Long Point Region Conservation Authority

Teeterville Dam Safety Review and Condition Assessment

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Executive Summary

This report presents the findings of the Dam Safety Review and Condition Assessment (DSRCA) carried out for Teeterville Dam, which is located on Big Creek in the Town of Teeterville in Norfolk County, Ontario. The dam is owned and operated by the Long Point Region Conservation Authority (LPRCA). The DSRCA included a background review, natural heritage review, dam inspections, a hydrotechnical assessment, including dam break analysis and inundation mapping, Hazard Potential Classification and selection of Inflow Design Flood, an assessment of the structural integrity, a geotechnical assessment, and a reservoir sediment quantity and quality assessment. The DSRCA was completed as per the requirements of the Lakes and Rivers Improvement Act (LRIA) Technical Bulletin and Best Management Practices (Ministry of Natural Resources and Forestry, 2011).

The existing documentation provided by LPRCA was reviewed, including the following:

- Pre-construction drawings for the modifications to Teeterville Dam dated 1962, showing a general layout of the site and the dam, as well as design details for the gantry crane structure;
- Pre-construction drawing of the new bridge and road realignment upstream of the dam dated 1971;
- Dam Operation and Maintenance Manual from 1999; and
- Dam Inspection Report from 2014 (Riggs Engineering).

Upon completion of the natural heritage review it has been determined that:

- A total of 15 SAR are likely to be present within the study area, nine (9) aquatic SAR and six (6) terrestrial SAR.
- BC31 Provincially Significant Wetland Complex is located throughout majority of the study area.
- Several Life Science and ANSI sites were identified within the study area and/or in close proximity to the study area. The list of Life Science and ANSI sites identified are as follows; La Salette Woods (Life Science Site) is located within 1 km of the study area, Delhi Swamp (Life Science Site) is located within the study area, Delhi Big Creek Valley (Life Science & ANSI) is located within the study area, Delhi Big Creek Valley (Carolinian Canada Site) is located within the study area, and Quance Bush (Life Science Site) is located within 1 km of the study area.
- Big Creek is a cold water watercourse containing a diverse fish community with migratory Rainbow trout and Chinook salmon.

A visual inspection of the dam and site area was carried out on Sept. 9, 2015 by AECOM accompanied by LPRCA staff. A supplemental visit was undertaken in conjunction with the site survey on September 16, 2015. AECOM also acquired the services of Watech Services Inc. to investigate the thickness of the downstream slab for stability evaluation. The inspection took place on October 15, 2015 and consisted of diver inspection, core drilling and drilling of holes.

A preliminary Hazard Potential Classification (HPC) was completed for the dam, which determined the Teeterville Dam's HPC as LOW for both sunny day and flood conditions. Based on the dam's HPC, the Inflow Design Flood (IDF) for the dam was selected as the 100-yr flood event.

Hydrotechnical assessment of the dam, including hydrologic and dam break analyses was conducted. The dam break analysis confirmed the dam's HPC as Low and the dam's IDF as the 100-yr event. A wave height and minimum freeboard analysis was completed, indicating that there is adequate freeboard under the IDF conditions.

Thurber Engineering Limited (Thurber) carried out a geotechnical investigation for the earthen berm portion of the Teeterville Dam. The scope of work for the investigation included a review of existing documentation and drawings provided by LPRCA, a visual inspection of the dam to assess areas of potential instability, and an intrusive investigation consisting of 1 borehole through the roadway immediately south of the dam. The investigation showed that the dam embankments meet the minimum stability criteria. A number of measures were recommended to reduce the potential for failure and internal erosion issues at the embankment.

The stability assessment of Teeterville Dam showed that The Dam fails to meet the required factors of safety for all loading conditions. The use of soil anchors can sufficiently increase the safety criteria. However, given the age, unknown structure properties and condition of the existing structure, use of soil anchors should be carefully weighed against other rehabilitation or replacement alternatives.

Quality and quantity assessment of the sediment in the Teeterville Dam reservoir was carried out. Samples of the sediment were collected and analyzed in the laboratory. The results of sediment analyses were used to identify levels of potential contaminants in the sediment and determine its suitability for release, disposal or reuse. Based on the completed analysis, it was determined that the sediment as a whole can be either released to downstream Big Creek or disposed on site. A bathymetric survey of the reservoir was completed to estimate he sediment volume.

As a result of the dam safety review and condition assessment, a number of actions and maintenance activities were recommended to ensure that the structure will satisfy current dam safety criteria. In addition to recommendation for additional studies and monitoring, four alternatives for future works at the Teeterville Dam were considered and evaluated against different criteria. The alternatives consisted of Do Nothing, Repair, Replacement, and Decommissioning. High level cost estimates were provided for each alternative. Based on this evaluation, the recommended option for Teeterville Dam was determined as decommissioning.

A Class Environmental Assessment will be required to be completed for the dam in order to investigate each alternative in more details and provide a preferred option. The Class EA study includes public input. It is recommended that MNRF be consulted regarding the requirements of completing a Class EA study for Teeterville Dam.

Table of Contents

Appendices

List of Figures

List of Tables

1. Introduction and Background

This report presents the findings of the dam stability and condition assessment (DSCA) carried out for Teeterville Dam, which is located on Big Creek approximately 36 km upstream of Lake Erie, within the village of Teeterville in Norfolk County, Ontario. The dam is owned and operated by the Long Point Region Conservation Authority (LPRCA). The DSCA includes an assessment of the structural integrity, a geotechnical assessment, a hydrotechnical assessment, including dam break analysis and inundation mapping, Hazard Potential Classification (HPC) and selection of Inflow Design Flood (IDF), and a reservoir sediment quantity and quality assessment.

Big Creek is the largest watershed within the Long Point Region, with a total area of 750 km^2. The watercourse flows through the communities of Teeterville and Delhi in a southerly direction, connecting with North Creek and Venison Creek before discharging into Lake Erie near the port community of Port Rowan. Wetlands are present at the mouth of Big Creek and are part of the Long Point Wetland Complex, which covers an area of 75 km^2 and helps to reduce the nutrient and sediment contribution entering Lake Erie (Lake Erie Source Protection Region, 2008). This watershed is located within the Norfolk Sand Plain, which is characterized by low runoff, high soil infiltration, and sustained base flows (Lake Erie Source Protection Region, 2008).

Numerous small dams have been constructed on the tributaries of Big Creek, but the most notable are the Lehman Reservoir located on the Big Creek tributary channel North Creek, which is used for water supply and recreation; Deer Creek Reservoir on a tributary of Big Creek, which is used for recreation and private water supply for the Deer Creek Conservation Area, and the Teeterville Reservoir, which is used for recreation, flood control, and low-flow augmentation (Lake Erie Source Protection Region, 2008).

The reservoir water level at the Teeterville Dam has historically been controlled by stop logs that were implemented after initial dam construction. No dam safety reviews have been completed for the dam and the dam does not have an official Emergency Preparedness and Response Plan. The Operation and Maintenance Plan is outlined in a document that includes several other LPRCA dams. LPRCA retained AECOM to complete a review of the structural and operational condition for Teeterville Dam under the guidance provided by MNRF as part of the Lakes and Rivers Improvement Act (LRIA).

1.1 Site Description

Teeterville Dam is located on Big Creek within the village of Teeterville in Norfolk County, Ontario. The dam is oriented in a general northwest-southeast direction and consists of an earthen berm and a concrete spillway structure controlled by wooden stop logs. Originally, the dam abutment and berm supported a bridge deck and roadway for Teeterville Road and Teeter Street, until a new bridge was constructed upstream of the dam in the 1970’s. The original bridge and roadway remain on site and have been abandoned. Currently, the reservoir is used for recreation, flood control, low flow augmentation, and as a water supply for agriculture and fire trucks. The site location map is presented in Figure 1-1.

The area surrounding the dam and reservoir is mainly treed, with some residential and agricultural properties located along Teeterville Road to the northwest and southeast of the site, including Norfolk County, LPRCA, and privately owned lands. Downstream of the dam, Big Creek meanders in a general southwest direction toward Lake Erie.

The earthen berm portion of the dam is approximately 160 m long, and the concrete structure is approximately 31.5 m long. A general arrangement drawing of Teeterville Dam in provided in Figure 1-2.

1.2 Site History and Existing Documentation

The available records indicate that the original Teeterville Dam was built in the early 1900's. The dam and reservoir was purchased by the former Big Creek Conservation Authority (BCCA) in 1954. After taking ownership, BCCA modified the dam in 1962, including the concrete piers on the downstream face and the construction of platforms and gantries used for the manual installation/removal of stop logs. This raised the water level in the reservoir by approximately 1 m. The piers divide the spillway into 4 bays that can hold 4 stop logs each. The winch system was fully replaced in 1997. Big Creek and Big Otter Conservation Authorities merged in 1970 to form the Long Point Region Conservation Authority.

The existing documentation provided by LPRCA includes the following:

- Pre-construction drawings for the modifications to Teeterville Dam dated 1962, showing a general layout of the site and the dam, as well as design details for the gantry crane structure;
- Pre-construction drawing of the new bridge and road realignment upstream of the dam dated 1971;
- Dam Operation and Maintenance Manual from 1999; and
- Dam Inspection Report from 2014 (Riggs Engineering).

The 2014 Dam Inspection Report noted seepage through the left and right downstream wingwalls and at the interface of the concrete piers at the Teeterville Dam spillway structure. The upstream wingwalls have since been buried by the construction of County Road 25 or covered with stacked blocks. Where visible on the left (facing downstream) upstream wingwall, a crack greater than 10 mm in width was identified. The report noted that the upstream embankment face for the earthen portion of the dam no longer abuts the reservoir, and that southern side of the County Road 25 embankment renders it obsolete. The downstream embankment slope was in good condition with no evidence of cracks or settlement with the exception of local voids adjacent to the grouted concrete at the right downstream wingwall. Wetness was observed at the left wingwall at the bank interface but the cause is unknown.

1.3 General Dam Descriptions

Teeterville Dam consists of an 160 m long earth berm and a 31.5 m long four bay concrete spillway structure at the south end of the reservoir. Flow is controlled with four 200 mm (nominal) wide timber stop logs at each bay. The dam consists of an upstream wall and downstream base slab supported by 3 piers and 2 abutments. The overall height of the dam from the top of the concrete base slab to the top of the piers and upstream wall is 3.1 m and 2.12 m, respectively. There are concrete wingwalls beyond each end of the structure related to the bridge. Based on the dam survey, the berm is approximately 4 m high, with side slopes of approximately 2H:1V.

The dam abutments extend northerly and are integral with the bridge abutments, with support a steel truss superstructure. Currently the bridge is closed to public access due to safety concerns. However, the walkway is used by LPRCA staff for accessing the operating platforms located on the piers and abutments, for stop log removal and installation. The operating platforms include steel hand rails

A General Arrangement Drawing of the Dam is provided in Figure 1-2. A brief summary of the significant dimensions and elevations of the dam structure is provided below in Table 1-1. Additional Dam information is provided in **Section 3**.

Table 1-1. Key Dimensions and Elevations for the Teeterville Dam

Component	Dimension/Elevations	Comment
Overall width of control structure	31.53 m	
Overall width of sluiceway	27.86 m	Net hydraulic width
Elevation of top of truss bridge walkway	237.91 m	Formerly Teeterville Road
Elevation of top of piers	236.20 m	Working platform
Elevation of top of base slab	233.15 m	Sill
Elevation of top of stop logs (summer)	236.00 m	4 stop logs in place
Elevation of top of stop logs (winter)	235.60 m	2 stop logs in place
Upstream dam height	3.05 m	Top of piers to top of base slab

