# Upper West Side Secondary Plan Area Fluvial Geomorphological Assessment And Natural Channel Design

## Twenty Road West, City of Hamilton

Prepared for:
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GEO MORPHIX
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Observations

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# 1 Introduction

This report summarizes a fluvial geomorphological assessment and preliminary natural channel design for the Upper West Side Secondary Plan Area ("subject lands"), bounded by Twenty Road to the north, Upper James Street to the east, Dickenson Road to the south, and Glancaster Road to the west. Characterization and management recommendations for the drainage feature reaches within the property are included based on desktop and field assessments. Notably, most features within the subject site are classified as headwater features. An erosion assessment was also completed in support of future stormwater management planning. Finally, a preliminary natural channel design concept is provided in association with several tributaries within the subject lands. A fluvial geomorphology Terms of Reference (TOR) was developed and submitted to the City of Hamilton for the Upper West Side Secondary Plan Area. The TOR is still under review and refinement. As such, the scope of work summarized here is based on the TOR completed to date and may be subject to refinement based on the outcome of discussions and review with the City.

In summary, the fluvial geomorphological assessment included the following activities:

- Background review of existing documents related to the subject lands, including topography, physiography, and geology maps, as well as any information pertaining to drainage feature form and function
- Reach delineation for all tributaries and drainage features throughout the subject lands
- A historical assessment of the channels within the study area using aerial imagery provided by the McMaster University Aerial Photo Collection and Google Earth Pro
- Detailed descriptions of channel and tributary characteristics based on field observations
- Headwater drainage feature (HDF) assessment to characterize and provide management recommendations for the channels within the property on a reach-by-reach basis
- Erosion threshold modelling and exceedance analysis based on pre- and post-development hydrology in support of erosion mitigation strategies for future stormwater management (SWM)
- Conceptual channel realignment following natural channel design principles for the main tributary within the subject lands

# 2 Background Review

Channel planform and morphology are largely governed by the flow regime and by the type and availability of sediment (i.e., surficial geology) within the stream corridor. Physiography, riparian vegetation, and land use will also influence the channel. These factors provide insight to the existing conditions and perception to the future potential changes as they relate to a proposed activity.

Physiographically, the study area is in the northern portion of the Haldimand Clay Plain region, which is characterized as a stratified clay plain which has a heavy texture and low drainage (Chapman and Putnam, 1984). The subject site is specifically located in a trough between two low-relief till moraines, which direct surface water along the generally eastwardly sloping plain between the features (Chapman and Putnam, 1984). The surficial geology of the subject site is composed of fine-textured glaciolacustrine deposits consisting of massive to well laminated silt and clay, with minor sand and gravel (OGS, 2010). The quaternary geology is consistent with surficial conditions, and is described as silt and clay, with minor sand, basin, and quiet water deposits (OGS, 2010).

The current land cover within the study area consists mainly of agricultural land, with several woodlots, wetlands, and open pond features of varying sizes. These features are characterized and discussed in detailed under the Master Environmental Impact Study (NRSI, 2023). Surrounding the subject site, land use includes residential and natural areas to the west, residential development to the north, agriculture to the east and the John C. Munro Hamilton International Airport to the south.

# 3 Branch and Reach Delineation

The study area extends north to south from Twenty Road in the north to Dickenson Road to the south. The east-west extent is roughly bounded by Upper James Street to the east and Glancaster Road to the west. Within this area, various tributaries and headwater systems were delineated and assessed.

To organize the drainage features within the study area into functional units, branches loosely defined here as tributaries draining directly into Twenty Mile Creek, were delineated as independent sub-catchments. Reaches, which are homogeneous segments of channel used in geomorphological investigations, were then delineated within each branch.

Reaches 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)
- Hydromodification, due to tributary inputs
- Soil type and surficial geology
- Certain types of anthropogenic channel modifications

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), Brierley and Fryirs (2005), and the Toronto and Region Conservation Authority (2004).

Reaches were initially identified through a desktop assessment completed by GEO Morphix based on changes in riparian conditions, channel morphology, and tributary confluences. During various field assessments completed since 2019, reach delineation was field verified within the subject lands. A reach map is provided in **Appendix A**.

Tributary branch **TTMC-2** is situated throughout the southeastern portion of the subject lands and is largely situated within non-participating properties. There are several branches of tributary **TTMC-2** that drain east to Upper James Street. The northern most branch extends the furthest west within participating properties of the subject lands. There is a large online pond along the main branch, but the other reaches appear to be low-order drainage features based on our desktop review. The surrounding land use along this tributary is primarily active agricultural fields, with wooded/wetland areas also present through the western and central extents of the property. Downstream of the study area, the main stem of the tributary conveys flows for approximately 1,750 m before merging with Twenty Mile Creek.

Tributary branch **TTMC-3** originates within the subject lands near the southwestern corner of the former orchard and conveys flows eastwards through the central portion of the study area. Surrounding land use is predominantly agricultural, with the reach also passing along the southern limit of the orchard and a provincially significant wetland (PSW) located nearby to Upper James Street. Within the PSW, a branch of the tributary forms a confluence with the mainstem of **TTMC-3**. Beyond the subject lands, on the east side of Upper James Street, the tributary meets Twenty Mile Creek.

Tributary branch **TTMC-5** originates near Glancaster Avenue and forms a series of ponds within the former Glancaster Golf and Country Club. The branch conveys flows on a generally north eastwardly path before leaving the subject lands near the corner of Twenty Road West and Twentyplace Boulevard. Within the subject lands, the branch transects four agricultural fields and passes along the northern limit of the central orchard area. Downstream of the property, the stream enters a series of storm water management (SWM) ponds constructed as part of the residential development north of Twenty Road, before forming a confluence with Twenty Mile Creek northeast of the subject lands.

Tributary branch **TTMC-6** originates within the subject lands near a hedgerow associated with the orchard property. The branch conveys flows northeastwards through 2 agricultural fields before discharging into the roadside ditch associated with Twenty Road. The total length of the branch is approximately 670 m before reaching the roadside ditch.

Tributary branch **TTMC-7** conveys flows northeastward and consists of only two reaches, one of which is located within the subject lands. The branch originates within a small private property located at Twenty Road approximately 100 m west of Garth Street before being conveyed through a small culvert into an agricultural field within the subject lands. This reach then discharges into the roadside ditch at Twenty Road.

Tributary branch **TTMC-8** originates within the former Glancaster Golf and Country Club and conveys flows north eastwards through the northwest corner of the subject lands. Land use in the immediate vicinity of the branch is predominantly agricultural. The branch crosses Twenty Road through a culvert which discharges into a woodlot located 140 m west of Garth Street, north of Twenty Road. Downstream of the woodlot, the channel is conveyed through storm water pipes and ponds within the residential development before forming a confluence with Twenty Mile Creek within the hydro corridor north of the residential development. An additional sub-branch was delineated immediately to the north within the subject lands, Reach **8-3-3** and **8-3-4**. This sub-branch conveys flows northeastward through an agricultural field. It is unknown specifically where a confluence between these two sub-branches is located, as they both become piped within the developed land to the north.

Tributary branch **TTMC9** originates within the woodlot which borders Dickenson Road within the subject lands and conveys flows southwardly across Dickenson Road. The feature consists of only two reaches, one within the woodlot and the roadside ditch associated with Dickenson Road.

Tributary branch **TTMC10** originates immediately east of Glancaster Road, within the woodlot which borders the former Glancaster Golf and Country Club. The branch has two sub-branches which convey flows through the former golf course lands. The feature has been heavily modified as a result of the development of the golf course.

Based on our desktop review of the subject lands, all tributaries and delineated reaches appear to be associated with low-order streams, or headwater drainage features. They are poorly defined and have generally been altered from local land use activities. Given the size of these features, a headwater drainage feature field assessment was completed to assess overall form and function of the streams. The headwater drainage feature assessment is summarized in **Section 6** and was conducted in tandem with Natural Resource Solutions Inc. (NRSI).

# 4 Historical Assessment

Historical aerial photographs were reviewed to determine changes to the channels and surrounding land use/cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics.

Our assessment used historical imagery retrieved from the McMaster University Aerial Photo Library and Google Earth Pro. A summary of the historical changes to the watercourses are provided in Table 1. Aerial photographs are provided in Appendix B.

### Table 1. Historical assessment summary

| Tributary | 1952 | 1959 | 2005 | 2017 |
|---|---|---|---|---|
| **TTMC2** | Land use near channel is mostly agricultural, with some woodland and grassland at the upstream extent. Riparian buffer predominantly absent within subject lands, apart from upstream and downstream extents. Downstream of subject lands, channel has a treed riparian buffer. Channel is generally straight. | No observable changes to land use, riparian conditions, or channel planform since 1952. | Only significant change along branch since 1959 is establishment of large online pond 600 m west of Upper James Street. | Only observable change to was removal of a row of trees southwest of the woodlot within which the online pond is located. |
| **TTMC3** | Land use near tributary is almost all agricultural within the subject lands, including an orchard located roughly in the central portion. No riparian buffer present on the branch. | Only significant change was expansion of the orchard and the creation of a large online pond to its south which is a part of the branch. | Since 1959, large wetland feature has formed at downstream extent of branch near Upper James Street. | No observable changes to land use, riparian conditions, or channel planform since 2005. |
| **TTMC5** | Land use near channel within the subject lands is agricultural and includes the central orchard. The channel is generally straight within the subject site. | Orchard property has expanded to the south of the tributary. No changes to channel planform observed due to poor visibility and land use activity. | Since 1958, Glancaster Golf Course constructed to the west, including presence of a pond impounding flows along tributary. | No observable changes to land use, riparian conditions, or channel planform since 2005. |
| **TTMC6** | Sinuous channel which conveys flows through three agricultural fields. Channel lacks riparian vegetation. | Expansion of the orchard to the north of the branch in the central part of the subject lands. Branch remains unchanged. | No significant changes to the branch are observed between 1959 and 2005. Downstream, channel has been piped to facilitate residential development. | No observable changes to land use, riparian conditions, or channel planform since 2005. |

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|---|---|---|---|---|
| **TTMC7** | Branch conveys flows through agricultural field within subject lands. Branch enters a woodlot downstream. Land use for the branch is exclusively agricultural, and no discernible riparian buffer is present. | No observable changes to land use, riparian conditions, or channel planform since 1952 | Since 1959, residential property was constructed, but channel maintains planform. Feature still lacks a riparian buffer, and a small pond has been installed. | No observable changes to land use, riparian conditions, or channel planform since 2005. |
| **TTMC8** | Branch conveys flows through agricultural fields with no riparian buffer. Planform of both branches is generally straight. | No observable changes to land use, riparian conditions, or channel planform since 1952 | Construction of Glancaster Golf Club upstream resulted in realignment of drainage. Short section of branch also interrupted by residential development. Straight planform and lack of riparian buffer maintained. | No observable changes to land use, riparian conditions, or channel planform since 2005. |
| **TTMC9** | No specific channel features discernible in aerial imagery. Present day, large woodlot present along northern side of Dickenson Road. | No specific channel features discernible in aerial imagery. Present day, large woodlot present along northern side of Dickenson Road. | No specific channel features discernible in aerial imagery. Present day, large woodlot present along northern side of Dickenson Road. | No specific channel features discernible in aerial imagery. Present day, large woodlot present along northern side of Dickenson Road. |
| **TTMC10** | No specific channel features discernible in aerial imagery. Large woodlot present along northern side of Dickenson Road in area of tributary. | No specific channel features discernible in aerial imagery. Large woodlot present along northern side of Dickenson Road in area of tributary. | Construction of Glancaster Golf Course since 1959 resulting in fragmented woodlot. Drainage system constructed likely in support of irrigation activities for golf course. | No observable changes to land use, riparian conditions, or channel planform since 2005. |

# 5 Existing Conditions

Reach observations and stream measurements were collected over the span of three visits between spring and summer in 2019 and 2020 for various reaches on participating properties by both GEO Morphix Ltd. and Natural Resource Solutions Inc. (NRSI). Supplemental field data and observations were also collected in Fall 2023. Because all features on site were determined to function as headwater drainage features, the TRCA and CVC Headwater Drainage Feature Assessment methodology (2014) was applied to evaluate these channels. This method requires three visits to understand the variability in flow and channel morphology throughout the year, which is required to determine the appropriate characterization, classification, and management classification to apply to each reach. This management classification is determined based on principles of hydrology, geomorphology, and ecology. To provide context, a photographic record has been included in **Appendix C**.

We provide a general summary below of existing conditions associated with each reach along the tributary branches. The headwater drainage feature assessment is specifically outlined in **Section 6**. It should be noted that field observations were initially collected between 2019 and 2020. Supplemental field data was obtained in Fall 2023 in support of this study; however, we recommend updated observations be completed through spring and summer to confirm existing conditions and support future stages of study.

## 5.1 Branch TTMC-2

Reach **TTMC2-8** is a short, poorly defined swale feature in the central portion of the subject lands. Only a short section of the feature was visible within the participating property. The feature was similar to that of **TTMC2-9**; however, there was slightly more riparian vegetation. It appears that flows from the feature enter a catch basin structure near the downstream extent, and it is possible that the feature receives flow inputs from a tile drainage system.

Reach **TTMC2-9** is characterized as a poorly defined swale which flows through agricultural fields located in the south-central portion of the subject lands. The feature has no riparian vegetation, with adjacent areas occupied by crops. Channel substrate was indistinguishable from the surrounding fields and consisted of clay and silt. In 2019, water with substantial flow was observed during the April 3 visit, but the feature was dry during the June and August visits resulting in a flow regime classification of ephemeral. The low gradient feature had an average bankfull width of 1.4 m, and average bankfull depth was 0.22 m.

Reach **TTMC2-10** conveyed flows eastwards through a wet meadow located south of the agricultural fields in the southwestern quadrant of the subject lands. The approximately 500 m long reach had poor channel definition with riparian and instream vegetation consisting predominantly of herbaceous and grass species. Although flow was minimal, water was evident within the channel during both the April and June 2019 visits; however, the feature was dry by summer. Average bankfull width in the spring was 2.3 m, and average bankfull depth was 0.37 m. Bed materials were not discernible from the floodplain and consisted of fine materials and organics.

Reach **TTMC2-10-1** is roughly 93 m long and conveyed flows eastwards within a wet meadow in the southwestern quadrant of the subject lands. The reach was poorly defined, with infrequent channel definition within the wet meadow corridor which consisted predominantly of hydrophilic herbaceous and grass species. Where observed, the average bankfull width of the feature in the spring was 1.9 m, and average bankfull depth was 0.22 m. Bed materials consisted of silt and organic material.

Reach **TTMC2-10-2** is roughly 270 m long and conveyed flows eastwards within a woodlot located in the southwestern quadrant of the subject lands. The reach is a best described as an intermittent swale, as it had water during both the April and June 2019 visits and showed poor channel definition. The average bankfull width in the spring was 1.9 m, and average bankfull depth was 0.3 m. Bed materials consisted of silt and clay and were consistent with the material found in the floodplain.

Reach **TTMC2-11** conveyed flows eastwards within a forest located south of the agricultural fields in the southwestern quadrant of the subject lands. The reach is approximately 70 m long and had a riparian buffer which consisted of deciduous trees. The average bankfull width of the feature at the time of assessment was 3.3 m, and the average bankfull depth was 0.46 m. The bed materials observed were predominantly silt and clay, although some gravel was also present.

Reach **TTMC2-12** is a roughly 112 m channel which conveyed flows eastwards through a woodlot at the southwest corner of the subject lands. Riparian vegetation was continuous and primarily consisted of deciduous trees, with one small area dominated by grasses and herbaceous species. Bed materials consisted of clay, silt and organic matter. Minimal flow was observed during the spring visit, and the feature was dry in subsequent assessments. Where observable, the average bankfull width of the feature was 1.3 m and the average bankfull depth was 0.2 m. The reach is best described as a poorly defined ephemeral swale, as made evident by the poor channel definition and the lack of consistent flows.

Reach **TTMC2-12-1** conveyed flows southeastwards within a significant woodlot in the southwestern quadrant of the subject lands. The reach was a low gradient ephemeral swale which is approximately 82 m long. The riparian vegetation consisted predominantly of deciduous trees. Bed materials consisted of clay, silt and organic matter. Although the channel was poorly defined, where measurable the bankfull width of the feature was 1.4 m and the average bankfull depth was 0.25 m.

Reach **TTMC2-12-1a** and **TTMC2-12-1b** were both poorly defined ephemeral swales which conveyed flows within a significant woodlot located in the southwestern quadrant of the subject lands. The low gradient swales had a riparian buffer which consisted of deciduous trees. Like **TTMC2-12-1**, bed materials consisted of sand, silt and organic matter with no coarse substrate observed. Bankfull measurements of the features were not determined due to a lack of channel definition.

## 5.2 Branch TTMC-3

Reach **TTMC3-2** is a defined, straight channel which conveys flows eastwards for approximately 100 m before reaching a culvert under Upper James St after receiving discharge from the upstream PSW. Riparian vegetation consisted of scrubland and some hydrophilic vegetation. The reach had a bankfull channel width of 8.1 m, and an average bankfull channel depth of 0.6 m. During the April 2019 visit, the wetted width of the feature was 5.45 m, and the average wetted depth was 0.17 m.

Reach **TTMC3-3** is a roughly 610 m long feature which conveyed flows eastwards in the northeast corner of the subject lands. The feature occupies a wide grassy corridor characterized as a provincially significant wetland (PSW). The feature was wet during all site visits which occurred in 2019, and had substrate which consisted of clay, silt and organic materials. The reach had no discernible banks, and given its wide corridor, measurements of the feature width were conducted using GIS which indicated the feature to be approximately 35-45 m in width.

Reach **TTMC3-3-1** and **TTMC3-3-2** comprised roughly 383 m in length and contained an intermittent channel through a woodlot near the eastern limit of the subject property. Riparian vegetation included mature deciduous trees as well as some shrubs and hydrophilic herbaceous vegetation. This hydrophilic vegetation was also commonly found within the channel. No geomorphic units were observed, and the substrate composition was predominately clay, silt and organic material. Water was present in the channel during the April and June 2019 field assessments. The average feature width was 1.1 m, and its average bankfull depth was 0.5 m, while its average wetted width and depth during the April 2019 visit were 0.5 m and 0.05 m, respectively.

Reach **TTMC3-3-3** is a roughly 150 m long intermittent channel which conveyed flows eastwards from an agricultural field to a woodlot near the northeast quadrant of the subject lands. The feature is surrounded by agricultural crops along its first portion and ends in a woodlot populated by deciduous trees. The substrate consisted predominately of clay, silt, and gravel. Water was present in the channel during the April and June 2019 site visits, but the feature was dry through the summer. The average bankfull width of this feature was 1.33 m, with a corresponding bankfull depth of 0.27 m. A very short section of Reach **TTMC3-3-4** was observed along the hedgerow at the upstream extent of **TTMC3-3-3** due to access restrictions on the non-participating property immediately south. The feature appeared to be similar to **TTMC3-3-3**.

Reach **TTMC3-4** is a roughly 200 m long feature which conveyed flows eastwards through an agricultural field in the northeast portion of subject area. Water was only observed within the feature during the first spring assessment. The channel’s riparian buffer consisted of an agricultural field which has gone fallow, while the feature itself was populated by herbaceous vegetation and grasses. Some evidence of sediment transport and deposition was observed within the feature, including sheet erosion and rilling within the floodplain. The channel had an average bankfull width of 3 m, and an average bankfull depth of 0.15 m.

Reach **TTMC3-5** is a short reach which conveyed flows eastwards between two agricultural fields along the southern border of a residential property. The riparian buffer consisted of herbaceous species to the north and agricultural crops to the south. The channel bed was predominantly composed of clay and gravel, which was overlaid by a thin layer of silt and sand which was deposited during freshet. The channel appears to have been channelized as made evident by its high entrenchment relative to adjacent reaches and its straight planform. The feature has an average bankfull width of 2.5 m, and an average bankfull depth of 0.2 m.

Reach **TTMC3-6** is a nearly 500 m long intermittent channel which conveyed flows eastwards through agricultural fields in the northeast portion of the subject lands. The upstream portion of the riparian corridor consisted of herbaceous vegetation, but a larger section of it was dominated by agricultural crops. The dominant substrate was clay and silt, but some sand, gravel and cobbles were also observed. Bed and banks were mostly composed of the same material as the agricultural fields, a clay, silt, sand mixture, although some cobbles were present. During the April 2019 site visit substantial flow was present because of the spring freshet. By August of 2019, isolated pools were present, but no flowing water was observed. A bluegill (*Lepomis macrochirus*) was observed in one of the pools which was located at the hedgerow near the central extent of the reach, where a tile drain discharged into the feature. The feature had an average bankfull width of 2.15 m, and an average bankfull depth of 0.2 m.

Reach **TTMC3-7** is a short 80 m long feature which conveyed flows eastwards from the central woodlot though a meadow to the agricultural field to the east. The bed composition observed was clay, silt, sand and sparse gravel. Water was present only during the April 2019 visit following freshet, indicating the feature is ephemeral and dry for most of the year. Given poor channel definition, it was difficult to discern feature bankfull geometries. During the April 2019 visit its average wetted width was 2 m and its average wetted depth was 0.09 m.

Reach **TTMC3-8** is an ephemeral feature which flows eastward from the upstream online pond to the meadow flanking the agricultural field to the east. The low gradient feature is roughly 48 m long, has a poorly defined channel, and its bed contained clay, silt, sand, and organic material. This material was equivalent to that found within the riparian buffer, which was populated by deciduous trees. The feature had an average width of 5.77 m, and during the April 2019 visit had an average wetted width of 3.7 m and an average wetted depth of 0.03 m.

Reach **TTMC3-9** is an approximately 3,000 $m^2$ online pond located approximately in the middle of the subject lands within a woodlot. The feature's riparian vegetation predominantly consists of mature deciduous trees which provides shading to the pond.

Reach **TTMC3-10** is roughly 194 m long feature conveying flows eastwards through a meadow area immediately south of the former orchard in the center of the subject lands. The reach is best described as a swale which is populated by dense hydrophilic vegetation in the feature itself and in its riparian zone. No clearly defined channel was observed, and the substrate was clay, silt and sand. Although water was present in the feature during all three visits of 2019, it was limited to fragmented, stagnant pools during the August visit with no observable flow. Given the poor channel definition, a feature width was measured which was an average of 6.3 m. The average wetted width of the feature in April 2019 was 3.32 m, and the average wetted depth was 0.12 m.

## 5.3 Branch TTMC-5

Reach **TTMC5-5** is a 336 m long intermittent swale which conveyed flows eastwards in the central-north portion of the subject area. The swale occupies a relatively wide corridor composed of hydrophilic herbaceous vegetation and grasses. Given the poor bank definition within the reach, the vegetated feature width was instead measured and determined to be an average of 21.7 m wide. Substrate within the feature was consistent with the agricultural fields which occupied the riparian buffer, and was clay, silt, and sand. Water was present during the first two visits of 2019, but it was dry during the summer. The feature discharges to a 750 mm culvert flowing under Twenty Road West.

Reach **TTMC5-6** is a roughly 327 m long intermittent swale which conveyed flows eastwards through an agricultural field. The headwater feature lacked a natural riparian corridor and was instead flanked by agricultural fields. It appeared that the feature was occasionally ploughed, and consequently substrate was generally consistent between the feature and adjacent fields with the exception of occasional cobbles. Water was present during April and June of 2019, and an unknown minnow species was observed within the upstream portion of the reach during June. The feature width of the reach was measured as 3.22 m.

Reach **TTMC5-7** is a roughly 500 m long feature which conveyed flows eastwards in the central-west portion of the subject lands. The reach is best described as a wide grassy corridor composed of hydrophilic vegetation with deciduous trees occupying the riparian buffer. Water was present during all visits in 2019 except the summer and is therefore considered an intermittent feature. The substrate was predominantly clay, silt and sand, and the feature was full of dense rooted emergent aquatic vegetation. The upstream extent of the reach, an offline agricultural pond was present which contained water during the first two site visits of 2019, but not the third. The feature was approximately 29.3 m wide (vegetation extent), and during April of 2019 had an average wetted width and depth of 20 m and 0.11 m, respectively. There was no defined bankfull channel or morphological units present.

Reach **TTMC5-8** is a roughly 450 m long feature which conveyed flows eastwards in the northwest portion of the subject lands. The reach is differentiated from Reach **TTMC5-7** by its riparian buffer which consisted of an agricultural field, and is otherwise a similar wet, grassy corridor. Like the adjacent reach, the feature was intermittent, had substrate which consisted of clay, silt and sand and was occupied by sparse rooted emergent aquatic vegetation. The feature had an average width of 24 m (no defined channel) and had an equivalent wetted width during the April 2019 assessment.

Reach **TTMC5-9** is a short 120 m long feature which originates at the outlet of a small pond within the former Glancaster Golf and Country Club and conveys flows eastwards in the western extent of the subject area. The feature is occupied by dense rooted emergent aquatic vegetation, particularly cattails, and is flanked by a deciduous forest to the north and an agricultural field to the south. The low gradient, intermittent feature's substrate was predominantly organic deposits, silt, and sand. The feature had an average width of approximately 20 m, and during the April, 2019 visit had an average wetted width of 14. 6 m, and an average wetted depth of 0.06 m. There was no discernible low flow channel.

Reach **TTMC5-10** is a pond feature located within the former Glancaster Golf Course lands. The pond is partially vegetated and surrounded by a riparian buffer consisting of predominantly herbaceous plants and grasses. The surface area of the pond is approximately 670 $m^2$.

Reach **TTMC5-11** is a roughly 260 m long feature which conveys flows eastwards through the former Glancaster Golf and Country Club Lands. The channel has a bankfull channel which has an average width of 2.66 m, and an average depth of 0.4 m. In the spring, the feature had an averaged wetted width of 1 m, and an average wedded depth of 0.08 m. Within the channel, wetland vegetation such as cattails were frequently observed, and the channel's riparian buffer was predominantly occupied by grasses and herbaceous species which provide little shading. Sediment transport was observed within the reach, with moderate deposition of up to 10 mm of sediment observed.

Reach **TTMC5-12** is a roughly 150 m reach with a bankfull channel which flows south-eastwards from a wetland at the western border of the subject lands. The channel has a bankfull width of 2.6 m, and a bankfull depth of 0.42 m and is predominantly occupied by hydrophilic vegetation, namely cattails and grasses. The feature has similar riparian vegetation to Reach **TTMC5-11**, namely grasses and herbaceous vegetation. At the downstream extent of the reach, a crushed culvert conveys flows across the driveway which previously led to the Glancaster Golf and Country Club clubhouse, which is 300 mm in diameter and is perched 0.3 m above the downstream channel bed. Sediment transport was observed within the reach, as was erosion to the channel banks although this was infrequent and likely a result of the poor culvert condition at the downstream end.

## 5.4 Branch TTMC-6

Reach **TTMC6-1** is a roughly 315 m long poorly defined feature which flows northeastwards towards a roadside ditch on the south side of Twenty Road West. The feature is surrounded by agricultural crops and showed evidence of being frequently ploughed. Vegetation within the feature was predominantly composed of the same crops which occupied the adjacent fields, with sparse aquatic vegetation infrequently observed. Minimal flow was observed within the feature during the April 2019 visit, and for the subsequent two visits the feature was dry resulting in it being classified as ephemeral. The substrate within the feature was consistent with that of the adjacent fields, and was clay, silt, and sand.

Reach **TTMC6-2** is a roughly 177 m long feature with poor channel definition which conveyed flows eastwards within the former orchard property. The feature was filled with dense, rooted emergent aquatic vegetation, particularly grasses, and was flanked by both meadow and scrubland within the riparian buffer. The substrate within the feature was predominantly clay, silt and sand. The reach had an intermittent flow regime, although the water observed during the June 2019 visit appeared to be standing and no water was observed during the third visit.

Reach **TTMC6-3** is a roughly 190 m long swale which flows eastwards through an agricultural field north of the central residential property. The channel was located within an agricultural field and had a narrow herbaceous riparian buffer. The substrate within the feature was clay, silt, and sand. Particularly at the upstream extent of the reach, no discernible channel could be located, and it appears that its connection with the upstream reach is somewhat limited.

Reach **TTMC6-4** is a short feature which occupies the relatively wide hedgerow between two agricultural fields. No channel could be clearly defined through the hedgerow, although a vernal pool was noted during the April and June visits of 2019 which received drainage from the field to the west. The feature was surrounded by scrubland and deciduous trees, and substrate within the pool was predominantly decomposing organics. The feature is considered intermittent since water was present during the first and second visits of 2019 and no water was observed in the summer of that year.

## 5.5 Branch TTMC-7

Reach **TTMC7-1** is a short 76 m long poorly defined feature originating from a culvert which flows eastwards across a driveway in the northwest portion of the subject lands before discharging into the roadside ditch of Twenty Road West. The feature was surrounded by meadow and grass species and had no discernible bankfull channel. The feature width occupied by hydrophilic vegetation was 32.5 m, and during the April 2019 visit the average wetted width and depth were 24.3 m and 0.03 m, respectively. Substrate within the feature was predominantly clay, silt, and sand. The flow regime of the feature was determined to be ephemeral given that water was only flowing during the April 2019 site visit.

## 5.6 Branch TTMC-8

Reach **TTMC8-7** is a roughly 120 m long intermittent swale which flows eastwards through an agricultural field near the northwest corner of the subject lands. The feature lacked a natural riparian buffer and was predominantly cropped with sparse areas lacking any vegetation. Substrate composition was predominantly clay, silt, sand, and sparse gravel. The feature had an average with of 2.55 m, and during the April 2019 visit the average wetted width and depth were 2.4 m and 0.05 m, respectively.

Reach **TTMC8-9** is a roughly 306 m long intermittent swale which flows eastwards through an agricultural field in the northwest portion of the subject lands. Riparian vegetation consisted exclusively of agricultural crops, which were generally absent from the channel. Substrate composition was consistent with the adjacent fields, and was predominantly clay, silt, and sand. The reach was considered intermittent since water was present during the April and June visits of 2019, and dry during the summer. The average bankfull width of the feature was 2.6 m, and its average bankfull depth was 0.1 m. During the spring of 2019, the average wetted width of the feature was 2.39 m, with a corresponding averaged wetted depth of 0.03 m.

Reach **TTMC8-9-1** is a roughly 248 m long intermittent swale which flows north-eastwards towards reach **TTMC8-9** from the former golf course lands at the northwest portion of subject land. The feature was surrounded by agricultural crops and itself was predominantly cropped. The reach was considered intermittent since water was present during the April and June 2019 site visits and dry during the summer. The average bankfull width of the feature was 1.1 m, and its averaged bankfull depth was 0.2 m. During the April 2019 visit, the average wetted width and depth of the feature were 0.3 m, and 0.03 m, respectively.

Reach **TTMC8-10** is a poorly defined feature which was difficult to discern from the surrounding landscape. During April of 2020, the feature held predominantly pooled standing water, with minimal flow observed towards the feature's downstream end. The average wetted width of this feature was 1.2 m, with an averaged wetted depth of 0.04 m. The feature's vegetation was equivalent to the riparian buffer and surrounding landscape and was populated by grasses. No sediment transport processes were observed within the reach.

Reach **TTMC8-3-3** is a roughly 283 m long intermittent swale which flows eastwards through an agricultural field at the northwest corner of subject lands. The feature lacked natural riparian vegetation and was flanked by crops, which encroached the channel. Substrate within the intermittent feature was predominantly clay, silt, and sand. The low gradient feature lacked clearly defined banks, and had an average vegetated width of 2.65 m. During April of 2019, the average wetted width of the feature was 2.65 m and had a corresponding average wetted depth of 0.04 m.

Reach **TTMC8-3-4** is a poorly defined feature which conveyed flows through the northern portion of the former golf course lands. The feature had an approximate width of 1.5 m, where observable, which was delineated based on the presence of herbaceous hydrophilic vegetation whereas its riparian buffer and the surrounding landscape was populated by grasses. Where observable, the feature had an averaged wetted width of 0.8 m and an averaged wetted depth of 0.11 m in April of 2020; however, the majority of the feature was dry. No sediment transport processes were observed within the channel, and the feature was dry during visits in the late spring and summer of 2020.

## 5.7 Branch TTMC-9

Reach **TTMC9-1** is a 60 m long section of channel adjacent to the roadside ditch of Dickenson Road West. The feature had equivalent dimensions to the upstream channel and was flanked on its northern side by deciduous trees and by Dickenson Road to the south. The channel enters a culvert near the eastern limit of the woodlot, where flows are conveyed across Dickenson Road west and into agricultural fields on the south side of the road.

Reach **TTMC9-2** is a 60 m long ephemeral swale which conveyed flows south eastwards towards a ditch on the north side of Dickenson Road West at the southern extent of the subject lands. Riparian vegetation adjacent to the feature was deciduous trees, as it conveyed flows within a woodlot. The low gradient feature's substrate was predominantly composed of decomposing organic matter and silt. Water was only observed within the feature during the April 2019 site visit, resulting in an ephemeral flow regime classification. The average bankfull channel width was 2.7 m, with a corresponding average bankfull depth of 0.23 m. The average wetted width of the feature during the Spring of 2019 was 0.23 m, and its average wetted depth was 0.03 m.

## 5.8 Branch TTMC-10

Reach **TTMC10-1-1** is a roughly 124 m long feature that begins just south of the open water pond located in the southeast portion of the subject property (**TTMC10-1-2a**) and flows in a southerly direction adjacent to and within woodland areas. The reach flows through a Corrugated Steel Pipe (CSP) culvert under a golf cart bridge crossing before ending at the subject lands boundary. The bridge culvert is approximately 60 cm in diameter and is not perched above the water level. The feature contained emergent hydrophytic vegetation and riparian vegetation consisted of meadow and forest communities. The reach contained minimal flow during the first 2 visits but was dry by summer and had substrates that consisted of clay and silt materials. No evidence of sediment transport or deposition was observed. During the first site visit, the average feature vegetation width was 12.9 m and the average wetted depth was 0.1 m.

Reach **TTMC10-1-2** is a roughly 160 m long swale that begins at the outflow of a CSP culvert at the edge of an agricultural field (planted with soybean in 2020) and flows in a southeasterly direction, eventually flowing adjacent to the southern edge of the open water pond located in the southeast portion of the subject property (**TMC10-1-2a**). This reach contains a tile drain input and flows under a small wooden pedestrian bridge. The feature contained meadow vegetation and the riparian vegetation consisted mainly of forest communities. The reach contained minimal flow during the first 2 visits but was dry by August and had substrate that consisted of clay and silt materials. During the first site visit, the average bankfull and wetted widths were 3.20 m and 2.40 m respectively, and the average bankfull and wetted depths were 0.28 m and 0.12 m respectively. Evidence of extensive sediment deposition was observed immediately downstream of the upstream culvert but only during the first survey. The sediment deposition was likely correlated with the exposed bare soils within the reach immediately upstream (**TTMC10-1-3**).

Reach T**TMC10-1-2a** is a roughly 900 $m^2$ pond that outflows to the south through a small channel into reach **TTMC10-1-2** in the southeast portion of the subject lands. This reach contained submergent hydrophytic vegetation and standing water during all visits and contained a significant amount of surface algae during the third visit. The water level did not change significantly between visits. Riparian vegetation consisted of meadow species and some forest communities, and the substrate consisted of organics and silt materials. No evidence of sediment deposition or transport were observed.

Reach **TTMC10-1-2b** is a roughly 110 m long defined channel that originates from a plastic pipe tile drain outlet at the subject property boundary. This reach flows in an easterly direction through a woodlot to its confluence with **TTMC10-1-2** just north of the open water pond located in the southeast portion of the subject property (**TMC10-1-2a**). The feature did not contain any vegetation and the riparian vegetation consisted of forest communities. The feature contained minimal flow during the first visit, standing water during the second visit and was dry by the third visit in August 2020. The substrate consisted of clay and silt materials and no evidence of sediment transport or deposition was observed. During the first site visit, the average bankfull and wetted widths were 2.32 m and 1.92 m respectively and the average bankfull and wetted depths were 0.09 m and 0.04 m respectively.

