceum	1
SOFT RUSH	*Juncus effusus*	5
SPOTTED JOE PYE WEED	*Eupatorium maculatum*	2
MONKEY FLOWER	*Mimulus ringens*	1
STALK GRAIN SEDGE	*Carex stipata*	2
TALL MANNA GRASS	*Glyceria grandis*	2
WOOLGRASS	*Scirpus cyperinus*	2
FOWL BLUEGRASS	*Poa palustris*	25

NOTES
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4. WATER SOIL AFTER SEED APPLICATION.

EROSION CONTROL BLANKET SPECIFICATIONS

1. A BIODEGRADABLE EROSION CONTROL BLANKET (ECB) SHALL BE INSTALLED ON ALL DISTURBED NATURAL SURFACES FOLLOWING THE PLACEMENT OF TOPSOIL AND APPLICATION OF THE NATIVE SEED MIX.
2. THE ECB MUST BE CONSTRUCTED OF 100% WOVEN COCONUT FIBRE (E.G., COIR) OR STRAW MAT WITHIN A GEOJUTE NETTING (TOP AND BOTTOM) WITH BIODEGRADABLE THREAD. NON-BIODEGRADABLE MATERIAL INCLUDING POLYPROPELENE OR PLASTICS WITH A BIODEGRADABLE RATING ARE NOT ACCEPTABLE. THE MINIMUM WEIGHT OF THE ECB MUST BE 400 g/m^2 (12 oz./yd^2).
3. TO INSTALL, THE ECB MUST BE UNROLLED DOWNSLOPE OR IN DIRECTION OF WATER FLOW. ADJACENT ECBS SHOULD OVERLAP A MINIMUM OF 150 mm ALONG THE EDGES. AT THE END OF EACH ROLL, FOLD BACK 100 mm TO 200 mm OF THE ECB. OVERLAP THIS 100 mm TO 200 mm OVER THE START OF THE NEXT ROLL. SECURE THE TWO LAYERS TO THE GROUND SECURELY.
4. BIODEGRADABLE OR TAPERED WOODEN STAKES SHALL BE USED TO SECURE THE BLANKET. STAKES SHALL BE INSTALLED AT THE SPACING RECOMMENDED BY THE ECB MANUFACTURER TO PREVENT SURFACE RUNOFF FROM ERODING THE UNDERLYING SOIL.

KEY MAP
N.T.S.

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N.T.S.

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TOWN OF OAKVILLE

RESTORATION DESIGN
DETAILS

PROJECT No.: 23026 | DRAWING No.: DET-3
SCALE: AS NOTED | SHEET 5 OF 5

SCALED FOR PLOT ON 'ARCH D'

Appendix G
Restoration Design Reference Photos

Appendix A- BCT-1 Tributary Design Recommendations Photographic Record

Photo 1	
	Gully erosion mitigation using a combination of materials including straw bales, coir logs, silt sock, 100% biodegradable erosion control blanket and pea gravel (provided as an alternative approach).
Photo 2	
	Gully erosion mitigation using a combination of materials including straw bales, coir logs, silt sock, 100% biodegradable erosion control blanket and pea gravel (provided as an alternative approach).

Photo 3	
	SWM Pond outlet within a natural gully feature using a rock weir and cascade bed treatment (this treatment is more extensive than proposed in this project).
Photo 4	
	SWM Pond outlet within a natural gully feature using a rock weir and cascade bed treatment (this treatment is more extensive than proposed in this project).

Photo 5	
	Alternating cascade within a steep gradient channel to attenuate high velocity flows (providing example of an alternating cascade design approach).
Photo 6	
	Alternating cascade within a steep gradient channel to attenuate high velocity flows (providing example of an alternating cascade design approach).