Figure 1-1. Site Location Map

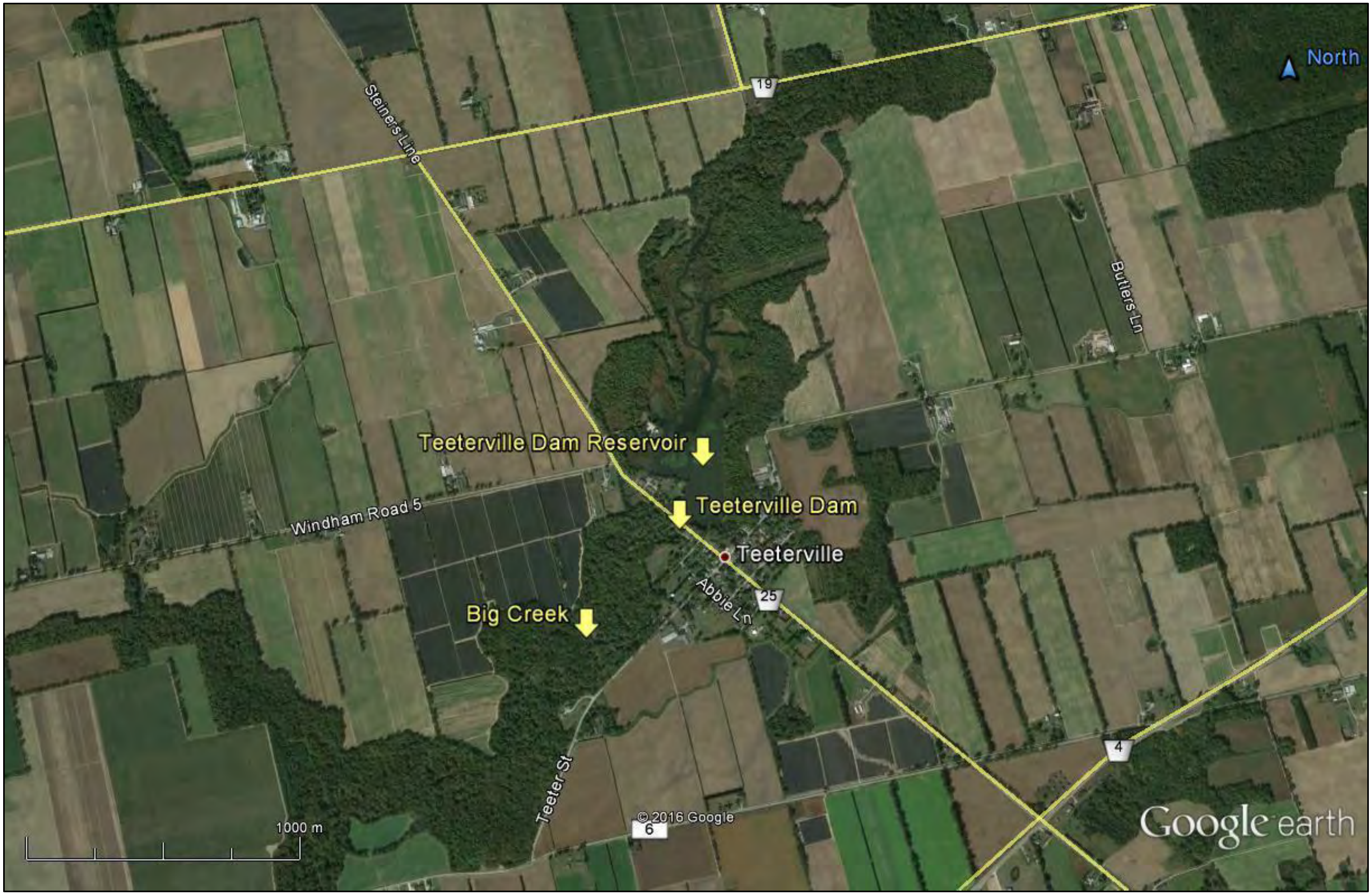
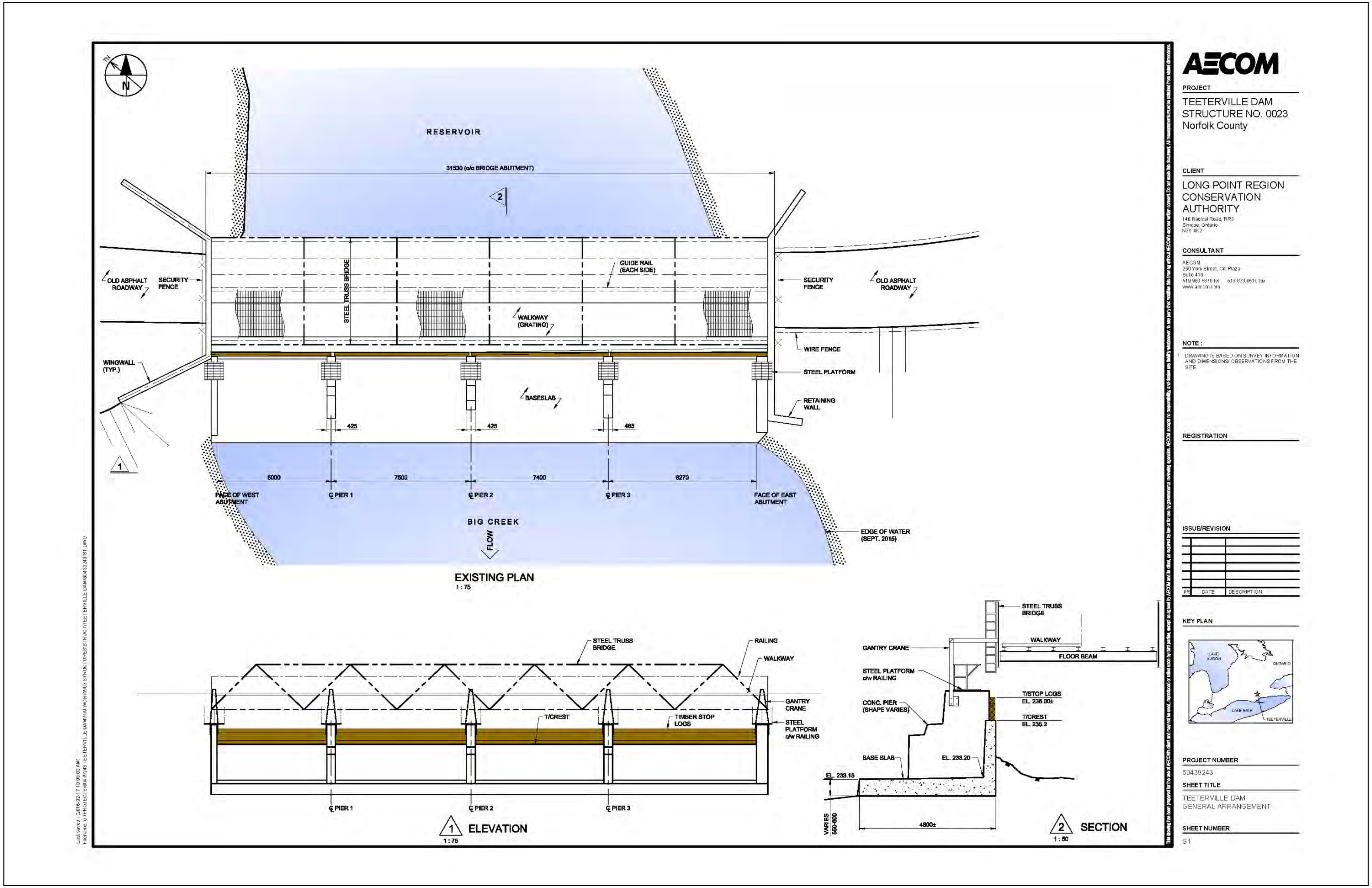


Figure 1-2. General Arrangement Drawing of Teeterville Dam



2. Natural Heritage Review

A desktop review of background information was completed to obtain an understanding of both terrestrial and aquatic heritage features within the Teeterville Dam study area. The study area includes the Teeterville Dam located at the Teeterville Road crossing and extends downstream to the railroad crossing in the town of Delhi, Ontario. The detailed review as well as the study area and natural heritage features are presented in **Appendix A**.

The following secondary sources were used during the background information review:

- Ontario Ministry of Natural Resources and Forestry (MNRF) Make-a-Map: Natural Heritage Areas Application;
- Norfolk County Official Plan (2011);
- LPRCA Watershed Reports;
- MNRF Land Information Ontario (LIO) Mapping;
- MNRF Natural Heritage Information Center (NHIC) Species at Risk (SAR) and Rare Species Records; and
- Fisheries and Oceans Canada (DFO) Aquatic Species at Risk Mapping.

The secondary sources listed above were used to collect background information on existing natural features located within and/or in close proximity to the study area. The search results are summarized in the following sections.

2.1 Aquatic Conditions

2.1.1 Watershed

The study area falls within the Big Creek watershed, which drains an area of approximately 725 km^2 (LPRCA, 2007). The Big Creek watershed primarily drains one major physiographic region, the Norfolk Sand Plain, and also drains a small section of two other physiographic regions, the Horseshoe Moraine located in the northwest section of the watershed and a small section of the Haldimand Clay Plain located at the southern tip of the watershed (LPRCA, 2007). The Big Creek watershed drains directly into Lake Erie (LPRCA, 2007).

There are several groundwater fed creeks and streams within the Big Creek watershed that provide several significant cold water fisheries in the area. Many of these smaller cold water creeks and streams within the watershed are tributaries of Big Creek and therefore contribute to the larger cold water fishery associated with Big Creek (LPRCA, 2007).

2.1.2 Fish Community

Fish records retrieved from MNRF LIO Mapping and through correspondence with the MNRF indicate that the following species are known to occur within Big Creek and potentially within the study area:

- Rock bass (*Ambloplites rupestris*)
- White sucker (*Catostomus commersonii*)
- Brook stickleback (*Culaea inconstans*)
- Rainbow darter (*Etheostoma caeruleum*)
- Brassy minnow (*Hybognathus hakinsoni*)
- Northern hog sucker (*Hypentelium nigricans*)
- Pumpkinseed (*Lepomis gibbosus*)

- Hornyhead chub (*Nocomis biguttatus*)
- Common shiner (*Luxilus cornutus*)
- Blacknose shiner (*Notropis heterolepis*)
- Rainbow trout (*Oncorhynchus mykiss*)- Resident population
- Blackside darter (*Percina maculate*)
- Bluntnose minnow (*Pimephales notatus*)
- Fathead minnow (*Pimephales promelas*)
- Eastern blacknose dace (*Rhinichthys atratulus*)
- Brown trout (*Salmo trutta*)- Resident population
- American brook lamprey (*Lethenteron appendix*)
- Mottled sculpin (*Cottus bairdii*)
- Brook trout (*Salvelinus fontinalis*)
- Johnny darter (*Etheostoma nigrum*)
- Emerald shiner (*Notropis atherinoides*)
- Central mudminnow (*Umbra limi*)
- Creek chub (*Semotilus atromaculatus*)

Results from fish community surveys performed by LPRCA from 2002 to 2005 show that Big Creek receives a healthy run of migratory Rainbow trout and Chinook salmon (*Oncorhynchus tshawytscha)* each year (LPRCA, 2005).

2.2 Terrestrial Conditions

2.2.1 Designated Natural Areas

The *Make-a-map: Natural Heritage Areas Application* (MNRF, 2015) as well as the *Norfolk County Official Plan* (Norfolk County, 2011) were used to collect background information on existing natural features located within and/or in close proximity to the study area. The search results are summarized in the following sections.

2.2.2 Areas of Natural and Scientific Interest (ANSI)

Several Life Science and ANSI sites were identified within the study area and/or in close proximity to the study area. The list of Life Science and ANSI sites identified are as follows: La Salette Woods (Life Science Site) is located within 1 km of the study area; Delhi Swamp (Life Science Site) is located within the study area; Delhi Big Creek Valley (Life Science & ANSI) is located within the study area; Delhi Big Creek Valley (Carolinian Canada Site) is located within the study area; and Quance Bush (Life Science Site) is located within 1 km of the study area.

2.2.3 Significant Wetlands

BC31 Provincially Significant Wetland Complex (BC 31) is present throughout the majority of the study area. This complex contains both swamp and marsh wetland communities.

2.3 Species at Risk

The *Make-a-map: Natural Heritage Areas Application* (MNRF, 2015) as well as DFO Aquatic SAR Mapping (DFO, 2015) were used to search for Species at Risk (SAR) records within the study area.

Based on the search results and agency correspondence, the following SAR are likely to be present within the vicinity of the study area:

- Silver lamprey (*Ichthyomyzon unicuspis*)- Great Lakes/ Upper St. Lawrence Population
- Grass pickerel (*Esox americanus vermiculatus*)
- Northern brook lamprey (*Ichthyomyzon fossor*)- Great Lakes/ Upper St. Lawrence Population
- River redhorse (*Moxostoma carinatum*)
- Silver chub (*Machrybopis storeriana*)- Great Lakes/ Upper St. Lawrence Population
- Warmouth (*Lepomis gulosus*)
- Eastern sand darter (*Ammocrypta pellucida*)
- Pugnose shiner (*Notropis Anogenus*)
- Lake chubsucker (*Erimyzon sucetta*)
- Bobolink (*Dolichonyx oryzivorus*)
- American Badger (*Taxidea taxus*)
- American Water-willow (*Justicia Americana*)
- Green Dragon (*Arisaema dracontium*)
- Blanding's Turtle (*Emydoidea blandingii*)
- Massasauga Rattlesnake (*Sistrurus catenatus*)

The following section provides a description of the preferred habitat for the aquatic SAR listed above.

Northern Brook Lamprey: Generally inhabits clear, cool water streams with areas of soft substrates such as sand and silt to facilitate burrowing of juveniles. Adults are generally found in areas of fast flowing riffles with a rock/gravel substrate. This species can typically be associated with the following ELC communities: OAO characterized as clear, cool water streams with silt and sand substrates.

River Redhorse: Primarily inhabits medium to large size rivers with substantial flows. In the early summer months (May to June) adults migrate from deep, slow moving pool and run habitat to shallow riffle-run habitats with coarse substrate and moderate to swift flows. This species can typically be associated with the following ELC communities: OAO characterized as medium to large-sized rivers with substantial flow.

Silver Chub: Preferred habitat throughout most of North American range consists of medium to large rivers with areas of substantial flow and a mix of sand, silt and/or gravel substrates. In Ontario this species is only found in the Great Lakes usually in areas with depths between 7 and 12 meters. This species can typically be associated with the following ELC communities: OAO characterized as medium to large rivers with a substantial current with silt, sand or gravel substrate or lake habitat.

Silver Lamprey: The adult life stage of this species requires clean, fast flowing streams and rivers with small amounts of sand and other materials for eggs to adhere to during spawning. Lakes and/or rivers with healthy populations of fish hosts are also required. Larval life stages require deep, slow moving areas of large streams and rivers with soft substrate such as sand and silt for burrowing.

Warmouth: Preferred habitat consists of silt-free marshes, ponds and lakes with an abundance of aquatic plants and mucky substrates. This species has been classified as a warm-water species.

Eastern Sand Darter: This species prefers shallow habitats in lakes, streams and rivers with clean, sandy bottoms. This species can typically be associated with the following ELC communities: OAO with sandy bottoms.

Pugnose Shiner: This species is generally found in lakes and calm areas of rivers and creeks having clear water and bottoms of sand, mud or organic matter. It prefers water bodies with plenty of aquatic vegetation, particularly stonewort (Chara sp.). This species can typically be associated with the following ELC communities: OAO with abundant aquatic vegetation, clear water with sand, mud or organic substrate.

Lake Chubsucker: In Ontario, this species generally lives in marshes and lakes with clear, still, warmer water and plenty of aquatic plants. This habitat is found in bays, channels, ponds, and coastal wetlands. During the breeding season, from April to early June in Ontario, adults move into marshes where eggs are laid among vegetation in shallower water. This species can typically be associated with the following ELC communities: OAO, SAS, SAM, and SAF with clear, still warm water and an abundance of aquatic plants.