Reach **TTMC10-1-3** is a roughly 144 m long defined feature that begins at the southern edge of the large open water pond (**TTMC10-1-4**) and flows in a southeasterly direction through a newly created soybean agricultural field. This reach flows through two CSP culverts that are not perched and are 50 cm and 38 cm in diameter. These culverts were likely used historically to control drainage from golf course fairways but are currently in very poor condition and do not function as intended; during spring flows, water was observed to travel both through and around these culverts. The feature contained meadow and emergent hydrophytic vegetation during the first two visits but was dominated by agricultural soybean plants in August 2020. The riparian vegetation consisted of cropland on the third visit as well. The reach contained minimal flow during the first 2 visits but was dry by summer and had substrate that consisted of clay and silt materials. During the first site visit, the average bankfull and wetted widths were 1.38 m and 0.95 m respectively and the average bankfull and wetted depths were 0.19 m and 0.12 m respectively. Evidence of sediment transport, as indicated by the presence of rills, was observed on adjacent lands during the first visit, but this was likely associated with tableland sheet flows.

Reach **TTMC10-1-4** is a 2,200 $m^2$ pond that connects to **TTMC10-1-3** at its southern edge through a concrete block outflow structure. This reach contained emergent and/or submergent hydrophytic vegetation during all visits and minimal flow was observed during the first two visits while standing water was observed during the final visit when no outflow to **TTMC10-1-3** was apparent. The riparian vegetation consisted of meadow during the first two visits and was dominated by soybean cropland on the third visit. Substrates consisted of clay, silt and organic materials and no evidence of sediment transport or deposition was observed.

Reach **TTMC10-1-5** is a roughly 40 m long channel that begins at the subject property boundary and flows through a newly created soybean agricultural field where it flows into the large open water pond (**TTMC10-1-4**). The feature contained emergent hydrophytic vegetation and the riparian vegetation consisted of meadow communities. The reach contained minimal flow during the first 2 visits but was dry by August, and had substrate that consisted of clay and silt materials. During the first site visit, the average bankfull and wetted widths were 2.35 m and 1.32 m respectively and the average bankfull and wetted depths were 0.21 m and 0.09 m respectively. Minimal evidence of sediment transport, as indicated by instream bank erosion, was observed within the feature on the first and second visits.

## 5.9 Branch TTMC-11

**Reach TTMC-11** flows northeastwardly through the former Glancaster Golf Course Lands to the roadside ditch at Twenty Road West in the northwest corner of the subject lands. The feature was poorly defined, with minimal flow observed within the reach even during the Spring freshet. At this time, the average feature width was estimated as being 5 m based on the presence of meadow vegetation compared with the grasses which occupied the riparian buffer and adjacent landscape, including one sparse cluster of cattails. The feature had an average wetted width of 1.5 m, and an averaged wetted depth of 0.05 m. Notably, these were measured at isolated locations where water was present; however, the majority of the reach was dry. No sediment transport processes were observed within the reach.

# 6 Headwater Drainage Feature Assessment and Classification

Reach observations and stream measurements were collected over the span of three visits between spring and summer in 2019 and 2020 for various reaches on participating properties by both GEO Morphix Ltd. and Natural Resource Solutions Inc. (NRSI). Because all features on site were determined to function as headwater drainage features, the TRCA and CVC Headwater Drainage Feature Assessment methodology (2014) was applied to evaluate these channels. The classification results are summarized in tabular form under **Appendix D**, and the management recommendations for each reach are shown graphically on **Figure 2** in **Appendix A**.

HDF classification is dependent on feature hydrology, riparian conditions, fish and fish habitat, and terrestrial habitat. These classifications are given a score based on function of either limited, contributing, valued or important depending on observations from the various site visits. For instance, the hydrological significance of a feature is established based on the presence and conveyance of water through the reach. Perennial systems where water is present during all three visits is considered important, whereas if only standing water or no water is observed during the three visits its function is considered limited.

The 'Modifiers' presented in the **Appendix D** table reflect local details that alter the form, function, or importance of the feature, such as downstream conditions or local anthropogenic influences. Consequently, the management recommendations identified via strict application of the Headwater Guideline decision are adjusted to account for the modifiers and professional judgement. For instance, for those features that are located immediately upstream of pipes and/or storm water management facilities, professional judgement was used to alter the classification recommendations to reflect the lack of downstream connectivity. The Headwater Guideline allows for these modifications through the following statement: "Classification should consider the influence of modifiers and professional judgement to determine the appropriate classification, where applicable. The results of the process need to be clearly articulated" (TRCA and CVC 2014).

Each of the classifications come with specific management requirements which are:

- *Protection* – Important functions: protect and/or enhance the existing feature and its riparian zone and groundwater discharge or wetland in-situ
- *Conservation* – Valued functions: maintain, relocate, and/or enhance drainage feature and its riparian zone corridor
- *Mitigation* – Contributing functions: replicate or enhance functions through enhanced lot level conveyance measures for downstream connection
  *No Management Required* – Limited functions: no feature and/or functions associated with the feature are present on the ground and/or there is no downstream connection

We have applied the TRCA and CVC HDF guidelines in numerous jurisdictions across southern Ontario, but the guidelines recognize that HDF protection status reduces the practitioner's ability to enhance a given feature because of the requirement that it remain in-situ. Several features along the central branches were classified as protection under the guidelines but have been listed with modifiers to support a final classification of conservation (**Appendix D**). In these cases, keeping the features as protection would reduce the overall function of the feature in the long-term. From an overall management perspective, slight realignment of these features (i.e., conservation classification) will not result in a decrease of the overall function of the system, and instead, will likely provide enhancement opportunities. This is especially beneficial, given the extensive impacts to headwater features within this watershed as a result of previous land use activities (e.g., agriculture, damming, golf course operations). A conceptual corridor realignment is summarized in **Section 8** in association with tributary/branch **TTMC3** and **TTMC5**.

# 7 Erosion Assessment

In support of the proposed stormwater management (SWM) plan, an erosion threshold analysis was completed. 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.

## 7.1 Detailed Geomorphic Assessments

To support erosion threshold determination, detailed geomorphological assessments of the channel at Reach **TTMC-3-2** and Reaches **TTMC-2-9/10** were completed to determine average bankfull channel characteristics, including cross-sectional geometry and hydraulics. The assessments were undertaken to define erosion thresholds for erosion exceedance analysis (outlined below). These two subject reaches were selected as they are located generally downstream of proposed development activities and flow inputs.

Both **TTMC-3-2** and **TTMC-2-9/10** are headwater drainage features (HDF) and the geomorphic characteristics of both suggest that they are likely not the most sensitive reaches within the receiving watercourses. However, for the purposes of our field assessments, access to potentially more suitable off-site reaches could not be obtained. While detailed assessments of potentially more sensitive downstream reaches can further inform erosion thresholds for the proposed development, information from Reaches **TTMC-3-2** and **TTMC-2-9/10** serve to support the analysis through providing details on bed and bank substrate, riparian habitat conditions, and channel gradient.

Representative cross sections were surveyed along Reaches **TTMC-3-2** and **TTMC-2-9/10**, and sediment samples were collected to characterize the bed and bank materials. A longitudinal survey of the bed was also completed to determine channel slope. Both reaches flow through wide, vegetated corridors, exhibit poorly defined banks, and were mostly dry at time of assessment, with some standing water present throughout. As a result of these channel characteristics accurately defining bankfull geometry was not straightforward. This resulted in challenges identifying bankfull geometry. A summary of measured and computed values is presented in **Table 2**.

### Table 2. Detailed assessment summary

| Channel Parameter | Reach TTMC-3-2 | Reach TTMC-2-9/10 |
|---|---|---|
| **Average bankfull channel width (m)** | Poorly defined banks, vegetation present throughout | |
| **Average bankfull channel depth (m)** | Poorly defined banks, vegetation present throughout | |
| **Average channel gradient (m/m)** | 0.33 | 0.67 |
| **Bed material** | Compact silt and clay | Compact silt and clay |
| **Bank material** | Compact silt and clay | Compact silt and clay |
| **Drainage area (ha)** | 133.9 | 54.3 |

## 7.2 Erosion Threshold Analysis

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank materials. As such, they may be used to inform erosion reduction strategies in channels influenced by conceptual flow management plans. The erosion threshold analysis provides a depth, velocity, or discharge at which sediment of a particular size may potentially be entrained.

The erosion threshold is the theoretical point at which entrainment of sediment would occur based on bed and bank materials. Due to the variability between bed and bank composition and structure, erosion thresholds are typically determined for both bed and bank materials.

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 (1998) can be applied.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge. Theoretically, above this discharge, entrainment and transport of sediment can occur. The streamflow velocity, *U* is calculated at various water depths, 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 Arcement and Schneider (1989) or calculated using Limerinos's (1970) approach. The velocity is mathematically represented as

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

where, *d* is depth of water, *S* is channel slope, and *n* is the Manning's roughness. The discharge is then calculated using the cross-sectional area of a representative cross section of the subject reach.

For the bank materials, following the approach detailed in Chow (1959), 75% of the bed shear stress is acting on the channel banks. As with the assessment of bed materials, to obtain an estimate of the bank erosion threshold the depth of flow is increased until the shear stress acting on the banks exceeds the resisting shear strength of the bank materials.

In this instance, due to the lack of well-defined banks and prominent vegetation within Reaches **TTMC-3-2** and **TTMC-2-9/20,** determining bankfull dimensions and an accurate erosion threshold was not straightforward. Additionally, these reaches are not likely the most sensitive reaches within the receiving watercourses. Therefore, a unitary erosion threshold defined for a proximal reach situated within a tributary of Welland River (Reach **WRT-1**) is used to determine scaled erosion thresholds for the two HDF along Twenty Mile Creek. The surrogate reach, Reach **WRT-1,** is a tributary of the Welland River located approximately 4.55 km south of the subject properties. **WRT-1** is located within the Haldimand Clay Plains, and surficial geology within the region consists of fine-textured, glaciolacustrine deposits (OGS 2010; Chapman and Putnam 1984). The channel flows unconfined through an agricultural field, lacks a riparian buffer, and exhibits intermittently defined banks. **TTMC-3-2** and **TTMC-2-9/10** share the same surficial geology and are also located within the Haldimand Clay Plains. While **WRT-1** has a slightly steeper channel gradient, its bed and bank materials are consistent with the silt/clay bed and banks found within **TTMC-3-2** and **TTMC-2-9/10**.

Furthermore, a field assessment for a downstream reach of Twenty Mile Creek was conducted by Aquafor Beech Ltd. and Dillon Consulting Ltd. 2011 as part of a subwatershed study. Along the main branch of Twenty Mile Creek, the bankfull width and depth were 8 m and 0.6 m, respectively. The channel was relatively straight and bed materials consisted of clay and silt. Herbaceous species and agricultural crops were dominant along the banks, with no riparian buffer present, similarly to **WRT-1**. Both are relatively low gradient, flowing through unconfined valleys. Given the proximity and similarities in substrate, surficial geology, physiography, and geomorphology between **WRT-1** and the HDF features and downstream reach of Twenty Mile Creek, the unitary threshold defined for **WRT-1** can be applied to define a critical discharge for **TTMC-3-2** and **TTMC-2-9/10**. For reference, a map showing the location of **WRT-1**, the assessment conducted on the downstream reach, and the subject property is found in **Appendix A**. Channel parameters for Reach **WRT-1** are outlined in **Table 3**.

### Table 3. WRT-1 erosion threshold summary

| Parameters | Representative Erosion Threshold (WRT-1) |
|---|---|
| **Bankfull width (m)** | 3.09 |
| **Bankfull depth (m)** | 0.47 |
| **Channel gradient (%)** | 0.25 |
| **Bed material** | Silt, clay, some cobbles |
| **Bank material** | Silt, clay |
| **Drainage area (ha)** | 105 |
| **Method** | 6 $N/m^2$ permissible shear stress for compact, heavy clay based on Chow (1959) |
| **Critical discharge ($m^3/s$)** | 0.254 |
| **Unitary erosion threshold ($m^3/s/ha$)** | 0.002419 |

The unitary erosion threshold defined for Reach **WRT-1** was used to determine scaled critical discharge for Reaches **TTMC-3-2** and **TTMC-2-9/10**. The results of the erosion assessment are provided in **Table 4**. The critical discharge to entrain materials was determined to be 0.324 $m^3/s$ within **TTMC-3-2** and 0.131 $m^3/s$ within **TTMC-2-9/10**.

These erosion thresholds were selected for post- to pre-development comparisons outlined in **Section 7.3**. For reference, the location of the assessed reaches and flow nodes for erosion analysis are included in **Appendix A**. We note that these erosion thresholds may be conservative due the presence of vegetation within the channel for both reaches. This information should be considered preliminary in nature, and should be reassessed and refined during future planning/study stages once more detail is available for the proposed stormwater management plan on site.

### Table 4. TTMC3-2 and TTMC2-9 erosion threshold summary

| Parameter | TTMC-3-2 | TTMC-2-9/10 |
|---|---|---|
| **Unitary erosion threshold ($m^3/s/ha$)** | 0.002419 | |
| **Drainage area (ha)** | 133.9 | 54.3 |
| **Critical discharge ($m^3/s$)** | 0.324 | 0.131 |

## 7.3 Erosion Exceedance Modelling

### 7.3.1 Modeling Overview

Using the results of the erosion threshold analysis, synthetic storm hydrological modelling analyses were applied to produce hydrographs for use in the exceedance analyses. These exceedance analyses were completed using our own in-house model, based on two indices:

1) Cumulative time of exceedance
2) Cumulative effective discharge

They, as a product, provide an evaluation of the period of transport, and magnitude. We note that the most relevant index is the cumulative effective stream power. Cumulative effective work ($N/m^2$) was not included in the analysis as a unitary erosion threshold approach was applied for this site (see details above).

Time of exceedance can be simply calculated from the discharge record. For more relevant indicators, hydraulic information is required. As such, 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 provided by Crozier (2023) 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. In this instance, synthetic storms ranging from the 25mm to 100-year event were evaluated to calculate the various erosion indices noted above to identify potential changes in the erosive potential of the watercourse following development.

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

$$Q_{T} = \sum Q_i \qquad \text{[Eq. 2]}$$

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

$$Q_i = U_i w_i d_i \qquad \text{[Eq. 3]}$$

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:

$$\tau_{o_{max}} = d_{max} \rho g S_{bed} \qquad \text{[Eq. 4]}$$

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

Time of exceedance $t_{ex}$ defined as:

$$t_{ex} = \sum \Delta t \text{ (for } Q_T > Q_{threshold}\text{)} \qquad \text{[Eq. 5]}$$

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

We note that when using synthetic storm simulations, the most relevant indices are the 2-year, and 5-year events, as they represent the majority of erosion events to occur within the watercourse. Consequently, a greater emphasis is placed on these synthetic storms when evaluating the results of an exceedance analysis completed without continuous modelling.

### 7.3.2 Modeling Results

**Table 5** and **6** provide the results of the assessment for Reach **TTMC-3-2** and **TTMC-2-9/10** respectively, based on the hydrographs provided by Urbantech Consulting (2023).

**Table 5. Erosion targets based on post- and pre-development modelling for Reach TTMC3-2 (Node 4)**

| Scenario | CEV ($m^3$) | $t_{ex}$ (hrs) |
|---|---|---|
| **2-year event** | | |
| **(PRE)** | 37,557 | 16.5 |
| **(POST)** | 72,489 | 34.25 |
| **Change (%)** | **93.01** | **107.58** |
| **5-year event** | | |
| **(PRE)** | 83,714 | 28 |
| **(POST)** | 131,641 | 45.5 |
| **Change (%)** | **57.25** | **62.50** |
| **10-year event** | | |
| **(PRE)** | 119,627 | 34 |
| **(POST)** | 173,693 | 50.25 |
| **Change (%)** | **45.20** | **47.79** |
| **25-year event** | | |
| **(PRE)** | 170,907 | 41.5 |
| **(POST)** | 230,724 | 56.25 |
| **Change (%)** | **35.00** | **35.54** |
| **50-year event** | | |
| **(PRE)** | 207,566 | 43.5 |
| **(POST)** | 270,902 | 60 |
| **Change (%)** | **30.51** | **37.93** |
| **100-year event** | | |
| **(PRE)** | 245,562 | 45.25 |
| **(POST)** | 312,313 | 63.75 |
| **Change (%)** | **27.18** | **47.40** |
| **Cumulative (25 mm – 100-year events)** | | |
| **(PRE)** | 864,934 | 208.75 |
| **(POST)** | 1,191,761 | 310 |
| **Change (%)** | **37.79** | **48.50** |

**Table 6. Erosion targets based on post- and pre-development modelling for Reach TTMC2-9/10 (Node 5)**

| Scenario | CEV ($m^3$) | $t_{ex}$ (hrs) |
|---|---|---|
| **2-year event** | | |
| **(PRE)** | 55,056 | 38.75 |
| **(POST)** | 40,016 | 42.25 |
| **Change (%)** | **-27.32** | **9.03** |
| **5-year event** | | |
| **(PRE)** | 109,346 | 43.5 |
| **(POST)** | 70,687 | 49.5 |
| **Change (%)** | **-35.35** | **13.79** |
| **10-year event** | | |
| **(PRE)** | 148,611 | 46.5 |
| **(POST)** | 92,210 | 53.75 |
| **Change (%)** | **-37.95** | **15.59** |
| **25-year event** | | |
| **(PRE)** | 202,312 | 49.75 |
| **(POST)** | 121,108 | 58.75 |
| **Change (%)** | **-40.14** | **18.09** |
| **50-year event** | | |
| **(PRE)** | 240,335 | 52 |
| **(POST)** | 141,320 | 61.75 |
| **Change (%)** | **-41.20** | **18.75** |
| **100-year event** | | |
| **(PRE)** | 279,601 | 53.75 |
| **(POST)** | 161,990 | 64.5 |
| **Change (%)** | **-42.06** | **20.00** |
| **Cumulative (2 – 100-year events)** | | |
| **(PRE)** | 1,035,260 | 284.25 |
| **(POST)** | 627,331 | 330.5 |
| **Change (%)** | **-39.40** | **16.27** |

Changes to the hydrological regime resulting from the proposed development are expected to cause an increase in cumulative effective volume and duration of the 2-year and 5-year events for Reach **TTMC3-2**. Conversely, cumulative effective volume is expected to decrease for the 2-year and 5-year events within Reach **TTMC-2-9/10** because of post-development changes in hydrology. Hydrographs for Node 4 (Reach **TTMC-3-2**) demonstrated a post-development increase both in peak flow and length of the storm event. Node 5 (**TTMC-2-9/10**) hydrographs demonstrated a significant decrease in post-development peak flow, with an increase in event duration.

The post-development exceedances in erosion metrics at Reach **TTMC3-2** (Node 4) could be addressed through implementation of LID mitigation strategies. We also note that our erosion analysis was based on synthetic storm events rather than on hydrological data from a continuous hydrological simulation model. The use of a continuous hydrological time-series would provide a more accurate assessment of erosion exceedance at this site. We recommend that the erosion analysis be updated and refined during subsequent phases of study.

# 8 Conceptual Channel Design

## 8.1 Design Objectives

Tributaries of Twenty Mile Creek (Branch **TTMC3** and **TTMC5**) are proposed for realignment, which provides an opportunity to replace the existing morphologically limited and historically impacted drainage features with a dynamically stable channel containing naturalized morphology, with cross sectional dimensions closer to that of a naturalized watercourse-type feature conveying similar flows. The natural corridor design will offer significant improvements to aquatic and terrestrial habitat through an open channel, wetland communities and terrestrial habitat features. The natural corridor design will offer significant improvements to channel form and function per unit length. It should be noted that the most important aspect of restoration is to improve environmental and physical function. The proposed design will provide an increased level of function than what is currently on the landscape. It may have geometric deficiencies (e.g., overall stream length replication). However, given the size of the corridor and the available sources of flow (i.e., adjacent back yard lots), additional opportunities may be reviewed and developed as the design concept is advanced to provide additional stream length that better mimics the existing system.

In general, the proposed design aims to mimic pre-disturbance channel conditions and focuses on creating a channel and corridor system that has a range of hydroperionds and is well-connected to its floodplain. The design will reinstate and enhance channel form and function, provide habitat variability, improve sediment transport, and provide greater substrate and morphological variability. Approximately 1.0 ha of open water wetland habitat and an additional 6-7 ha of online and offline wetland will be constructed throughout the floodplain. These features will enhance terrestrial habitat by increasing diversity and providing a more natural floodplain form. They also provide functional benefits by storing and discharging water over longer, attenuated periods.

The primary objectives of the designs are to:

- Improve the physical form of the channel, including planform and instream characteristics
- Improve the channel function and promote interaction with its floodplain
- Improve water quality by extending detention of water through offline wetland features
- Enhance aquatic habitat through the provision of a morphologically diverse channel with spatially varied flows
- Enhance and replicate the existing wetland features that will be removed from the site
- Improve riparian habitat by installing woody plantings and floodplain features

The conceptual natural channel designs are included in **Appendix E** and described in further detail below.

## 8.2 Bankfull Channel

The recommended restoration design focuses on a riffle-pool system that will provide significant improvements to not only the channel, as it essentially mimics natural systems, but also to aquatic habitat. The proposed design will provide a self-maintaining low-flow channel, allow for fish passage, and provide a connection to its floodplain. The channel carries the bankfull discharge, equivalent to a portion of the 2-year return post-development flow. This approach will generally result in wetland inundation during the spring freshet and by rain-related flooding events.

The riffle-pool system offers numerous benefits, namely:

- Channel bed relief for flow variability
- Water aeration in riffle sections
- Relatively quiescent flows in pool sections to provide potential refuge for fish (if present) during high flows
- Instream energy dissipation
- Tortuous meanders to increase scour and pool depth, providing potential over wintering habitat for fish species

Channel dimensions are determined by bankfull discharge, as this represents what is generally considered the channel-forming discharge or the dominant discharge. Several methods can be applied to select an appropriate bankfull discharge. Given the significant historical channel modifications, hydraulic modelling was used to determine an appropriate bankfull discharge for the design. The bankfull discharge used to model the sections was assumed to be a portion of the modelled 2-year flow. The central channel corridor has been divided into five sub-reaches (**Reaches 1** through **5**) based on changes in gradient and flow magnitude. The bankfull discharges were based on hydrologic modelling completed by Urbantech Consulting Inc. (2023).

The central corridor riffle and pool geometries, as well as anticipated bankfull conditions, are provided in **Tables 7** to **9**. A simple Manning's approach was used to iteratively back-calculate bankfull dimensions for the proposed channels. Since pools are designed to contain ineffective space, this model over-predicts the amount of discharge that they convey. However, the modelled values for the riffles give a better prediction of the channel capacity.

**Table 7. Bankfull parameters for Reach 1 and Reach 2 of the proposed channel**

| Channel parameter | Reach 1 | | Reach 2 | |
|---|---|---|---|---|
| | Riffle†† | Pool† | Riffle†† | Pool† |
| **Bankfull width (m)** | 1.65 | 2.25 | 1.70 | 2.30 |
| **Average bankfull depth (m)** | 0.20 | 0.24 | 0.20 | 0.25 |
| **Maximum bankfull depth (m)** | 0.30 | 0.45 | 0.30 | 0.45 |
| **Bankfull width-to-depth ratio** | 8.44 | 9.29 | 8.63 | 9.36 |
| **Channel gradient (%)** | 1.77 | 0.59 | 1.55 | 0.50 |
| **Bankfull gradient (%)** | 0.59 | | 0.50 | |
| **Average radius of curvature (m)** | 5 | | 5 | |
| **Riffle-pool spacing (m)** | 15 | | 15 | |
| **Manning's roughness coefficient, *n*** | 0.04 | 0.03 | 0.04 | 0.03 |
| **Mean bankfull velocity (m/s) *** | 0.97 | 0.87 | 0.92 | 0.81 |
| **Actual bankfull discharge ($m^3/s$) *** | 0.31 | 0.47 | 0.31 | 0.46 |
| **1.5 Year discharge to accommodate ($m^3/s$)** | 0.31 | | 0.31 | |
| **Tractive force at bankfull ($N/m^2$)** | 52 | 26 | 46 | 22 |
| **Stream power (W/m)** | 54 | 27 | 47 | 22 |
| **Unit stream power ($W/m^2$)** | 33 | 12 | 27 | 10 |
| **Froude Number (unitless)** | 0.70 | 0.57 | 0.66 | 0.52 |
| **Maximum grain size entrained (m) **** | 0.05 | 0.03 | 0.05 | 0.02 |
| **Mean grain size entrained (m)**** | 0.03 | 0.01 | 0.03 | 0.01 |

† Based on bankfull gradient
†† Based on riffle gradient
* Based on Manning's equation; as pools contain ineffective space, the velocity and discharge conveyed in them are not representative
** Based on a modified Shields equation (Miller et al. 1977), assuming Shields parameter equals 0.06 for gravel

**Table 8. Bankfull parameters for Reach 3 and Reach 4 of the proposed channel**

| Channel parameter | Reach 3 | | Reach 4 | |
|---|---|---|---|---|
| | Riffle†† | Pool† | Riffle†† | Pool† |
| **Bankfull width (m)** | 1.70 | 2.30 | 2.20 | 2.80 |
| **Average bankfull depth (m)** | 0.22 | 0.25 | 0.27 | 0.31 |
| **Maximum bankfull depth (m)** | 0.35 | 0.50 | 0.40 | 0.60 |
| **Bankfull width-to-depth ratio** | 7.63 | 9.04 | 8.20 | 9.06 |
| **Channel gradient (%)** | 2.35 | 0.75 | 1.95 | 0.60 |
| **Bankfull gradient (%)** | 0.75 | | 0.60 | |
| **Average radius of curvature (m)** | 5 | | 6 | |
| **Riffle-pool spacing (m)** | 15 | | 19 | |
| **Manning's roughness coefficient, *n*** | 0.04 | 0.03 | 0.04 | 0.03 |
| **Mean bankfull velocity (m/s) *** | 1.21 | 1.02 | 1.26 | 1.03 |
| **Actual bankfull discharge ($m^3$/s) *** | 0.46 | 0.59 | 0.74 | 0.89 |
| **1.5 Year discharge to accommodate ($m^3$/s)** | 0.46 | | 0.74 | |
| **Tractive force at bankfull (N/$m^2$)** | 81 | 37 | 76 | 35 |
| **Stream power (W/m)** | 105 | 44 | 142 | 53 |
| **Unit stream power (W/$m^2$)** | 62 | 31 | 64 | 31 |
| **Froude Number (unitless)** | 0.82 | 0.64 | 0.77 | 0.59 |
| **Maximum grain size entrained (m) **** | 0.08 | 0.04 | 0.08 | 0.04 |
| **Mean grain size entrained (m)**** | 0.05 | 0.02 | 0.05 | 0.02 |

† Based on bankfull gradient
†† Based on riffle gradient
* Based on Manning's equation; as pools contain ineffective space, the velocity and discharge conveyed in them are not representative
** Based on a modified Shields equation (Miller et al. 1977), assuming Shields parameter equals 0.06 for gravel

### Table 9. Bankfull parameters for Reach 5 of the proposed channel

| Channel parameter | Reach 5 | |
|---|---|---|
| | Riffle†† | Pool† |
| **Bankfull width (m)** | 2.35 | 2.95 |
| **Average bankfull depth (m)** | 0.27 | 0.33 |
| **Maximum bankfull depth (m)** | 0.40 | 0.70 |
| **Bankfull width-to-depth ratio** | 8.63 | 8.95 |
| **Channel gradient (%)** | 3.06 | 1.02 |
| **Bankfull gradient (%)** | 1.02 | |
| **Average radius of curvature (m)** | 6 | |
| **Riffle-pool spacing (m)** | 19 | |
| **Manning's roughness coefficient, *n*** | 0.04 | 0.03 |
| **Mean bankfull velocity (m/s) *** | 1.60 | 1.40 |
| **Actual bankfull discharge ($m^3/s$) *** | 1.02 | 1.37 |
| **1.5 Year discharge to accommodate ($m^3/s$)** | 1.02 | |
| **Tractive force at bankfull ($N/m^2$)** | 120 | 70 |
| **Stream power (W/m)** | 307 | 137 |
| **Unit stream power ($W/m^2$)** | 131 | 46 |
| **Froude Number (unitless)** | 0.98 | 0.78 |
| **Maximum grain size entrained (m) **** | 0.12 | 0.07 |
| **Mean grain size entrained (m)**** | 0.08 | 0.03 |

† Based on bankfull gradient
†† Based on riffle gradient
* Based on Manning's equation; as pools contain ineffective space, the velocity and discharge conveyed in them are not representative
** Based on a modified Shields equation (Miller et al. 1977), assuming Shields parameter equals 0.06 for gravel

## 8.3 Channel Planform

The channel planform layout was created using modelled radii of curvature (*Rc*) values as a guide. The radius of curvature of meanders can be used to evaluate channel stability. For example, stable meanders typically exhibit larger *Rc* values as opposed to lower values that indicate increased channel bank erosion and avulsion. Bankfull width is often an appropriate indicator for this instability. Hickin and Nanson (1983) note that channel avulsions are common when meander *Rc* is approximately 1-2 times the channel bankfull width. For larger *Rc* (e.g., >5), the upstream limb of the meander will migrate more rapidly than the downstream limb (Hooke, 1975).

Williams (1986) was used to derive values for the channel radii of curvature, using the following equation (Eq. 6):

$$Rc = 2.43 \times w \qquad \text{[Eq. 6]}$$

where *Rc* is the radius of curvature and *w* is the average bankfull width.

Empirical models derived by Hey and Thorne (1986) were followed to determine riffle spacing. Hey and Thorne's (1986) modelled values are often applied in larger watercourses. As such, multiple methods (Eq.2-4) were considered in order to provide a range of riffle spacing values. These are:

$$Z = 6.31 \times w \qquad \text{[Eq. 7]}$$

$$Z = 9.1186 \times w^{0.8846} \qquad \text{[Eq. 8]}$$

$$Z = 7.36 \times w^{0.896} \times S^{-0.03} \qquad \text{[Eq. 9]}$$

where *Z* represents riffle spacing.

Stream power and unit stream power were calculated as a function of bankfull discharge and channel gradient (Eq. 5-6) in each corridor. Stream power values are important to determine the need for mitigating channel bank and bed erosion. Stream power is given by:

$$\Omega = \rho \times g \times d \times S \qquad \text{[Eq. 10]}$$

where $\rho$ is the density of water ($kg/m^3$), *g* is the acceleration due to gravity ($m/s^2$), and *Q* and *S* are discharge ($m^3/s$) and channel gradient, respectively.

Stream power per unit width (Eq. 11), is given by:

$$\omega = \frac{\Omega}{w} \qquad \text{[Eq. 11]}$$

where as before, $\Omega$ and *w* are stream power and bankfull width, respectively. Stream power for the realigned reaches is provided in **Table 7**, **Table 8**, and **Table 9**.

The final channel planform was established through an iterative process. First, cross-sections with defined bankfull geometries were developed to calculate parameters for the channel planform (i.e., radius of curvature). The cross-sections were then further refined, and riffle and pool lengths were determined based on channel gradients.

## 8.4 Channel Substrate Hydraulic Sizing

The sizing of the proposed substrate materials was guided by a review of hydraulic conditions (i.e., tractive force, flow competence) in the typical channel cross sections. The channel bed substrate is derived by balancing the average shear stress acting on the bed with the critical shear stress for the material. When the critical shear stress slightly exceeds the average shear stress acting on the bed, sediment transport is initiated.

To provide for a stable bed and level of sorting the reaches have a mix of 30% granular 'b' and 70% 0.10 m – 0.15 m riverstone materials proposed for the riffles. For the pools in all reaches and the deep undulations, 70% granular 'b' and 30% native material are proposed. Granular' b' consists of a mix of stone where approximately 20% - 50% of the stone is greater than 0.005 m in diameter, but nothing larger than 0.15 m in diameter. Given the pools experience lower velocities smaller stone is proposed for the substrate.

## 8.5 Channel Corridor

### 8.5.1 Corridor Sizing

As part of the design, meander belt widths were calculated based on design bankfull dimensions to ensure that the planform has meander belt widths that fall within the corridor requirements. Given the scale of the watercourse and limited migration potential, the hazard limits calculated can be considered conservative. The meander belt widths provided are based on modelled relations from Williams (1986), which were modified to include channel width and a factor of safety and applied using the bankfull channel dimensions such that:

$$B_w = (4.3 {W_b}^{1.12} + W_b) \times 1.2 \qquad \text{[Eq. 12]}$$

where $B_w$ is meander belt width (m), and $W_b$ is bankfull channel width (m). An additional 20% buffer, or factor of safety, was applied to the computed belt width values. This addresses issues of under prediction and provides a factor of safety.

To take a more conservative approach, the meander belt width is based on a slightly larger channel than designed that accommodates the 2-year return flow. Based on this assumption, the average width of designed **Reach 1**, **Reach 2**, **Reach 3**, **Reach 4**, and **Reach 5**, are 2.20 m, 2.30 m, 2.40 m, 2.88 m, and 2.65 m, respectively. The resulting meander belt width estimates are provided in **Table 10**.

### Table 10. Meander belt width for the proposed channel

| Reach | Meander Belt Width (m)* |
|---|---|
| **Design Reach 1** | 15 |
| **Design Reach 2** | 16 |
| **Design Reach 3** | 17 |
| **Design Reach 4** | 20 |
| **Design Reach 5** | 19 |

*Based on modified Williams (Width) method (Eq. 7)

The predicted meander belt widths for realigned Reach **1**, Reach **2**, Reach **3**, Reach **4**, and Reach **5** are 15 m, 16 m, 17 m, 20 m, and 19 m, respectively. The proposed valley bottom width ranges from 34 m to 42 m and is substantially wider than the meander belt width for each reach based on back-calculated channel geometries using the 2-year return flow. The proposed corridor bottom width easily accommodates the potential erosion hazard.

### 8.5.2 Corridor Wetland Replication

Wetland replication is proposed as part of the development to compensate for the removal of approximately 4.0 ha of existing wetlands. These features enhance terrestrial habitat by increasing diversity and providing a more natural floodplain form. They also provide functional benefits such as short-term water retention and sediment banking. The short-term water retention function of these wetland types helps to polish water and moderate the discharge of water into the channel.

Given the adjacent airport and concerns related to waterfowl, the wetlands are designed as irregularly shaped, linear features (i.e., similar to an oxbow) to limit potential areas of open water. In addition, it is recommended that the restoration planting plan, to be prepared at a later date, include vegetation (e.g., woody plantings) in proximity to wetland areas to deter use by waterfowl. The wetlands are designed to varying depths, up to a maximum of 1 m to 1.5 m) to accommodate turtle overwintering habitat.

Within the corridor, the total area of designed wetlands is between 7 and 8 ha, which is greater than the replication area requirements. The proposed wetlands have an average depth of 0.60 m with deeper areas of up to 1 m provided for amphibian and reptile overwintering habitat. Variability is included in the design to assure that from year-to-year a range of water depths and hydroperiods are provided.

The depressional storage provided within the proposed natural corridor design is intended to elongate the hydroperiod.

### 8.5.3 Habitat Restoration

Several habitat elements are incorporated into the design within the channel corridor to improve riparian habitat and promote wildlife biodiversity. The habitat elements include potential overwintering pools, brush mattresses, basking logs, brush piles, raptor poles, turtle nesting sites, snake hibernacula, rock piles and terrestrial mounds. The proposed elements provide a variety of topographies and woody debris that maximize the potential for wildlife passage, forage, and residency. Further details and directions for the implementation are provided in the accompanying design drawings in **Appendix E.**

Potential overwintering pools are proposed to provide critical habitat for resident fish. The overwintering pools are located within the tortuous meander pattern, which will increase scour and pool depth. This habitat feature will provide fish with potential refuge from freezing conditions in the winter and ideal habitat during low flow periods and increase habitat heterogeneity within the channel. Due to the size of the proposed channel, the pools could freeze completely during the winter.