Grass Pickerel: This species is found in wetlands, ponds, slow-moving streams and shallow bays of larger lakes with warm, shallow, clear water and an abundance of aquatic plants. This species can typically be associated with the following ELC communities: OAO, SAS, SAM and SAF with warm, shallow, clear water and an abundance of aquatic plants.

The following section provides a description of the preferred habitat for the terrestrial SAR listed above.

Bobolink: Nests primarily in forage crops, particularly hayfields and pastures, dominated by a variety of species such as clover, tall grasses and broadleaved plants; also occurs in wet prairie, graminoid, peatlands and abandoned fields; generally requires tracts of grassland >5 ha. Also nests in lightly grazed pastures, fallow and abandoned fields and shallow grassy marshes. This species can be associated with the following ELC communities: TPO, TPS, CUM1 and MAM2.

American Badger: This species can be found in a variety of habitats such as tall grass prairies, sand barrens and farm lands as these habitats provide badgers with small prey and areas to construct dens. This species can typically be associated with the following ELC communities: TPS1, CUM1, CUS and SBO with dry sandy soil.

American Water-willow: This species prefers to grow along the shores of rivers, streams and lakes. It can also be found growing in the waters of rivers, streams, lakes, ditches and occasionally wetlands. This species also requires periodic flooding and wave action in the areas in which it is growing in order to reduce competition from other aquatic plants.

Green Dragon: This species is generally found growing in wet deciduous forests along streams and rivers. Preferred deciduous forest communities are dominated by maple species, Red Ash and White Elm. This species can typically be associated with the following ELC communities: FOD6, FOD7, FOD8, FOD9 and SWD with moist soils.

Blanding's Turtle: This species lives in shallow waters of large wetlands and shallow lakes with an abundance of aquatic vegetation. From October until the end of April this species is found hibernating in the mud at the bottom of permanent water bodies. This species can typically be associated with the following ELC communities: SWT2, SWT3, SWD, SWM, MAS2, SAS1, SAM1, where open water is present.

Massasauga Rattlesnake: This species can be found in several different types of habitats including tall grass prairies, bogs, marshes, shorelines, forests and alvars. Within these habitats Massasaugas require open areas containing bedrock in order to bask and warm themselves. Pregnant females are often found in dry, open habitats such as rock barrens and forest clearings as temperature plays a big role in the development of offspring. Non-pregnant females and males can generally be found foraging in low land habitats such as grasslands, wetlands, bogs and shorelines of lakes and rivers. Hibernaculum generally consists of crevices of bedrock, sphagnum swamps, tree root cavities and animal burrows where they can get below the frost line but above the water table.

2.4 Summary

Upon completion of the background information review it has been determined that:

- A total of 15 SAR are likely to be present within the study area, nine (9) aquatic SAR and six (6) terrestrial SAR;
- BC31 Provincially Significant Wetland Complex is located throughout majority of the study area;
- Several Life Science and ANSI sites were identified within the study area and/or in close proximity to the study area. The list of Life Science and ANSI sites identified are as follows; La Salette Woods (Life Science Site) is located within 1 km of the study area, Delhi Swamp (Life Science Site) is located within the study area, Delhi Big Creek Valley (Life Science & ANSI) is located within the study area, Delhi Big Creek Valley (Carolinian Canada Site) is located within the study area, and Quance Bush (Life Science Site) is located within 1 km of the study area; and
- Big Creek is a cold water watercourse containing a diverse fish community with migratory Rainbow trout and Chinook salmon.

3. Dam Inspections

A visual inspection of the dam and site area was carried out on September 9, 2015 by AECOM accompanied by LPRCA staff. A supplemental visit was undertaken in conjunction with the site survey on September 16, 2015.

The summary of the conditions observed during AECOM's field investigation is provided in the following sub-sections. Selected photographs of these observations and the inspection form are included in **Appendix B**. A structural assessment of the dam stability is provided in **Section 7** and utilizes the nominal measurements and member thickness as determined on site.

3.1 General Site

The asphalt approaches to the truss bridge were in fair condition with random light to medium cracking and raveling. Light to medium localized settlements of the asphalt were observed. Grass was growing through the cracks and missing sections of the asphalt.

The southwest dry stacked soil retaining system was in fair condition with no signs of distress. The dry stacked system was composed of reused concrete slabs and rock. Vegetation was growing through gaps and between the units. Dry stacked walls do not really constitute a structural wall type (does not really provide a true retaining function).

Vegetated embankments were in fair to good condition. Light erosion was noted on the upstream embankments between Teeterville Dam and the upstream County bridge.

Scattered rocks were noted downstream of the stilling basin. There was significant sediment buildup upstream of the dam.

3.2 Bridge

The structural steel bridge was a warren truss structure consisting of six panels, transverse floor beams, longitudinal stringers and riveted connections. The concrete deck slab was removed sometime in the past and replaced with a metal grating (for access to the stop log platforms).

There was limited inspection of the steel bearings due to difficult access conditions as well as debris / vegetation buildup around the bearings. Severe corrosion of steel on the bolts, nuts, plates, and truss components connected to the bearings were noted. Some pack rust and severe section loss was noted at some locations. Some anchor bolts appeared to be deformed

Top chord members were in fair condition with medium surface corrosion throughout the members. Light to medium pitting of the steel surfaces was typically observed. Gusset plates were in fair condition with medium surface corrosion. Despite the surface corrosion, there was minor loss of section to the structural steel.

Vertical cross bracing members were in fair condition with medium surface corrosion of the members. Light to medium pitting of the steel surfaces was typically observed. Gusset plates were in fair condition with medium surface corrosion. There was some slight distortion to several vertical members, likely the result of past vehicular impact damage. Despite the surface corrosion, there was minor loss of section to the structural steel

Bottom chord members were in poor condition with medium to severe corrosion and light to medium pitting of the members. The north truss bottom chord at the east end (near the bearing) was completely severed and discontinuous. There was very severe section loss noted at the other remaining bottom chords (near the bearings). The diagonal bars were in fair condition with medium corrosion and were sagging. The truss relies on the integrity of the bottom chord connections to maintain overall structural competency.

The floor beams were in fair condition with medium corrosion and light to medium pitting. The longitudinal stringers were in fair to poor condition with medium corrosion and pitting throughout the members. The northerly three stringers were fully exposed and not supporting any decking. The westerly four stringers support the steel access grating on the south side of the bridge. The stringers had minor section loss. There was one missing stringer at southeast side of the bridge. Localized section loss of the floor beams was evident.

Decking on the truss consisted of a galvanized steel grate with galvanized railing and was found to be in good condition. The grating defected under heavy point loads (e.g. individual) and appeared to be undersized for this application. A wire fence on the west side of the deck was in fair to poor condition with corrosion. The wire fence was connected to the truss diagonal members.

In general, there was no coating system to protect the steel.

3.3 Dam

Lower portions of the foundation and the upstream Dam face were not visible for inspection. As well, there was only limited inspection of the abutment sections upstream of the dam (below the bridge) and on the downstream surfaces of spillway due to flowing water.

Concrete abutments were in fair to poor condition overall with medium to severe disintegration, medium scaling and spalling, and narrow to wide horizontal cracking with efflorescence staining. The sections of abutment wall (downstream of the dam) generally appeared to be in better condition than upstream portions. For example, light to medium delamination (near the top), severe disintegration and numerous narrow horizontal cracking (with vegetation growing through the cracks) was noted on the west abutment below the bridge. There was light to medium scaling noted on the entire surface of the east abutment. The downstream section of the east abutment wall appeared to be refaced as part of a past rehabilitation. There was light erosion along the spillway and base of the downstream abutment walls.

The bridge wingwalls at the west end were in fair condition with light scaling, spalls, light delaminations and horizontal narrow cracks with efflorescence staining.

The three concrete piers on the downstream side were in fair condition with light honeycombing, light to severe spalling, light to medium delamination, medium to severe erosion and exposed reinforcing steel at the base of the center and west pier. Several vertical surfaces were refaced and built out from original surfaces. Localized light honeycombing at several areas were observed.

Although obscured from full visual review resulting from flowing water, the horizontal and vertical surfaces of the concrete spillway appeared to be in fair condition (with localized poor areas) with light to medium erosion, localized light to medium spalling / delamination, and light to medium disintegration.

3.4 Stop Logs

Visual review of the stop logs was obscured as a result of flowing water. However, the timber stop logs appeared to be in fair condition with section loss, some decay, checks, and splitting. There were four vertically stacked stop logs consisting of 200 mm x 200 mm (nominal) square sawn timber members. A significant amount of water was leaking between the stop logs. It was not possible to inspect the stop log gains.

There were platforms with a support frame of each pier and abutment for the installation and removal of the stop logs. The platform and support frames appeared to be in fair to good condition with light corrosion.

3.5 Diver Inspection and Concrete Coring

AECOM acquired the services of Watech Services Inc. to investigate the thickness of the downstream slab for stability evaluation. The inspection took place on October 15, 2015 and consisted of diver inspection, core drilling and drilling of holes. Watech's Report is included in **Appendix C**.

A total of two 100 mm diameter cores were extracted and eight holes were drilled in the downstream slab. The concrete cores indicated that the concrete was in fair to good condition, with large aggregate greater than 19 mm diameter. The slab thickness was difficult to determine given the fragmented rock or concrete at the bottom of the slab. There was no adhesion or bond of the fragments indicating that the bottom of concrete slab was found. Although the observations were not entirely conclusive, the concrete slab thickness appeared to range from 550 mm to 600 mm. Further, it appeared that the slab was constructed on rock fill, which is not typical or ideal for dam construction.

Drilling and probing also lead to an additional observation that the base slab was undermined along a large portion of the south end. The largest area of undermining was measured as 3 m from the end of the slab. The undermining varied in depth from 150 mm to 500 mm.

3.6 Public Safety

The following observations of public safety around the Teeterville Dam are provided:

- Padlocked chain link fencing was placed on each end of the bridge. Three warning signs are placed on the fencing including "DANGER - Keep off Dam", "DANGER - No Swimming" and LPRCA Sign "Teeterville Dam – In Case of Emergency call 911";
- There was one sign (placed on the south truss) "DANGER - Keep off Dam" that is somewhat visible from the upstream watercourse;
- There was an original (open) concrete railing system on the wingwalls at the west end. The embankment immediately beyond the ends of west wingwalls was steep, but flattens out;
- There was a non-robust wire fencing system on the approaches to the east end;
- No signage was noted on the watercourse upstream, alerting the public of the Dam;
- No upstream physical barriers across the watercourse upstream of the dam were noted;
- There was no special illumination near the dam; and
- There is relatively simple access to the downstream watercourse on both sides of the dam.

4. Preliminary Hazard Potential Classification and Inflow Design Flood

The Inflow Design Flood (IDF) is the most severe inflow flood (peak, volume, shape, duration, timing) for which a dam and its associated facilities are designed (CDA, 2007). The determination of the IDF for a dam would be based on the Hazard Potential Classification (HPC) involving loss of life, economic and social losses, environmental losses, and cultural – built heritage losses in the event of a dam failure.

The IDF may be determined directly from Table 2 of the LRIA Technical Bulletin for Classification and Inflow Design Criteria (MNRF, 2011) based on the dam HPC or by assessing the most severe flood at or above which there would be no further incremental consequences.

The IDF of a dam is best selected based on the results of an incremental hazard evaluation through a dam break analysis. This evaluation involves simulating a dam failure during the normal (sunny day) and flood flow conditions, and routing the flood wave downstream. The additional downstream threat due to the incremental increase in water surface elevation from a dam failure is assessed in each case. In cases where the dam owner wishes to explore the possibility of selecting a lower magnitude IDF, an incremental analysis is performed.

The preliminary HPC for Teeterville Dam has not been previously determined. In this section, the preliminary HPC and IDF for the dam are evaluated based on the LRIA Technical Bulletin for Classification and Inflow Design Flood Criteria (MNRF, 2011) *Table 1: Hazard Potential Classification* and *Table 2: Range of Minimum Inflow Design Floods*.

4.1 Hazard Potential Classification

In order to determine the dam preliminary HPC according to the Table 1 of the LRIA Technical Bulletin for Classification and Inflow Design Flood Criteria (MNRF, 2011) note the following pertinent facts and assumptions:

The life safety could have a range as follows:

- LOW – No potential loss of life; or
- MODERATE – No expected loss of life.

Teeterville Dam is located within the community of Teeterville; however, there is little development in the area immediately downstream of the dam. A residential building is located immediately downstream of the dam; however, its lowest elevation appears to be above the reservoir water level. Town of Delhi is located approximately 24 km downstream of Teeterville Dam. Big Creek meanders between the Teeterville Dam and the Town of Delhi within its floodplain. Considering the size of the Teeterville Dam reservoir, the flood wave resulting from a potential dam failure would likely be diminished by the time it reaches the Town of Delhi. There would likely be no potential loss of life.

The incremental property losses could have a range as follows:

- LOW – Minimal damage to property with estimated losses not to exceed $300,000; or
- MODERATE – Moderate damage with estimated losses not to exceed $3 million, to agricultural, forestry, mineral aggregate and mining, and petroleum resource operations, other dams or structures not for human habitation, infrastructure and services. The inundation area is typically undeveloped or predominantly rural or agricultural. Minimal damage to residential, commercial, or industrial areas.

Property losses solely consider third-party losses. Loss of the dam or impact to other property of the dam owner is not considered. The area immediately downstream of the dam is mostly undeveloped. Town of Delhi is located approximately 24 km downstream of the dam. As discussed above, the flood wave from a potential dam failure would likely be diminished by the time it reaches the Town of Delhi. Potential incremental property damage as the result of the dam failure is not expected to exceed $300,000.