Brush mattresses are proposed along the outside bends of tortuous meanders. This treatment consists of live brush cuttings installed parallel to the banks and tied with coir twine and stakes. The brush mattress will provide bank stability and improve aquatic habitat through shading.

Basking logs consist of a mixture of hardwood and softwood species, placed in shallow areas of wetlands and anchored with a mix of stone or limestone blocks. These logs are angled in a way to promote turtle basking.

Brush piles consist of logs, snags and other wood debris placed in a way that forms a stable interconnected mound shaped like a pallet. Additionally, the brush piles are planted with native fruit-bearing vines, which provide forage opportunities for wildlife. Brush piles are placed at various locations along the length of the floodplain.

Raptor poles are constructed from large conifer tree trunks embedded into the ground, providing perches for larger raptors.

Turtle nesting sites are installed on south or west-facing slopes away from the watercourse. These are constructed by excavating a slight depression in the ground and filling it with granular 'b' material.

Snake hibernacula are constructed similarly to turtle nesting sites on south or west-facing slopes away from the watercourse. The excavated depressions are filled with a mix of angular stones of various sizes and woody debris.

Rock piles consist of a mix of stones of varying sizes piled up to create small mounds. These features provide hibernation habitats for various terrestrial species. The base of the piles is partially buried to prevent rock falls. Rock piles are installed at multiple locations along the corridor length within the buffer.

Terrestrial mounds consist of native material piled up to create small mounds with a small dimple on the top. The bottom of the mound is seeded with the specified seed mix, while the top has limited soil and seed on it to provide foraging opportunities.

## 8.6 Interim and Long-Term Channel Conditions

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 within the realigned corridor is recommended. This includes deep rooting native grasses and other 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 banks 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.

## 8.7 Best Management Practices

The accompanying drawings in **Appendix E** provide design details and direction for implementation of the proposed channel corridor and should be reviewed in conjunction with this report. Mitigation measures and best management practices include but are not limited to the following:

- Instream construction should be carried out only during low-flow or dry conditions, and as regulated by the appropriate fisheries timing window set out by Fisheries and Oceans Canada and/or the Ministry of Northern Development, Mines, Natural Resources and Forestry
- The limits of construction should be delineated to prevent unanticipated impacts to natural surroundings, including trees and the watercourse
- Where in-channel works are required, the work area must be fully isolated from the active flow area using cofferdams
- All isolated work areas will be unwatered to perform the work under dry conditions
- Water will be pumped to a sediment filtration system located at least 30 m from the receiving watercourse and be allowed to naturally flow over a well-vegetated surface and ultimately return to the channel to allow particles to settle before reaching the watercourse.
- The weather forecast will be monitored prior to construction to ensure favourable working days.
- Should temporary crossings be required for construction access, all temporary crossing materials are to be removed from the channel following their use
- 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 re-fuelling and/or maintenance will be conducted away from the watercourse, and they shall be free of fluid leaks and externally cleaned/degreased to prevent the release of deleterious substances

## 8.8 Detailed Design Recommendations

To support detailed design and ensure proper implementation of the channel corridors, the following activities are recommended at the detailed design stage:

- Confirm valley and channel gradients
- Refine the designs based on final assessments and hydraulic/hydrologic modelling
- Confirm the locations and configurations of habitat features
- Confirm locations and requirements for outlet treatments from stormwater management facilities

- Develop a comprehensive planting plan for the proposed corridor that will complement the bioengineered treatments, wetland features, and riparian live stake plantings
- Establish site access routes, staging and storage areas for construction
- Develop recommendations for implementation during construction, including an erosion and sediment control plan
- Finalize a post-construction monitoring plan for the realigned channel

## 8.9 Construction Observation

Construction observation will be performed by an inspector with experience overseeing channel works, as this type of work differs considerably from engineering projects. The inspector must be a certified fluvial geomorphologist or an experienced environmental inspector under direction from the designer. A geomorphologist and/or experienced inspector will be able to provide a quick and appropriate response to issues that may arise and ensure that construction proceeds in accordance with the approved design and contract. Erosion and sediment control monitoring should be performed by a CAN-CISEC certified monitor.

Construction observation by the designer or designated representative should be completed at key points in the construction schedule such as:

- Design layout
- Initiation of channel and wetland grading and channel substrate mixing/placement along the realigned corridor
- Implementation of first series of geomorphic units (e.g., five or more channel meanders) to ensure proper installation
- Finalization of channel grading and substrate mixing/placement
- Stabilization of newly constructed channel corridor prior to flow introduction
- Flow introduction to newly constructed channel corridor
- Addressing non-minor channel related or erosion and sediment control issues encountered during construction

The frequency and timing of additional on-site inspections should be coordinated at the time of construction at the discretion of the designer/principal geomorphologist to ensure successful design implementation. Following successful installation and stabilization of the natural corridor design and prior to the introduction of flows to the realigned corridor, a conformance letter should be issued that is signed by a Professional Geoscientist (P.Geo.) and will signify that, based on the signee's best knowledge, the constructed fluvial elements are in conformance or in general conformance with the design and are functionally stable.

## 8.10 Post-Construction Monitoring Recommendations

A post-construction monitoring program is recommended to assess the performance of the implemented channel design and wetlands. Monitoring observations can also be used to determine the need for remedial works, if required. The following monitoring and reporting activities are suggested for the realigned channel and wetlands following construction completion:

- Document general observations of the channel works after construction and after the first large flooding event to identify any potential areas of erosion concern
- Collect a photographic record of site conditions
- Complete a total station survey of the longitudinal profile and monumented cross sections that will serve as the as-built reference condition for use in comparing surveys completed in subsequent monitoring years
- Install erosion pins at monumented cross sections to record potential adjustments in channel geometry

- Prepare a summary report to document design implementation

The following monitoring and reporting activities are suggested for the realigned channel and wetland design in years 1, 2, 5 and 10, commencing the year following construction completion:

- Re-survey the longitudinal profile and monumented cross sections
- Re-measure erosion pins at monumented cross sections
- Characterize bed material based on Wolman (1954) pebble counts
- Complete general vegetation surveys to determine survivorship of planted materials (any dead, diseased or damaged plant materials will be replaced within the warranty period)
- Collect a photographic record of site conditions
- Prepare a summary report that documents findings during each year of monitoring

# 9 Summary and Recommendations

The fluvial geomorphological assessment summarized here is in support of the Upper West Side Secondary Plan Area. This study provides a summary of existing conditions associated with the drainage features on site and can be used to inform future development plans for the subject lands. The study has been completed in accordance with the fluvial geomorphology TOR provided to the City of Hamilton. Although, we note that the TOR is still under review by the City.

The fluvial geomorphological component included a background review of site conditions and a historical review of drainage features and adjacent land use practices. Field reconnaissance was completed in conjunction with NRSI staff over the 2019 and 2020 field seasons. Supplemental field observations were also collected in Fall 2023. The study provided reach delineation and characterization, classification and management recommendations using the Headwater Drainage Feature Assessment framework developed by the TRCA/CVC (2014) based on a combination of desktop analysis and field observations. Although field data was collected over 2019, 2020, and 2023, we recommend that reconnaissance-level work be completed in spring to confirm the appropriateness of observations collected and documented to date. Spring assessment will be especially beneficial given the abundance of headwater drainage features on site.

Further geomorphological assessment and analysis was completed to review preliminary erosion mitigation strategies for stormwater management (SWM). The initial modelling completed did not account for any Low Impact Development (LID) strategies no site. The lack of onsite retention, in part, resulted in higher rates of erosion. It is our understanding that the current SWM plan will be refined at future planning stages. As such, the erosion mitigation assessment provided here in preliminary in nature. The modelling should be updated with a level of integrated LID strategy to assess erosion potential. We note that continuous modelling may also be required at a future date.

Finally, a conceptual channel realignment design was completed for the subject lands. There may be an opportunity to update and refine certain design elements to provide a higher level of functionality than what is currently on the landscape. The results, analysis, and design components summarized in this study are preliminary and should be reviewed and refined during future planning/study stages.

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

Respectfully submitted,

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Jan Franssen, Ph.D.
Senior Watershed Scientist

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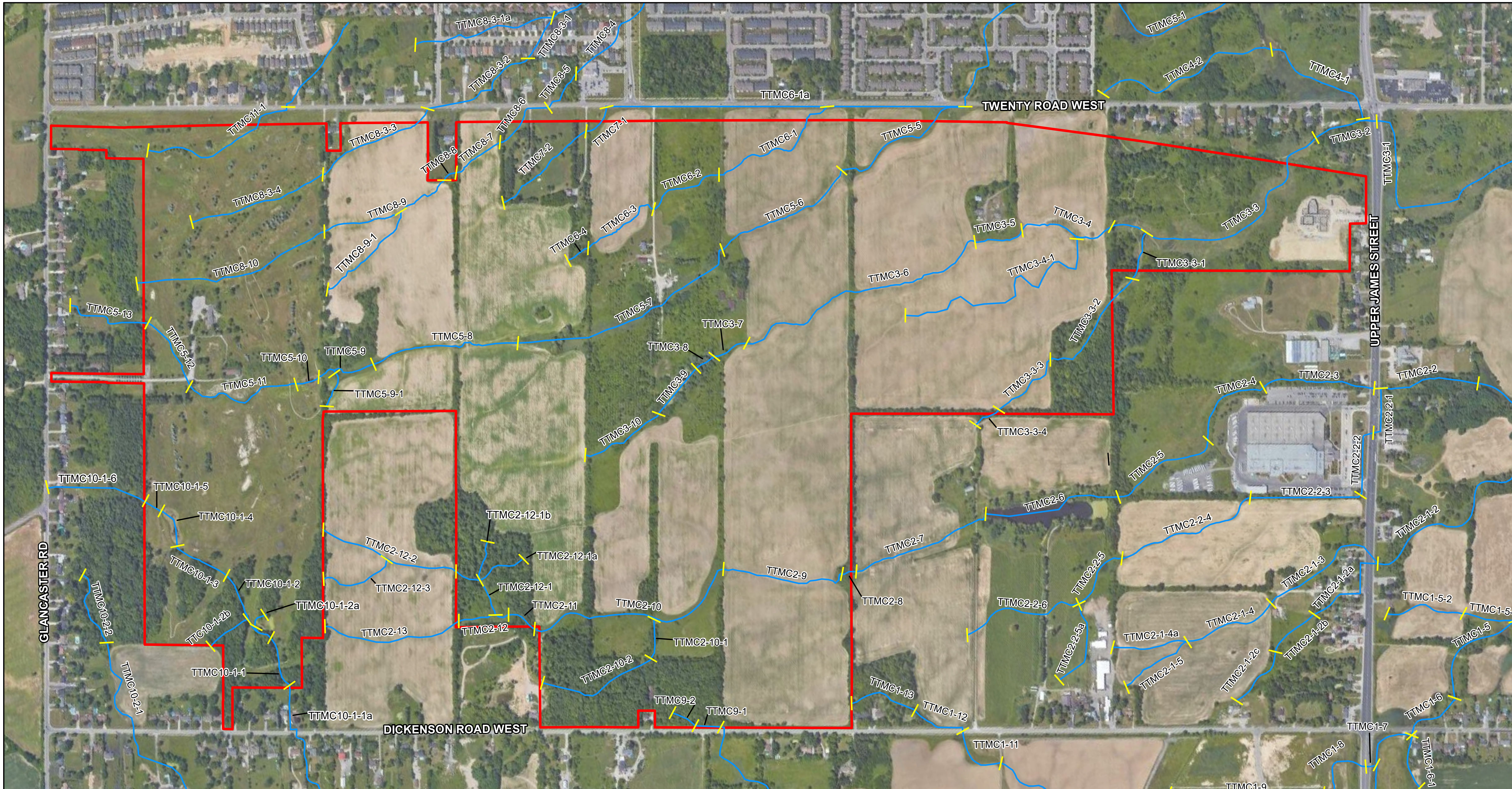
# Appendix A
# Subject Lands Mapping




**Legend**

Reach Break and ID

Watercourse

Participating Properties

Figure 1

**Tributaries of Twenty Mile Creek**

Upper West Side Study Area and Reach Delineation

Hamilton, Ontario

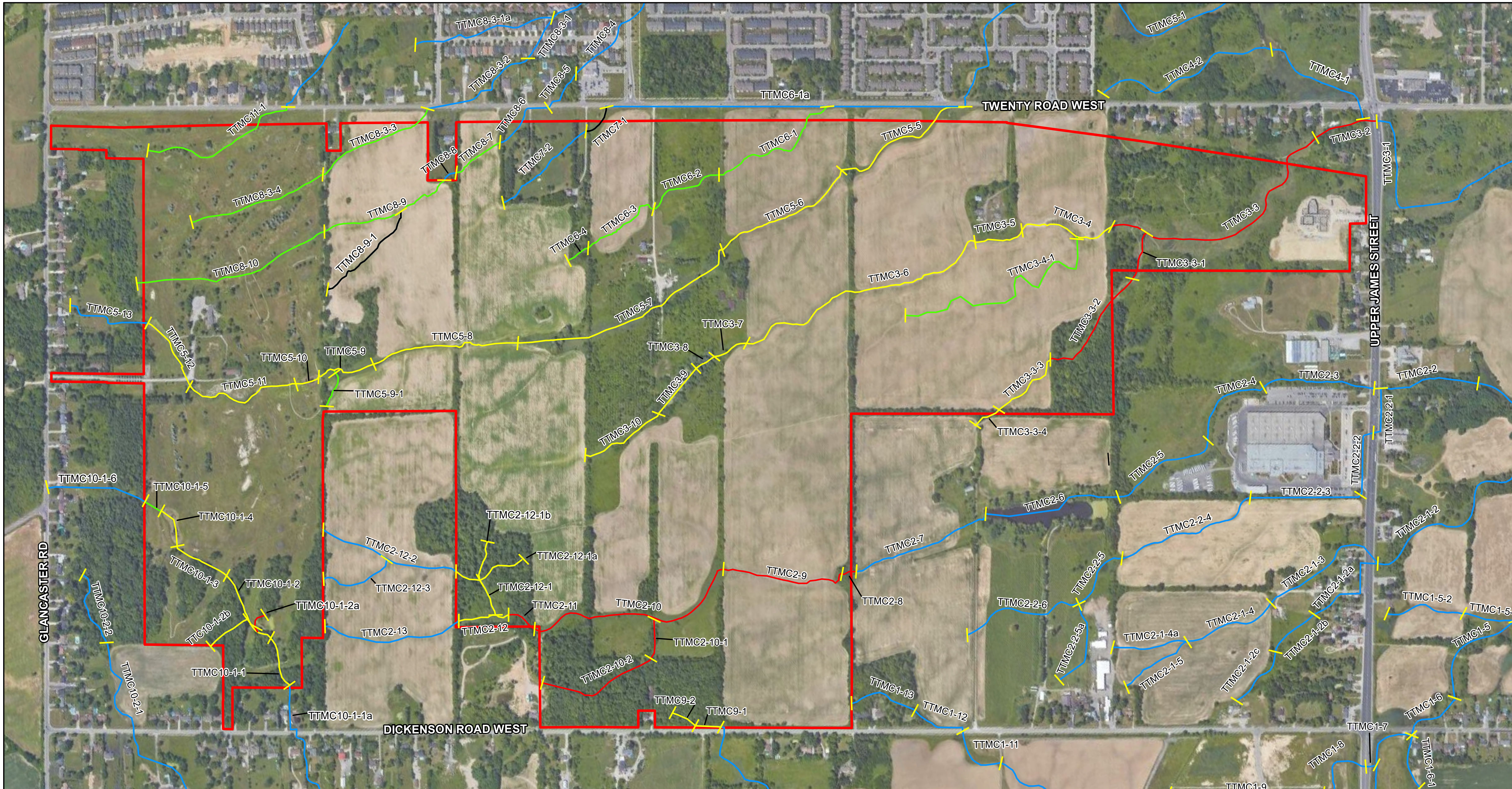
GEO MORPHIX™

N

0 160 320

Metres

Imagery: Google Earth Pro, June 2018.
Reach Break: Natural Resource Solutions Inc., 2013,
and GEO Morphix Ltd., 2018. Watercourse: GEO Morphix Ltd., /
NRSI, 2023. Participating Properties. NRSI, 2023.
Printed: November 2023. PN23079. Drawn By: M.O., K.W.




**Legend**

- Reach Break and ID (TTMC4-1)
- Watercourse
- Participating Properties

**HDF Management Classification**

- Drainage Feature - Not Assessed
- Protection
- Mitigation
- Conservation
- No Management Required

Figure 2
**Tributaries of Twenty Mile Creek**

Upper West Side Study Area
and Headwater Classification

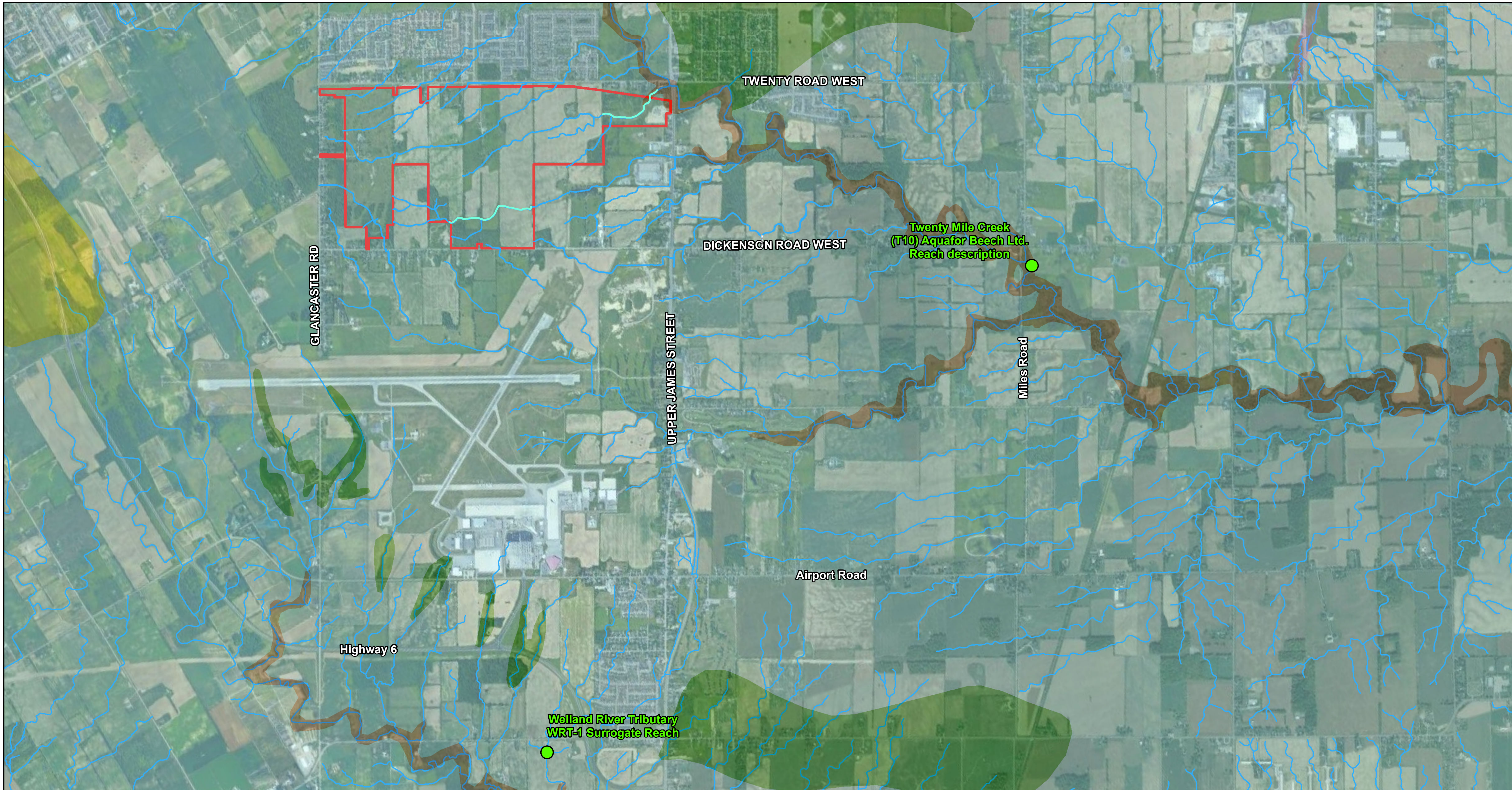
Hamilton, Ontario

GEO MORPHIX™

N

0 160 320
Metres

Imagery: Google Earth Pro, June 2018.
Reach Break: Natural Resource Solutions Inc., 2013,
and GEO Morphix Ltd., 2018. Watercourse: GEO Morphix Ltd., /
NRSI, 2023. Participating Properties. NRSI, 2023.
Printed: November 2023. PN23079. Drawn By: M.O., K.W.




**Legend**

- Reach Break and ID
- TTMC4-1 Past Assessments
- Watercourse
- Detailed Assessment
- Participating Properties

**Surficial Geology**

- 3: Paleozoic bedrock
- 5d: Glaciolacustrine-derived silty to clayey till
- 8a: Massive-well laminated
- 9: Coarse-textured glaciolacustrine deposits
- 19: Modern alluvial deposits



Figure 3

**Upper West Side**

Study Area Context

Hamilton, Ontario

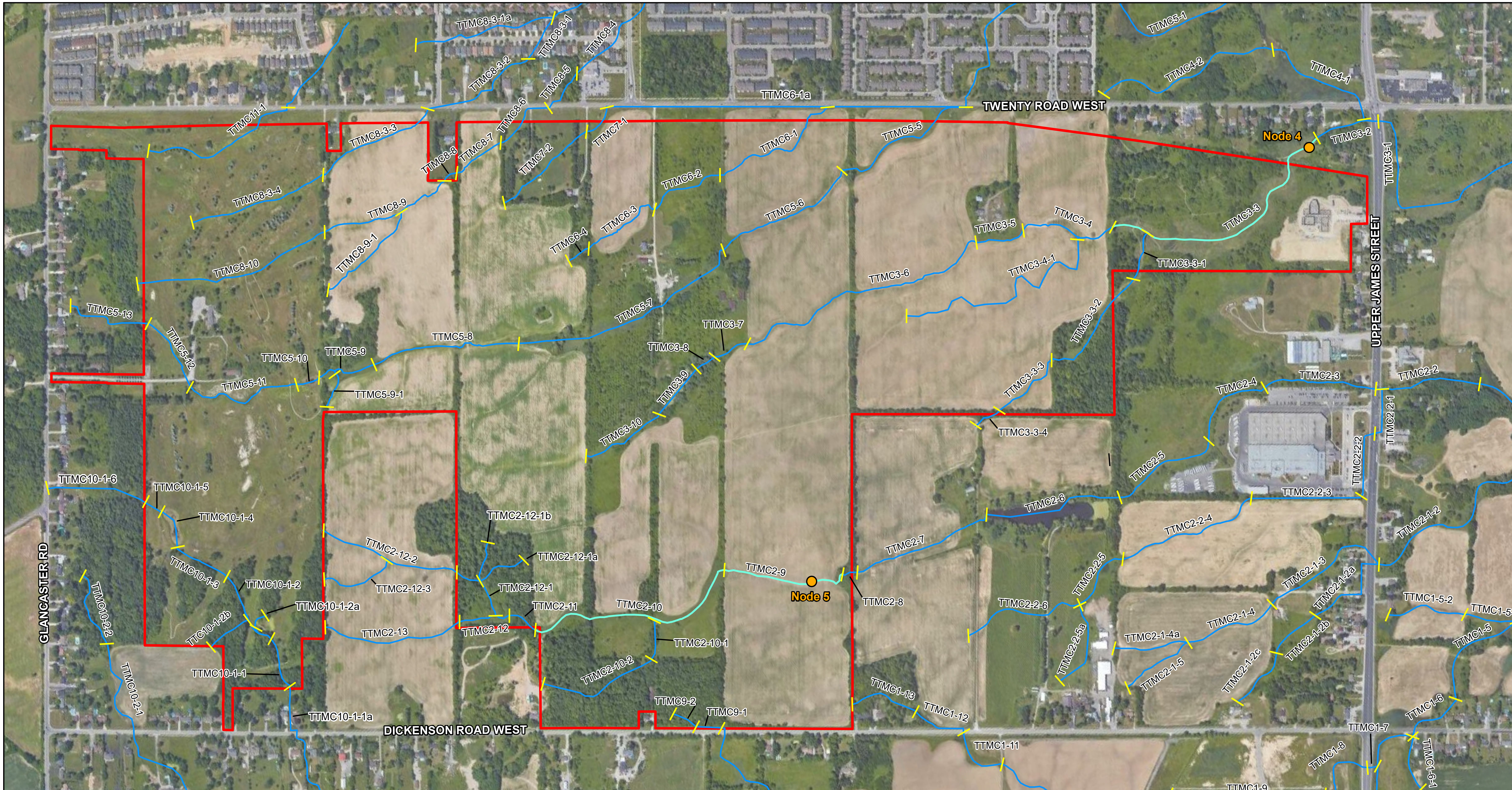
GEO MORPHIX™

N

0 600 1,200

Metres

Imagery: Google Earth Pro, June 2018. Surficial Geology: MNRF, 2020.
Reach Break: Natural Resource Solutions Inc., 2013,
and GEO Morphix Ltd., 2018. Watercourse: GEO Morphix Ltd., /
NRSI, 2023. Participating Properties. NRSI, 2023.
Past Assessment: GEO Morphix Ltd. / Aquafor Beech Ltd..
Printed: November 2023. PN23079. Drawn By: J.F., M.O., K.S.




**Legend**

- Reach Break and ID
- Node Location
- Watercourse
- Detailed Assessment Location
- Participating Properties

Figure 4

**Upper West Side**

Tributaries of Twenty Mile Creek Erosion Assessment

Hamilton, Ontario

GEO MORPHIX™

N

0 160 320

Metres

Imagery: Google Earth Pro, June 2018.
Reach Break: Natural Resource Solutions Inc., 2013,
and GEO Morphix Ltd., 2018. Watercourse: GEO Morphix Ltd., /
NRSI, 2023. Participating Properties. NRSI, 2023.
Detailed Assessment, Node Location: GEO Morphix ltd., 2023.
Printed: November 2023. PN23079. Drawn By: J.F., M.O., K.S.

# Appendix B
# Historical Aerial Photographs

**Year:** 1952
**Location** (blue dot):Upper James Street and Twenty Road West
**Source:** McMaster University Aerial Photo Library

**Year:** 1959
**Location** (blue dot):Upper James Street and Twenty Road West
**Source:** McMaster University Aerial Photo Library


**Year**: 2005
**Location** (blue dot):Upper James Street and Twenty Road West
**Source:** Google Earth Pro

**Year**: 2017
**Location** (blue dot):Upper James Street and Twenty Road West
**Source:** Google Earth Pro

# Appendix C
# Photographic Record

| | |
|---|---|
| Photo 1<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTCM2-9** | <br><br>The feature lacked defined bed and banks and conveyed substantial flow through an agricultural field during the spring visit. The Yellow arrow denotes the flow direction. |
| Photo 2<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTCM2-9** | <br>No riparian or aquatic vegetation was observed within or adjacent to the feature. Notably, the feature's substrate was equivalent to that of the surrounding fields. |

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| Photo 3<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTCM2-9** | <br>The feature was indistinguishable from the surrounding landscape during the summer, with no channel formation or hydrophilic vegetation observed. |
| Photo 4<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC2-10** | <br><br>The feature was a poorly-defined channel with substantial water flowing through an agricultural field and a hedgerow during the spring visit. |

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| Photo 5<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC2-10** | <br>Herbaceous and grass vegetation were observed within and adjacent to the channel. Bed materials were equivalent to the surrounding fields. |
| Photo 6<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC2-10** | <br>The feature was dry and indistinguishable from the surrounding fields during the summer, with no channel formation or hydrophilic vegetation observed. |

| Photo 7<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC2-10-1** |  |
|---|---|
| | The feature lacked defined bed and banks and conveyed minimal flow through an agricultural field and a hedgerow during the spring visit. |
| Photo 8<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC2-10-1** |  |
| | The wet meadow corridor consisted mostly of hydrophilic herbaceous and grass species. Bed materials were silt and organic material. |

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| Photo 9<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC2-10-1** | <br>The feature was dry and indistinguishable from the surrounding landscape during the summer, with no channel formation. |
| Photo 10<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC2-10-2** | <br>The feature lacked defined bed and banks and conveyed substantial flow through a woodlot during the spring visit. |

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| Photo 11<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC2-10-2** | <br>Deciduous tree species were observed adjacent to the channel and minimal flow was present during the second visit. |
| Photo 12<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC2-10-2** | <br>Feature was dry but distinguishable from the surrounding landscape during the third visit. Bed materials consisted predominantly of silt and clay. |

Photo 13
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC2-11**


The feature had defined bed and banks, with substantial water flowing during the spring visit.

Photo 14
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC2-11**

Minimal flow was conveyed through the deciduous forest during the second visit.

| | |
|---|---|
| Photo 15<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC2-11** |  |
| | Feature was dry but distinguishable from the surrounding landscape in the summer visit. Bed materials consisted predominantly of silt, clay and some gravel which were poorly sorted. |
| Photo 16<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC2-12** |  |
| | The feature lacked defined bed and banks and conveyed minimal flow nearby to the woodlot during the spring visit. |

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| Photo 17<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC2-12** |  |
| | The poorly defined channel had some standing water during the second visit, and lacked banks to distinguish it from the adjacent grassland. |
| Photo 18<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC2-12** |  |
| | The feature was dry and indistinguishable from the surrounding landscape during the summer, with no channel formation. Bed materials consisted of clay, silt and organic matter. |

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| Photo 19<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC2-12-1** | <br>The feature lacked defined bed and banks and conveyed minimal flow through the woodlot during the spring visit. |
| Photo 20<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC2-12-1** | <br>Riparian vegetation for the reach consisted predominantly of deciduous trees. Standing water was present during the second visit. |

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| Photo 21<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC2-12-1** | <br>The feature was dry during the summer visit but was distinguishable from the surrounding woodlot. Bed materials consisted of clay, silt and organic matter. |
| Photo 22<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC2-12-1b** | <br>The feature was a low gradient swale conveying minimal flow through a woodlot. No bed or bank definition were observed. |

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| Photo 23<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC2-12-1b** | <br>Riparian vegetation consisted of herbaceous vegetation and deciduous tree species. Standing water was observed during the second visit. |
| Photo 24<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC2-12-1b** | <br>The feature was dry during the summer visit but distinguishable from the surrounding woodlot. Bed materials consisted of sand, silt and organic matter |

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| Photo 25<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-1** | <br>The feature was a defined straight channel conveying flows towards its confluence with Twenty Mile Creek on the east side of Upper James Street. |
| Photo 26<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-1** | <br>Riparian vegetation consisted of scrubland and some hydrophilic vegetation. Bed materials consisted of clay and silt. |

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| Photo 27<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-1** | <br>A culvert discharged flows into the feature near its downstream extent. No water was observed within the pipe during the second visit. |
| Photo 28<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-2** | <br>The feature had no discernible banks, and occupied a wide grassy corridor characterized as a provincially significant wetland (PSW). |

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| Photo 29<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-2** |  |
| | Riparian vegetation consisted of grasses with sparse herbaceous vegeation, and water was present during all 3 visits. |
| Photo 30<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-2** |  |
| | Tadpoles were observed within an isolated pool. Substrate consisted of clay, silt and organic materials. |

Photo 31
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC3-2-1**

The feature was a defined channel which conveyed flows through a woodlot.

Photo 32
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC3-2-1**

Riparian vegetation included mature deciduous trees as well as some shrubs and hydrophilic herbaceous vegetation

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| Photo 33<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-2-1** | <br>The feature was dry during the summer visit but distinguishable from the surrounding landscape. Bed materials consisted predominantly of clay, silt and organic material |
| Photo 34<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-2-2** | <br>The feature had defined bed and banks within the agricultural lands during freshet. |

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|---|---|
| Photo 35<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-2-2** |  |
| | The feature was surrounded by agricultural crops along its upstream section and ends in a woodlot populated by deciduous trees. Some water was flowing during the second visit. |
| Photo 36<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-2-2** |  |
| | The feature was dry during the last visit and the substrate consisted predominantly of clay, silt and gravel. |

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| Photo 37<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-3** | <br>The feature lacked defined bed and banks and conveyed flows through an agricultural field during the spring visit**.** |
| Photo 38<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-3** | <br>Riparian vegetation consisted predominantly of crops, with some grasses. Bed materials were indistinguishable from the surrounding fields. |

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|---|---|
| Photo 39<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-3** | <br>The feature was dry and almost indistinguishable from the surrounding landscape during the summer. |
| Photo 40<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-4** | <br>The feature had well defined bed and banks within the agricultural fields during the spring visit and was conveying flow**.** |

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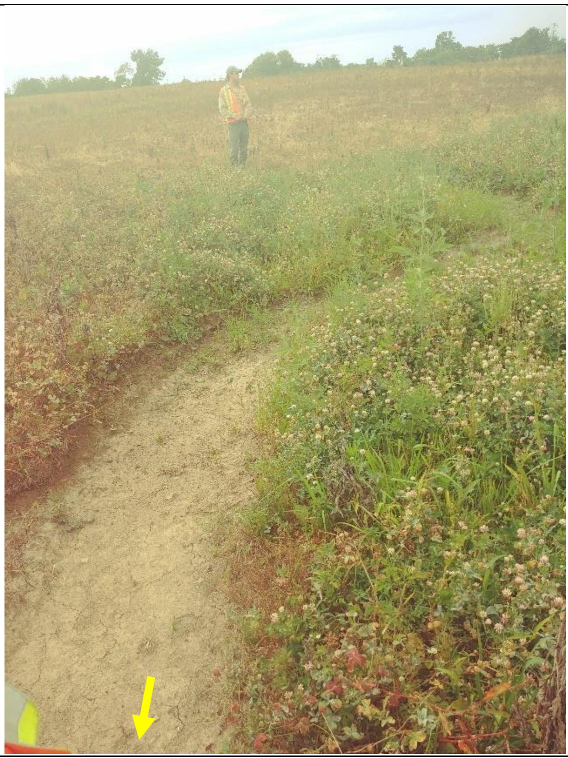
| Photo 41<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-4** | <br><br>The riparian buffer consisted predominantly of herbaceous species, with some agricultural crops noted on the south side of the channel further downstream. |
| Photo 42<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-4** | <br>The channel bed was predominantly composed of clay and gravel and was dry during the summer visit. |

| | |
|---|---|
| Photo 43<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-5** | <br>The feature had some bed and bank definition within the agricultural lands during the spring and was conveying flow**.** |
| Photo 44<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-5** | <br>The majority of the riparian buffer consisted of agricultural crops. |

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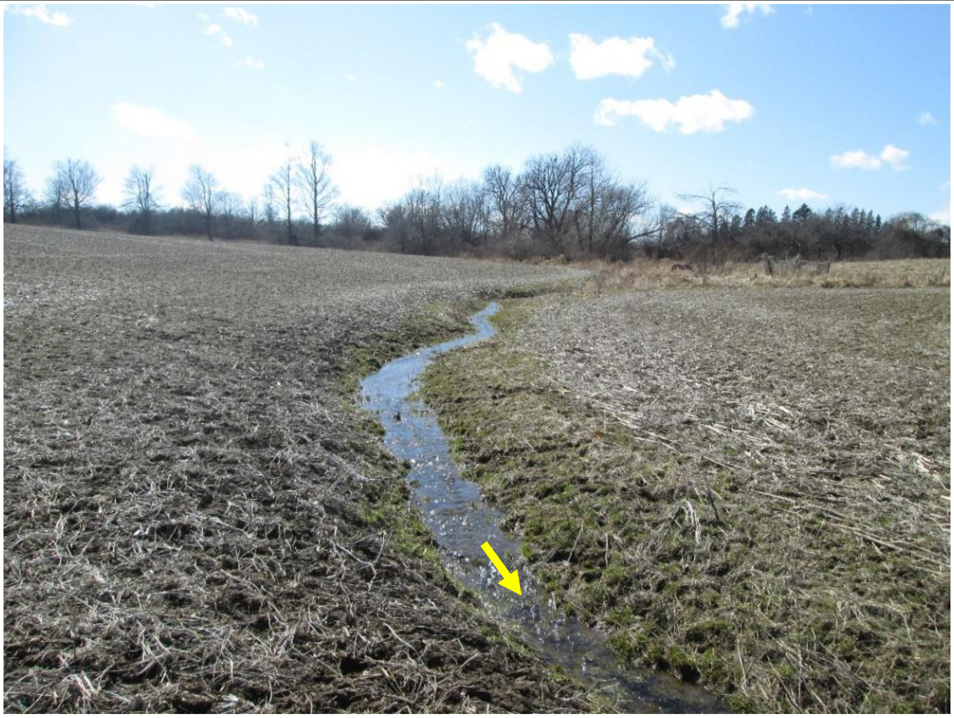
|---|---|
| Photo 45<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-5** | <br>The dominant substrate was clay and silt, but some sand, gravel and, cobbles were also observed. The channel was mainly dry with some isolated stagnant pools. |
| Photo 46<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-6** | <br>The feature conveyed flows through an agricultural field, with water present during the spring visit**.** |

| Photo 47<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-6** | <br>Riparian vegetation was predominantly agricultural crops, with some herbaceous and grass species also observed. |
|---|---|
| Photo 48<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-6** | <br>Bed and banks were mostly composed of the same material as the agricultural fields, a clay, silt, sand mixture, although some cobbles were present. |

Photo 49
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC3-7**

The feature lacked bed and bank definition and conveyed flows from the central woodlot though a meadow to the agricultural field.

Photo 50
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC3-7**


The feature was dry and indistinguishable from the surrounding landscape during the summer, with no discernible channel.

Photo 51
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC3-7**


The bed was composed of poorly sorted clay, silt, sand and sparse gravel. The feature was dry during the summer visit.

Photo 52
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC3-8**

The feature was poorly defined and conveyed flows from the online pond to the meadow flanking the agricultural field to the east.

Photo 53
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC3-8**


Riparian vegetation consisted of deciduous trees and herbaceous vegetation.

Photo 54
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC3-8**


Bed materials consisted of clay, silt, sand and organic material. The feature was dry during the summer visit.

| | |
|---|---|
| Photo 55<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-9** |  |
| | The feature was an online pond located roughly in the middle of the subject lands within a woodlot. |
| Photo 56<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-9** |  |
| | Riparian vegetation consisted predominantly of mature deciduous trees which provided shading to the pond |

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|---|---|
| Photo 57<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC3-10** | <br>The feature lacked bed and bank definition and conveyed flows through a meadow. |
| Photo 58<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC3-10** | <br><br>The swale was populated by dense hydrophilic vegetation in the feature itself and its riparian zone. |

| Photo 59<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC3-10** | <br>The substrate within the reach was clay, silt and sand. No flows were observed during the summer visit. |
|---|---|
| Photo 60<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC5-4** | <br>The feature had poor channel definition and conveyed flows through an agriculture field. |

Photo 61
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC5-4**


The feature occupied a relatively wide corridor composed of hydrophilic herbaceous vegetation and grasses.

Photo 62
Tributary of Twenty Mile Creek: Visit 3
Reach TTMC5-4


The substrate material was equivalent to the surrounding fields and consisted of clay, silt and sand.

Photo 63
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC5-5**

The feature lacked bed and bank definition and conveyed flows through an agricultural field.

Photo 64
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC5-5**


The swale lacked a natural riparian corridor and was instead flanked by agricultural fields.

| | |
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| Photo 65<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC5-5** | <br>The feature was dry during the summer visit and substrate was generally consistent with the adjacent fields. |
| Photo 66<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC5-6** | <br>The feature lacked bed and bank definition and conveyed flows within a wooded area. |

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| Photo 67<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC5-6** | <br><br>The feature was a wide grassy corridor composed of hydrophilic vegetation with deciduous trees occupying the riparian buffer. |
| Photo 68<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC5-6** | <br><br>The substrate within the channel was predominantly clay, silt and sand. No water was observed during the summer visit. |

| Photo 69<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC5-7** | <br>The feature had some bed and bank definition during the spring as it conveyed flows through an agricultural field. |
|---|---|

| Photo 70<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC5-7** | <br>Riparian vegetation consisted of grasses, with some areas lacking a buffer and instead being flanked by crops. |
|---|---|

Photo 71
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC5-7**


Substrate within the feature consisted of clay, silt, and sand and the channel was occupied by sparse rooted emergent aquatic vegetation and grasses.

Photo 72
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC5-8**

The feature was a swale which conveyed flows through an agricultural field.

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|---|---|
| Photo 73<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC5-8** | <br>The feature had a narrow riparian corridor composed of herbaceous vegetation and grasses. |
| Photo 74<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC5-8** | <br>Substrate composition was predominantly clay, silt and sand with some scattered gravels. The feature was dry during the summer visit. |

Photo 75
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC5-8-1**

The feature had poorly defined banks, but a discernible channel was observed. Water was flowing during the spring visit.

Photo 76
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC5-8-1**


Riparian vegetation consisted of herbaceous vegetation and grasses. The channel was dry during the second visit.

Photo 77
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC5-8-1**


Bed substrate consisted of clay, silt and sand. The feature was again dry during the summer visit.

Photo 78
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC5-9**

The feature originated at the outlet of a small pond within the former Glancaster Golf and Country Club and conveyed flows through an agricultural field.

| Photo 79<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC5-9** | <br><br>The feature's substrate consisted predominantly of organic material, silt and sand. |
|---|---|
| Photo 80<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC6-1** | <br>The feature lacked defined bed and banks, and minimal flow was observed during the spring site visit. |

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|---|---|
| Photo 81<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC6-1** | <br>The channel was dry during the 2nd visit and the substrate was predominantly clay, silt, and sand. Some gravel and cobbles were also observed. |
| Photo 82<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC6-1** | <br>Vegetation within the feature was predominantly composed of the crops which occupied the adjacent fields, with sparse aquatic vegetation was infrequently observed. |

Photo 83
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC6-2**

The feature had poor channel definition and originated at a culvert. The reach conveyed flows within the fallow orchard**.**

Photo 84
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC6-2**


The feature was filled with dense, rooted emergent aquatic vegetation, particularly grasses, and was flanked by both meadow and scrubland within the riparian buffer.

| | | |
|---|---|---|
| Photo 85<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC6-2** | <br><br>Bed substrate within the feature was predominantly clay, silt and sand. No water was present during the summer visit. | |
| Photo 86<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC6-3** | <br>The feature lacked bed and bank definition and conveyed flows through an agricultural field north of a central residential property**.** | |

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| Photo 87<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC6-3** | <br>The channel was located adjacent to an un-planted agricultural field and had a narrow herbaceous riparian buffer. |
| Photo 88<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC6-3** | <br>Substrate within the feature was clay, silt and sand. No discernable channel could be located at the upstream extent of the reach. The feature was dry during the summer visit. |

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|---|---|
| Photo 89<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC6-4** | <br>The feature lacked definition and is best described as a vernal pool within a wide hedgerow between two agricultural fields. |
| Photo 90<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC6-4** | <br>The feature was surrounded by scrubland and deciduous trees. |

Photo 91
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC6-4**


The feature was dry during the summer visit and its substrate consisted predominantly of decomposing organics.

Photo 92
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC7-1**

The feature originated at a culvert and was poorly defined.

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| Photo 93<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC7-1** | <br>The feature was surrounded by meadow and grass species and some standing water was observed during the second visit. |
| Photo 94<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC7-1** | <br>Bed material for the reach was predominantly clay, silt and sand. No water was present within the reach during the third visit. |

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| Photo 95<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC8-6** | <br>The feature lacked bed and bank definition and conveyed flows towards a roadside ditch at Twenty Road West. |
| Photo 96<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC8-6** | <br><br>The feature's vegetation was equivalent to the surrounding area, and consisted of a manicured lawn. |

Photo 97
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC8-6**


The feature was dry during the 2nd visit.

Photo 98
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC8-7**


The feature lacked a natural riparian buffer, and was predominantly cropped with some areas lacking any vegetation.

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| Photo 99<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC8-7** |  | |
| | Substrate composition was predominantly clay, silt, sand and sparse gravel. The feature was dry during the summer visit. | |
| Photo 100<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC8-9** |  | |
| | The feature was a swale which conveyed flows through an agricultural field. | |

| | | |
|---|---|---|
| Photo 101<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC8-9** | <br>Riparian vegetation consisted predominantly of agricultural crops, which were generally absent from the channel during the spring. |
| Photo 102<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC8-9** | <br>Substrate composition was consistent with the adjacent fields, and was predominantly clay, silt, and sand. The feature was dry during the summer visit. |

Photo 103
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC8-9-1**


The feature lacked definition and conveyed flows through an agricultural field. Standing water was observed during the 2nd visit.

Photo 104
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC 8-9-1**


Bed composition was predominantly clay, silt and sand. The feature was dry during the summer visit.

Photo 105
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC8-10**

The feature lacked channel definition and conveyed flows through an agricultural field.

Photo 106
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC8-3-3**

The feature lacked channel definition and conveyed flows through an agricultural field.

Photo 107
Tributary of Twenty Mile Creek: Visit 2
**Reach TTMC8-3-3**


The feature lacked natural riparian vegetation and was flanked by crops, which encroached the channel**.**

Photo 108
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC8-3-3**

Substrate within the intermittent feature was predominantly clay, silt, and sand. No water was observed during the 3rd visit.

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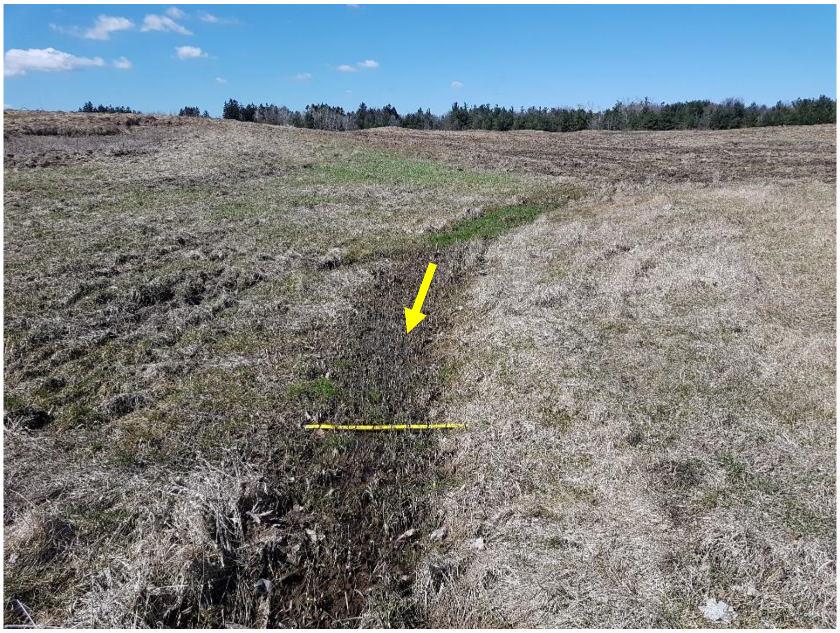
|---|---|
| Photo 109<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC8-3-4** | <br>The feature lacked channel definition and contained limited water during first round visit. |
| Photo 110<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC9-1** | <br>The feature lacked channel definition and conveyed flows through a woodlot. |

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|---|---|
| Photo 111<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC9-1** | <br>Riparian vegetation adjacent to the feature consisted of deciduous trees. No water was present during the 2nd visit. |
| Photo 112<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC9-1** | <br>The low gradient feature's substrate was predominantly composed of decomposing organic matter and silt. Water was not observed during the 3rd visit. |

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| Photo 113<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC9-1a** |  |
| | The feature ran parallel to a road and a woodlot with water present during visit 1. |
| Photo 114<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC9-1a** |  |
| | The feature was narrow, but partially defined. Dense vegetation present during visit 2. |

Photo 115
Tributary of Twenty Mile Creek: Visit 3
**Reach TTMC9-1a**

Extreme vegetation encroachment during visit 3. Poorly defined feature.

Photo 116
Tributary of Twenty Mile Creek: Visit 1
**Reach TTMC10-1-2**

The feature lacked channel definition and ran through a meadow.

| Photo 117<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC10-1-2** | <br>The feature lacked channel definition and conveyed through area with wooded riparian area. |
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| Photo 118<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC10-1-2** | <br>The feature lacked channel definition and was overgrown by grasses in the summer months |
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| Photo 120<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC10-1-2a** | <br>The feature is composed of a small pond which outflows to the south. Contained submergent vegetation and standing water |
| Photo 121<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC10-1-2a** | <br>The feature is composed of a small pond which outflows to the south. Contained submergent vegetation and standing water. |

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| Photo 122<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC10-1-3** | <br>The feature lacked channel definition and conveyed flow through a woodlot into an open meadow. |
| Photo 123<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC10-1-3** | <br>A culvert was present at the feature and was well defined. |

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| Photo 124<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC10-1-3** |  | |
| | The feature lacked channel definition and was surrounded by dense vegetation. | |
| Photo 125<br>Tributary of Twenty Mile Creek: Visit 1<br>**Reach TTMC10-1-4** |  | |
| | The feature had poor channel definition and originated at a culvert. | |

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| Photo 126<br>Tributary of Twenty Mile Creek: Visit 2<br>**Reach TTMC10-1-4** | <br>The feature flowed through a grassy meadow and had a defined channel |
| Photo 127<br>Tributary of Twenty Mile Creek: Visit 3<br>**Reach TTMC10-1-4** | <br>The feature lacked channel definition and was surrounded by dense vegetation. |

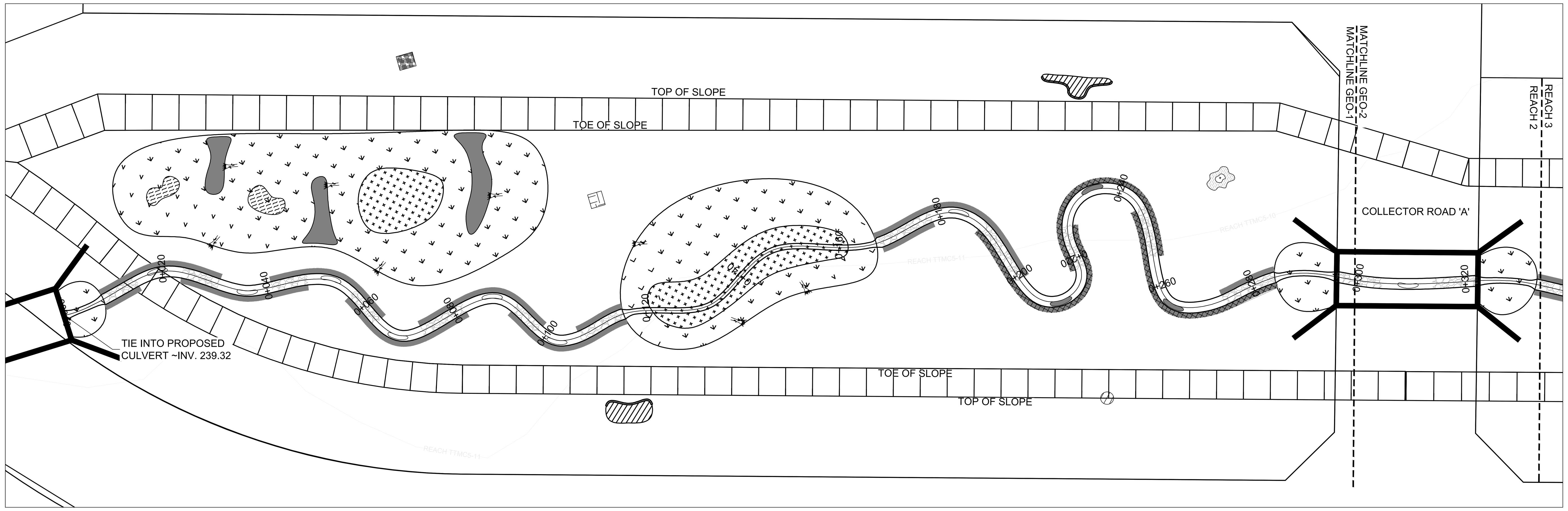
# Appendix D
# Headwater Assessment Summary Table

| Tributary / Reach | Hydrology | Hydrology Modifier | Riparian Conditions | Fish and Fish Habitat | Terrestrial Function | Management Classification | Final Management Classification | Notes |
|---|---|---|---|---|---|---|---|---|
| **Tributary TTMC2** | | | | | | | | |
| **TTMC2-8** | Important | Modified drainage at downstream end (flows enter a catchbasin-like structure). Feature may receive flows from tile drain system (circular concrete structure built at field edge upstream, possibly to limit flooding within agricultural field) | Important | Contributing | Valued | Protection | Protection | - |
| **TTMC2-9** | Valued | Tile drain outlet located at upstream end | Limited | Contributing | Limited | Mitigation | Protection | Upgraded to Protection due to upstream and downstream Protection reaches. |
| **TTMC2-10** | Valued | None | Important | Contributing | Important | Protection | Protection | - |
| **TTMC2-10-1** | Valued | None | Valued | Contributing | Important | Conservation | Protection | Upgraded to Protection due to upstream and downstream Protection reaches. |
| **TTMC2-10-2** | Valued | None | Important | Contributing | Important | Protection | Protection | - |
| **TTMC2-11** | Valued | None | Important | Contributing | Important | Protection | Protection | - |
| **TTMC2-12** | Valued | None | Important | Contributing | Contributing | Conservation | Conservation | - |
| **TTMC2-12-1** | Valued | None | Important | Contributing | Contributing | Conservation | Conservation | - |
| **TTMC2-12-1a** | Contributing | None | Important | Contributing | Contributing | Conservation | Conservation | - |
| **TTMC2-12-1b** | Contributing | None | Important | Contributing | Contributing | Conservation | Conservation | - |
| **Tributary TTMC3** | | | | | | | | |
| **TTMC3-2** | Valued | None | Important | Important | Important | Protection | Protection | - |
| **TTMC3-3** | Valued | None | Important | Important | Important | Protection | Protection | - |
| **TTMC3-3-1** | Valued | Feature originates from tile drain at property edge | Important | Valued | Important | Protection | Protection | - |
| **TTMC3-3-2** | Valued | | Important | Valued | Important | Protection | Protection | - |
| **TTMC3-3-3** | Valued | | Limited | Valued | Limited | Conservation | Conservation | - |
| **TTMC3-3-4** | Important | | Important | Valued | Limited | Protection | Conservation | Protection classification result of hydrology and riparian conditions. Hydrology and vegetation communities sustained by artificial tile drain contributions. Management downgraded to Conservation. |
| **TTMC3-4** | Contributing | None | Limited | Valued | Contributing | Conservation | Conservation | - |
| **TTMC3-4-1** | Valued | Regularly tilled | Limited | Contributing | Limited | Mitigation | Mitigation | - |
| **TTMC3-5** | Contributing | None | Valued | Valued | Contributing | Conservation | Conservation | - |
| **TTMC3-6** | Valued | None | Limited | Valued | Contributing | Conservation | Conservation | - |
| **TTMC3-7** | Contributing | None | Important | Valued | Valued | Protection | Conservation | Feature classifications downgraded to Conservation to allow flexiblity in location of these reaches to preserve and enhance overall habitat and maintain connectivity with downstream reaches that are candidate for realignment/enhancement. Opportunity to create more connected system with morphological and habitat diversity. |
| **TTMC3-8** | Contributing | None | Important | Valued | Valued | Protection | Conservation | |
| **TTMC3-9** | Important | Feature is an online anthropogenic pond | Important | Important | Important | Protection | Conservation | Reach downgraded to Conservation due to anthopogenic pond constructed to support historic orchard activites. Poor quality habitat, thermal impacts downstream, and disruption to sediment regime presents opportunity for enhancement. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TTMC3-10** | Valued | None | Important | Valued | Valued | Protection | Conservation | Reach downgraded to Conservation to allow flexiblity in location of reach and to preserve and enhance overall habitat and maintain connectivity with downstream reaches that are candidate for realignment/enhancement. Opportunity to create more connected system with morphological and habitat diversity. |
| **Tributary TTMC5** | | | | | | | | |
| **TTMC5-5** | Contributing | Flows from these reaches must pass through SWM ponds north of Twenty Road West prior to entering downstream aquatic habitats. | Important | Valued | Limited | Protection | Conservation | Feature classifications modified to Conservation to preserve linkage function. Protection status' were result of riparian and/or fish habitat. No connection to natural system downstream (flows enter existing SWM infrastrcture). Benefit in allowing flexiblity in location of these reaches to preserve and enhance overall habitat and maintain connectivity with Twenty Mile Creek downstream of subject lands (in association with Tributary TTMC3 and proposed natural corridor design). |
| **TTMC5-6** | Valued | | Limited | Valued | Limited | Conservation | Conservation | |
| **TTMC5-7** | Valued | | Important | Valued | Important | Protection | Conservation | |
| **TTMC5-8** | Valued | | Limited | Valued | Contributing | Mitigation | Conservation | |
| **TTMC5-9** | Contributing | | Important | Valued | Important | Protection | Conservation | |
| **TTMC5-9-1** | Valued | | Limited | Valued | Limited | Mitigation | Mitigation | - |
| **TTMC5-10** | Important | Feature is an online anthropogenic pond, and flows from this reach must pass through SWM ponds north of Twenty Road West prior to entering downstream aquatic habitats. | Valued | Important | Important | Protection | Conservation | Reach downgraded to Conservation due to anthopogenic pond constructed to support historic golf course activites. Poor quality habitat, thermal impacts downstream, and disruption to sediment regime presents opportunity for enhancement. |
| **TTMC5-11** | Valued | Flows from these reaches must pass through SWM ponds north of Twenty Road West prior to entering downstream aquatic habitats. | Important | Valued | Important | Protection | Conservation | Feature classifications modified to Conservation to preserve linkage function. Protection status' were result of riparian and/or fish habitat. No connection to natural system downstream (flows enter existing SWM infrastrcture). Benefit in allowing flexiblity in location of these reaches to preserve and enhance overall habitat and maintain connectivity with Twenty Mile Creek downstream of subject lands (in association with |
| **TTMC5-12** | Valued | | Important | Valued | Important | Protection | Conservation | |
| **Tributary TTMC6** | | | | | | | | |
| **TTMC6-1** | Limited | No connection to a downstream watercourse (flows are piped through subdivision north of Twenty Road West and presumably enter the municipal sewer system) | Limited | None | Limited | No Management Required | Mitigation | Feature upgraded to Mitigation given upstream Mitigation reaches. |
| **TTMC6-2** | Contributing | | Important | None | Limited | Conservation | Mitigation | Feature downgraded to Mitigation given lack of connection to natural downstream system. |
| **TTMC6-3** | Contributing | | Limited | None | Limited | Conservation | Mitigation | Feature downgraded to Mitigation given lack of connection to natural downstream system. |
| **TTMC6-4** | Contributing | | Important | None | Limited | Conservation | Mitigation | Feature downgraded to Mitigation given lack of connection to natural downstream system. |
| **Tributary TTMC7** | | | | | | | | |
| **TTMC7-1** | Limited | Flows from this reach must pass through a roadside ditch and SWM ponds north of Twenty Road West prior to entering downstream aquatic habitats. | Valued | None | Limited | No Management Required | No Management Required | - |
| **Tributary TTMC8** | | | | | | | | |
| **TTMC8-3-3** | Valued | Regularly tilled, no connection to a downstream watercourse (flows are piped through subdivision | Limited | None | Limited | Mitigation | Mitigation | - |
| **TTMC8-3-4** | Valued | | Limited | None | Limited | Mitigation | Mitigation | - |
| **TTMC8-7** | Limited | | Limited | None | Limited | No Management Required | Mitigation | Upgraded to Mitigation due to upstream and downstream Mitigation reaches |

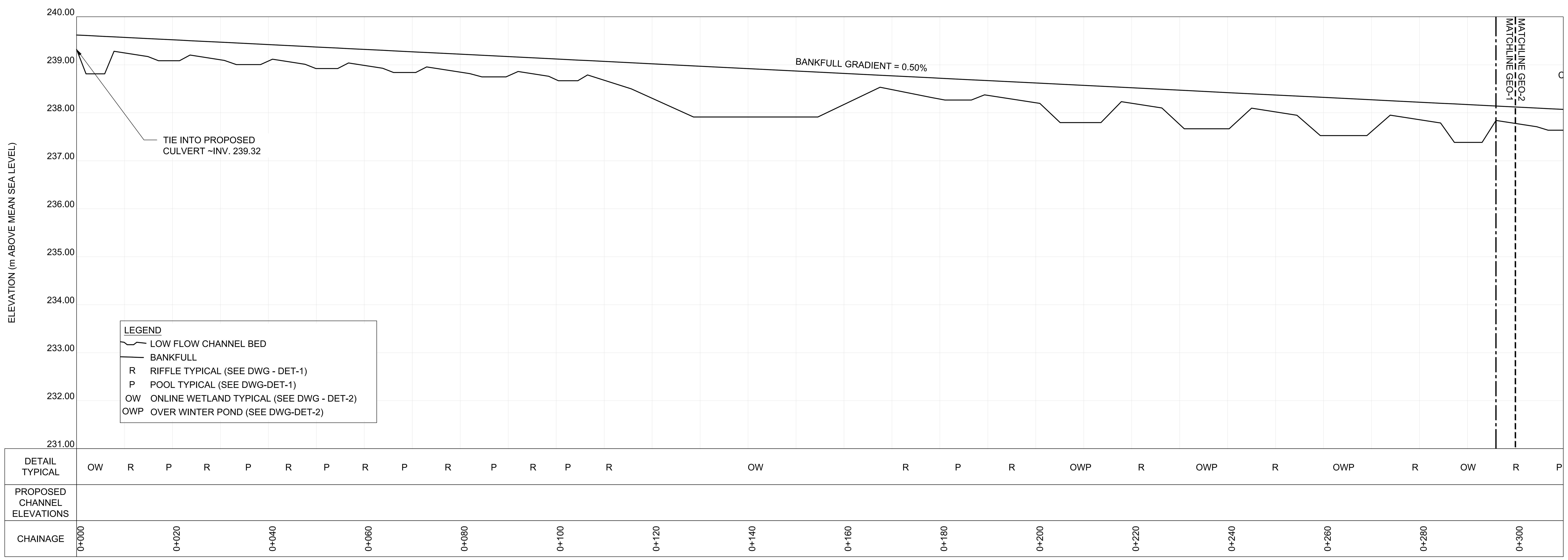
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **TTMC8-9** | Valued | north of Twenty Road West and presumably enter the municipal sewer system) | Limited | None | Limited | Mitigation | Mitigation | - |
| **TTMC8-9-1** | Limited | | Limited | None | Limited | No Management Required | No Management Required | - |
| **TTMC8-10** | Valued | | Limited | None | Limited | Mitigation | Mitigation | - |
| **Tributary TTMC9** | | | | | | | | |
| **TTMC9-1** | Contributing | Feature also functions as a roadside ditch | Important | Contributing | Contributing | Conservation | Conservation | - |
| **TTMC9-2** | Valued | None | Important | Contributing | Contributing | Conservation | Conservation | - |
| **Tributary TTMC10** | | | | | | | | |
| **TTMC10-1-1** | Valued | None | Important | Contributing | Valued | Conservation | Conservation | - |
| **TTMC10-1-2** | Valued | None | Important | Contributing | Contributing | Conservation | Conservation | - |
| **TTMC10-1-2a** | Important | Feature is an online anthropogenic pond | Important | Important | Important | Protection | Protection | - |
| **TTMC10-1-2b** | Valued | Feature originates from tile drain at property edge | Important | Contributing | Contributing | Conservation | Conservation | - |
| **TTMC10-1-3** | Valued | Regularly tilled | Limited | Contributing | Limited | Mitigation | Conservation | Upgraded to Conservation to preserve linkage function between reaches. Existing habitat poor quality and feature is regularly tilled. |
| **TTMC10-1-4** | Important | Feature is an online anthropogenic pond | Limited | Important | Important | Protection | Conservation | Reach downgraded to Conservation due to anthopogenic pond constructed to support historic golf course activities. Poor quality habitat, thermal impacts downstream, and disruption to sediment regime presents opportunity for enhancement. |
| **TTMC10-1-5** | Valued | None | Valued | Contributing | Limited | Mitigation | Mitigation | - |
| **Tributary TTMC11** | | | | | | | | |
| **TTMC11-1** | Limited | Regularly tilled, no connection to a downstream watercourse (flows are piped through subdivision north of Twenty Road West and presumably enter the municipal sewer system) | Limited | None | Limited | No Management Required | No Management Required | - |

# Appendix E
# Conceptual Channel Design Drawings




LEGEND
- CHANNEL CENTRELINE
- SWALE (SEE DWG DET-2)
- RIFFLE (SEE DWG DET-1)
- POOL (SEE DWG DET-1)
- OVERWINTER POOL (SEE DWG DET-2)
- ONLINE WETLAND ((SEE DWG DET-2)
- OFFLINE WETLAND (SEE DWG DET-2)
- OVERWINTER WETLAND POOL (1000 mm BELOW FLOODPLAIN ELEVATION)
- SUBMERGED MOUND (300 mm - 400 mm BELOW FLOODPLAIN ELEVATION)
- DRY MOUND (50 mm - 100 mm BELOW FLOODPLAIN ELEVATION)
- STONE CORE (SEE DWG DET-3)
- SEASONAL POOL (SWW DWG DET-3)
- 100% BIODEGRADABLE EROSION CONTROL BLANKET AND LIVE STAKES (SEE DWG DET-3)
- PALLET TYPE WOOD PILE (SEE DWG DET-2)
- BASKING LOG (SEE DWG DET-3)
- ROCK PILE (SEE DWG DET-2)
- RAPTOR POLE (SEE DWG DET-3)
- TURTLE NEST (SEE DWG DET-2)
- SNAKE HIBERNACULUM (SEE DWG DET-2)
- TERRESTRIAL MOUND (SEE DWG DET-3)
- BRUSH MATTRESS BANK TREATMENT (SEE DWG DET-2)

**PLANFORM**
1:500




**PROFILE**
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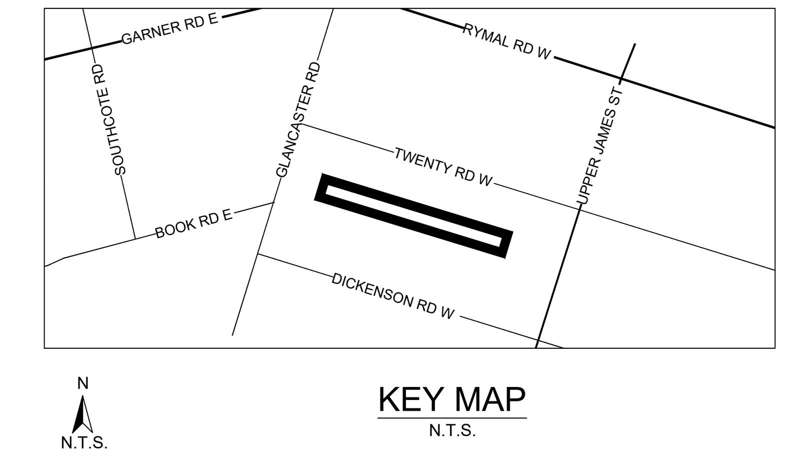


KEY MAP
N.T.S.

## GENERAL NOTES

1. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
2. THE CONTRACTOR MUST NOTIFY THE CONTRACT ADMINISTRATOR AND CONSERVATION AUTHORITY OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
3. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
4. LAYOUT MUST BE REVIEWED AND APPROVED BY THE CONTRACT ADMINISTRATOR.

## TIMING OF WORKS

1. IN WATER WORKS SHALL BE COMPLETED BETWEEN JULY 1ST TO MARCH 31ST.
2. TREE CLEARING SHOULD BE COMPLETED OUTSIDE THE BIRD NESTING SEASON TO COMPLY WITH THE FEDERAL MIGRATORY BIRDS CONVENTION ACT. ANY TREES THAT REQUIRE REMOVAL OUTSIDE OF THIS TIMING WINDOW MUST FIRST BE INSPECTED BY A QUALIFIED BIOLOGIST TO DETERMINE THE PRESENCE OF NESTING BIRDS.
3. THE WEATHER FORECAST SHOULD BE CONTINUALLY MONITORED TO ENSURE THAT WORKS ARE UNDERTAKEN ONLY DURING FAVOURABLE WEATHER CONDITIONS.
4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

## SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
2. IN THE EVENT OF AN UNEXPECTED STORM, ALL UNFIXED ITEMS THAT HAVE THE POTENTIAL TO CAUSE A SPILL OR AN OBSTRUCTION TO FLOW MUST BE MOVED A STABLE AREA ABOVE ACTIVE FLOODPLAIN.
3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE STOCKPILED SOILS THAT ARE STORED FOR PROLONGED PERIODS WITH THE APPLICATION OF A NURSE CROP AT A RATE OF 60 kg/ha.
5. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW. ON SOILS THAT WILL BE EXPOSED FOR PROLONG PERIODS, TEMPORARILY INSTALL A BIODEGRADABLE EROSION CONTROL BLANKET ON EXPOSED SOILS, OR APPLY A NURSE CROP AT A RATE OF 60 KG/HA.
6. MINIMIZE THE AREA OF DISTURBANCE TO THE EXTENT POSSIBLE.
7. ALL VEGETATION, ADJACENT TO THE WORK AREA, MUST BE PROTECTED AND DELINEATED WITH CONSTRUCTION FENCING OR TREE PROTECTION BARRIERS.
8. ALL GRADES IN THE AREA REGULATED BY THE CONSERVATION AUTHORITY MUST BE MAINTAINED OR MATCHED, UNLESS OTHERWISE AUTHORIZED IN THE APPLICABLE PERMIT.

## EROSION AND SEDIMENT CONTROL

1. ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES MUST BE INSTALLED PRIOR TO START OF WORKS.
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3. EROSION AND SEDIMENT CONTROLS MUST BE MAINTAINED DURING CONSTRUCTION, AND ANY REQUIRED REPAIRS OR REPLACEMENTS MUST BE COMPLETED WITHIN 24 HOURS AFTER THEY HAVE BEEN IDENTIFIED DURING THE MONITORING.
4. EROSION AND SEDIMENT CONTROLS MAY REQUIRE PERIODIC ADJUSTMENTS TO REFLECT CHANGING SITE CONDITIONS. THE CONTRACTOR WILL BE RESPONSIBLE FOR THESE ADJUSTMENTS TO ENSURE PROPER FUNCTION.
5. ANY CHANGES TO THE EROSION AND SEDIMENT CONTROL PLAN BEYOND MINOR ADJUSTMENTS MUST BE APPROVED BY THE CONTRACT ADMINISTRATOR.
6. ADDITIONAL EROSION AND SEDIMENT CONTROL SUPPLIES MUST BE KEPT ON SITE IN ORDER TO FACILITATE IMMEDIATE REPAIRS AND/OR UPGRADES AS NEEDED.
7. ALL TEMPORARY SEDIMENT CONTROLS MUST BE REMOVED AFTER THE CONTRACT ADMINISTRATOR DEEMS THE SITE TO BE STABLE.