The incremental environmental losses could have a range as follows:

- LOW – Minimal loss of fish and/or wildlife habitat with high capability of natural restoration resulting in a very low likelihood of negatively affecting the status of the population; or
- MODERATE – Minimal loss of or deterioration of fish and/or wildlife habitat with moderate capability of natural restoration resulting in low likelihood of negatively affecting status of population.

Teeterville Dam reservoir and downstream provides fish and terrestrial habitat. Big Creek is a cold water system containing a diverse community with known migratory runs of Rainbow Trout and Chinook Salmon. Also there are several known ANSI's and a Provincially Significant Wetland complex. Some habitat loss with respect to aquatic and terrestrial communities within proximity to the existing banks would be expected; however, natural restoration within approximately five years or less with no long term losses is feasible considering the communities present. The majority of the study area contains wooded communities with species that can withstand temporary flood conditions. There is also a good possibility that substrates would re-establish over this period of time as well. Temporary measures could be readily implemented near the dam to re-establish lake levels for spawning and bank stability in the short term. Past observations at dams that had been decommissioned showed vegetation at newly exposed shorelines quickly re-established, mitigating the erosion potential.

Damages to cultural and built heritage could have a range as follows:

- LOW – Reversible damage to municipally designated cultural heritage sites; or
- MODERATE – Irreversible damage to municipally designated cultural heritage sites or reversible damage to provincially designated cultural heritage sites.

There are no municipally or provincially designated cultural heritage sites identified in the area downstream of the dam.

Based on these assumptions, the preliminary HPC for Teeterville Dam can be determined as LOW. A dam break analysis is carried out to confirm the dam HPC.

4.2 Inflow Design Flood

Based on a LOW HPC for Teeterville Dam, the IDF can be determined using Table 2 of the LRIA Technical Bulletin for Classification and Inflow Design Flood Criteria (MNRF, 2011) as a flood having a magnitude between the 25-year and the 100-year flood events.

5. Hydrotechnical Assessment

5.1 Hydrologic Analysis

The purpose of the hydrologic analysis is to estimate peak flows and hydrographs for various flood events. Hydrologic modeling to estimate the flood flows was performed in accordance with the Technical Guide – River and Stream Systems: Flooding Hazard Limits (MNR, 2002).

For this study, the 100-year rainfall event was analyzed.

5.1.1 100-year Event

A 24 hour SCS Type II distribution, which is applicable to watersheds in Southern Ontario, was used for the 100-year rainfall event. The rainfall data was obtained from the Environments Canada's Delhi Station (#6131983), which is located within the Big Creek watershed. The data is provided in **Appendix D**.

Based on the size of the watershed at Teeterville Dam, an aerial reduction factor of 0.84 was applied. The rainfall hyetograph is presented in Figure 5-1.

5.1.2 Hydrologic Model

A PCSWMM model was developed for the Teeterville Dam watershed to estimate the flow hydrograph for the 100-year rainfall event at the dam. The watershed parameters and land cover were obtained using the Ontario Flow Assessment Tool (OFAT III) provided by MNRF. The data is provided in **Appendix D**. The Teeterville Dam watershed is approximately 200.6 km^2. The watershed map is presented in Figure 5-2.

The soil characteristics of the watershed were obtained from the surficial geology data for Southern Ontario, provided by the Ministry of Northern Development and Mines (OGSEarth). The Green-Ampt method was used to calculate the infiltration loss. The inflow hydrograph for the 100-year event is presented in Figure 5-3. The model output is provided in **Appendix D**.

5.1.3 Model Verification

The peak flow estimated using the PCSWMM model was verified by the following two methods:

- Primary Multiple Regression Method (Moin & Shaw 1985) provided by OFAT III; and
- Statistical analysis of the Water Survey of Canada's streamflow gauge located on Big Creek upstream of the dam (Big Creek Near Kelvin), provided by OFAT III. This gauge has a drainage area of approximately 146.8 km^2 and was selected since it is not affected by the flow attenuation at Teeterville Dam reservoir. Single station transfer method, which is recommended by MNRF, was used to estimate the peak flows at the dam.

The peak flows estimated using the three methods are presented in Table 5-1. Detailed calculations are provided in Appendix C.

Figure 5-1. 100-year Rainfall Distribution (24 hr SCS Type II) for Teeterville Dam Watershed