## DELETERIOUS SUBSTANCE CONTROL/SPILL MANAGEMENT

1. PREVENT THE RELEASE OF SEDIMENT, SEDIMENT-LADEN WATER, RAW CONCRETE, CONCRETE LEACHATE OR ANY OTHER DELETERIOUS SUBSTANCES INTO ANY WATERBODY, RAVINE OR STORM SEWER SYSTEM.
2. ENSURE EQUIPMENT AND MACHINERY ARE IN GOOD OPERATING CONDITION (POWER WASHED), FREE OF LEAKS, EXCESS OIL, AND GREASE.
3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
5. THE CONTRACT ADMINISTRATOR MUST BE NOTIFIED IMMEDIATELY IN THE EVENT OF A SPILL OF DELETERIOUS SUBSTANCE.

## WORK AREA ISOLATION

1. ALL WORK IN ISOLATED WORK AREAS MUST BE COMPLETED IN THE DRY. AN ADEQUATE NUMBER OF PUMPS MUST BE USED FOR UNWATERING.
2. THE UNWATERING DISCHARGE LOCATION MUST BE LOCATED AT LEAST 30 M FROM ANY WATERCOURSE OR WETLAND IN AN AREA WITH DENSE VEGETATIVE GROUNDCOVER, AND WHERE THE DISCHARGE CAN RETURN TO THE WATERBODY DOWNSTREAM OF THE WORK AREA OVER THE GROUNDCOVER.
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.

**SCALED FOR PLOT ON 'ARCH D'**

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| DESIGNED BY: AS | CHECKED BY: PV |
| DRAWN BY: AS | DATE: NOVEMBER 2023 |

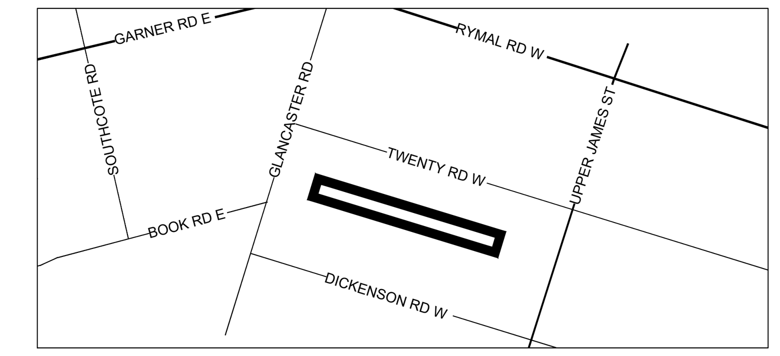
**DRAFT FOR DISCUSSION**

GEO MORPHIX™
36 Main Street North, PO Box 205
Campbellville, Ontario L0P 1B0
T: 416.920.0926
www.geomorphix.com

UPPER WEST SIDE COMMUNITY
TRIBUTARY OF TWENTY MILE CREEK

CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

| | |
|---|---|
| PROJECT No.: 23079 | DRAWING No.: GEO-1 |
| SCALE: AS NOTED | SHEET 1 OF 12 |

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## KEY MAP
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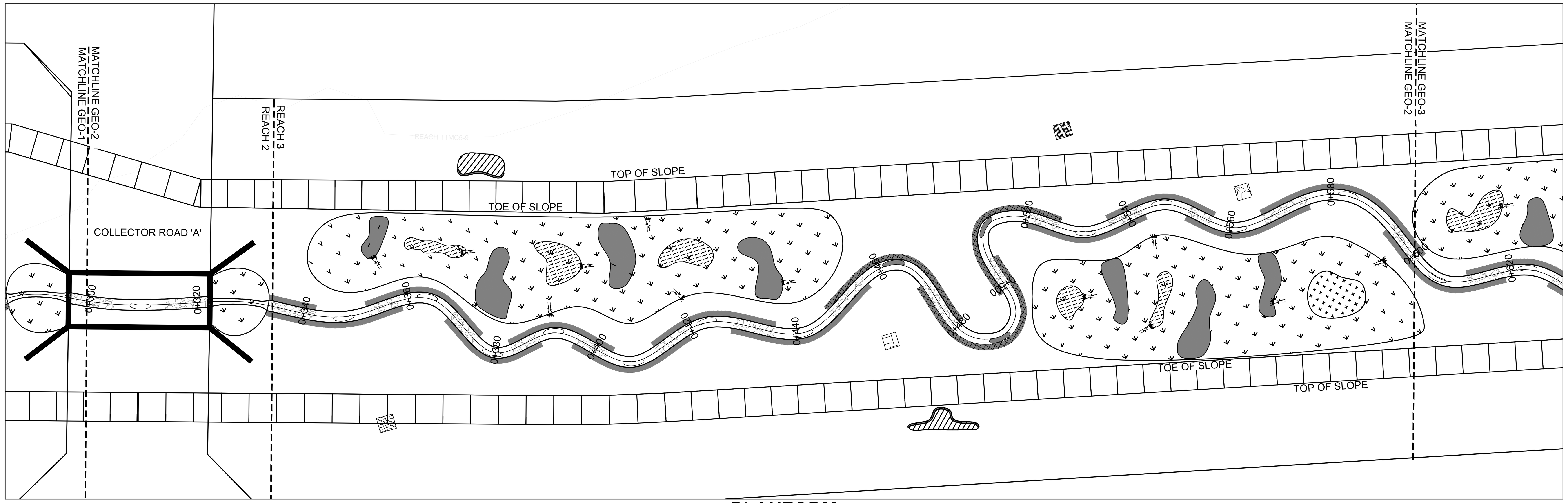


LEGEND
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**PLANFORM**
1:500

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3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
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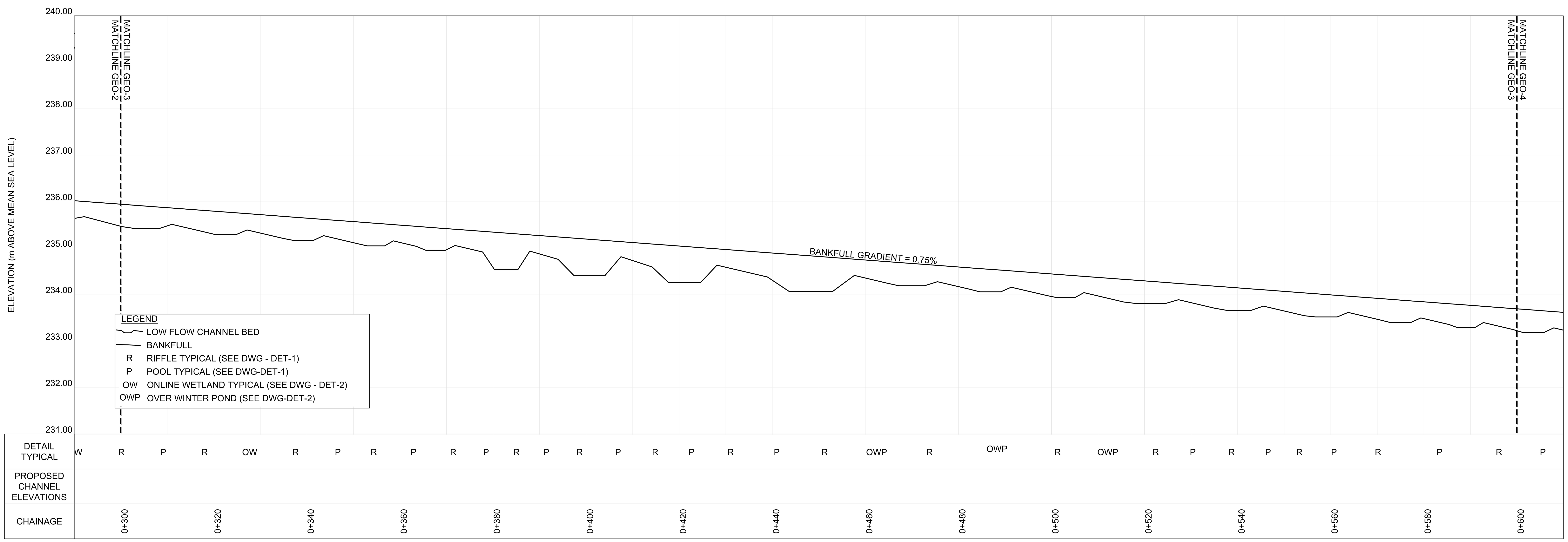


**PROFILE**
H = 1:500; V=1:50

**SCALED FOR PLOT ON 'ARCH D'**

| DATE | BY | REVISIONS |
|---|---|---|
| DESIGNED BY: AS | | CHECKED BY: PV |
| DRAWN BY: AS | | DATE: NOVEMBER 2023 |

**DRAFT FOR DISCUSSION**

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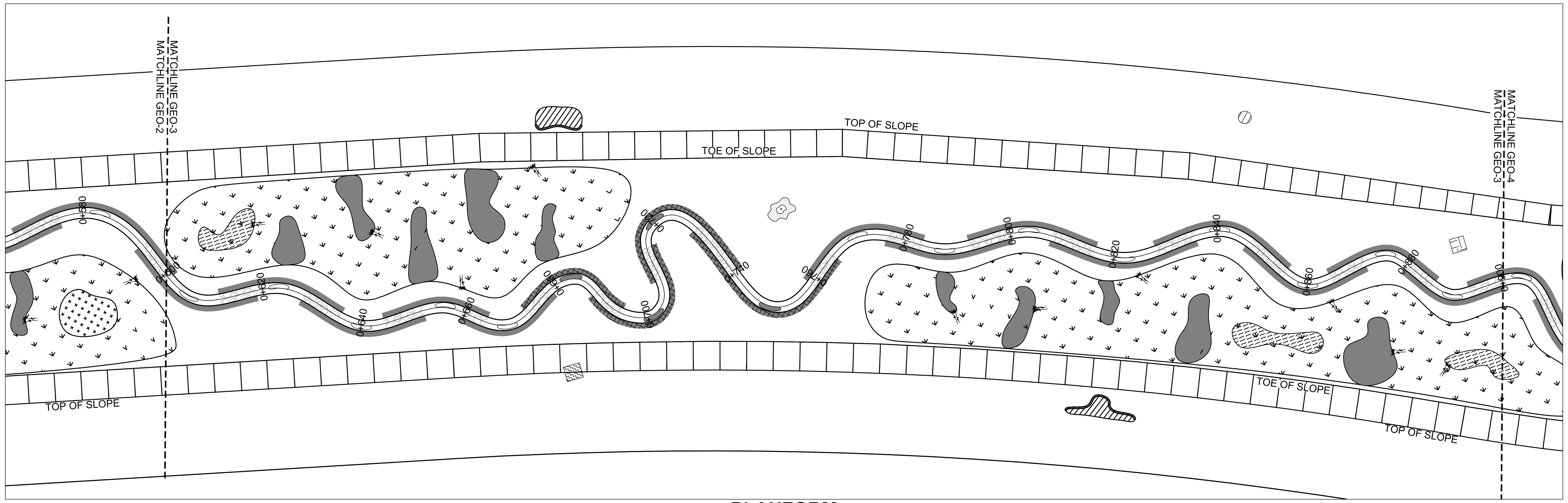
# UPPER WEST SIDE COMMUNITY TRIBUTARY OF TWENTY MILE CREEK

## CONCEPTUAL CHANNEL DESIGN PLANFORM AND PROFILE

| | |
|---|---|
| PROJECT No.: 23079 | DRAWING No.: GEO-2 |
| SCALE: AS NOTED | SHEET 2 OF 12 |




LEGEND
- CHANNEL CENTRELINE
- SWALE (SEE DWG DET-2)
- RIFFLE (SEE DWG DET-1)
- POOL (SEE DWG DET-1)
- OVERWINTER POOL (SEE DWG DET-2)
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- STONE CORE (SEE DWG DET-3)
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- 100% BIODEGRADABLE EROSION CONTROL BLANKET AND LIVE STAKES (SEE DWG DET-3)
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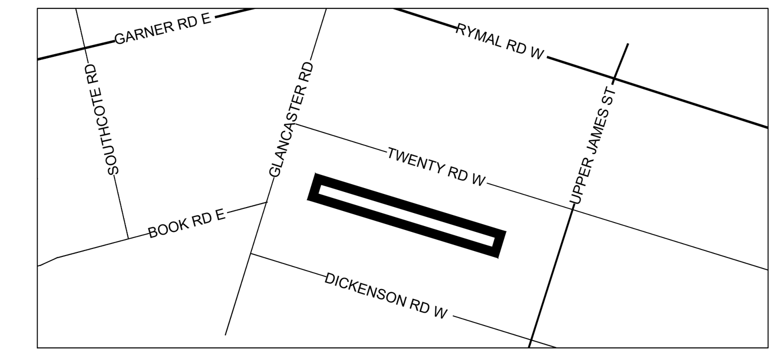
- BRUSH MATTRESS BANK TREATMENT (SEE DWG DET-2)

**PLANFORM**
1:500

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## KEY MAP
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1. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
2. THE CONTRACTOR MUST NOTIFY THE CONTRACT ADMINISTRATOR AND CONSERVATION AUTHORITY OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
3. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
4. LAYOUT MUST BE REVIEWED AND APPROVED BY THE CONTRACT ADMINISTRATOR.

## TIMING OF WORKS

1. IN WATER WORKS SHALL BE COMPLETED BETWEEN JULY 1ST TO MARCH 31ST.
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3. THE WEATHER FORECAST SHOULD BE CONTINUALLY MONITORED TO ENSURE THAT WORKS ARE UNDERTAKEN ONLY DURING FAVOURABLE WEATHER CONDITIONS.
4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

## SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
2. IN THE EVENT OF AN UNEXPECTED STORM, ALL UNFIXED ITEMS THAT HAVE THE POTENTIAL TO CAUSE A SPILL OR AN OBSTRUCTION TO FLOW MUST BE MOVED A STABLE AREA ABOVE ACTIVE FLOODPLAIN.
3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE STOCKPILED SOILS THAT ARE STORED FOR PROLONGED PERIODS WITH THE APPLICATION OF A NURSE CROP AT A RATE OF 60 kg/ha.
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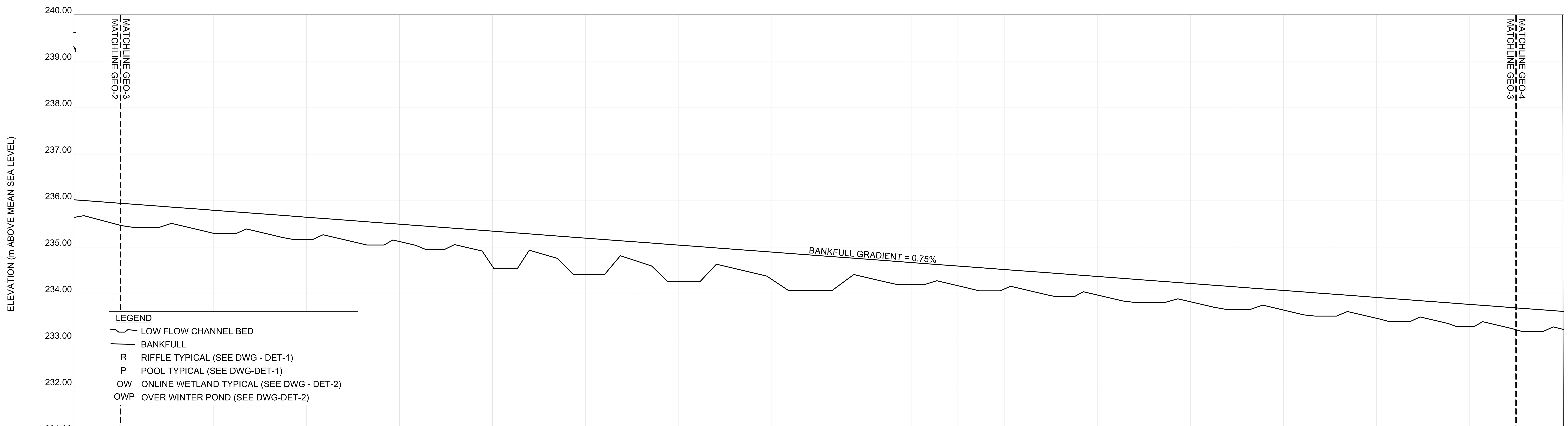


DETAIL TYPICAL: R P R P R P R P R P R OWP R OWP R OWP R OWP R P R P R P R P R P R P R P R P R P

PROPOSED CHANNEL ELEVATIONS

CHAINAGE: 0+600 0+620 0+640 0+660 0+680 0+700 0+720 0+740 0+760 0+780 0+800 0+820 0+840 0+860 0+880 0+900

**PROFILE**
H = 1:500; V=1:50

**SCALED FOR PLOT ON 'ARCH D'**

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UPPER WEST SIDE COMMUNITY
TRIBUTARY OF TWENTY MILE CREEK

CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

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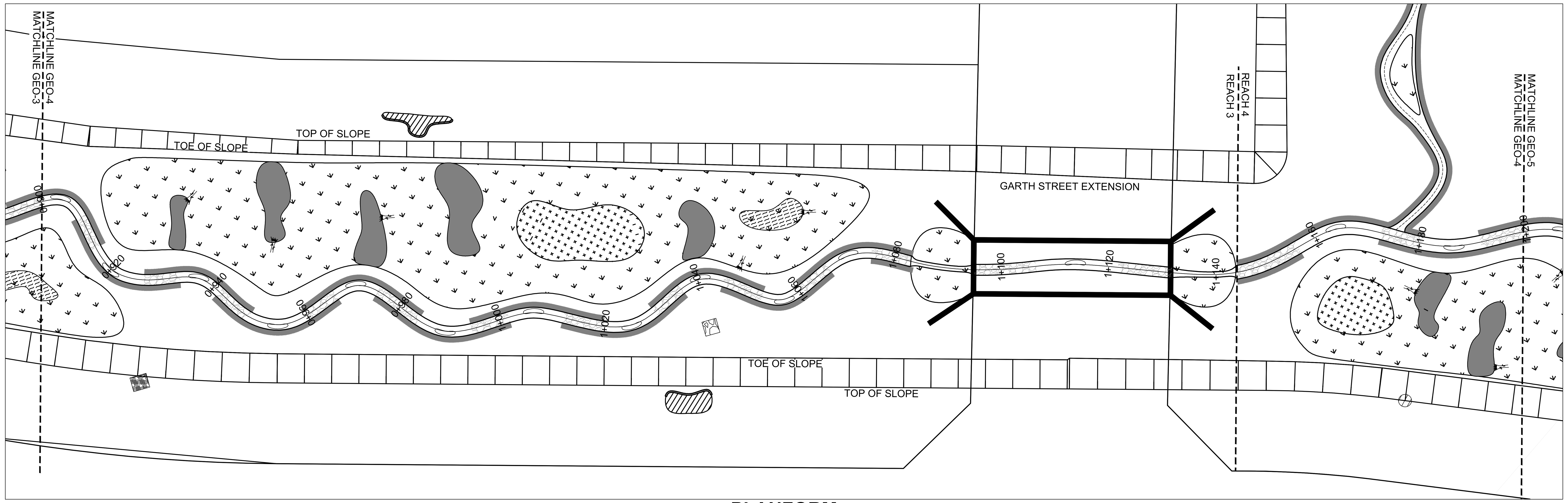
| PROJECT No.: 23079 | DRAWING No.: GEO-3 |
| SCALE: AS NOTED | SHEET 3 OF 12 |




**PLANFORM**
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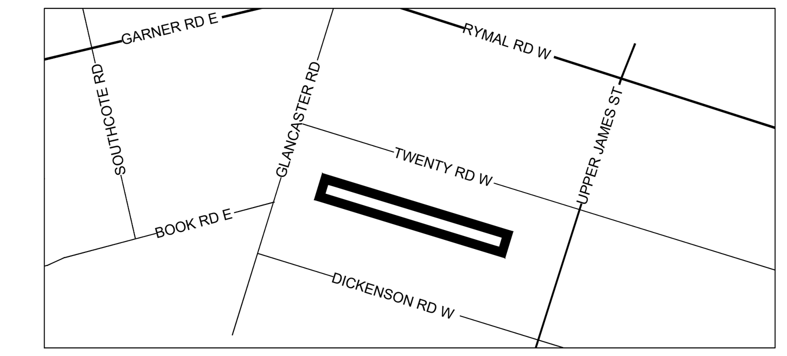


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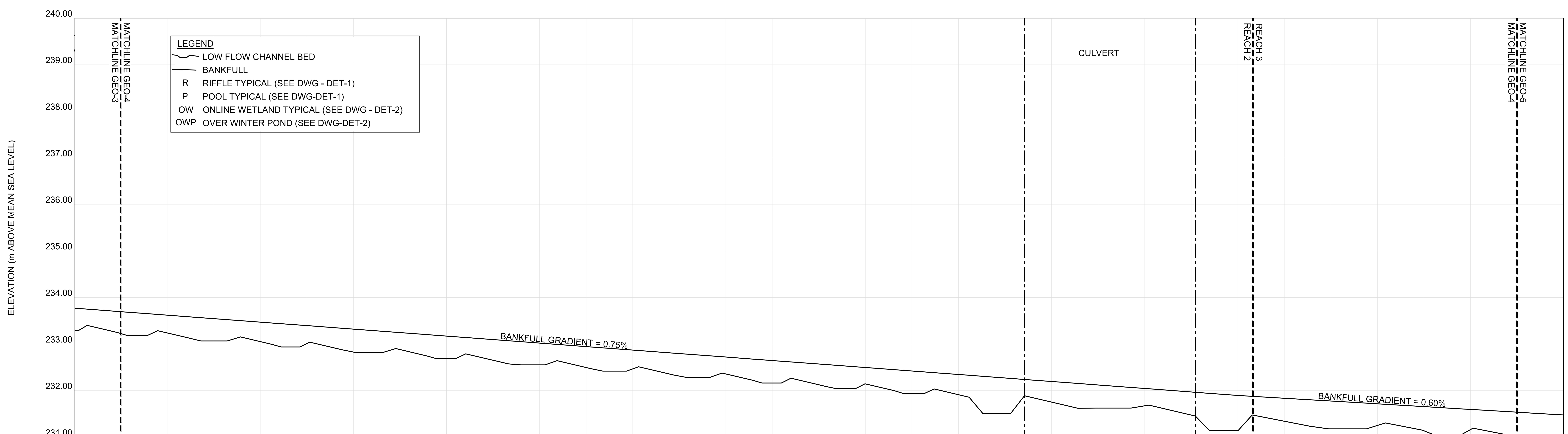


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**PROFILE**
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CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

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| PROJECT No.: 23079 | DRAWING No.: GEO-4 |
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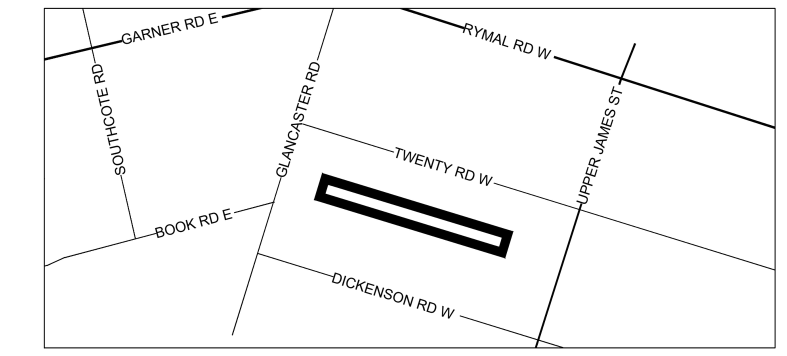


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## KEY MAP
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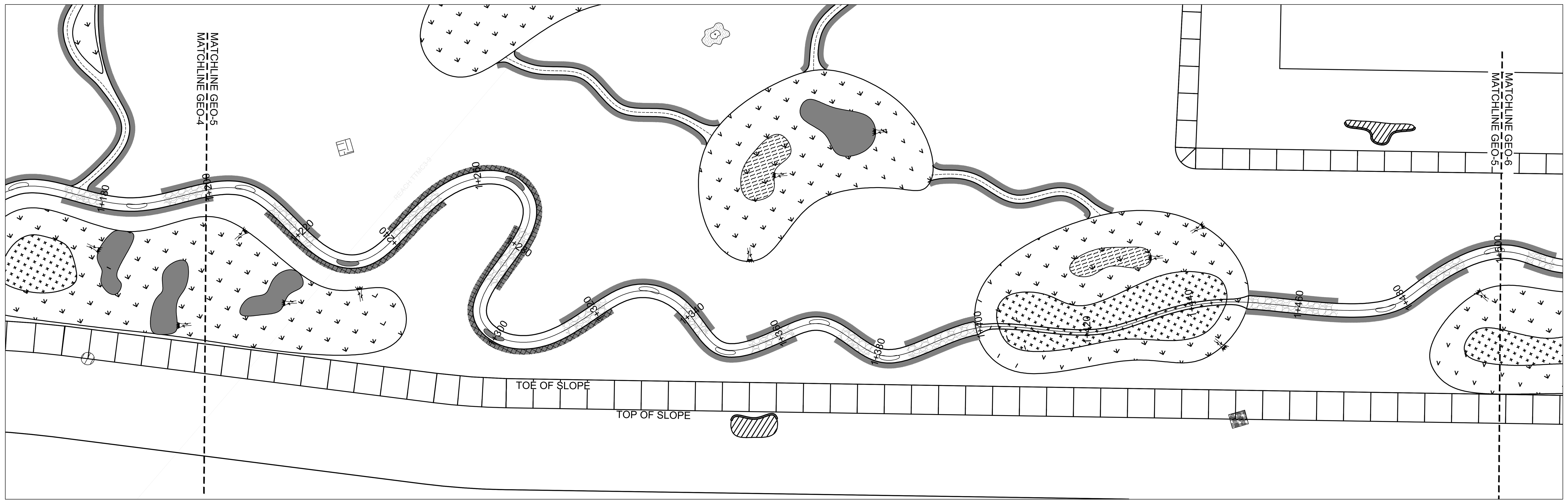


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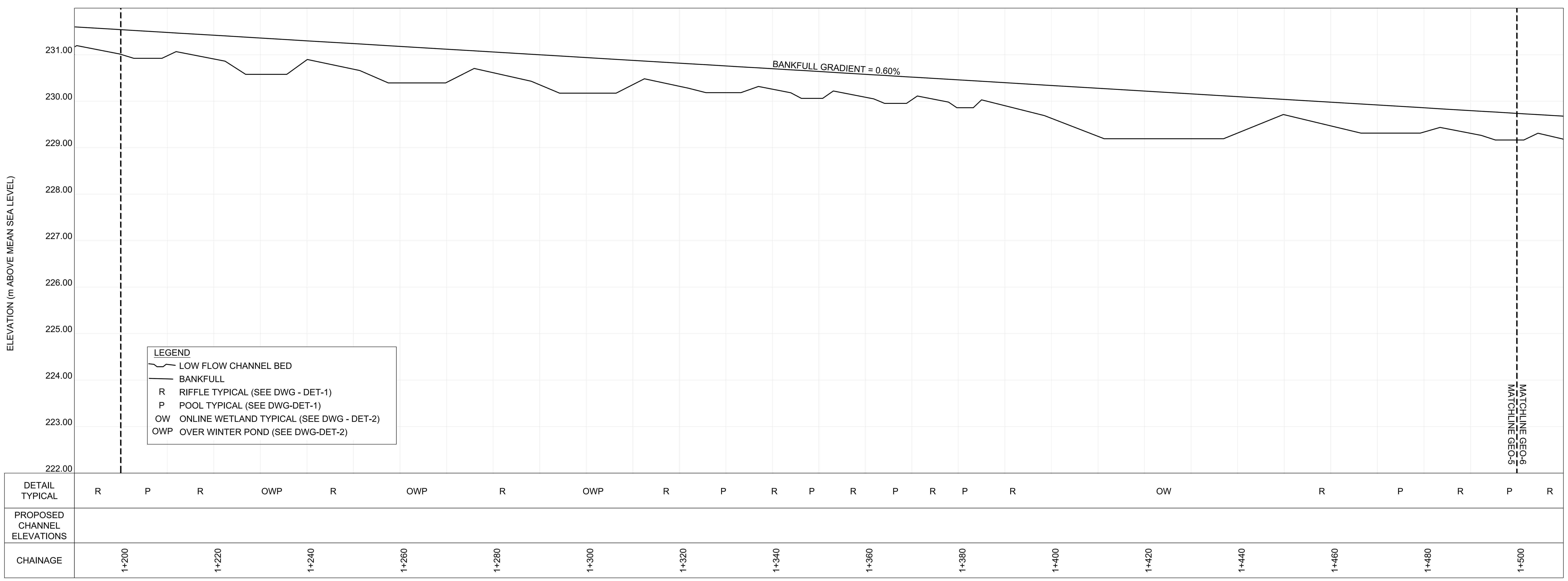


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2. ENSURE EQUIPMENT AND MACHINERY ARE IN GOOD OPERATING CONDITION (POWER WASHED), FREE OF LEAKS, EXCESS OIL, AND GREASE.
3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
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5. THE CONTRACT ADMINISTRATOR MUST BE NOTIFIED IMMEDIATELY IN THE EVENT OF A SPILL OF DELETERIOUS SUBSTANCE.

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2. THE UNWATERING DISCHARGE LOCATION MUST BE LOCATED AT LEAST 30 M FROM ANY WATERCOURSE OR WETLAND IN AN AREA WITH DENSE VEGETATIVE GROUNDCOVER, AND WHERE THE DISCHARGE CAN RETURN TO THE WATERBODY DOWNSTREAM OF THE WORK AREA OVER THE GROUNDCOVER.
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.

**SCALED FOR PLOT ON 'ARCH D'**

| | DATE | BY | REVISIONS |
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|---|---|
| DESIGNED BY: AS | CHECKED BY: PV |
| DRAWN BY: AS | DATE: NOVEMBER 2023 |

**DRAFT FOR DISCUSSION**

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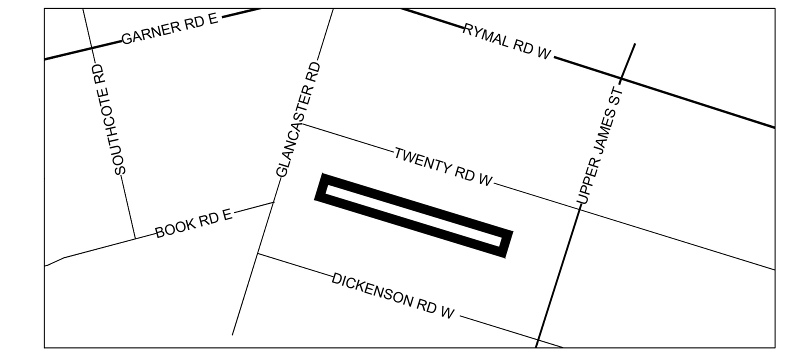
UPPER WEST SIDE COMMUNITY
TRIBUTARY OF TWENTY MILE CREEK

CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

| | |
|---|---|
| PROJECT No.: 23079 | DRAWING No.: GEO-5 |
| SCALE: AS NOTED | SHEET 5 OF 12 |




## KEY MAP
N.T.S.

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1. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
2. THE CONTRACTOR MUST NOTIFY THE CONTRACT ADMINISTRATOR AND CONSERVATION AUTHORITY OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
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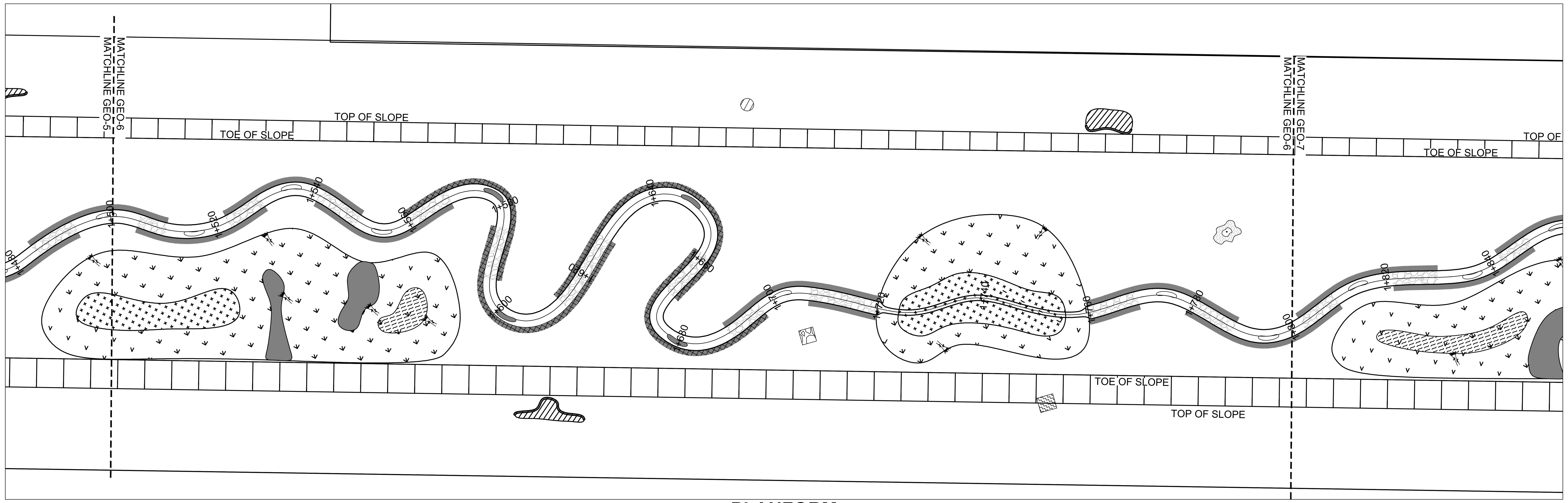


LEGEND
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- RIFFLE (SEE DWG DET-1)
- POOL (SEE DWG DET-1)
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- TERRESTRIAL MOUND (SEE DWG DET-3)
- BRUSH MATTRESS BANK TREATMENT (SEE DWG DET-2)

**PLANFORM**
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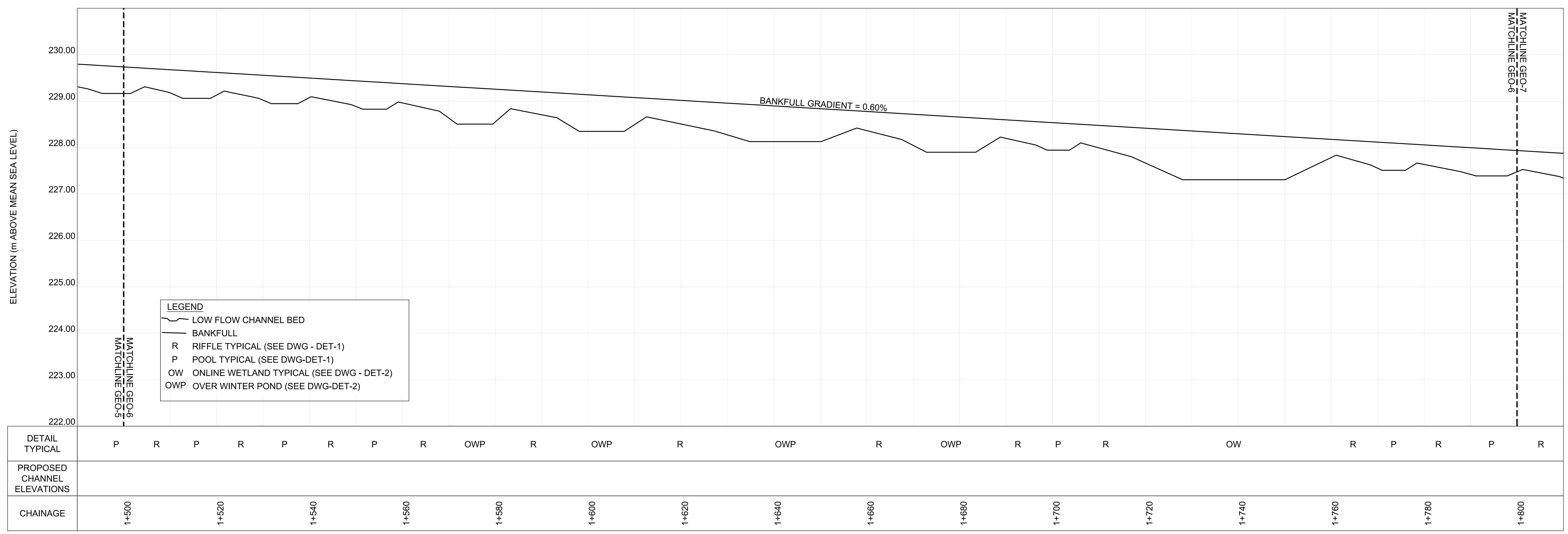


**PROFILE**
H = 1:500; V=1:50

SCALED FOR PLOT ON 'ARCH D'

| DATE | BY | REVISIONS |
|---|---|---|

DESIGNED BY: AS
CHECKED BY: PV
DRAWN BY: AS
DATE: NOVEMBER 2023

**DRAFT FOR DISCUSSION**

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UPPER WEST SIDE COMMUNITY
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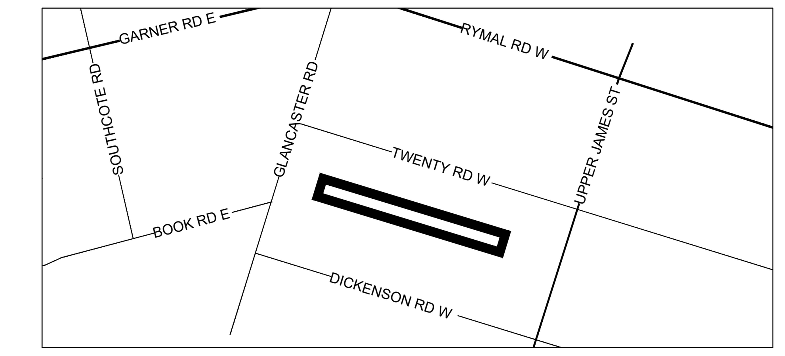
CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

PROJECT No.: 23079
DRAWING No.: GEO-6
SCALE: AS NOTED
SHEET 6 OF 12

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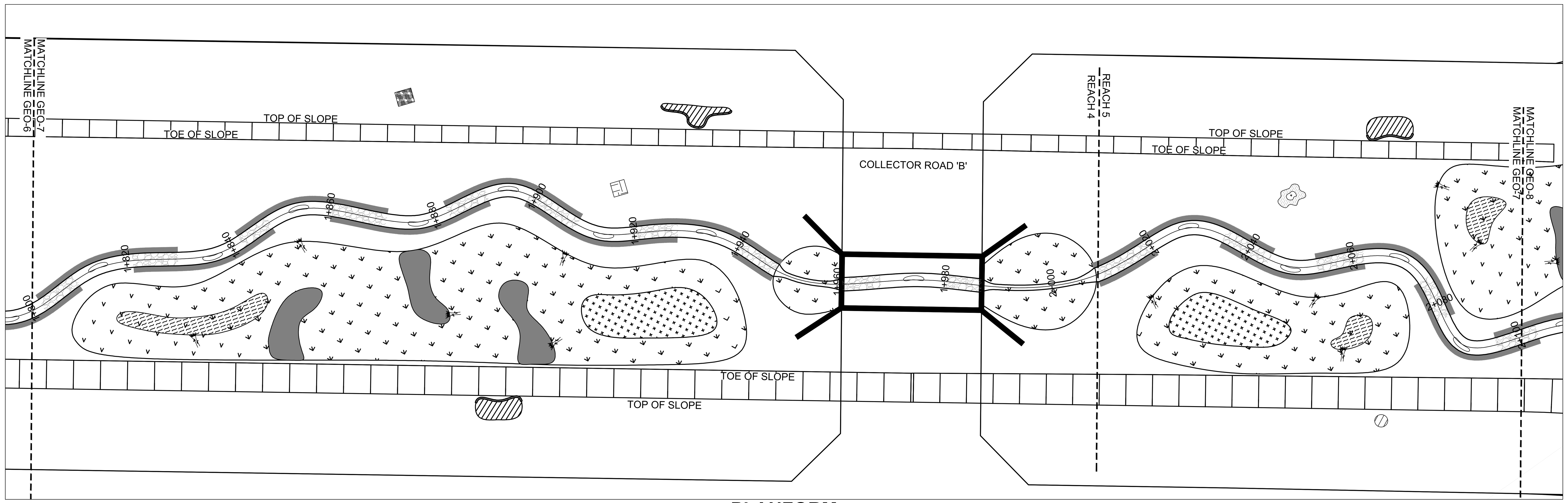
## KEY MAP
N.T.S.