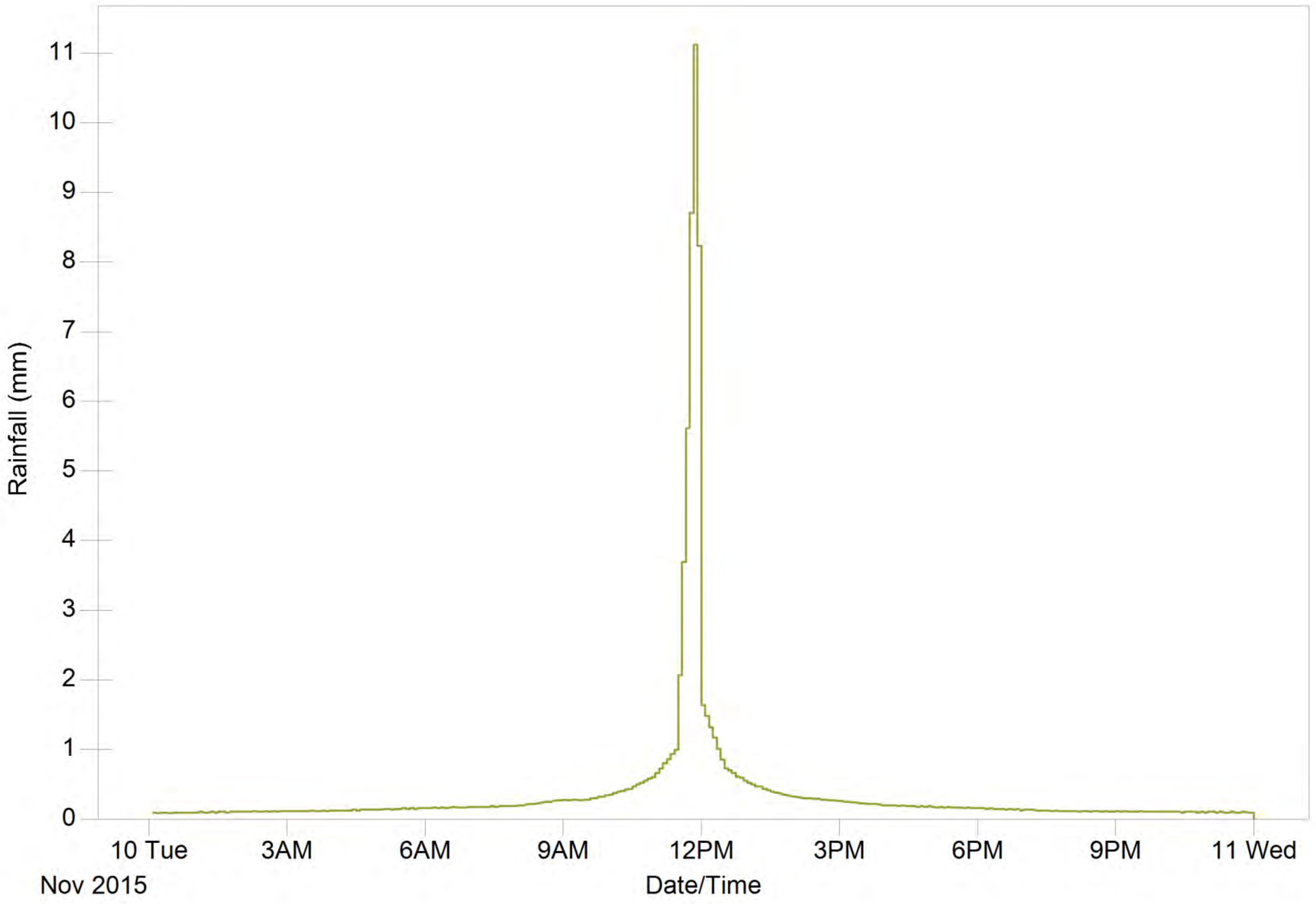


Figure 5-2. Teeterville Dam Watershed

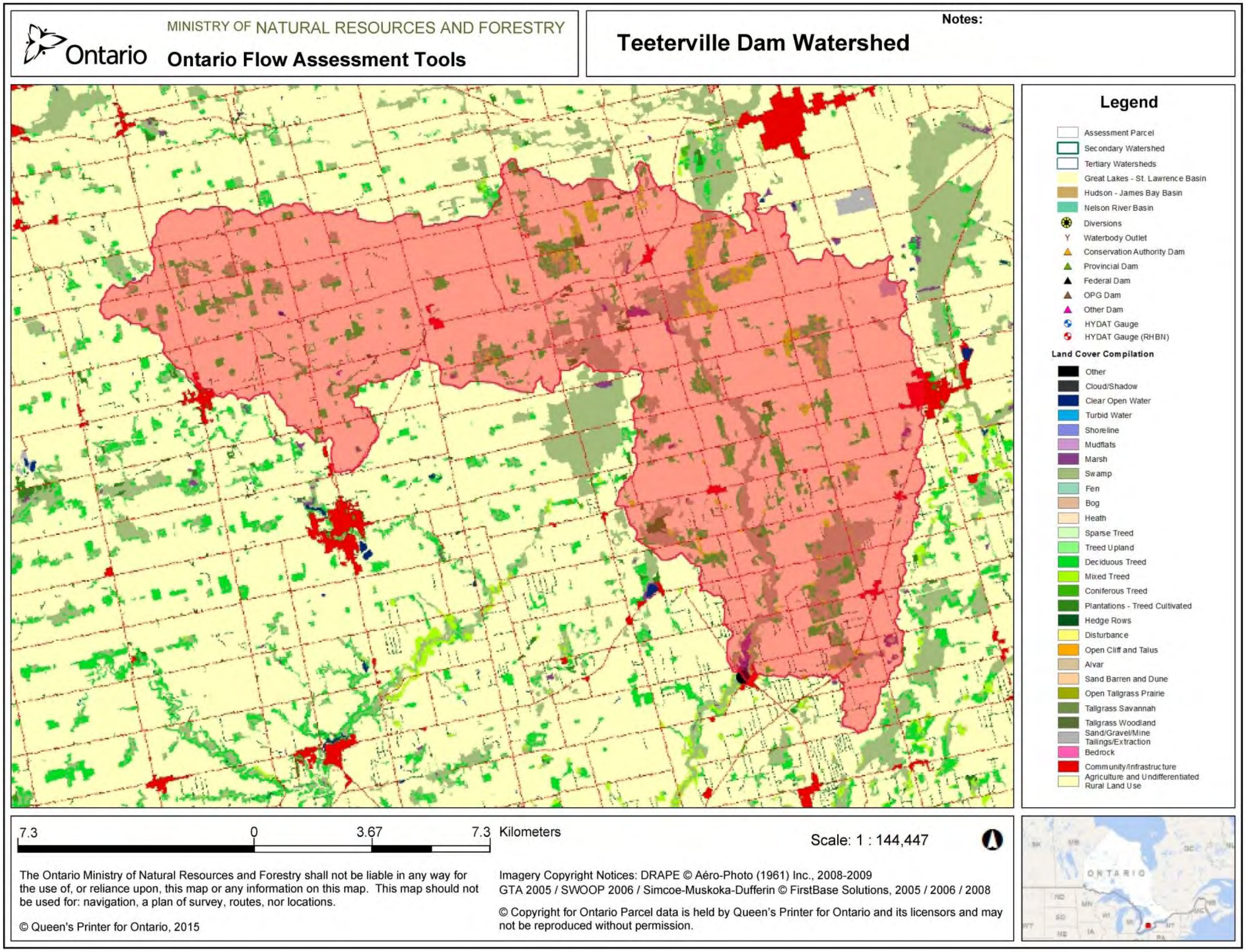


Figure 5-3. 100-year Inflow Hydrograph at Teeterville Dam

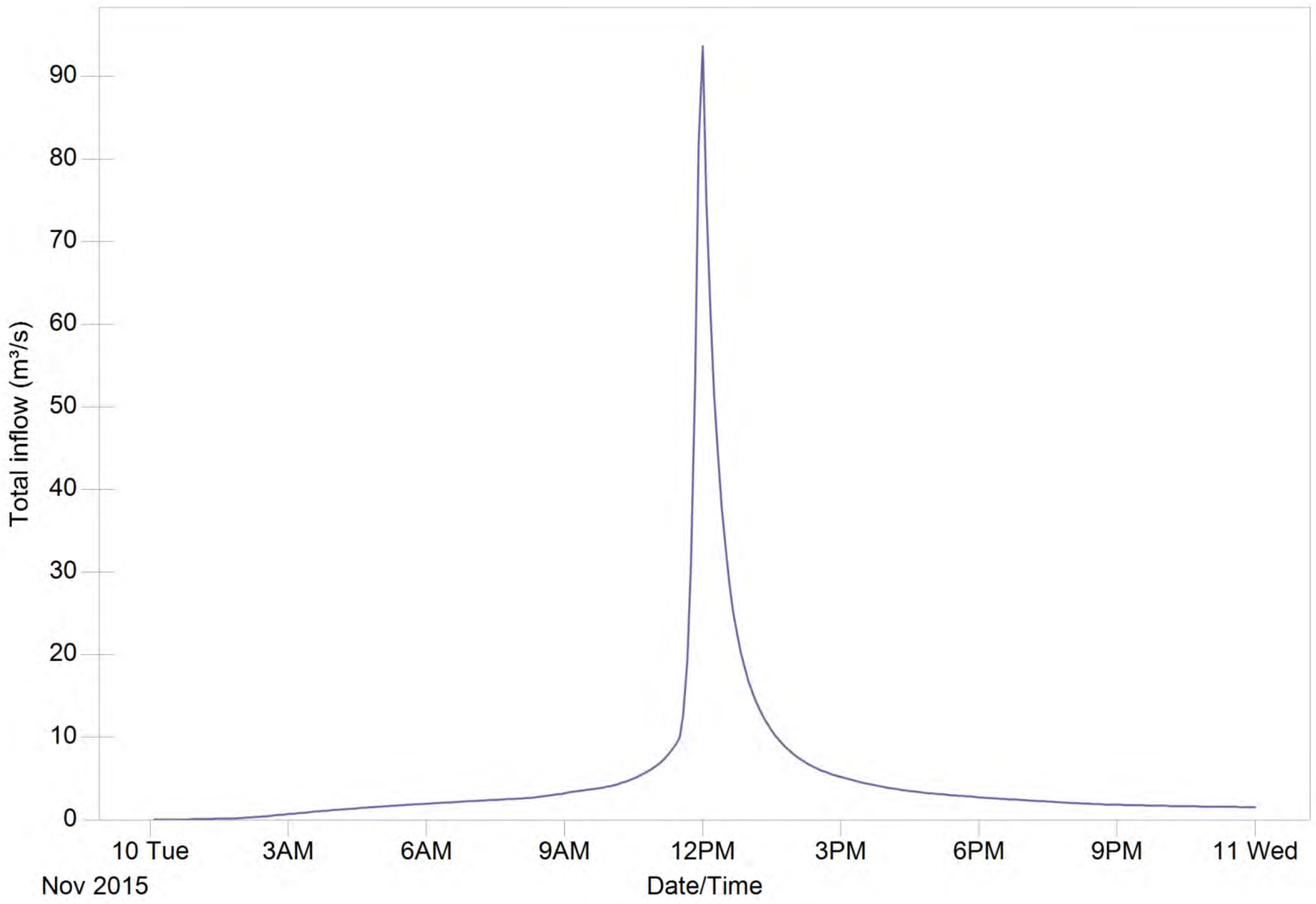


Table 5-1. Estimated Peak Flows for the 100-year Event

Method	Peak Flow (m^3/s)
Moin & Shaw	89.8
Statistical Analysis	96.2
PCSWMM	93.7

5.2 Dam Break Analysis

A preliminary evaluation indicated that the Hazard Potential Classification (HPC) for Teeterville Dam would be LOW. A dam break analysis is completed to confirm the dam HPC and IDF, based on the greatest incremental losses that could result from dam failure.

Incremental losses refer to losses from dam failure, which are above and beyond those that may be expected to occur under the same natural conditions with the dam in place, but without failure of the dam.

To assess the potential loss of life as a result of a dam failure, the 2 x 2 rule can be applied. According to the LRIA Technical Bulletin for Classification and Inflow Design Flood Criteria (MNR, 2011), The 2 x 2 rule defines that the people would be at risk if the product of the velocity and the depth exceeded 0.37 m^2/s, or if the velocity exceeded 1.7 m/s, or if the depth of water exceeded 0.8 m.

5.2.1 Model Development

A dynamic flood routing model is required to simulate the unsteady flow in a river and floodplain system resulting from a dam failure. The progression of a flood along a river reach is determined by routing the computed dam outflow and local inflow hydrographs. As the flood progresses, the effects of channel storage, frictional resistance, flood wave acceleration, and channel constrictions and obstructions modify these hydrographs. Dynamic flood routing methods use typical channel flow equations to establish the water surface profile using related flood flows and the physical parameters of the channel, including its gradient (slope), cross sectional area and roughness (Manning’s coefficient ‘n’).

The HEC-RAS (Hydrologic Engineering Center - River Analysis System) software developed by the US Army Corp of Engineers was used for this study to develop the dam break model. HEC-RAS can simulate the rapidly varying, unsteady flow conditions caused by dam failure.

The model requires the following input data:

- Cross-section information, including roughness coefficients, for reservoirs, river channels, and floodplains;
- Spillway specifications for the dam;
- Upstream inflow hydrograph;
- Dam breach characteristics;
- Culvert and bridge information; and
- Downstream control information.

Cross-sections

Data Elevation Model (DEM) points (20 m grid) and contours (1 m) provided by LPRCA were used to create a Triangulated Irregular Network (TIN) surface for the study area. The cross-sections were cut using this surface at approximately 200 m intervals and imported into HEC-RAS. A bathymetric survey of the reservoir and a topographic survey of the dam and the downstream reach, including the watercourse crossings, were completed. The bathymetric and topographic survey points were imported into HEC-RAS at appropriate locations. Since the DEM and contour map did not include the bottom of the river channel, some cross-sections were altered to reflect the channel bottom. The derived cross-sections were modified to improve the model stability.

Based on the site conditions, the Manning's roughness coefficients considered for the river channel and the floodplain were 0.035 and 0.08, respectively. A Manning's coefficient of 0.035 is generally applied to natural channels, whereas a Manning's coefficient of 0.08 is suitable for channel banks that are vegetated with trees.

Dam Discharge Characteristics

The characteristics of the stop log controlled sluiceways at Teeterville Dam were incorporated into the model.

As a conservative approach, it was assumed that under both normal operations (Sunny Day condition) and emergency operations (flood condition), all the stop logs will remain in place.

Inflow Hydrograph

The inflow hydrograph at Teeterville Dam, which was estimated using the PCSWMM model (Figure 3), was used as input to the model. There are no significant tributaries to Big Creek within the study area.

Dam Breach Characteristics

The Engineering Guidelines for the Evaluation of Hydropower Projects (Federal Energy Regulatory Commission, FERC) recommend ranges for breach parameters, based on the type of dam (Chapter II – Selecting and Accommodating Inflow Design Floods for Dams).

Teeterville Dam consists of a concrete gravity structure including stop log controlled sluiceways. Considering the concrete and foundation conditions of the structure, the most likely breach scenario would be the failure of one of the piers at the sluiceways. As a worst case scenario, the central pier was considered to fail for the dam break analysis.

The breach parameters considered for Teeterville Dam, based on FERC recommendations, are presented in Table 5-2.

Table 5-2. Teeterville Dam Breach Parameters

Parameter	Value
Average Width of Breach (BR)	BR = 27.7 m
Side Slope of Breach (Z horizontal to 1 vertical)	Z = 0
Time to Failure (TFH)	TFH = 0.2 hr
Failure Mode	Overtopping
Final Breach Bottom Elevation	234.87 m

Culverts and Bridges

The bridges in the study area were incorporated into the model. The 5 road crossings immediately downstream of the dam were surveyed by AECOM. The remaining crossings were imported from a HEC-2 model for the Delhi, which was provided by LPRCA.

Downstream Control

The downstream control was considered to be channel control (normal depth).

5.2.2 Model Extent

The HEC-RAS model extended from just upstream of the reservoir to the railway bridge at Delhi, a distance of approximately 24 km.

5.2.3 Failure Scenarios

Two failure scenarios were considered for Teeterville Dam:

- Failure under normal condition (Sunny Day); and
- Failure under flood condition.

Sunny Day Failure

Normally under a "Sunny Day" failure condition, the reservoir water level would be close to the summer operating level. The Teeterville Dam reservoir water level at the time of breach was considered to be 236.04 m, to generate a nominal flow of 0.37 cms for the initial condition.

The inundation maps for the Sunny Day failure are provided in **Appendix E**. The Sunny Day inundation maps show the inundated area as a result of a Sunny Day dam failure. No buildings are located in the flood inundation area. Therefore, there will be no potential for loss of life and economic losses will be minimal.

Flood Failure

Normally under flood conditions, the failure occurs when the reservoir water level is at maximum. The Teeterville Dam reservoir water level at the time of breach under the flood condition was considered to be 236.72 m (maximum water level under the 100-year event). The 100-year reservoir level was calculated by running the HEC-RAS model without dam failure.

The inundation maps for flood condition (with and without dam failure) are provided in **Appendix E**. The flood inundation maps show an initial inundation as a result of the 100-year flood and an incremental inundation due to the dam failure. There is little difference between the two inundation areas and generally, water levels for dam failre under flood condition are equal to or greater than those for the flood condition alone, which is to be expected. In some cases they are negligibly less, but this is likely due to rounding errors in the dynamic analysis. Therefore, there will be no incremental increase in loss of life, economic losses, environmental losses, and cultural built heritage losses.

The HPC for Teeterville Dam under flood condition is confirmed as LOW. Based on *Table 2: Range of Minimum Inflow Design Floods* of the LRIA Technical Bulletin for Classification and Inflow Design Flood Criteria (2011), the IDF for Teeterville Dam is conservatively selected as the 100-year flood.

The HEC-RAS model results are provided in **Appendix D**. Under both sunny day and flood scenarios, there was no need to apply the 2 x 2 rule to assess the potential for loss of life.

5.3 Emergency Preparedness Plan

The MNR 2011 Best management Practices for Dam Safety Reviews, and the CDA 2007 Dam Safety Guidelines outline the necessity of an Emergency Preparedness Plan (EPP). The EPP should include emergency response procedures that operations staff is to follow in the event of an emergency at the dam. The plan should clearly state the key roles and responsibilities of staff in order of priority, as well as the required notifications and contact information. The EPP procedures should include management of urgent situations including the full range of operating and surveillance procedures of the dam, as well as situations relating to downstream stakeholders. These should include:

- Procedures for identification and evaluation of the emergency - including potential dam safety hazards(whether natural, structural, or caused by human actions);
- Contact information and communication procedures - including informing of authorities responsible for emergency response and evacuation of the dam operators and people in the inundation zone who are in immediate danger; and
- Remedial management actions –procedures should be documented for providing the emergency responders with communication systems, site access, inundation maps, data, and other required resources.

The EPP should be documented, distributed, and clearly communicated in advance to all response agencies with responsibility for public safety within the floodplain.

Exercises should be carried out regularly to test the emergency procedures. The EPP should be updated regularly, and distribution should be controlled so that all copies are kept up to date.

5.4 Wave Height and Minimum Freeboard

Freeboard is defined as the additional height of a structure between the design high water level and the crest of the structure to prevent overtopping by wind effects.

The LRIA Technical Bulletin for Spillway and Flood Control Structures (MNRF, 2011) provides the minimum freeboard for dams with varying reservoir fetch lengths. For reservoir fetch lengths up to 800 m, comprehensive assessment is not required.

The fetch length at Teeterville Dam reservoir is between 400 m and 800 m. Therefore, a minimum freeboard of 600 mm will be required. The provided freeboard at Teeterville Dam is 1.19 m (bridge deck elevation – IDF level). Therefore, the minimum freeboard requirement is met.

6. Geotechnical Investigation

This section represents the findings from the geotechnical investigation carried out by Thurber Engineering Limited (Thurber) on the earthen berm portion of the Teeterville Dam. The scope of work for the investigation included a review of existing documentation and drawings provided by LPRCA, a visual inspection of the dam to assess areas of potential instability, and an intrusive investigation consisting of 1 borehole through the roadway immediately south of the dam. The assessment was carried out to meet the requirements of the 2011 technical bulletin for geotechnical design for the Lakes and River Improvement Act (LRIA). The Geotechnical Investigation Report is provided in **Appendix F**. The findings of this investigation are summarized below.

6.1 Geotechnical Site Observations

The embankment that carries County Road 25 over Big Creek upstream of Teeterville Dam is connected and elevated relative to the original earth berm. Although this extension of the earthen berm now abuts the reservoir, no evidence of seepage or sinkholes was observed between the road embankment and the berm. In addition, no evidence of sinkholes or seepage was identified on the downstream side of the berm on either side of the spillway structure. The downstream slope on the east side of the structure is vegetated with shrubs and tall grass.

The northwest downstream slope shows evidence of erosion from run-off at the crest of the slope. A loss of material was also observed at the downstream wingwall on the northwest side as a result of run-off (Photo 7). Seepage between the concrete wingwall and pier was also observed at this location.

Large trees with approximately 0.6 m diameter trunks were present at both abutments and consisted of Poplar on the northwest side and Willow on the southeast side.

6.2 Investigation Procedures

Following the visual inspection, a borehole investigation was carried out to obtain preliminary information on subsurface materials in the dam and relative piezometric pressures below the dam. The drilling was carried out on October 9th, 2015 and consisted of drilling one (1) borehole immediately south of the concrete spillway structure.

The borehole was advanced to a depth of 11.3 m. Soil samples of the embankment fill and native overburden soils were retrieved for laboratory testing and standard penetration tests (SPT) completed at routine intervals within the borehole. A 50 mm diameter monitoring well was installed in the borehole to allow for measurement of the groundwater level in the dam. The LPRCA was responsible for obtaining water level measurements, under direction by Thurber staff.

6.3 Site Conditions

6.3.1 Regional Geologic Conditions

The Teeterville Dam is located within the Norfolk Sand Plain physiographic region. The geology generally comprises older to modern alluvial deposits including clay, silt, sand and organic material (OGS Map P. 1054, Quaternary Geology, Simcoe Area, 1976). The deep bedrock (greater than 30 m deep) in the area comprises Devonian limestone of the Onondaga Formation (OGS Map P. 2234, 1975). Recently, agriculture, dam, and road construction activities in the area have resulted in placement of anthropogenic (fill) deposits in some areas.

6.3.2 Soil Conditions

The borehole was advanced through the abandoned roadway immediately south of the concrete spillway structure. The stratigraphy encountered in Borehole 15-01 consisted of a surficial layer of asphalt underlain by a sand fill. Native silty sand was encountered below the fill, and was further underlain by a layer of sandy silt. The borehole was terminated in a sand deposit.

6.3.3 Water Levels

A monitoring well was installed in the borehole to monitor the groundwater elevation at the Teeterville Dam. In addition to the well, a groundwater level measurement was taken upon completion of drilling. This was an unstabilized reading and therefore gives an approximate elevation of the groundwater at the time of drilling. The groundwater levels measured are summarized in Table 6-1.

Table 6-1. Measured Groundwater Levels at Teeterville Dam

Date	Depth to Groundwater (m)	Groundwater Elevation (m)	Comment
Oct. 9, 2015	4.1	233.7	Open Borehole
Oct. 22, 2015	4.5	233.3	Monitoring Well
Nov. 6, 2015	4.5	233.3	Monitoring Well

6.4 Embankment Stability

6.4.1 Foundation Assessment

Based on the subsurface stratigraphy found in the borehole, the dam and the earthen berm are likely founded on loose to compact silty sand to sandy silt, with an estimated angle of internal friction of approximately 28 to 30 degrees. The estimated bearing resistance at the downstream toe of the embankment will vary depending on base width, elevation, and seepage conditions.

Based on the results of the inspection of the concrete spillway structure completed by Watech Services Inc, the structure is likely founded on an aggregate material, such as rock fill, which has been significantly undermined.

6.4.2 Stability Assessment

As per the LRIA Technical Bulletin for Geotechnical Design and Factors of Safety (2011), a detailed stability assessment is not required for existing dams with a LOW HPC.

A preliminary stability analysis was carried out for the dam using Slope/W of the GeoStudio software package which calculates limit equilibrium stability conditions based on the Morgenstern-Price method. The configuration of the dam used in the analysis was based on the survey information as well as visual observations and existing map data. Soil parameters used in the analysis were based on the borehole data obtained from the drilling investigation. The piezometric surface was approximated using survey measurements of the reservoir and creek water levels, and the water levels measured in the piezometer installed at the borehole.

Based on an approximate embankment configuration consisting of a 4 m high berm with a 2H:1V downstream side slope, adjacent to the existing roadway embankment, a Factor of Safety of 1.9 for the downstream slope was obtained from the analysis. This is above the recommended minimum Factor of Safety of 1.5 for a stable embankment slope under long-term steady-state conditions with normal reservoir level (based on LRIA Technical Bulletin for Geotechnical Design and Factors of Safety, August 2011).

6.4.3 Internal Erosion

Aside from undermining of the base slab, localized seepage at the interface with the concrete wingwalls, and localized erosion at the crest of the dam due to runoff, the history of site observations does not include significant reported evidence of internal erosion occurring at the site.

The embankment fill and underlying native soils are generally fine-grained, poorly graded, uniform sands and silts, with low plasticity. These soil types are considered to be extremely erodible and offer little piping resistance. Depending on seepage conditions within the berm, there is a potential for the loss of fine soil particles, and internal erosion or piping. Therefore, the site conditions indicate that there is a risk that internal erosion issues may develop under high water conditions.

6.5 Remedial Options and Recommendations

Some measures that may be taken to reduce the potential for future internal erosion issues include the following:

- Trees should be removed from the surface of the dam, particularly on the downslope area;
- Divert stormwater runoff away from the spillway and original dam surface to reduce potential erosion at the crest of the embankment berm; and
- Conduct regular observations of the berm and the downstream soil to note the presence of potential indicators of erosion. This may include sinkholes, depressions, stream bank erosion, or deposition of material downstream.

Further investigation and analysis would be required to carry out a detailed assessment of the embankment stability and potential for internal erosion, and development of detailed remedial measures.

7. Structural Assessments

Stability analyses of the concrete structure were performed using the parameters and the general methods as described herein. The stability analyses were used to determine if the concrete structure of the Teeterville Dam satisfies current Safety Criteria outlined in the Lakes and Rivers Improvement Act and Technical Bulletins. The results from these analyses, together with the results obtained from the various other assessments prepared as part of this study, form the basis of the recommendations provided in **Section 9** of this report. Detailed calculations for the structural assessment of Teeterville Dam are presented in **Appendix G**.

7.1 Loading Cases and Sliding Stability Analysis

Water levels used in the stability analysis were derived from the hydrotechnical assessment, including the IDF equivalent to the 100-year flood event.

The following loading conditions were reviewed for the stability analysis of Teeterville Dam:

Case 1: Usual Loading (normal summer)

- Dead load of the concrete dam, including slabs, walls and piers
- Upstream water level = El. 236.00 m (water elevation is at the top of the stop logs)
- Downstream water level = El. 232.33 m
- Four (4) stop logs in place (top of stop log elevation = 236.00 m)
- Soil load from silt pressure at the upstream
- Uplift pressure (varying linearly from 100% headwater pressure at the upstream face to zero tailwater pressure at the downstream face, and assumed to act on the entire base slab)

Case 2: Usual Loading (normal winter)

- Dead load of the concrete dam, including slabs, walls and piers
- Upstream water level = El. 235.60 m (water elevation is at the top of the stop logs)
- Downstream water level = El. 232.33 m
- Two (2) stop logs in place (top of stop log elevation = 235.60 m)
- Soil load from silt pressure at the upstream
- Uplift pressure (varying linearly from 100% headwater pressure at the upstream face to zero tailwater pressure at the downstream face, and assumed to act on the entire base slab)
- Ice load = 29 kN/m ice load on the stop logs applied 0.3 m below the water level

Case 3: Unusual Loading (1:100 year flood)

- Dead load of the concrete dam, including slabs, walls and piers
- Upstream water level = El. 236.72 m (water elevation is 0.72 m above the top of the stop logs)
- Downstream water level = El. 233.75 m
- Four (4) stop logs in place (top of stop log elevation = 236.00 m)
- Soil load from silt pressure at the upstream
- Uplift pressure (varying linearly from 100% headwater pressure at the upstream face to tailwater pressure at the downstream face, and assumed to act on the entire base slab)

Teeterville Dam has a LOW hazard potential classification (HPC). According to the LRIA Technical Bulletins for “Structural Design and Factors of Safety” and “Seismic Hazard Criteria, Assessment and Considerations”, stability analysis under earthquake loading is not required for existing dams with a LOW HPC.

7.2 Performance Indicators

The assessment of the suitability of the concrete structures was based on the following predominate performance indicators:

- Factor of safety for sliding; and
- Position of Load Resultant force

Additional performance indicators include normal stresses at the heel / toe and compressive forces within the concrete.

The resistance of a gravity dam against sliding on any surface is assessed by comparing the net driving force with available shear strength and passive resistance. The ratio of these components is the factor of safety (FOS) against sliding. Shear strength is based on the normal vertical stress and an angle of internal friction. A non-cohesive soil with a shear strength of zero was assumed. An internal angle of friction of 30 degrees was assumed for calculation of soil loading.

Load Resultant is calculated by summing the net overturning moment about the downstream end of the dam base and dividing by the sum of the vertical forces.

7.3 Acceptance Criteria

Table 7-1 summarizes the minimum safety factor requirements used for the stability analysis of Teeterville Dam and are consistent with the Lakes and Rivers Improvement Act Technical Bulletin for ‘Structural Design and Factors of Safety’, which describes the criteria for safety factors for concrete control structures.

Table 7-1. Minimum Safety Factor for Sliding

Load Combination	Factor of Safety (unbonded)
Usual	1.5
Unusual	1.3

The position of the Load Resultant should fall within the middle third of the dam base for Usual Loading conditions. Although the middle third requirement is desirable for the evaluation of an existing dam, it is not mandatory as long as the Load Resultant falls within the base of the dam and the allowable bearing stresses of the underlying soil are not exceeded.

Generally, tensile stresses are acceptable so long as the stresses remain within 0.05 to 0.1 times the compressive strength of concrete within the mass of concrete and lift joints. Compressive strengths at the toe of the dam should normally not exceed 0.3 to 0.5 times the compressive strength of concrete for Usual and Unusual loading conditions.

7.4 Assumed Material Parameters and Model

A summary of the parameters used in the stability analysis of Teeterville Dam is provided in Table 7-2.

Table 7-2. Parameters used in Stability Analysis

Component	Unit Weight (kN/m^3)	Comments
Water	9.81	
Concrete	24.0	Minimum Strength 20.7 MPa (3,000 psi)
Soil	20.5 (unsaturated)	angle of internal friction of 30° (no cohesion)

An internal angle of friction of 30 degrees for soil properties is consistent with Geotechnical recommendations.

The dam was divided into five sections for stability analysis, two abutment sections and three pier sections. The sections were considered independent of each other for the purposes of calculations. Two representative sections chosen for analysis were:

- Pier section, with a tributary width equal the typical (nominal) pier spacing, or 3.09 m:
  - includes the dead load from one pier and the length of base slab / wall equal to the tributary width; and
  - horizontal loads (water, soil pressure and ice) acting on the tributary width of the section.

- Abutment section, with a tributary width equal to half of the distance between the abutment and first interior pier, or 7.49 m:
  - includes the dead load from one abutment and the length of base slab / wall equal to the tributary width; and
  - horizontal loads (water, soil pressure and ice) acting on the tributary width of the section.

The concrete member sizes and dimensions used in the structural analysis were taken from the site inspection. Despite some minor differences in shape and width, one typical simplified geometry was assumed for the abutments and one for the piers, which are reflected in the idealized sections in Figures 7-1 and 7-2, respectively.

Figure 7-1. Typical Abutment Section of Teeterville Dam

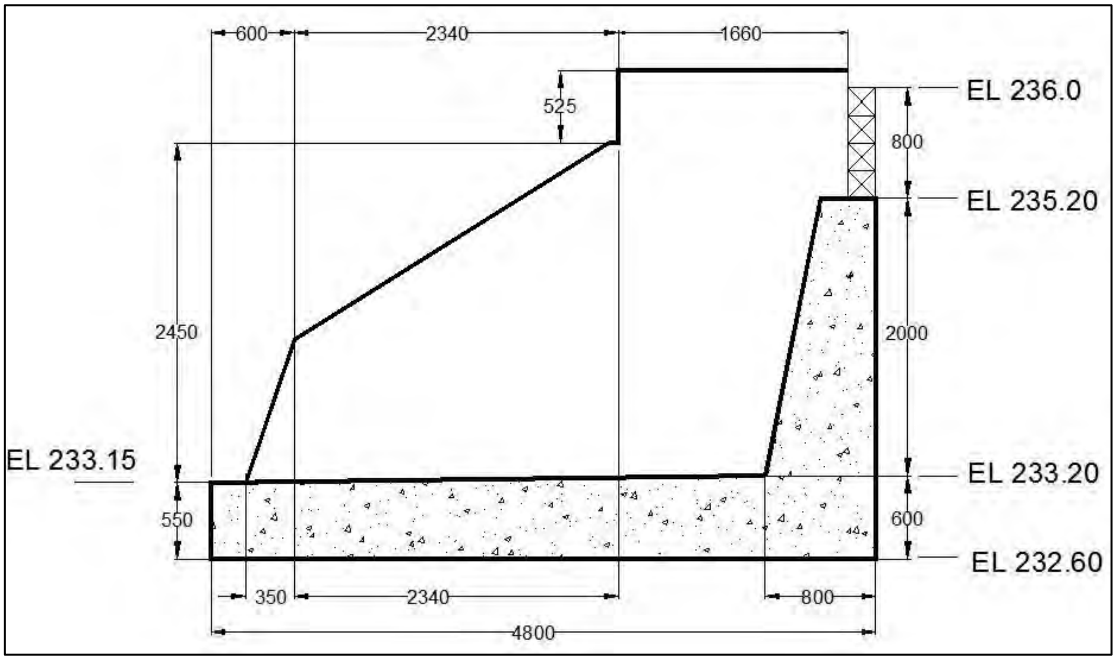
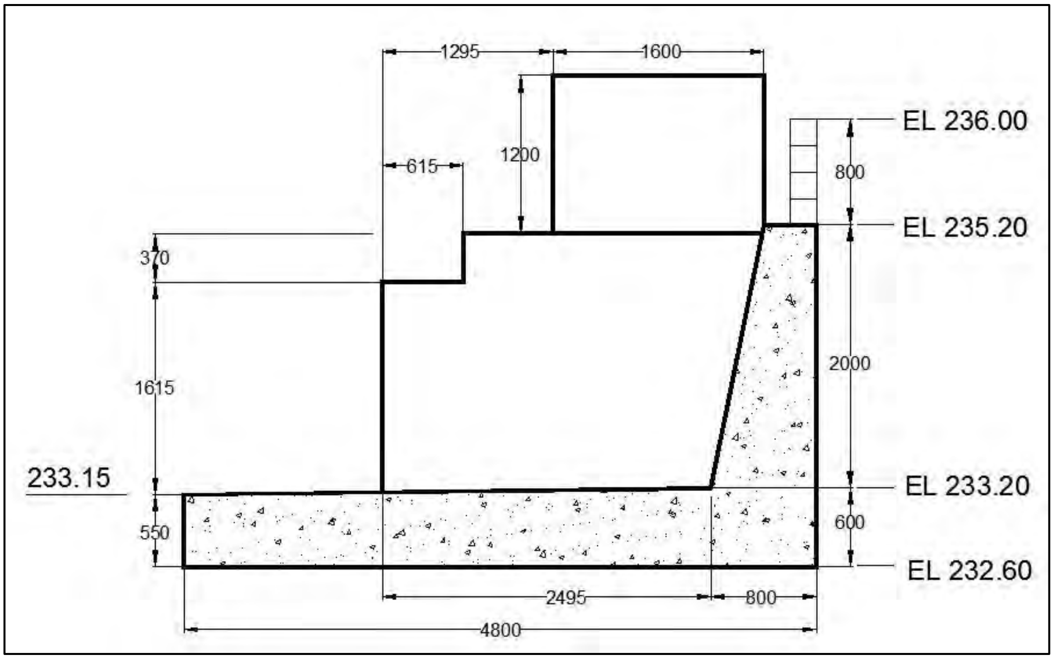


Figure 7-2. Typical Abutment Section of Teeterville Dam



7.5 Analysis of Dam Stability

The results of the stability analyses for the two sections are summarized in Tables 7-3 and 7-4, for the abutment and pier sections, respectively.