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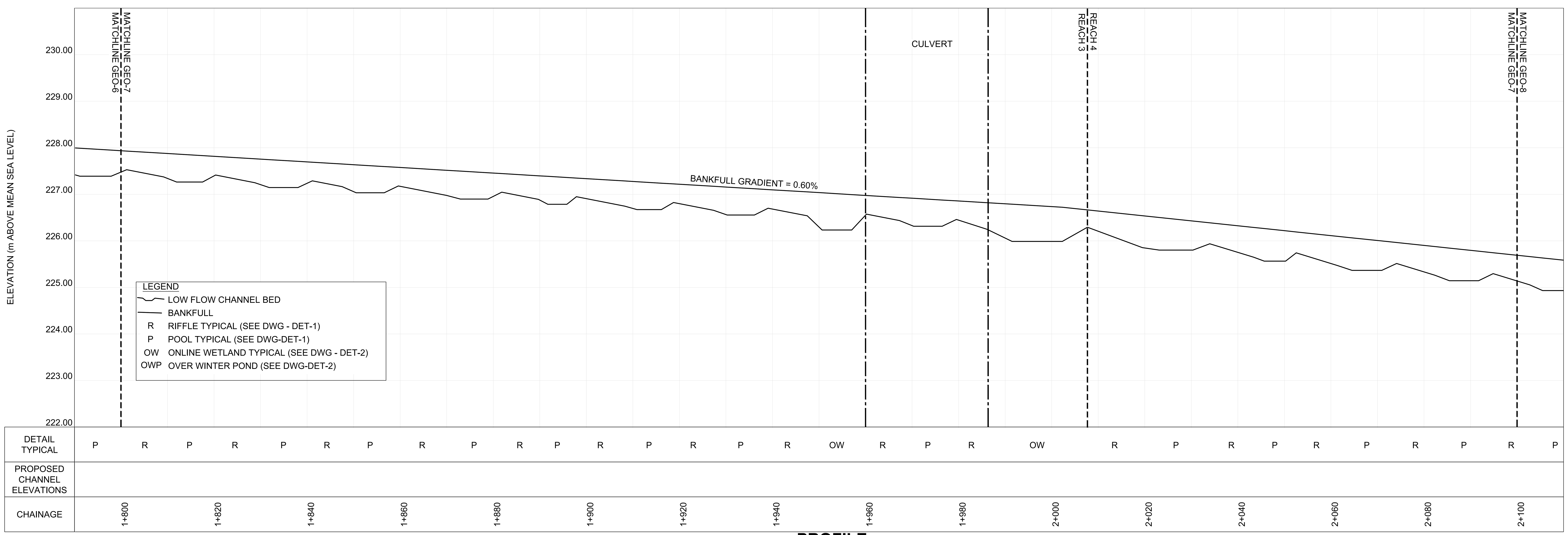


**PROFILE**
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**SCALED FOR PLOT ON 'ARCH D'**

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CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

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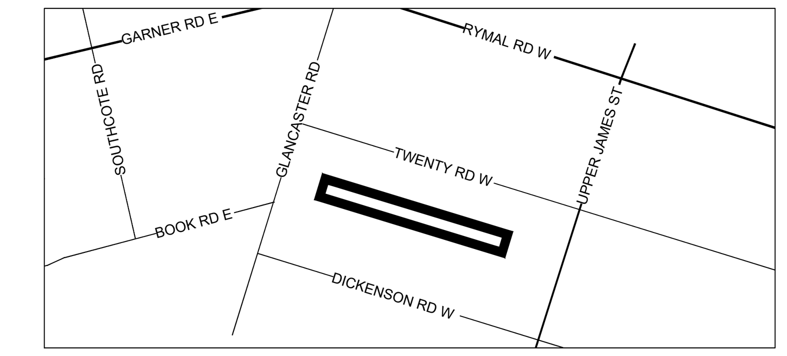
|---|---|
| PROJECT No.: 23079 | DRAWING No.: GEO-7 |
| SCALE: AS NOTED | SHEET 7 OF 12 |

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KEY MAP
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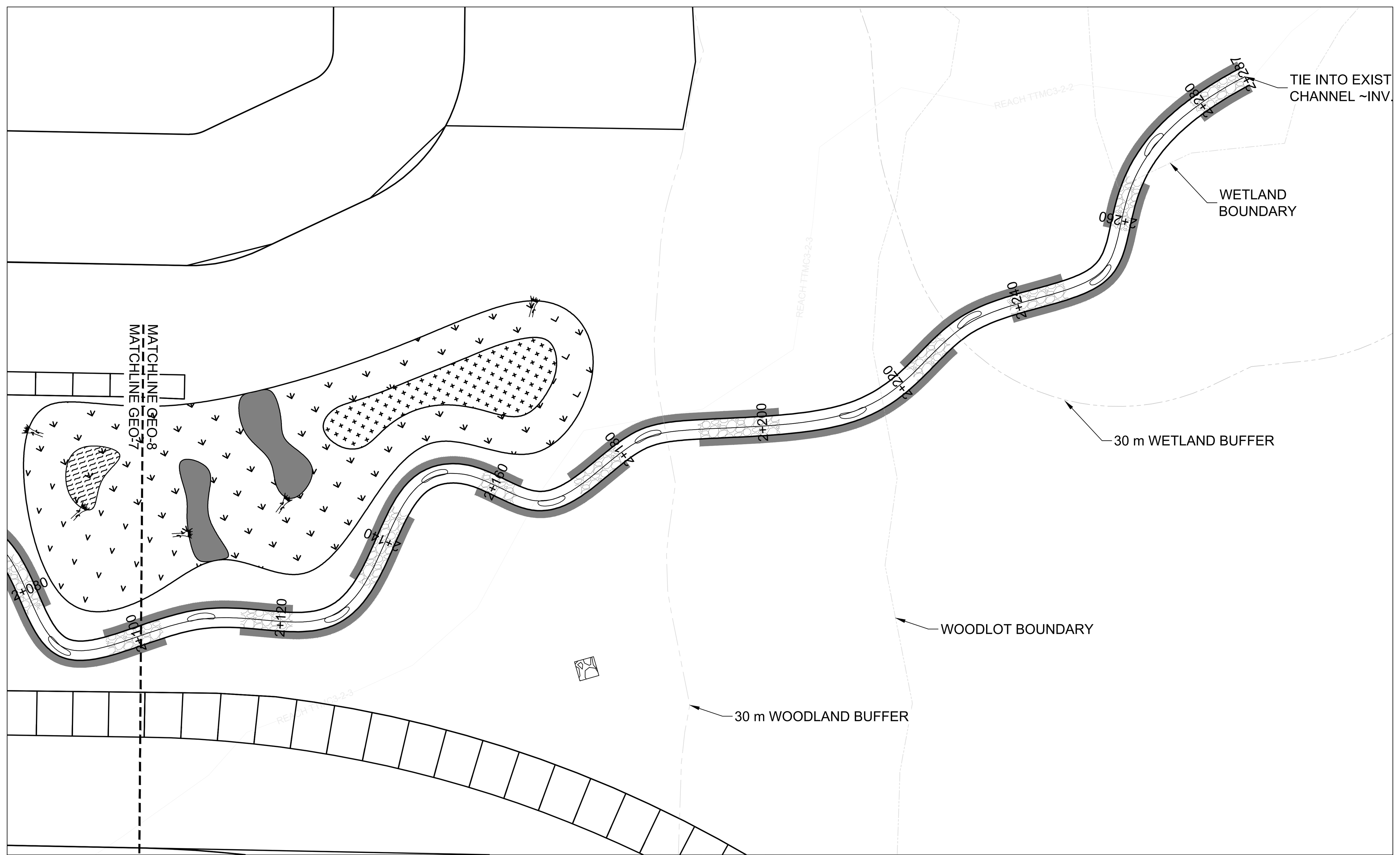


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**PLANFORM**
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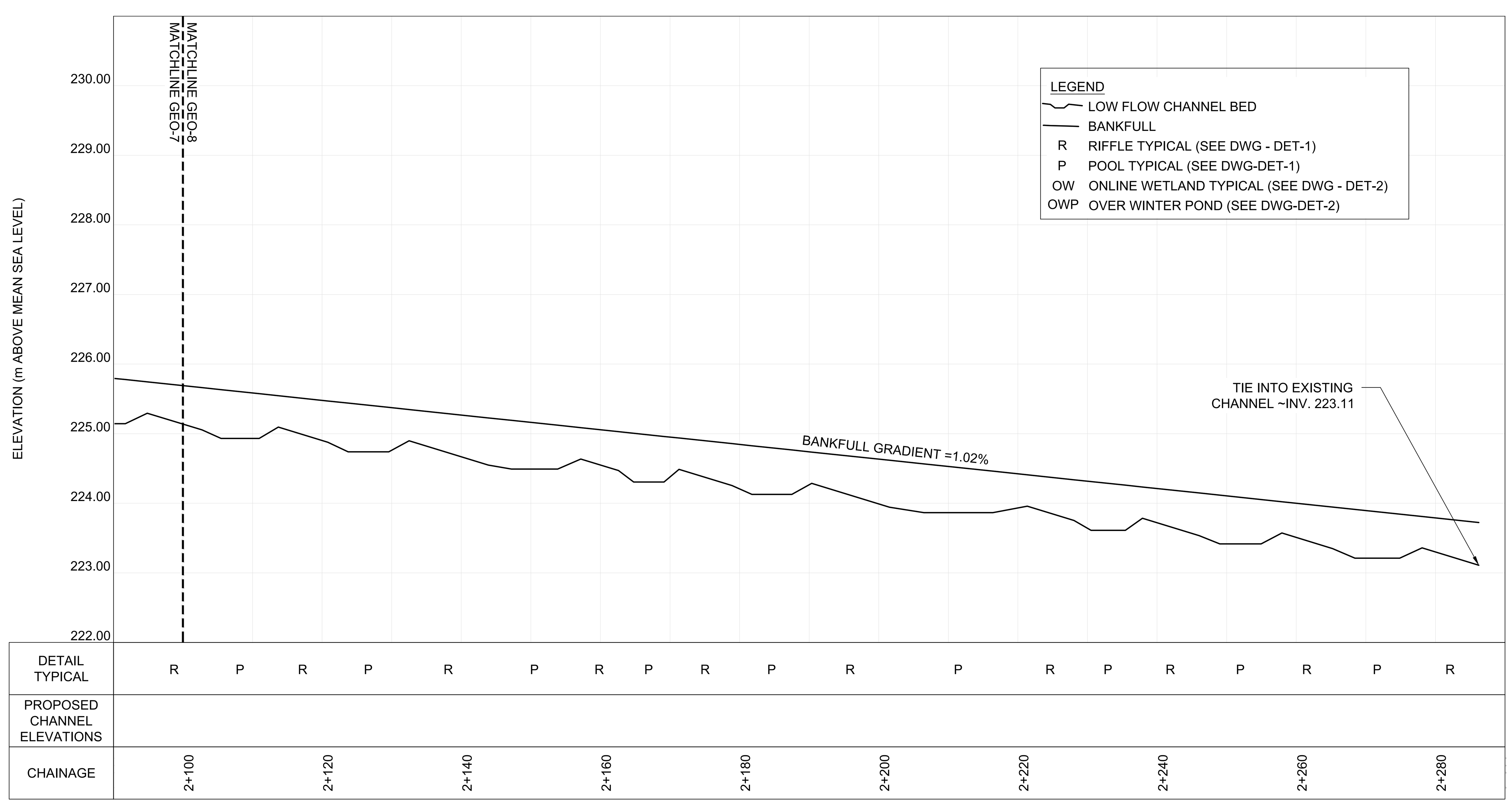


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3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
5. THE CONTRACT ADMINISTRATOR MUST BE NOTIFIED IMMEDIATELY IN THE EVENT OF A SPILL OF DELETERIOUS SUBSTANCE.

## WORK AREA ISOLATION

1. ALL WORK IN ISOLATED WORK AREAS MUST BE COMPLETED IN THE DRY. AN ADEQUATE NUMBER OF PUMPS MUST BE USED FOR UNWATERING.
2. THE UNWATERING DISCHARGE LOCATION MUST BE LOCATED AT LEAST 30 M FROM ANY WATERCOURSE OR WETLAND IN AN AREA WITH DENSE VEGETATIVE GROUNDCOVER, AND WHERE THE DISCHARGE CAN RETURN TO THE WATERBODY DOWNSTREAM OF THE WORK AREA OVER THE GROUNDCOVER.
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.

**SCALED FOR PLOT ON 'ARCH D'**

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| DESIGNED BY: AS | CHECKED BY: PV |
| DRAWN BY: AS | DATE: NOVEMBER 2023 |

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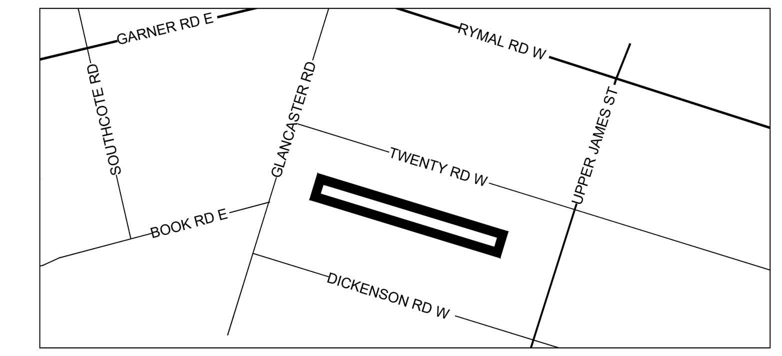
UPPER WEST SIDE COMMUNITY
TRIBUTARY OF TWENTY MILE CREEK

CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

| | |
|---|---|
| PROJECT No.: 23079 | DRAWING No.: GEO-8 |
| SCALE: AS NOTED | SHEET 8 OF 12 |




N
N.T.S.

KEY MAP
N.T.S.

## GENERAL NOTES

1. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
2. THE CONTRACTOR MUST NOTIFY THE CONTRACT ADMINISTRATOR AND CONSERVATION AUTHORITY OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
3. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
4. LAYOUT MUST BE REVIEWED AND APPROVED BY THE CONTRACT ADMINISTRATOR.

## TIMING OF WORKS

1. IN WATER WORKS SHALL BE COMPLETED BETWEEN JULY 1ST TO MARCH 31ST.
2. TREE CLEARING SHOULD BE COMPLETED OUTSIDE THE BIRD NESTING SEASON TO COMPLY WITH THE FEDERAL MIGRATORY BIRDS CONVENTION ACT. ANY TREES THAT REQUIRE REMOVAL OUTSIDE OF THIS TIMING WINDOW MUST FIRST BE INSPECTED BY A QUALIFIED BIOLOGIST TO DETERMINE THE PRESENCE OF NESTING BIRDS.
3. THE WEATHER FORECAST SHOULD BE CONTINUALLY MONITORED TO ENSURE THAT WORKS ARE UNDERTAKEN ONLY DURING FAVOURABLE WEATHER CONDITIONS.
4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

## SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
2. IN THE EVENT OF AN UNEXPECTED STORM, ALL UNFIXED ITEMS THAT HAVE THE POTENTIAL TO CAUSE A SPILL OR AN OBSTRUCTION TO FLOW MUST BE MOVED A STABLE AREA ABOVE ACTIVE FLOODPLAIN.
3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE STOCKPILED SOILS THAT ARE STORED FOR PROLONGED PERIODS WITH THE APPLICATION OF A NURSE CROP AT A RATE OF 60 kg/ha.
5. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW. ON SOILS THAT WILL BE EXPOSED FOR PROLONG PERIODS, TEMPORARILY INSTALL A BIODEGRADABLE EROSION CONTROL BLANKET ON EXPOSED SOILS, OR APPLY A NURSE CROP AT A RATE OF 60 KG/HA.
6. MINIMIZE THE AREA OF DISTURBANCE TO THE EXTENT POSSIBLE.
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2. SEDIMENT CONTROLS MUST BE INSPECTED DAILY TO ENSURE THAT THEY ARE IN GOOD REPAIR AND FUNCTIONING AS INTENDED.
3. EROSION AND SEDIMENT CONTROLS MUST BE MAINTAINED DURING CONSTRUCTION, AND ANY REQUIRED REPAIRS OR REPLACEMENTS MUST BE COMPLETED WITHIN 24 HOURS AFTER THEY HAVE BEEN IDENTIFIED DURING THE MONITORING.
4. EROSION AND SEDIMENT CONTROLS MAY REQUIRE PERIODIC ADJUSTMENTS TO REFLECT CHANGING SITE CONDITIONS. THE CONTRACTOR WILL BE RESPONSIBLE FOR THESE ADJUSTMENTS TO ENSURE PROPER FUNCTION.
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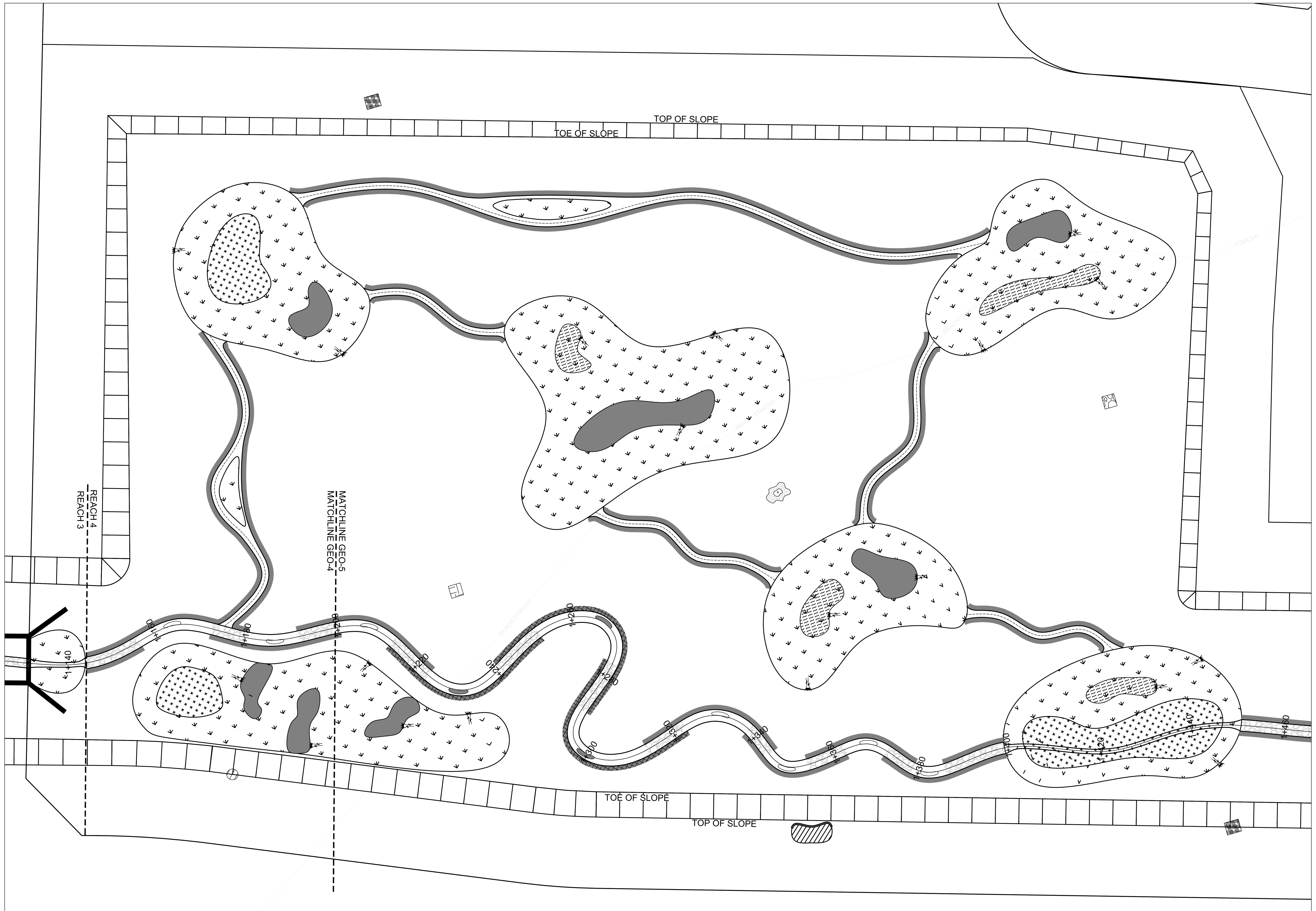


**PLANFORM**
1:500

LEGEND

- CHANNEL CENTRELINE
- SWALE (SEE DWG DET-2)
- RIFFLE (SEE DWG DET-1)
- POOL (SEE DWG DET-1)
- OVERWINTER POOL (SEE DWG DET-2)
- ONLINE WETLAND ((SEE DWG DET-2)
- OFFLINE WETLAND (SEE DWG DET-2)
- OVERWINTER WETLAND POOL (1000 mm BELOW FLOODPLAIN ELEVATION)
- SUBMERGED MOUND (300 mm - 400 mm BELOW FLOODPLAIN ELEVATION)
- DRY MOUND (50 mm - 100 mm BELOW FLOODPLAIN ELEVATION)
- STONE CORE (SEE DWG DET-3)
- SEASONAL POOL (SWW DWG DET-3)
- 100% BIODEGRADABLE EROSION CONTROL BLANKET AND LIVE STAKES (SEE DWG DET-3)
- PALLET TYPE WOOD PILE (SEE DWG DET-2)
- BASKING LOG (SEE DWG DET-3)
- ROCK PILE (SEE DWG DET-2)
- RAPTOR POLE (SEE DWG DET-3)
- TURTLE NEST (SEE DWG DET-2)
- SNAKE HIBERNACULUM (SEE DWG DET-2)
- TERRESTRIAL MOUND (SEE DWG DET-3)
- BRUSH MATTRESS BANK TREATMENT (SEE DWG DET-2)

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**SCALED FOR PLOT ON 'ARCH D'**

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| DRAWN BY: AS | DATE: NOVEMBER 2023 |

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UPPER WEST SIDE COMMUNITY
TRIBUTARY OF TWENTY MILE CREEK

CONCEPTUAL CHANNEL DESIGN
PLANFORM

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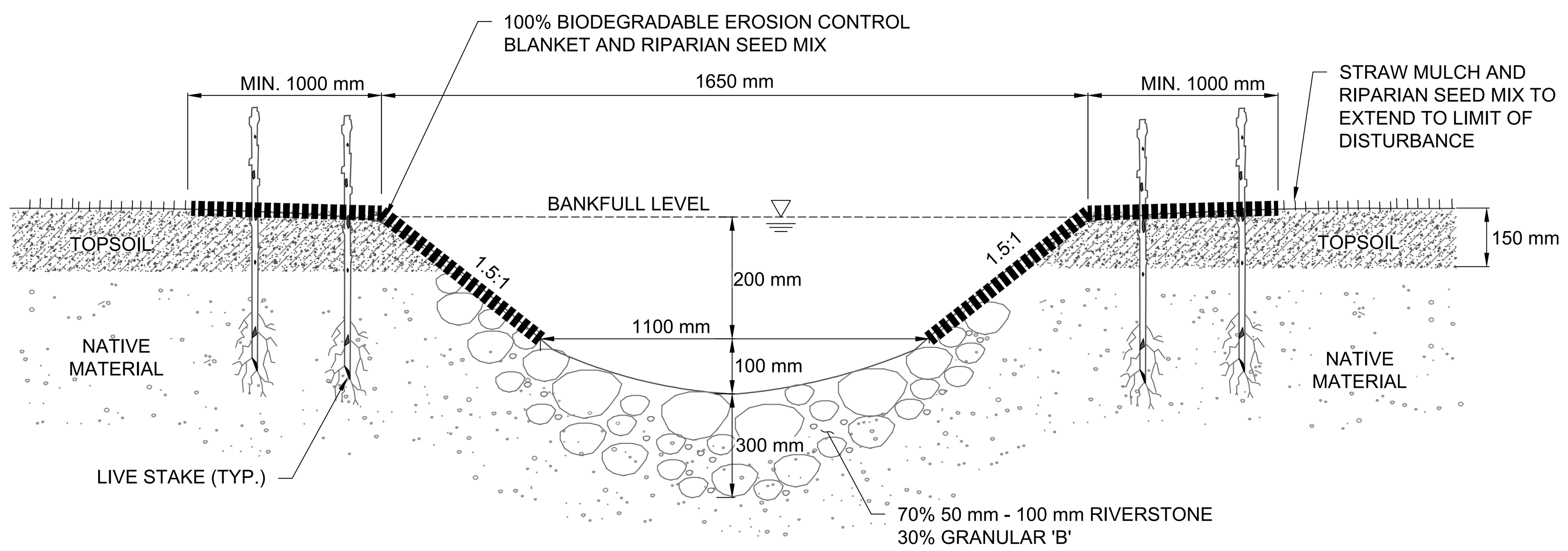
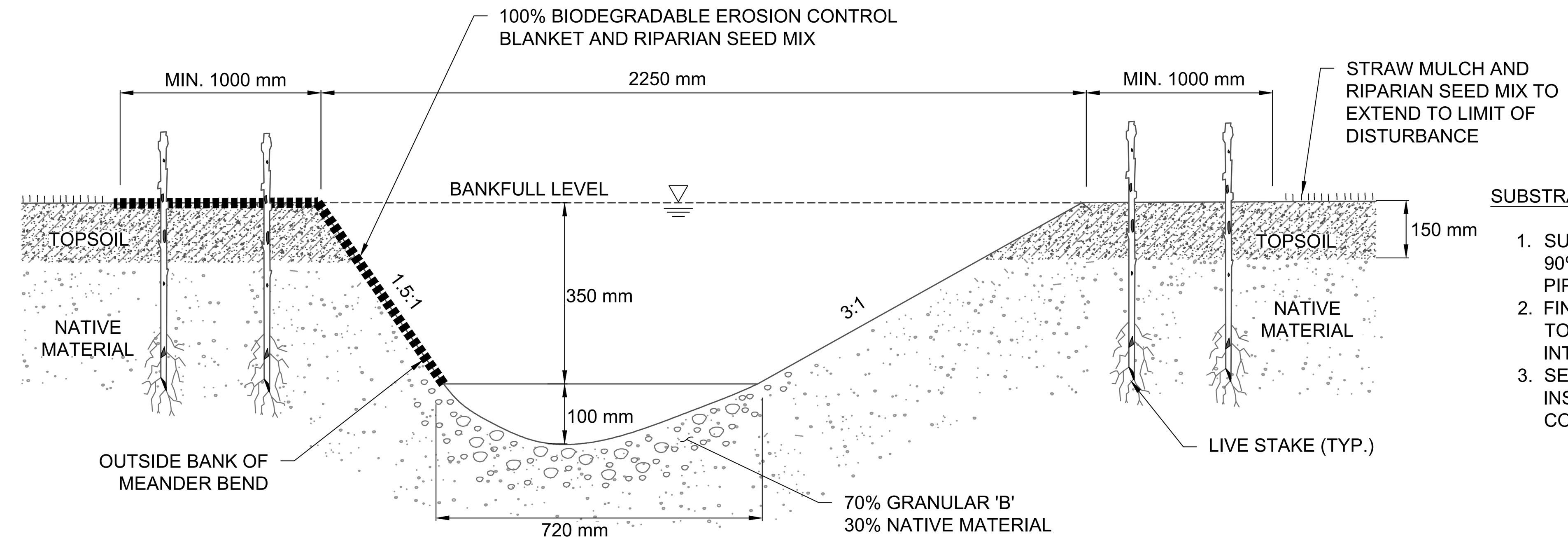
| PROJECT No.: 23079 | DRAWING No.: GEO-9 |
| SCALE: AS NOTED | SHEET 8 OF 12 |




TYPICAL RIFFLE

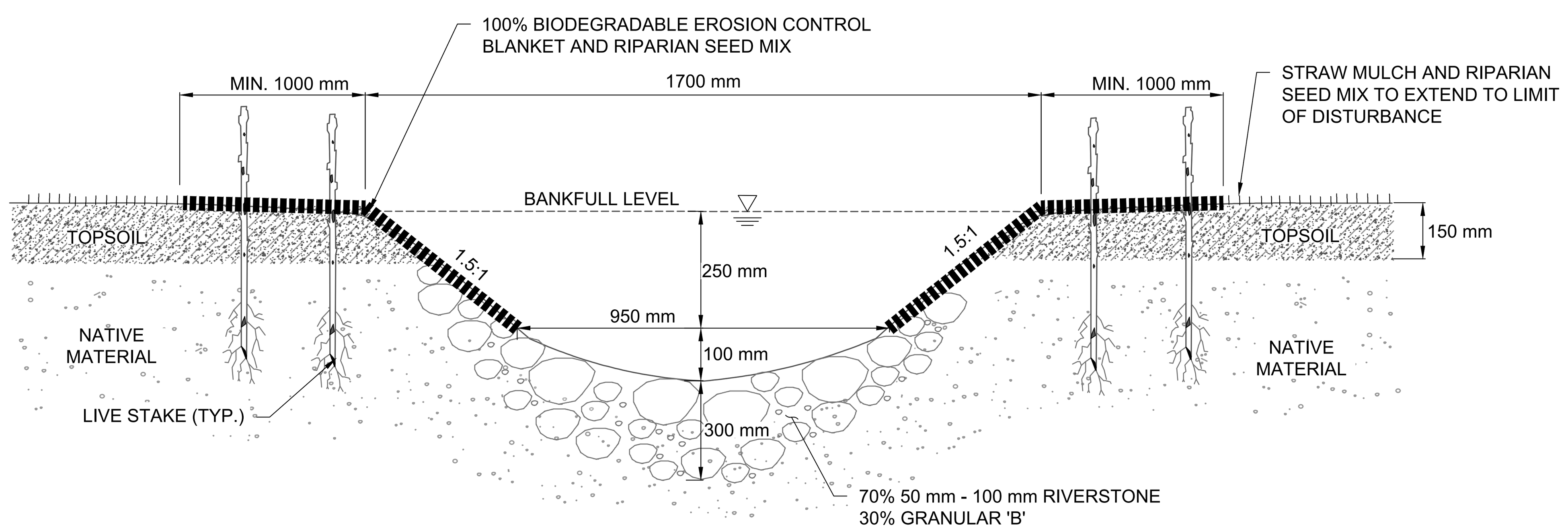



TYPICAL POOL

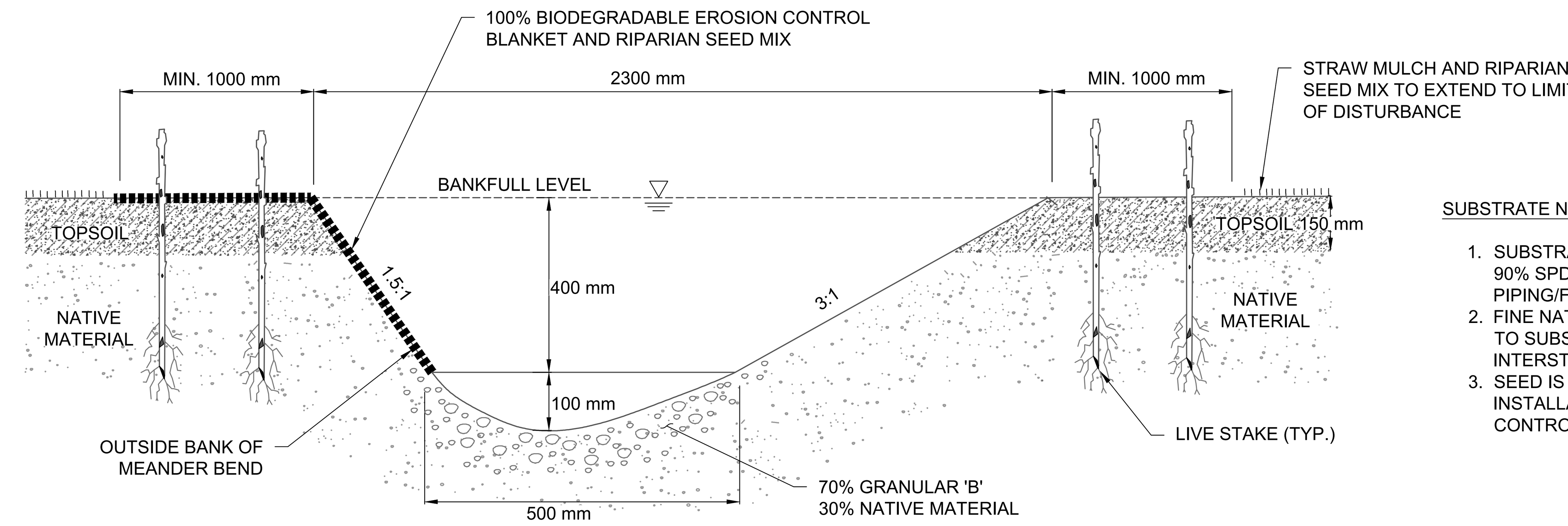
SUBSTRATE NOTES

1. SUBSTRATES TO BE COMPACTED TO 90% SPD TO PREVENT PIPING/FLOW-THROUGH.
2. FINE NATIVE MATERIAL TO BE ADDED TO SUBSTRATE MIX TO FILL INTERSTITIAL VOIDS, AS REQUIRED.
3. SEED IS TO BE PLACED PRIOR TO INSTALLATION OF EROSION CONTROL BLANKET.

**CHANNEL CROSS SECTIONS - REACH 1**
N.T.S.




TYPICAL RIFFLE




TYPICAL POOL

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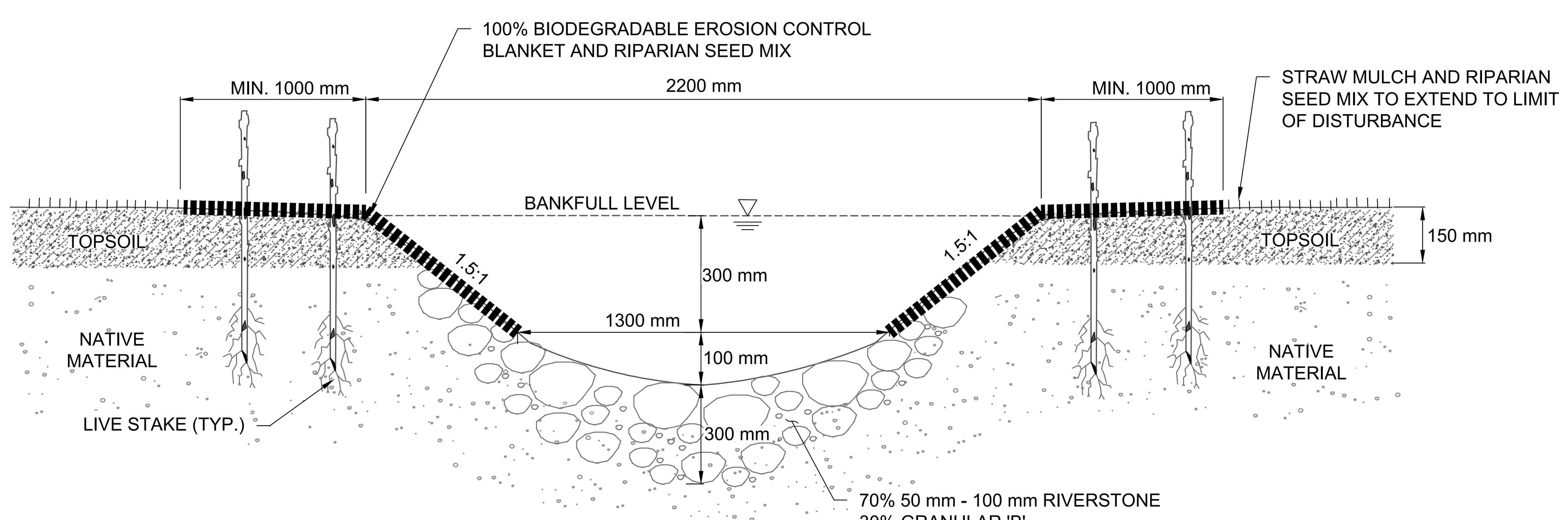
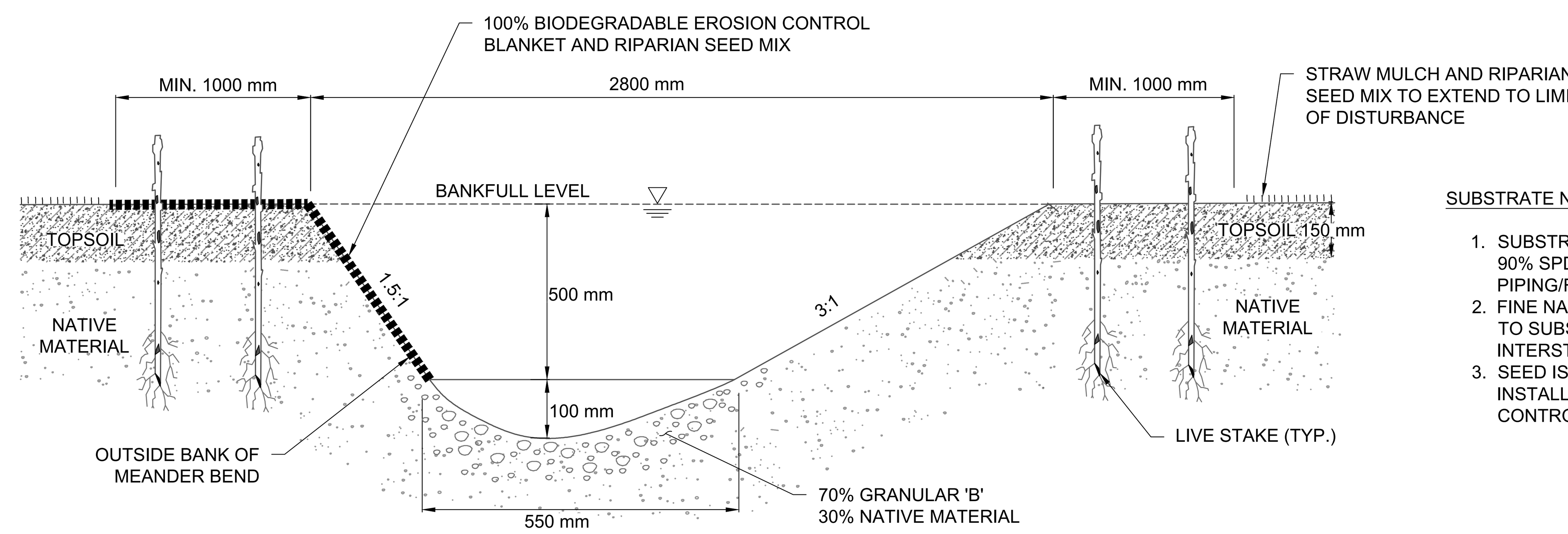
**CHANNEL CROSS SECTIONS - REACH 2**
N.T.S.




TYPICAL RIFFLE




TYPICAL POOL

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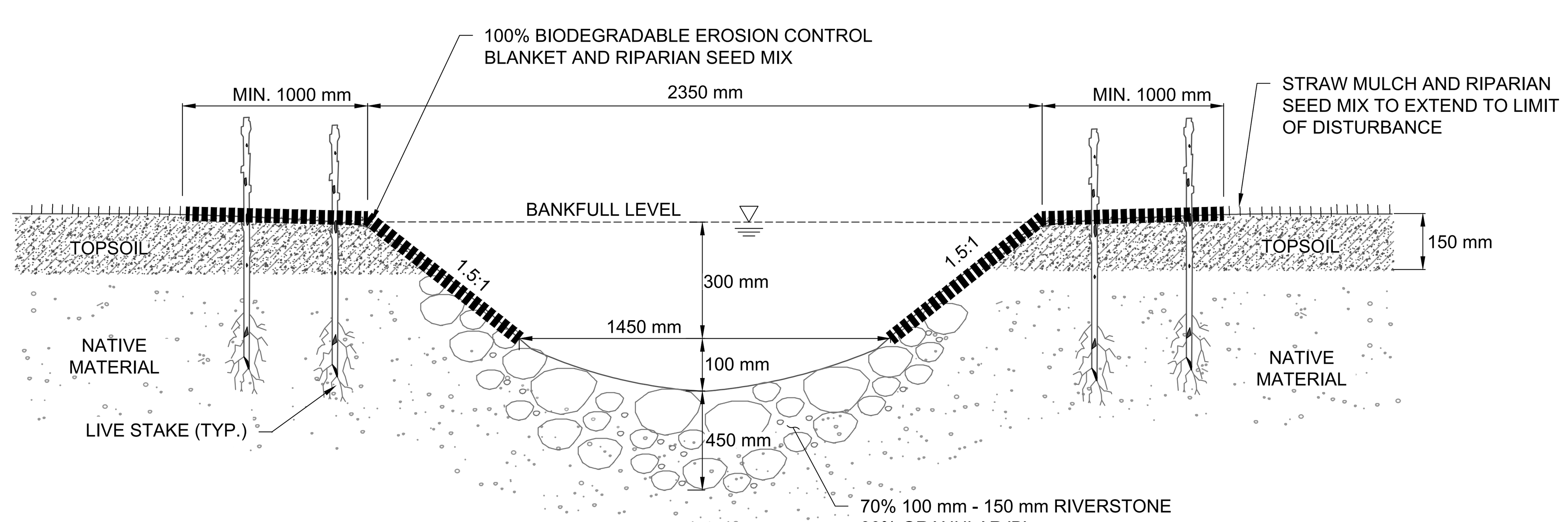
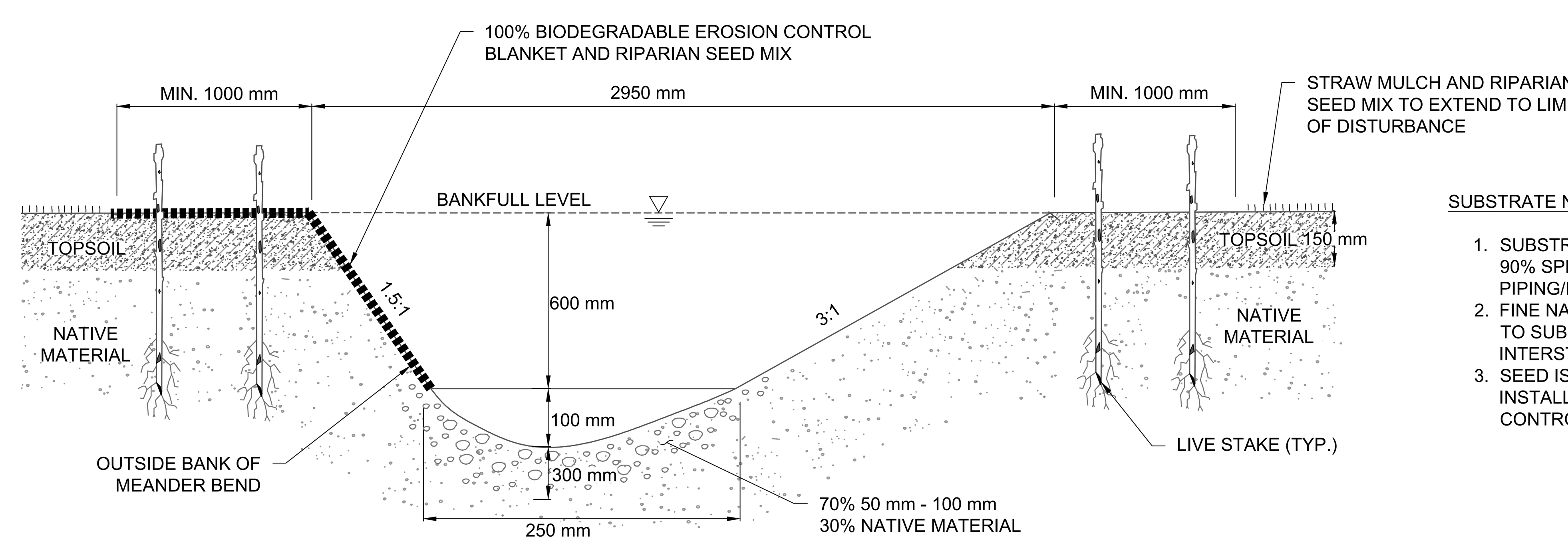
**CHANNEL CROSS SECTIONS - REACH 3**
N.T.S.




TYPICAL RIFFLE




TYPICAL POOL

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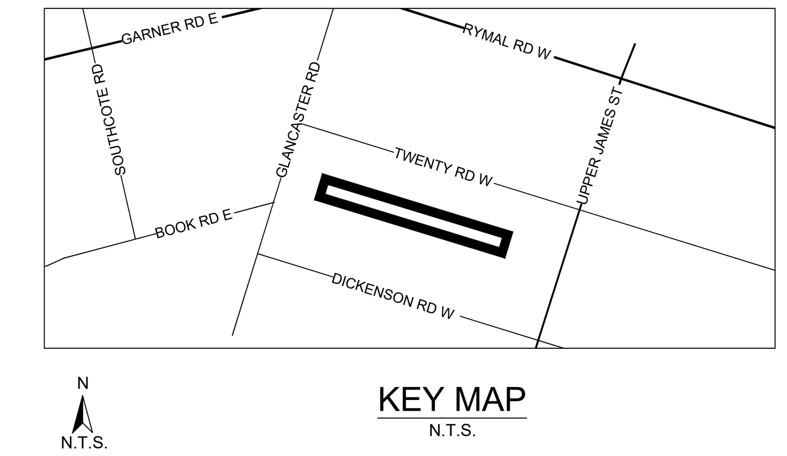
**CHANNEL CROSS SECTIONS - REACH 4**
N.T.S.




KEY MAP
N.T.S.

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**SCALED FOR PLOT ON 'ARCH D'**

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| DRAWN BY: AS | DATE: NOVEMBER 2023 |

**DRAFT FOR DISCUSSION**

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UPPER WEST SIDE COMMUNITY
TRIBUTARY OF TWENTY MILE CREEK

CONCEPTUAL CHANNEL DESIGN
RESTORATION DETAILS

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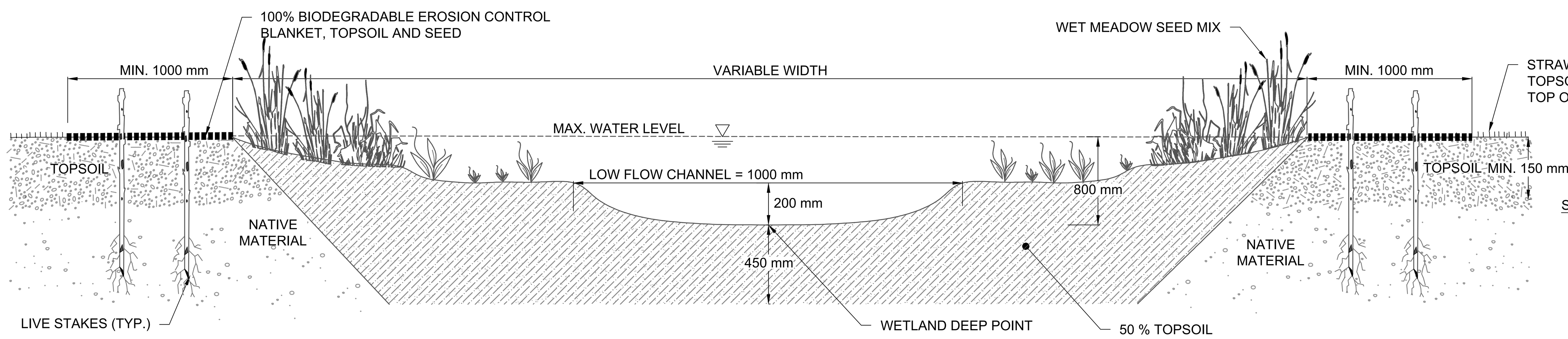
| PROJECT No.: 23079 | DRAWING No.: DET-1 |
| SCALE: AS NOTED | SHEET 10 OF 12 |




## ONLINE WETLAND CROSS SECTION

N.T.S.

SUBSTRATE NOTES

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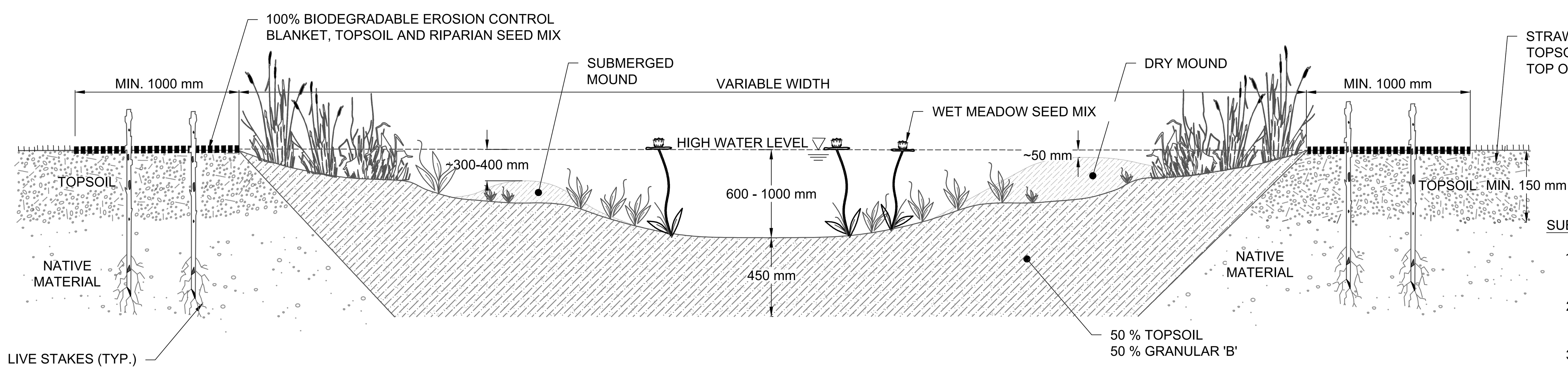


## WETLAND CROSS SECTION

N.T.S.

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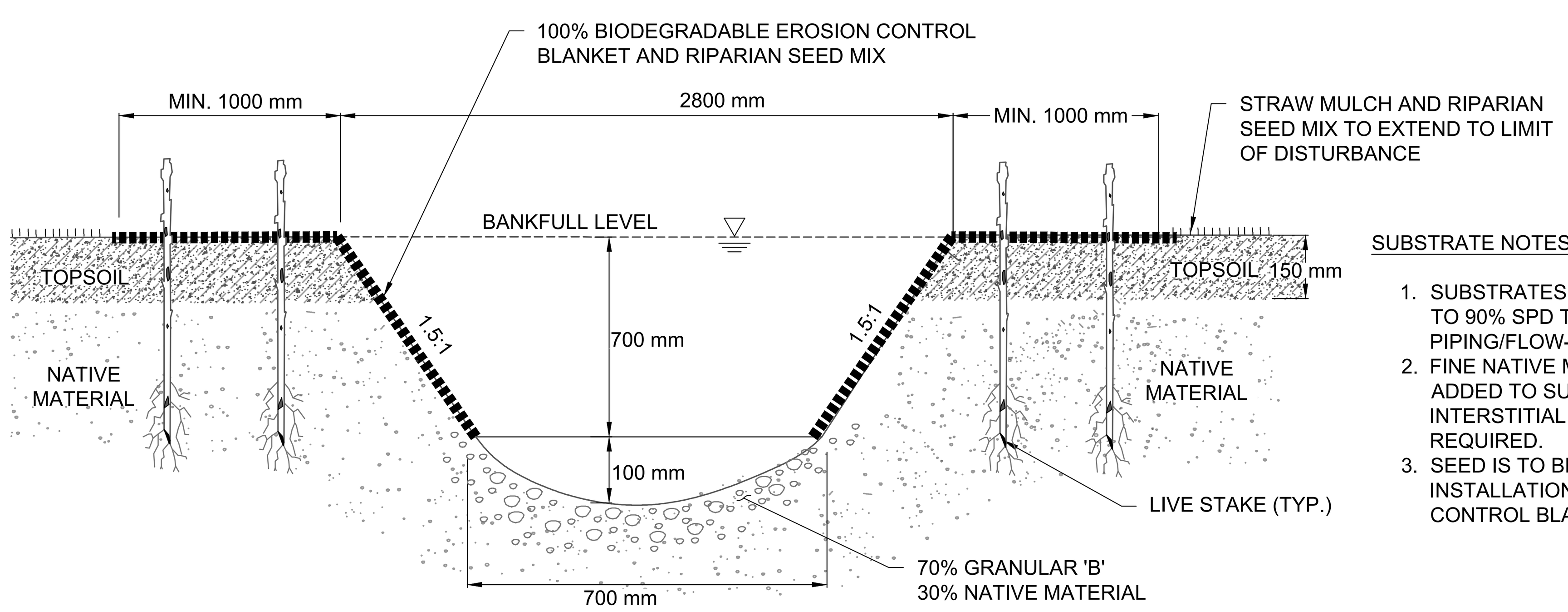


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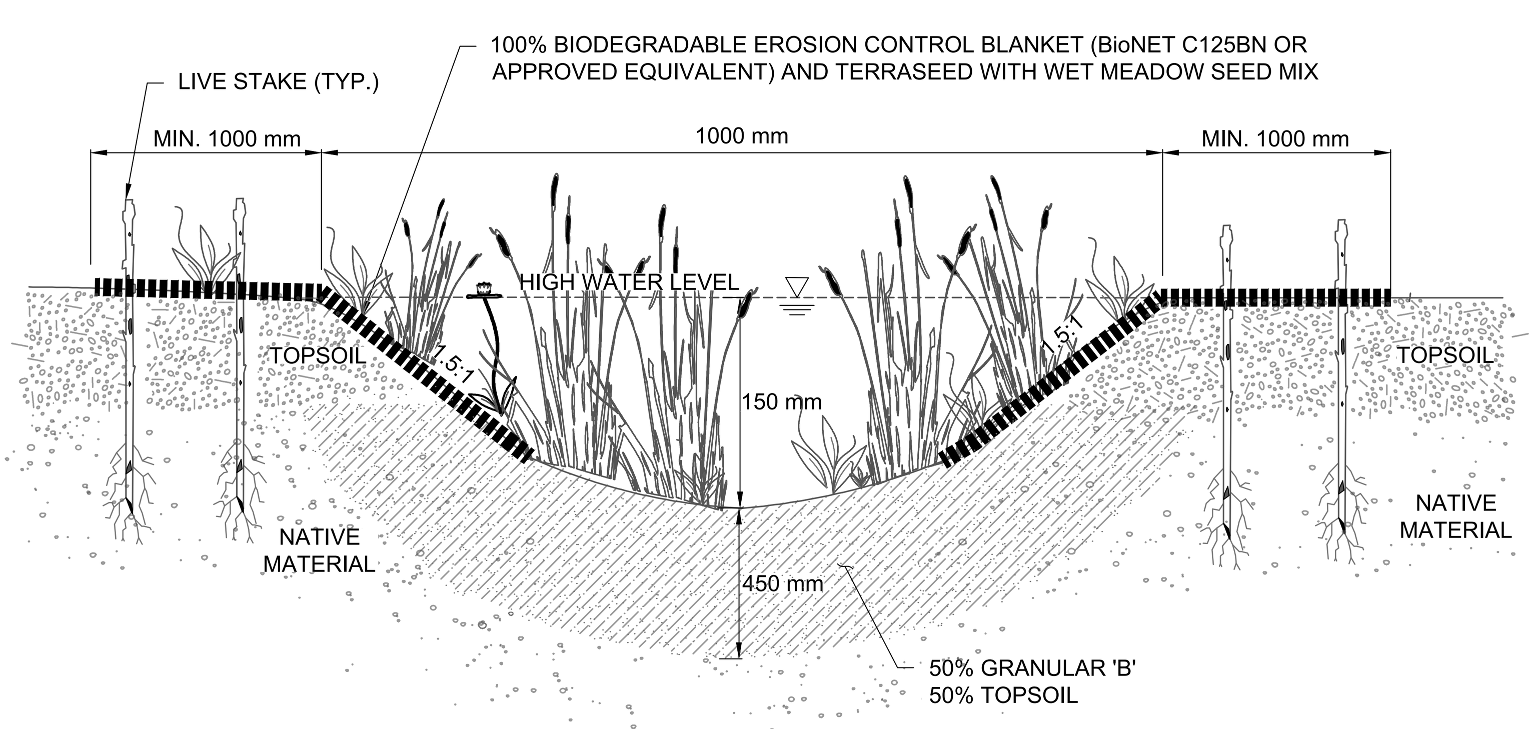
## OVER WINTER POOL

N.T.S.

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## TYPICAL BIOSWALE CROSS SECTION

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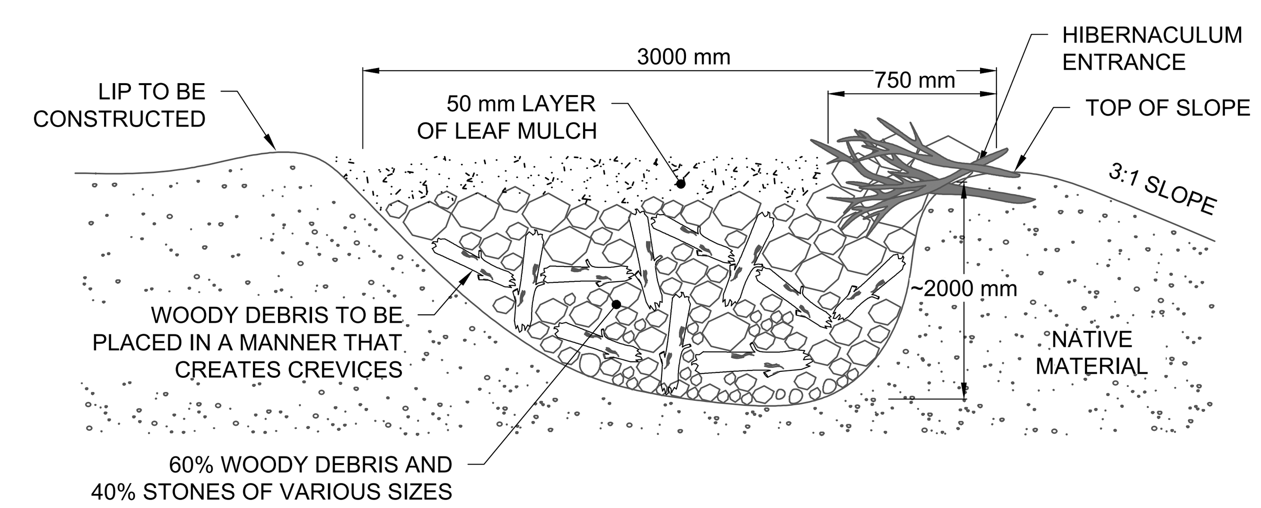
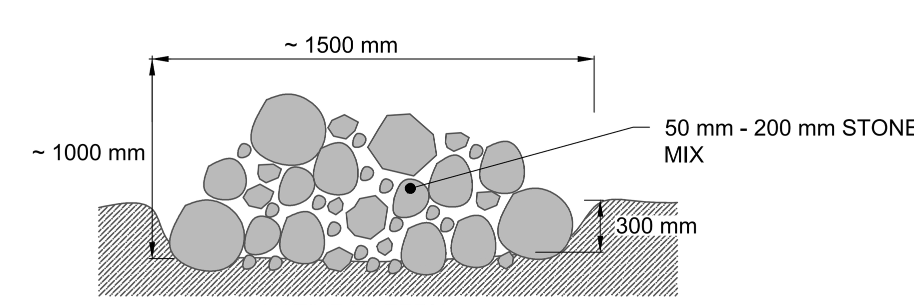



NOTES

1. SNAKE HIBERNACULUM PLACEMENT TO BE CONFIRMED BY A QUALIFIED BIOLOGIST.
2. SNAKE HIBERNACULUM TO BE CONSTRUCTED INTO TOP OF SLOPE (SEE PLAN) ALONG WEST OR SOUTH FACING SLOPES IN A LOCATION FREE OF SHADE.
3. A LIP IS TO BE CONSTRUCTED ALONG THE TOP OF SLOPE TO PREVENT RUNOFF FROM ENTERING THE HIBERNACULUM.
4. LARGER STONES WITH BRUSH TO BE INSTALLED AT OPENING. DO NOT FILL VOIDS OR COMPACT MATERIAL AROUND STONES. CREATE CREVICES TO PROMOTE ENTRANCE INTO HIBERNACULUM.
5. LOOSELY PLACE ANGULAR STONE RANGING IN SIZE FROM 0.10 m - 0.50 m AND WOODY DEBRIS SUCH THAT VOIDS REMAIN.
6. CONCRETE DEBRIS MAY BE USED IF SOURCED ON SITE.
7. HARDWOOD OR SOFTWOOD SPECIES ARE ACCEPTABLE FOR WOODY DEBRIS. LOGS SHOULD BE SOURCED ON SITE (WHERE POSSIBLE).

## SNAKE HIBERNACULUM

N.T.S.

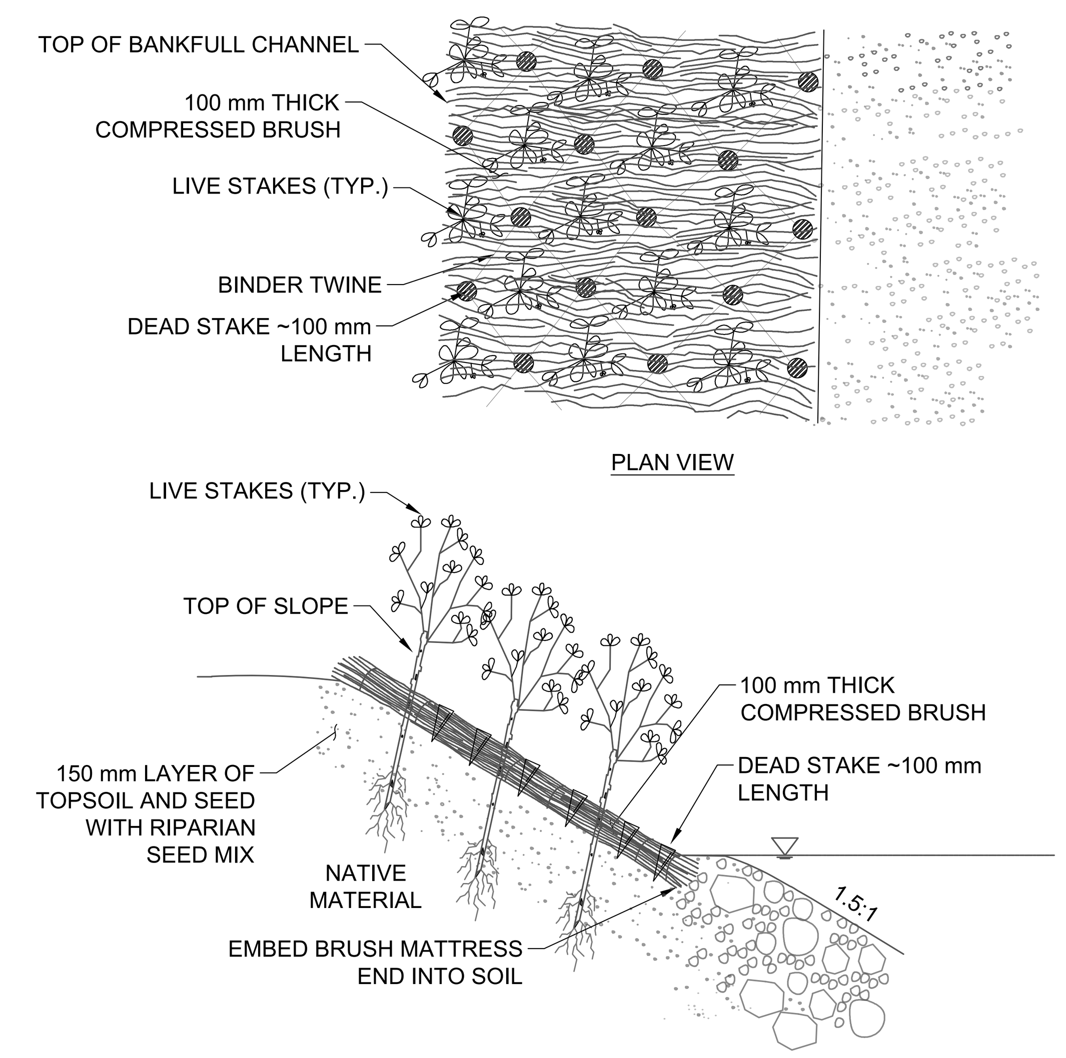



NOTES

1. 50 mm - 200 mm STONE MIX WITH SOME ANGULAR STONES.
2. THE STONE MIX SHOULD PROVIDE A VARIETY OF INTERSTITIAL SPACES.
3. PILES ARE AT LEAST 1500 mm IN DIAMETER AND ~1000 mm HIGH.
4. PARTIALLY BURY PILES 300 - 400 mm TO AVOID ROCKFALL.

## ROCK PILE

N.T.S

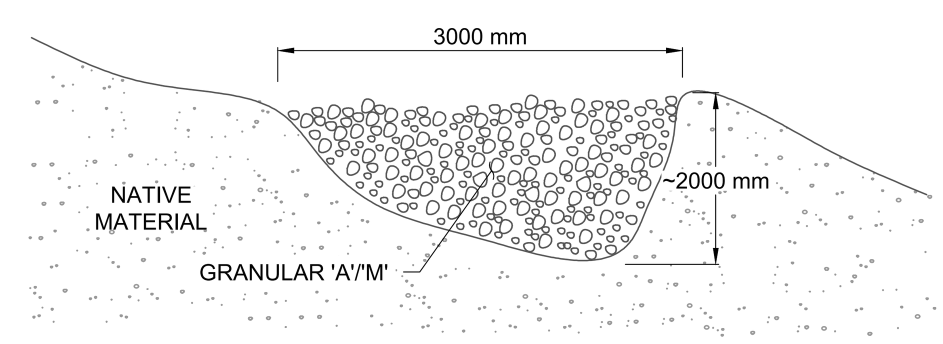



NOTES

1. LIVE BRANCHES TO CONSIST OF WILLOW AND DOGWOOD SPECIES ~ 1000 mm IN LENGTH AND COMPRESSED TO A WIDTH OF ~100 mm.
2. LIVE BRANCHES TO BE SOURCED ON-SITE, WHERE POSSIBLE.
3. BRUSH MATTRESS TO BE PLACED ON BANK WITH THE BUTT END EXTENDING BELOW THE LOW WATER LEVEL AND EMBEDDED INTO THE SOIL.
4. POUND DEAD STAKES THROUGH BRUSH MATTRESS AND TIE BINDER TWINE AROUND DEAD STAKE TOPS. ENSURE TWINE IS TIGHT OVER BRANCHES.
5. TAMP LIVE STAKES BETWEEN DEAD STAKES AT A DENSITY OF 3 PER SQUARE METRE.
6. FILL VOIDS BETWEEN BRUSH MATTRESS BRANCHES WITH TOPSOIL TO PROMOTE ROOTING.

## BRUSH MATTRESS DETAIL

N.T.S.