Table 7-3. Calculated Safety Parameters for Abutments

		Sliding Factor of Safety		Position of Resultant (middle third: yes/no)	Contact Base Pressures (kPa)	
Load Case	Description	Calculated	Required		Toe (downstream)	Heel (upstream)
1	Usual Load (Summer)	0.46	1.5	No	31	-7
2	Usual Load (Winter)	0.44	1.5	No	47	-19
3	Unusual Load (IDF)	0.19	1.3	No	38	-25

Note 1: A negative value indicates theoretical tensile values

Table 7-4. Calculated Safety Parameters for Piers

		Sliding Factor of Safety		Position of Resultant (middle third: yes/no)	Contact Base Pressures (kPa)[1]	
Load Case	Description	Calculated	Required		Toe (downstream)	Heel (upstream)
1	Usual Load (Summer)	0.25	1.5	No	23	-11
2	Usual Load (Winter)	0.27	1.5	No	38	-22
3	Unusual Load (IDF)	0.05	1.3	No	31	-28

Note 1: A negative value indicates theoretical tensile stresses

The pier section and the abutment section fail to meet safety criteria for sliding factor of safety under all of the load cases. The force resultant falls outside of the middle third of the base for all load cases for both the pier and abutment sections.

7.6 Dam Stability Discussion

Teeterville Dam fails to meet the required factors of safety for all loading condition as previously noted. Given that the uncertainly of various conditions (including base slab thickness) and variability of various assumptions (including upstream soil pressure and internal angle of friction), the stability calculations were reviewed for sensitivity to assumed parameters.

Modifications to various parameters were only completed for the analysis of the pier and included:

- Removal of soil pressure upstream;
- Increasing base slab thickness by increments of 200 mm (from a base thickness of 600 mm to 1,200 mm); and
- Increasing internal angle of friction by increments of 5° (from the base angle of 30° to 40°).

For the removal of soil pressure upstream, the sliding Factor of Safety increases to a maximum of 0.33 for the Usual Load case (summer and winter) and has no impact to the Unusual Load case.

The sliding Factor of Safety is sensitive for each incremental increase to the base slab thickness particularly for the Unusual Load case. However, a sliding Factor of Safety over 1.0 cannot be achieved for the piers. For example, the sliding Factor of Safety only increased to a maximum of 0.89 for a slab thickness of 1,200 mm under the Unusual Load case (summer). For the Unusual Load case, the sliding Factor of Safety increased from 0.05 (for the base case) to 0.52 for a slab thickness of 1,200 mm.

The sliding Factor of Safety has a minor sensitivity to increasing internal angle of friction by increments of 5°, to a maximum of for 40°. The sliding Factor of Safety increased to a maximum of 0.43 for the Unusual Load case (summer and winter) and experiences a minor increase to 0.07 for the Unusual Load case.

Modifications to the various parameters were applied one-by-one and the results show that the sliding Factor of Safety for the piers remained well below 1.0.

Additional preliminary analyses were undertaken to investigate the stabilizing effect of soil anchors. In particular, one soil anchor (equivalent to approximately 600 kN) was applied to abutment sections while two soil anchors (equivalent to approximately 1,200 kN) was applied to pier sections.

The use of soil anchors appears to sufficiently increase the sliding Factor of Safety for all loads cases at the abutments. Soil anchors in the piers also have a positive influence on stability, increasing the sliding Factors of Safety for the winter Usual Load and Unusual Load (IDF) cases to approximately 1.4 and 1.1, respectively. Although the required Factors of Safety are not fully achieved, there are many unknown impacts to applying the soil anchors, including the increased contact base pressures and the ability (of the base slab) to resist these pressures. Given the age, unknown structure properties and condition of the existing structure, use of soil anchors should be carefully weighed against other rehabilitation or replacement alternatives.

8. Sediment Quality and Quantity Assessment

8.1 Sediment Quality

8.1.1 Methodology

In order to determine the quality of the sediment and an appropriate disposal option, three combined samples were collected and submitted to a certified laboratory for analysis. A maximum of ten subset samples were taken from near the dam and near the centre of the reservoir to obtain sufficient volume of sample to represent the corresponding location. Subset samples were combined to create a discrete confirmatory sample and submitted for laboratory analyses.

Samples were collected at regular intervals by advancing handheld core sampling equipment through the stratified layers of sediment. Sampling equipment was decontaminated between intervals using a potable water rinse. At each location, the coring equipment was advanced until refusal or until the base of the pond was encountered. The sample retrieval depths and depths to refusal were used to confirm existing sediment depth. The confirmatory samples were placed in dedicated sampling containers immediately following the retrieval of the sample from the core hole. The samples were placed in a cooler on ice and samples that were selected for potential chemical, biological and physical analyses were delivered to the laboratory upon the conclusion of the sample collection activities.

The confirmatory sediment samples from the reservoir were submitted to ALS laboratory for the following analyses:

- Complete Metals Scan;
- Volatile Organic Compounds (VOCs);
- Petroleum Hydrocarbons (fractions F1 to F4);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Organochlorinated Pesticides, and
- Grain size and bulk density.

These analyses are based on the listing of parameters contained in Table 1 and Table 2 of the Ministry of Environment and Climate Change (MOECC) Ontario Regulation 153/04 “Soil, Ground Water and Sediment Standards for Use under Part XV.1 of the Environmental Protection Act”. ALS report is provided in **Appendix H**.

8.1.2 Results

The analysis completed on the three samples (TV-1, TV-2 and TV-3) were summarized and compared to Tables 1 and 2 of O. Reg. 153/04. Complete results are provided in Attachment 1. Based on the grain analysis for the samples (Table 8-1), TV-1 and TV-2 are considered to be fine, while TV-3 is categorized coarse soil. This classification applies to Table 2 of the Regulation.

Table 8-1. Grain Size Analysis

Grain Type	Diameter Range (mm)	Weight Percent		
		TV-1	TV-2	TV-3
Gravel	>4.5	0	0.72	30.85
Coarse Sand	2.0-4.5	0	1.45	12.5
Medium Sand	0.425-2.0	0	0	31.38
Fine Sand	0.075-0.0425	62	15.65	25
Silt	0.002-0.075	29.25	77.67	0.27
Clay	<0.002	18.21	10.54	

Figure 8-1 provides a comparison of the results to MOECC Table 1 (Full Depth Background Site Condition Standards) for sediment, agricultural or other property use, and for residential, parkland, institutional, industrial, commercial, or community property use (RPIICC). The figure shows all contaminants analyzed (and detected), which also have corresponding guidelines. All concentrations are below background sediment concentrations as defined by the Regulation, except for arsenic at TV-2, which is slightly above the background level. A number of organic compounds exceed background conditions by up to 3.5 times for TV-3. All samples meet RPIICC guidelines, except for Fluoranthene, which is at the guideline level. Figure 8-1 only provides an overview of measured values and observed exceedances. All other results have been below method detection limits.

Figure 8-2 provides a comparison of the results to MOECC Table 2 (Full Depth Generic Site Condition Standards in a Potable Ground Water Condition). TV-1 and TV-33 results have been compared with fine/medium texture soil standards where applicable. This comparison indicates that only Benzo(a)pyrene is above the guidelines for Agricultural uses for TV-3.

The results were also compared to the Non-Agricultural Source Materials (NSAM) guidelines for 11 metals (arsenic, cadmium, cobalt, chromium, copper, lead, mercury, molybdenum, nickel, selenium and zinc) regulated through the *Nutrient Management Act* (2002). None of the results exceeded maximum allowable concentrations in soil.

8.1.3 Conclusions

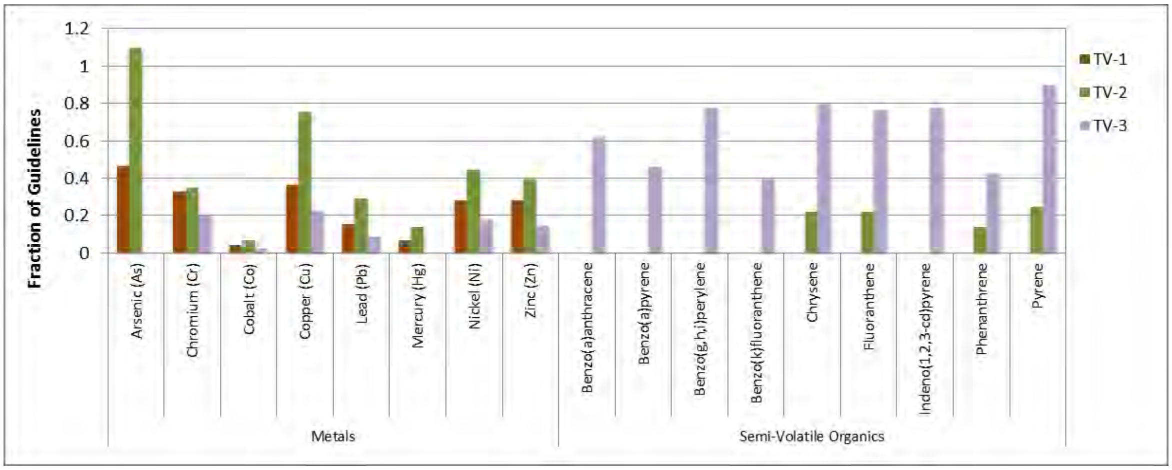
The results of sediment analyses were used to identify levels of potential contaminants in the sediment and determine its suitability for release, disposal or reuse.

Based on comparison to the MOECC Table 1 (O. Reg. 153/04), measured concentrations are below the defined background concentrations for sediment (except for arsenic in one sample, which is about 10% above background). As arsenic in the other two samples is either not detected or less than half background concentration, it is expected that enough dilution will be provided for the bulk of the sediment to fall below background concentration for arsenic. It is therefore our opinion that based on the completed analysis, the sediment as a whole can be released to downstream Big Creek.

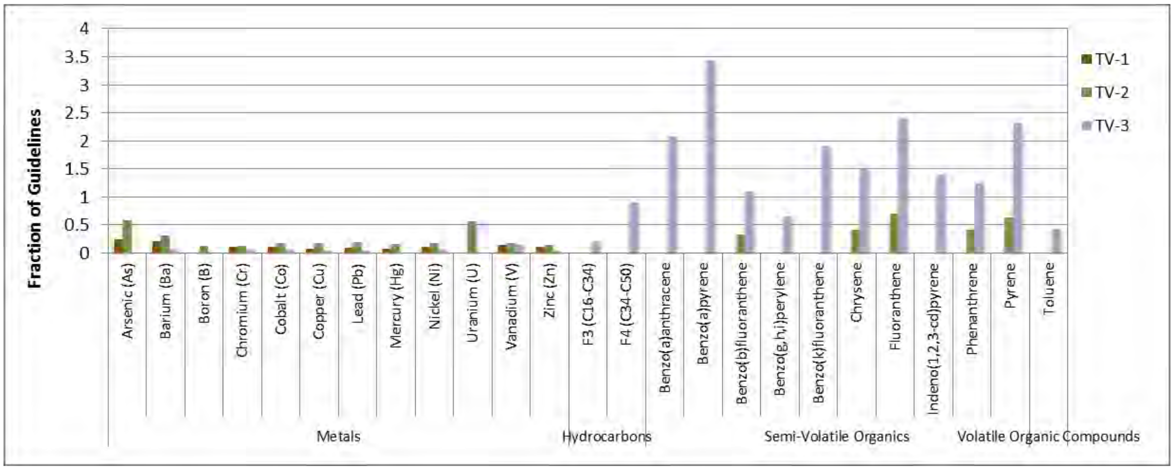
A number of volatile or semi-volatile organic compounds are above background and/or generic soil concentrations for agricultural and/or other uses in one of the three samples. Since these parameters are mainly non-detectable in the other two samples, it is anticipated that the bulk of sediment would also meet the background or generic site conditions for disposal on agricultural and other property use lands if sediment is removed from the reservoir.