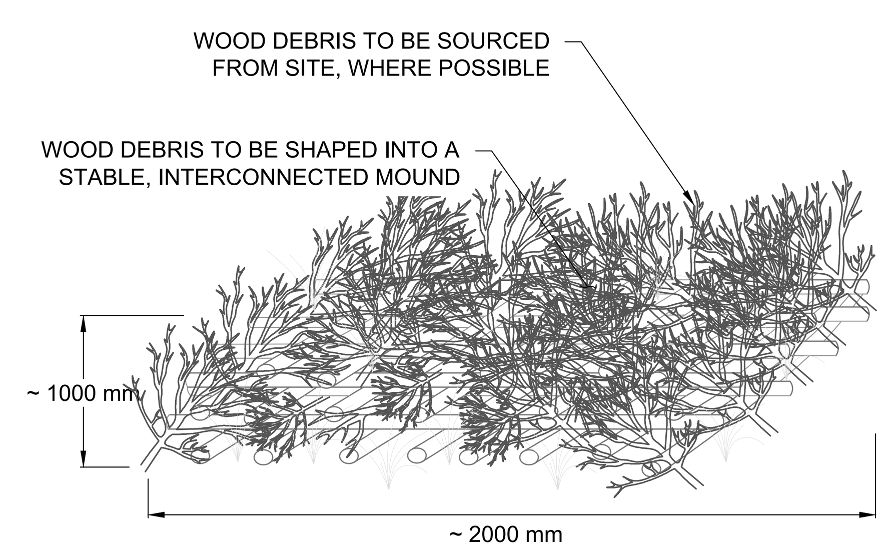



NOTES

1. TURTLE NESTING SITE TO BE INSTALLED ON SLOPES AWAY FROM THE WATERCOURSE AND ON SOUTH OR WEST FACING SLOPES.
2. FEATURE TO BE CONSTRUCTED USING ROAD SHOULDER GRANULAR 'A'/'M' TYPE MATERIAL ONLY.
3. NO VEGETATION OR WOODY DEBRIS IS TO BE INCLUDED.

## TURTLE NEST

N.T.S

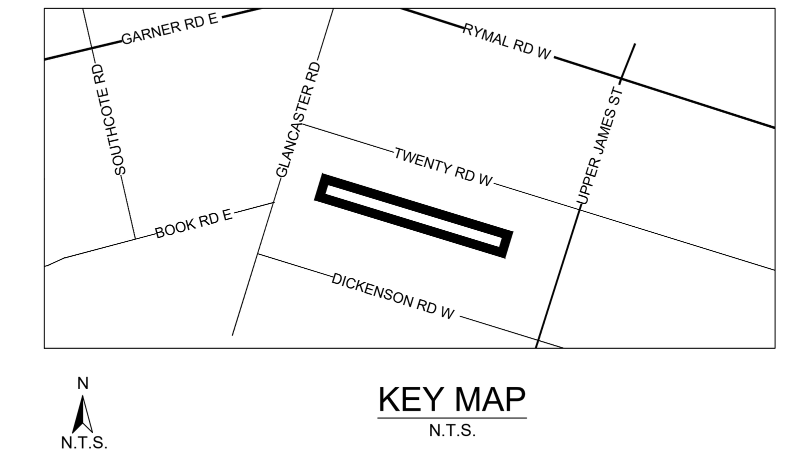



NOTES

1. LARGEST AND HEAVIEST LOG MATERIAL SHOULD BE PLACED ON THE BASE OF THE BRUSH PILE. THE SMALLEST BRUSH MATERIAL SHOULD BE PLACED AT THE TOP.
2. LOGS SHOULD BE FORMED INTO A PALLET SHAPE.
3. HEIGHT OF BRUSH PILE IS NOT TO EXCEED 1.0 M.
4. A MIX OF HARDWOOD AND SOFTWOOD SHOULD BE USED.
5. PLANT WITH NATIVE FRUIT BEARING VINES.

## PALLET TYPE WOOD PILE

N.T.S




## KEY MAP

N.T.S.

## GENERAL NOTES

1. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
2. THE CONTRACTOR MUST NOTIFY THE CONTRACT ADMINISTRATOR AND CONSERVATION AUTHORITY OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
3. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
4. LAYOUT MUST BE REVIEWED AND APPROVED BY THE CONTRACT ADMINISTRATOR.

## TIMING OF WORKS

1. IN WATER WORKS SHALL BE COMPLETED BETWEEN JULY 1ST TO MARCH 31ST.
2. TREE CLEARING SHOULD BE COMPLETED OUTSIDE THE BIRD NESTING SEASON TO COMPLY WITH THE FEDERAL MIGRATORY BIRDS CONVENTION ACT. ANY TREES THAT REQUIRE REMOVAL OUTSIDE OF THIS TIMING WINDOW MUST FIRST BE INSPECTED BY A QUALIFIED BIOLOGIST TO DETERMINE THE PRESENCE OF NESTING BIRDS.
3. THE WEATHER FORECAST SHOULD BE CONTINUALLY MONITORED TO ENSURE THAT WORKS ARE UNDERTAKEN ONLY DURING FAVOURABLE WEATHER CONDITIONS.
4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

## SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
2. IN THE EVENT OF AN UNEXPECTED STORM, ALL UNFIXED ITEMS THAT HAVE THE POTENTIAL TO CAUSE A SPILL OR AN OBSTRUCTION TO FLOW MUST BE MOVED A STABLE AREA ABOVE ACTIVE FLOODPLAIN.
3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE STOCKPILED SOILS THAT ARE STORED FOR PROLONGED PERIODS WITH THE APPLICATION OF A NURSE CROP AT A RATE OF 60 kg/ha.
5. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW. ON SOILS THAT WILL BE EXPOSED FOR PROLONG PERIODS, TEMPORARILY INSTALL A BIODEGRADABLE EROSION CONTROL BLANKET ON EXPOSED SOILS, OR APPLY A NURSE CROP AT A RATE OF 60 KG/HA.
6. MINIMIZE THE AREA OF DISTURBANCE TO THE EXTENT POSSIBLE.
7. ALL VEGETATION, ADJACENT TO THE WORK AREA, MUST BE PROTECTED AND DELINEATED WITH CONSTRUCTION FENCING OR TREE PROTECTION BARRIERS.
8. ALL GRADES IN THE AREA REGULATED BY THE CONSERVATION AUTHORITY MUST BE MAINTAINED OR MATCHED, UNLESS OTHERWISE AUTHORIZED IN THE APPLICABLE PERMIT.

## EROSION AND SEDIMENT CONTROL

1. ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES MUST BE INSTALLED PRIOR TO START OF WORKS.
2. SEDIMENT CONTROLS MUST BE INSPECTED DAILY TO ENSURE THAT THEY ARE IN GOOD REPAIR AND FUNCTIONING AS INTENDED.
3. EROSION AND SEDIMENT CONTROLS MUST BE MAINTAINED DURING CONSTRUCTION, AND ANY REQUIRED REPAIRS OR REPLACEMENTS MUST BE COMPLETED WITHIN 24 HOURS AFTER THEY HAVE BEEN IDENTIFIED DURING THE MONITORING.
4. EROSION AND SEDIMENT CONTROLS MAY REQUIRE PERIODIC ADJUSTMENTS TO REFLECT CHANGING SITE CONDITIONS. THE CONTRACTOR WILL BE RESPONSIBLE FOR THESE ADJUSTMENTS TO ENSURE PROPER FUNCTION.
5. ANY CHANGES TO THE EROSION AND SEDIMENT CONTROL PLAN BEYOND MINOR ADJUSTMENTS MUST BE APPROVED BY THE CONTRACT ADMINISTRATOR.
6. ADDITIONAL EROSION AND SEDIMENT CONTROL SUPPLIES MUST BE KEPT ON SITE IN ORDER TO FACILITATE IMMEDIATE REPAIRS AND/OR UPGRADES AS NEEDED.
7. ALL TEMPORARY SEDIMENT CONTROLS MUST BE REMOVED AFTER THE CONTRACT ADMINISTRATOR DEEMS THE SITE TO BE STABLE.

## DELETERIOUS SUBSTANCE CONTROL/SPILL MANAGEMENT

1. PREVENT THE RELEASE OF SEDIMENT, SEDIMENT-LADEN WATER, RAW CONCRETE, CONCRETE LEACHATE OR ANY OTHER DELETERIOUS SUBSTANCES INTO ANY WATERBODY, RAVINE OR STORM SEWER SYSTEM.
2. ENSURE EQUIPMENT AND MACHINERY ARE IN GOOD OPERATING CONDITION (POWER WASHED), FREE OF LEAKS, EXCESS OIL, AND GREASE.
3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
5. THE CONTRACT ADMINISTRATOR MUST BE NOTIFIED IMMEDIATELY IN THE EVENT OF A SPILL OF DELETERIOUS SUBSTANCE.

## WORK AREA ISOLATION

1. ALL WORK IN ISOLATED WORK AREAS MUST BE COMPLETED IN THE DRY. AN ADEQUATE NUMBER OF PUMPS MUST BE USED FOR UNWATERING.
2. THE UNWATERING DISCHARGE LOCATION MUST BE LOCATED AT LEAST 30 M FROM ANY WATERCOURSE OR WETLAND IN AN AREA WITH DENSE VEGETATIVE GROUNDCOVER, AND WHERE THE DISCHARGE CAN RETURN TO THE WATERBODY DOWNSTREAM OF THE WORK AREA OVER THE GROUNDCOVER.
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.

**SCALED FOR PLOT ON 'ARCH D'**

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DESIGNED BY: AS | CHECKED BY: PV

DRAWN BY: AS | DATE: NOVEMBER 2023

**DRAFT FOR DISCUSSION**

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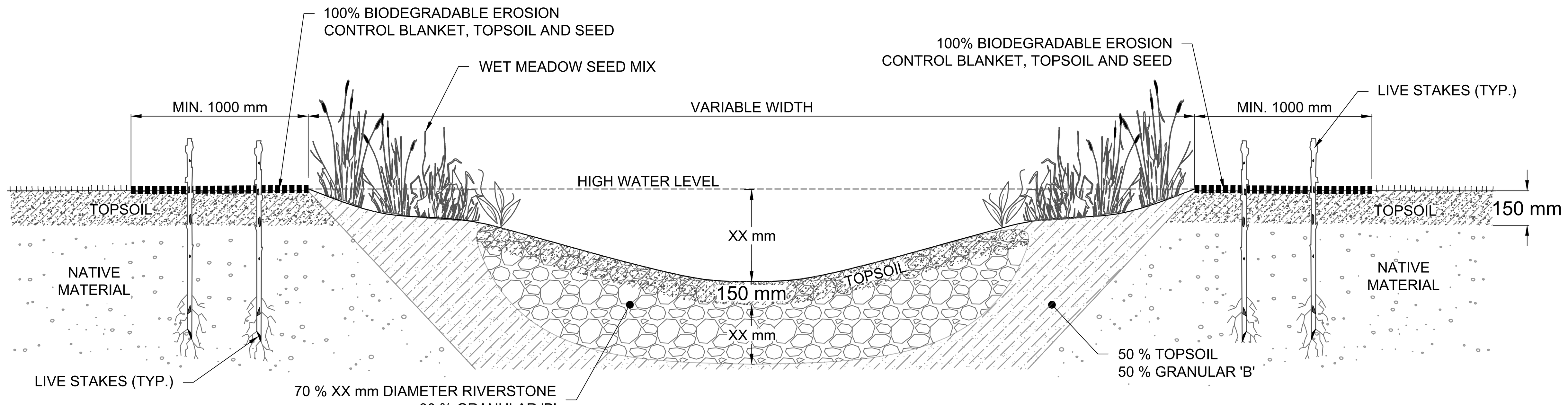
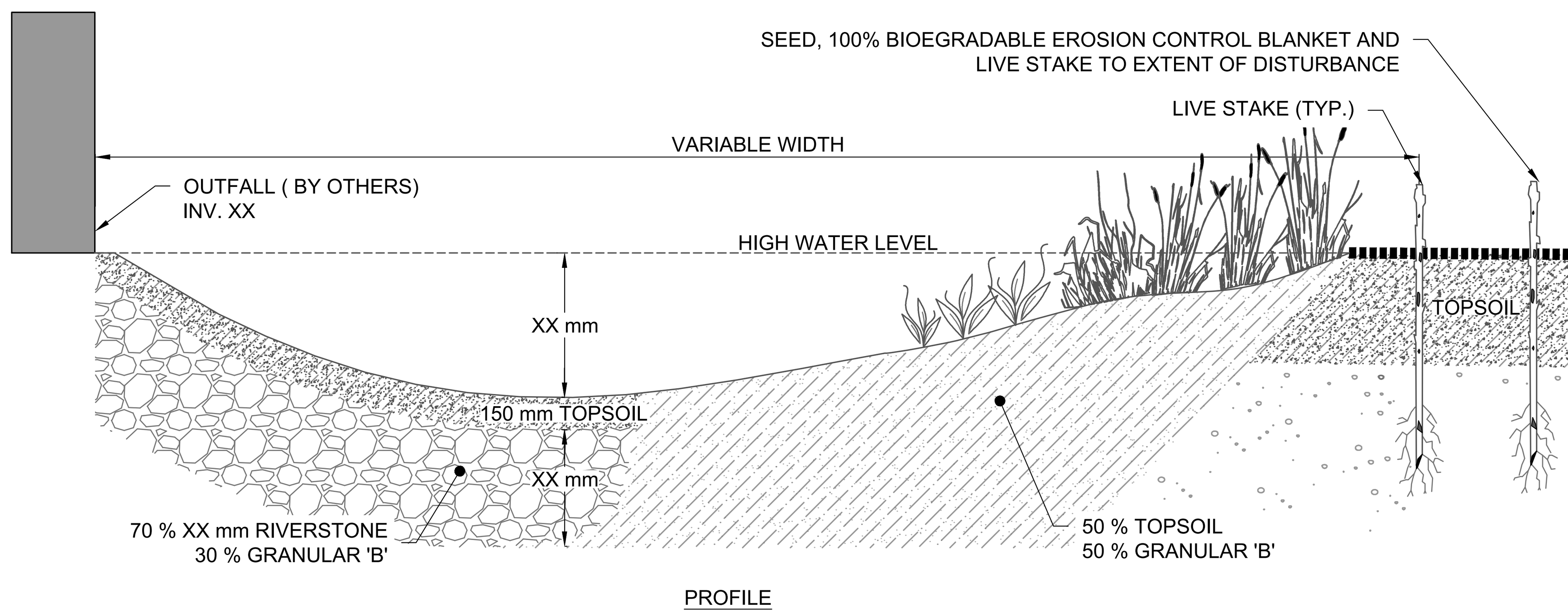
# UPPER WEST SIDE COMMUNITY TRIBUTARY OF TWENTY MILE CREEK

# CONCEPTUAL CHANNEL DESIGN RESTORATION DETAILS

PROJECT No.: 23079 | DRAWING No.: DET-2

SCALE: AS NOTED | SHEET 11 OF 12



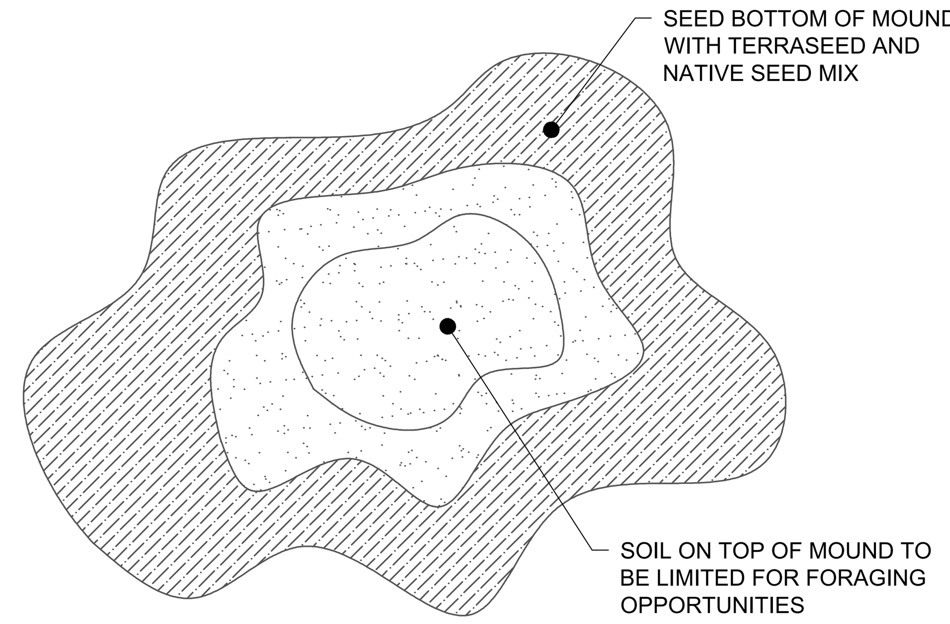




SUBSTRATE NOTES

1. SUBSTRATES TO BE COMPACTED TO 90% SPD TO PREVENT PIPING/FLOW-THROUGH.
2. FINE NATIVE MATERIAL TO BE ADDED TO SUBSTRATE MIX TO FILL INTERSTITIAL VOIDS, AS REQUIRED.
3. SEED IS TO BE PLACED PRIOR TO INSTALLATION OF EROSION CONTROL BLANKET.

## STONE CORE WETLAND

N.T.S




NOTES
1. HEIGHT OF TERRESTRIAL MOUND SHALL BE 1000 mm TO 2000 mm.
2. PLACEMENT OF VEGETATED TERRESTRIAL MOUND TO BE AS PER PLAN, IN DRY AREAS ONLY.
3. CONSTRUCTION OF MOUND TO BE COMPLETED IN CONJUNCTION WITH SITE GRADING ACTIVITIES AS TERRESTRIAL MOUNDS TO BE GRADED TO MATCH EXISTING GROUND AND/OR TIE INTO EXISTING SLOPES.
4. TERRESTRIAL MOUND TO BE SLIGHTLY CONCAVE/DIMPLED ON TOP.
5. SEED MIX TO BE COMPRISED OF RIPARIAN / UPLAND SPECIES AS PER PLANTING PLAN.

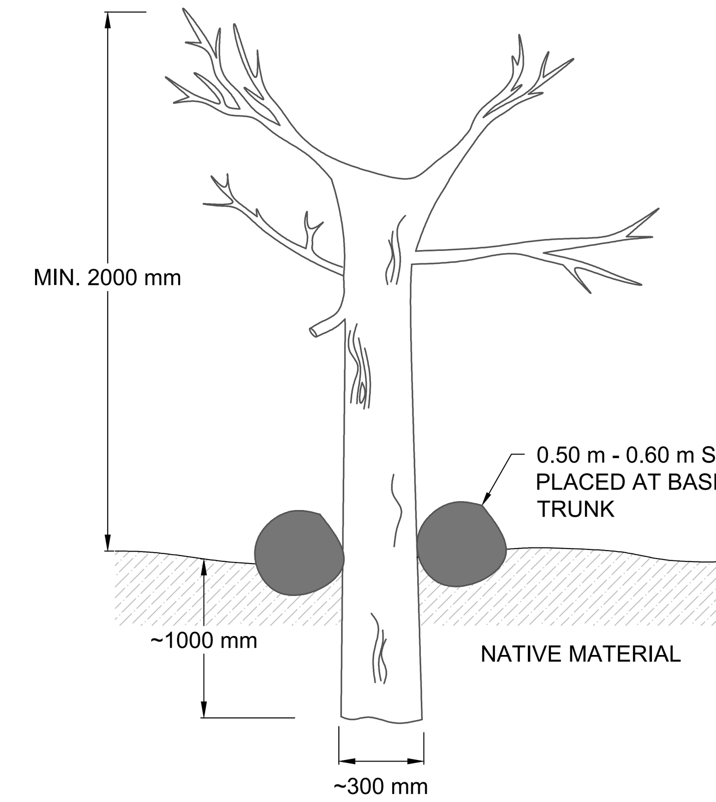
## TERRESTRIAL MOUND

N.T.S

## RIPARIAN SEED MIX

| COMMON NAME | SCIENTIFIC NAME | % OF MIX |
|---|---|---|
| FOWL MANNA GRASS | *Glyceria striata* | 2 |
| FOWL BLUEGRASS | *Poa palustris* | 30 |
| FOX SEDGE | *Carex vulpinoidea* | 30 |
| PATH RUSH | *Juncus tenuis* | 8 |
| VIRGINIA WILD RYE | *Elymus virginicus* | 30 |

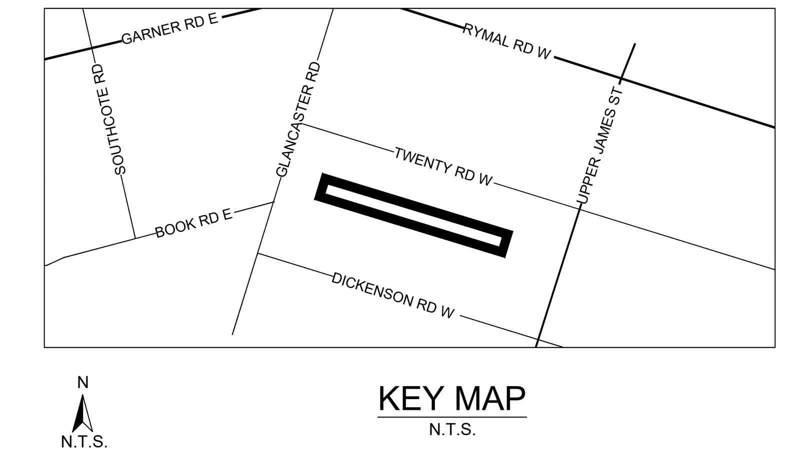
NOTES
1. APPLY SEED MIX AT A RATE OF 25 kg PER HECTARE.
2. SEEDING SHALL OVERLAP ADJACENT GROUND COVER BY 300 mm.
3. APPLY COMMON OAT (AVENA SATIVA) NURSE CROP AT A RATE OF 22 kg PER HECTARE.
4. WATER SOIL AFTER SEED APPLICATION.




NOTES
1. CONSTRUCT WITH CONIFER TRUNKS WITH TWO OR MORE NATURAL BRANCHES.
2. AT LEAST 75% OF THE BARK SHOULD BE INTACT.
3. AUGER HOLE TO A DEPTH OF ~1.0 m INSTALL TRUNK AND TAMP IN SAND AROUND BASE.
4. ~1.0 m OF TRUNK IS TO BE BURIED.
5. PLACE 0.50 m - 0.60 m STONE AROUND BASE FOR ADDITIONAL SUPPORT.
6. IF ROOT WAD IS USED PLACE ROOT AT TOP.
7. LOGS SHOULD BE SOURCED ON SITE (WHERE POSSIBLE).

## RAPTOR POLE

N.T.S.

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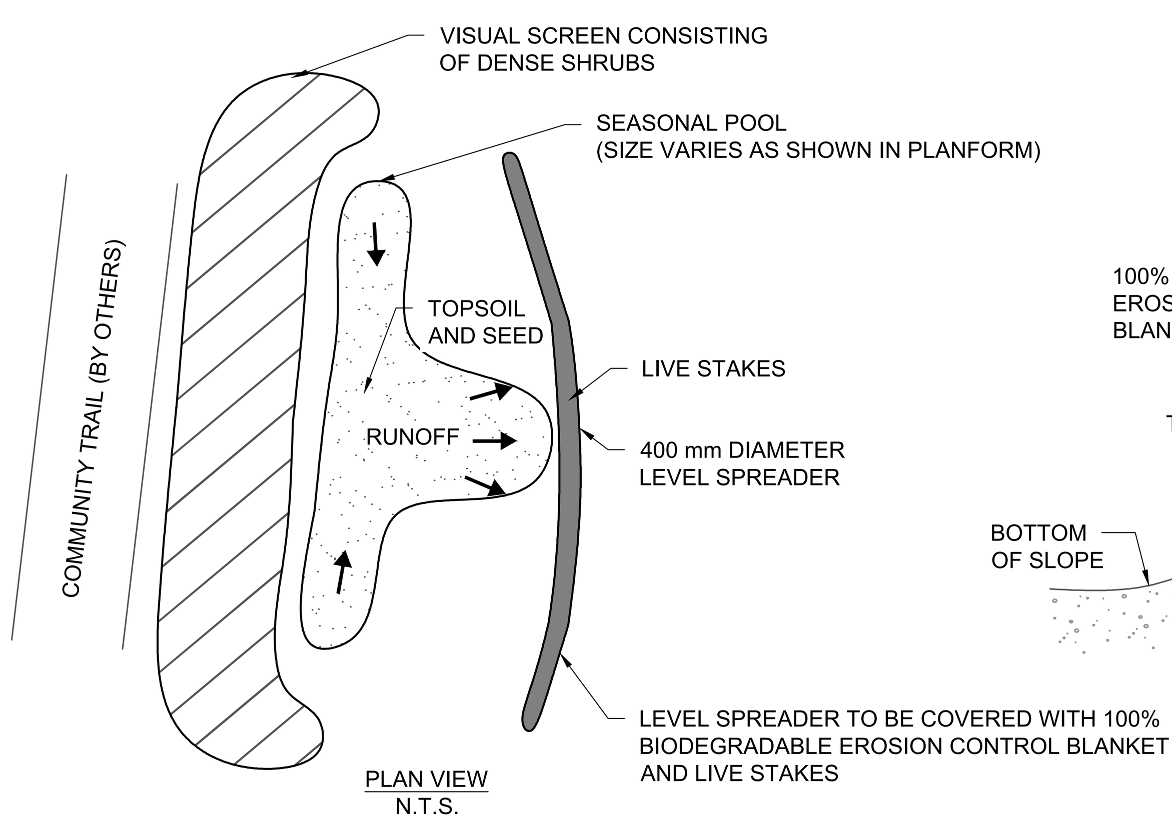
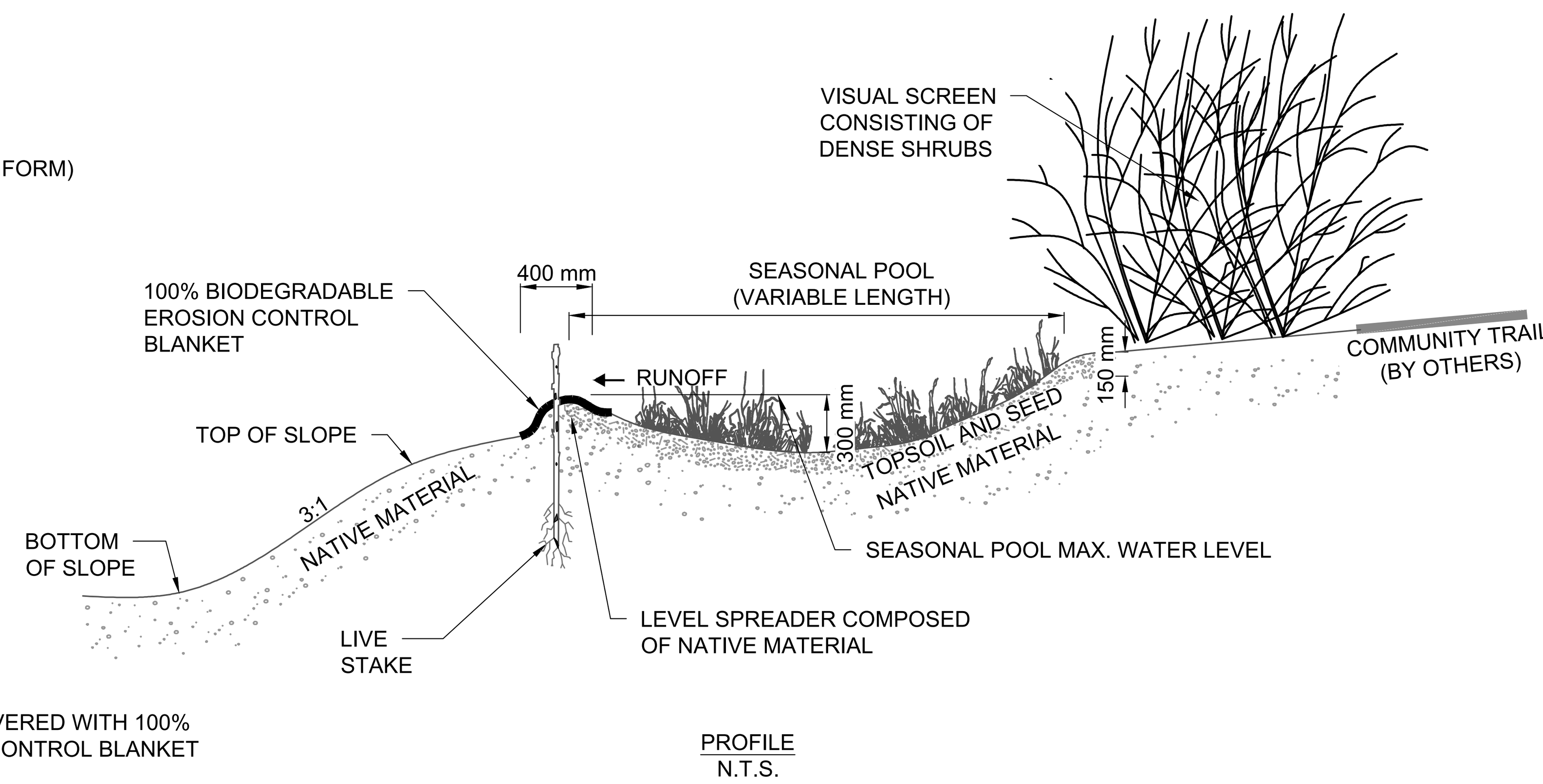


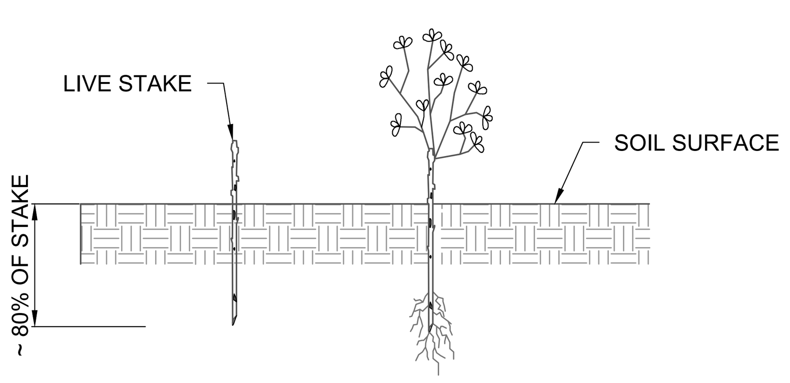

## SEASONAL POOL WITH LEVEL SPREADER

N.T.S.

## WET MEADOW SEED MIX

| COMMON NAME | SPECIES | % OF MIX |
|---|---|---|
| BLUE VERVAIN | *Verbana hastata* | 9 |
| BLUE FLAG | *Iris versicolor* | 1 |
| DARK GREEN BULRUSH | *Scirpus atrovirens* | 8 |
| PURPLE STEMMED ASTER | *Aster puniceus* | 1 |
| FOX SEDGE | *Carex vulpinoidea* | 35 |
| NEW ENGLAND ASTER | *Aster novae-angliae* | 1 |
| SOFT RUSH | *Juncus effusus* | 5 |
| RICE CUTGRASS | *Leersia oryzoides* | 1 |
| SPOTTED JOE PYE WEED | *Eupatorium maculatum* | 1 |
| SQUARE STEMMED MONKEY FLOWER | *Mimulus ringens* | 1 |
| SWAMP MILKWEED | *Asclepias incarnata* | 1 |
| VIRGINIA WILD RYE | *Elymus virginicus* | 35 |
| WOOL GRASS | *Scirpus cyperinus* | 1 |

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 COMMON OAT NURSE CROP AT A RATE OF 22 kg PER HECTARE.
4. WATER SOIL AFTER SEED APPLICATION.




SPECIES AND QUANTITIES

| COMMON NAME | SCIENTIFIC NAME | SIZE |
|---|---|---|
| RED OSIER DOGWOOD | *Cornus stolonifera* | 1 m |
| PUSSY WILLOW | *Salix discolor* | 1 m |
| SANDBAR WILLOW | *Salix exigua* | 1 m |

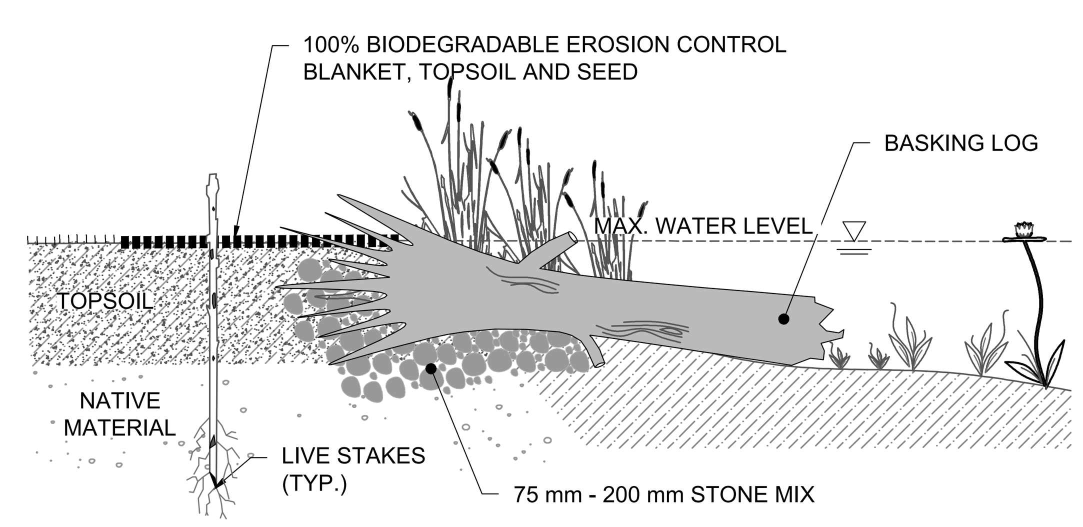
NOTES
1. QUANTITY TO BE DETERMINED BASED ON AREA OF DISTURBANCE TO BE RESTORED
2. LIVE STAKES SHOULD BE FROM AT MINIMUM 2-YEAR OLD STOCK.
3. LIVE STAKES ARE TO BE INSTALLED AT A DENSITY OF 3 STAKES PER SQUARE METRE.
4. LIVE STAKES SHOULD BE PRE-SOAKED (SUBMERGED IN WATER) FOR AT LEAST 24 HOURS AFTER 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

N.T.S.

## 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. BIODEGRADBLE 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.




NOTES
1. ANCHOR AND SUPPORT BASKING LOGS WITH 75 mm - 200 mm STONE MIX.
2. FIRMLY COMPACT STONE MIX TO PREVENT THROUGH FLOW.
3. BURY 1/3 OF LOG INTO SOIL.
4. LENGTH OF BASKING LOGS ARE TO BE INSTALLED 1000 - 1500 mm INTO WET AREA.
5. BASKING LOGS TO BE A MINIMUM 500 mm IN DIAMETER AND 2000 - 2500 mm IN LENGTH.
6. BASKING LOGS SHOULD BE ANGLED TO PROMOTE TURTLE BASKING.
7. BASKING LOGS SHOULD BE A MIXTURE OF SUITABLE HARDWOOD AND SOFTWOOD SPECIES.

## BASKING LOG

N.T.S.

SCALED FOR PLOT ON 'ARCH D'

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| DESIGNED BY: AS | CHECKED BY: PV |
| DRAWN BY: AS | DATE: NOVEMBER 2023 |

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UPPER WEST SIDE COMMUNITY
TRIBUTARY OF TWENTY MILE CREEK

CONCEPTUAL CHANNEL DESIGN
RESTORATION DETAILS

| | |
|---|---|
| PROJECT No.: 23079 | DRAWING No.: DET-3 |
| SCALE: AS NOTED | SHEET 12 OF 12 |