Figure 8-1. Comparison to MOECC Table 1

a) Sediment



b) Agricultural or Other Property Use



c) Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use

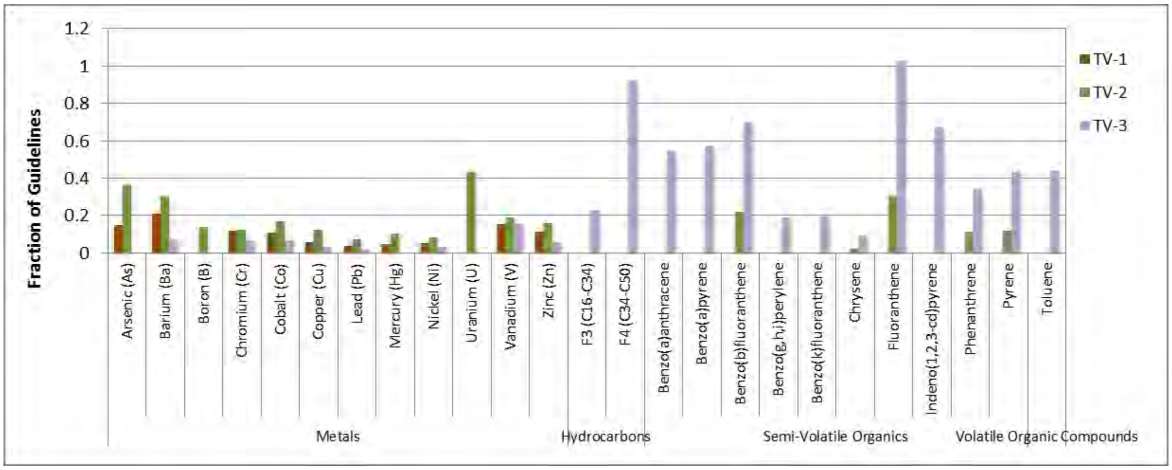
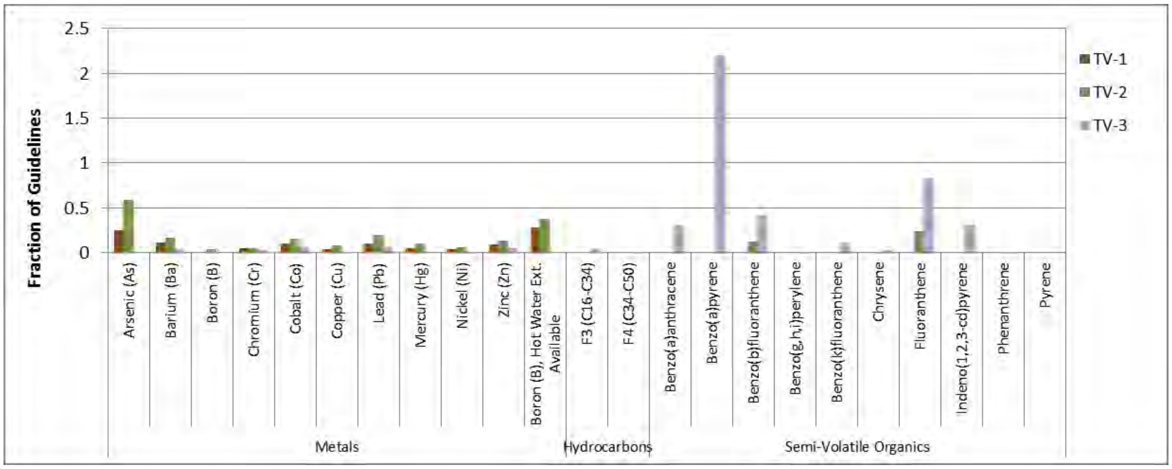
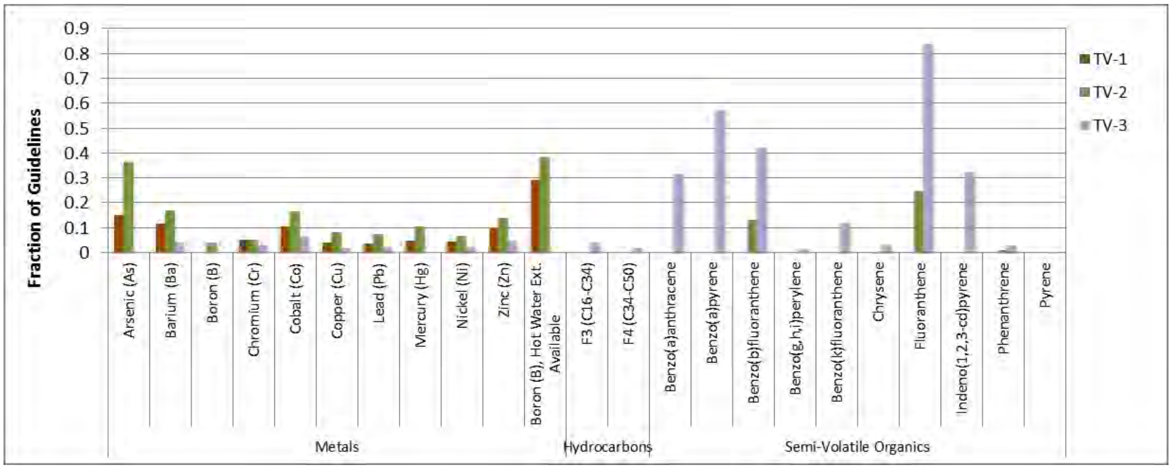


Figure 8-2. Comparison to MOECC Table 2

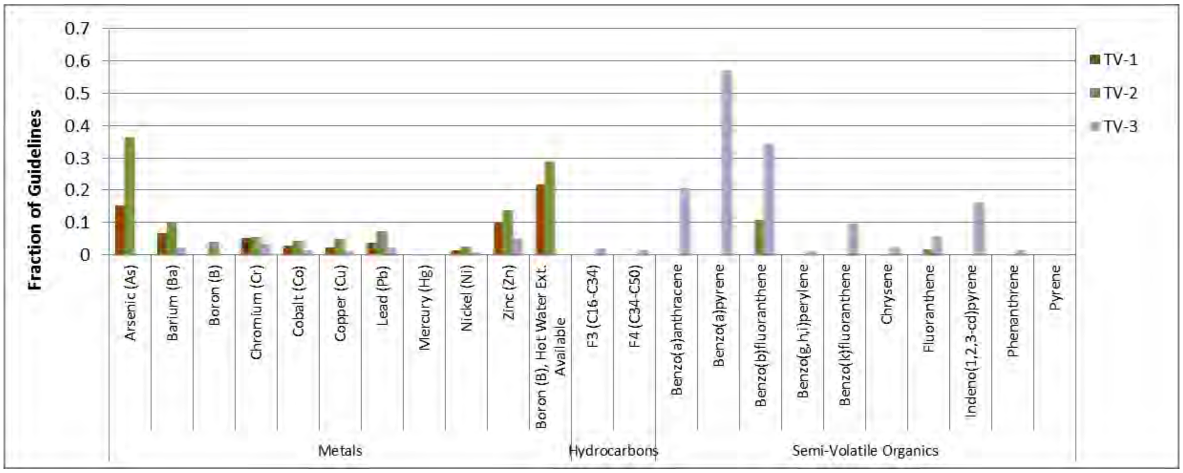
a) Agricultural or Other Property Use



b) Residential/Parkland/Institutional Property Use



c) Industrial/Commercial/Community Property Use



8.2 Sediment Quantity

In order to estimate the sediment volume, a bathymetric survey of the reservoir was conducted using an eco-sounding sonar devise, where depth permitted. In areas shallower than 0.3 m, manual measurements were taken. Bathymetric survey was conducted along a longitudinal section along the middle of the reservoir as well as several sections across the reservoir.

The sediment volume was calculated by creating two surfaces: one for the top of the sediments and one for the bottom of the reservoir. The surface for the bottom of the reservoir was estimated assuming a straight line connecting the bottom of the channel just upstream of the reservoir to the bottom of the channel just downstream of the dam.

The total sediment in the Teeterville reservoir was estimated to be approximately 321,500 m^3. The details of the analysis are provided in **Appendix H**.

9. Remedial Options and Recommendations

As a result of the dam safety review and condition assessment, a number of actions and maintenance activities were recommended to ensure that the structure will satisfy current dam safety criteria.

9.1 Additional Studies and Monitoring

Recommendations are provided for additional studies and further monitoring to be undertaken at the dam.

- Conduct regular observations of the berm and the downstream soil to note the presence of potential indicators of erosion. This may include sinkholes, depressions, stream bank erosion, or deposition of material downstream;
- Prepare an Emergency Preparedness Plan (EPP) for the dam;
- Update the dam Operation, Maintenance, Safety and Surveillance (OMSS) manual;
- Undertake a Public Safety Assessment (PSA) of the dam to determine whether a Public Safety Plan (PSP) should be completed for this site. Completion of the PSA should be within 3 years from this Dam Safety Review. Public safety issues may include the lack of warning zones across the upstream dam side to deter access by the public and general public safety signage.

9.2 Recommendations for Future Work

There were no immediate or “urgent” maintenance or repair requirements (less than 1 year) identified for the dam structure. However, a strong caution is provided in the use of the bridge for access.

Although closed to public access, the steel truss bridge is used to access the steel operating platforms on the piers for stop log replacement and removal. The truss relies on the integrity of the bottom chord connections to maintain overall structural competency. However, the integrity and connectivity of the bottom chord members near the ends (at the bearings) were compromised. As the bridge carries virtually no load other than its self-weight, redistribution of load and alternate load paths must be occurring for the bridge to be standing. In reality, additional loads on the bridge for access are negligible. In its current form the bridge represents a potential liability and a danger to users. Its use should be limited and phased out, until rehabilitation or replacement.

The following options were considered for future work at Teeterville Dam:

- Do nothing;
- Rehabilitation and maintenance;
- Replacement; and
- Decommissioning.

9.2.1 Do Nothing

The stability analysis of Teeterville Dam showed that the dam do not meet the safety criteria as set in the LRIA Technical Bulletins. In addition, the truss bridge is in a poor condition and requires repairs or replacement to provide continued access required for dam operations. Therefore, the Do Nothing option is not recommended.

9.2.2 Rehabilitation and Maintenance

The rehabilitation scope of work will include the following:

- Trees should be removed from the surface of the dam, particularly on the downslope area;

- Divert stormwater runoff away from the spillway and original dam surface to reduce potential erosion at the crest of the embankment berm;
- Undertake fencing upgrades on the east approach;
- Repair concrete on wingwalls, piers and abutments. Repair may be achieved by partial depth patches according the following general procedures:
    - Undertake a detailed visual and delamination survey (with hammer sounding) to identify locations of concrete spalling, delaminations and exposed corroded reinforcing steel. Remove concrete (partial depth) to a depth of 25 mm uniformly behind the first layer of reinforcing steel and an additional 25 mm locally behind the second layer of reinforcing steel. Abrasive blast clean concrete and reinforcing steel. Repair areas with 30 MPa concrete patches by form and pump method.
- Repair steel truss structure;
- Undertake stability improvements to the Dam structure. This may include coring and grouting of soil anchors through the abutments and piers;
- Grouting of the void below the base slab of the Dam and underlying subgrade; and
- Remove the buildup of sediment on the upstream face of the dam.

9.2.3 Replacement

Teeterville Dam and the truss bridge used to access the dam for operation are in poor conditions and will require extensive repair works. Despite higher initial cost, dam replacement may economically be a better long term option.

9.2.4 Decommissioning

The dam may be decommissioned if the reservoir will no longer be needed for providing recreation as well as water supply for agricultural use and fire trucks. The sediment quality analysis showed that the sediment built up in the reservoir can be safely disposed on site and/or used for natural channel restoration. This option will have a lower long term cost compared to repair or replacement.

High level cost estimates for repair, replacement, and decommissioning options are provided in the following sub-section.

9.3 Preliminary Cost Estimates

The following is a brief summary of the various options and “Order-of-Magnitude” cost estimates. The estimates include a project contingency and allowance for engineering. The costs do not include permits and HST. The costs will largely depend on the approach and efficiencies related to grouping the work (e.g. a single stand-alone repair will tend to be more expensive).

Table 9-1. Preliminary Capital Cost Estimates

Description	Preliminary Cost
1. Repairs	$350,000
1.1. Dam Structural Repairs	$225,000
1.2. Bridge Structural Repairs	$93,750
1.3. Safety Upgrades (e.g. signs, fencing)	$12,500
1.4. Sediment Removal	$18,750
2. Replacement	$1,450,000
3. Decommissioning	$950,000

9.4 Evaluation of Alternatives

A summary of a high level qualitative assessment of the alternatives based on different criteria is provided in Table 9-2. This evaluation is completed using information collected and analyzed as part of this project. Each alternative received a score based on the potential effect on the evaluation criteria, as follows:

- Positive effect: (+1) for Low, (+2) for Medium, and (+3) for High;
- Negative effect: (-1) for Low, (-2) for Medium, (-3) for High;
- No effects: 0

The scores for each alternative are added at the end and the preferred alternative is selected as the one with the highest score.

9.5 Conclusions

A Dam Safety Review and Condition Assessment for Teeterville Dam was completed as per the LRIA Technical Bulletins and Best Management Practices (MNRF, 2011). Different alternatives for future works at the dam were considered and evaluated against various criteria, including social/cultural, natural environment, technical, and economic/financial. Based on this evaluation, the recommended option for Teeterville Dam is decommissioning.

A Class Environmental Assessment will be required to be completed for the dam in order to investigate each alternative in more details and provide a preferred option. The Class EA study includes public input. It is recommended that MNRF be consulted regarding the requirements of completing a Class EA study for Teeterville Dam.

Table 9-2. Evaluation of Alternatives for Teeterville Dam

CRITERIA	ISSUE	CONSIDERATIONS	ALTERNATIVE			
			Do Nothing	**Repair**	**Replacement**	**Decommissioning**
SOCIAL / CULTURAL	Public Health and Safety	Safety related risk of failure	-2	+2	+3	+3
		Disruption / inconvenience to public during construction	0	+2	+2	+2
		Flooding downstream	-1	+1	+1	-1
	Cultural Heritage Resources	Disruption of site / structures having significant archaeological, historical, or architectural value	0	0	0	0
	Aesthetics	Visual appearance of structure	-3	+1	+2	+3
	Aboriginal Issues	Land Claims / Treaty Rights	0	0	0	0
NATURAL ENVIRONMENT	Terrestrial Wildlife / Vegetation on Habitat including Linkages and Corridors	Effects on wildlife and habitat	0	0	0	+2
		Effects of timing of construction on breeding periods	0	-1	-2	-1
		Effects on significant trees and/or ground flora	0	0	0	+1
	Aquatic Life / Vegetation / Water Quality	Effects on aquatic life and habitat	0	0	0	+2
		Effects on aquatic vegetation	0	0	0	+2
		Effects on water quality	0	0	0	+3
	Climate Change	Ability to accommodate impacts / flexibility of design	-2	+2	+3	0
TECHNICAL	Design	Floodplain restoration / enhancement	0	0	0	+3
		Utility impacts	0	0	0	-1
		Property Impacts	0	0	0	-1
	Construction	Diversion and dewatering	0	-1	-3	-2
		Excavation and groundwater control	0	-2	-3	-2
		Noise / Vibration during construction	0	-2	-3	-2
		Construction access	0	-1	-2	-1
	Operation and Maintenance	Adjacent property impacts	0	+1	+2	0
		Ease of access	0	+2	+3	0
		Vegetation establishment (with maintenance)	0	+1	+2	0
	Approval and Regulatory Requirements	Federal, Provincial and Municipal Requirements	-3	-2	-1	+1
		Conservation Authority Requirements	-2	+1	+2	+3
		Special Policy Areas-Opportunity to coordinate with planned land uses	0	0	0	+1
ECONOMIC / FINANCIAL	Initial Costs	Total Project Costs (design, construction, property acquisition)	0	-1	-3	-2
	Operating and Maintenance Costs	Costs associated with operation and maintenance	0	-3	-2	+3
		Total Score	**-13**	**0**	**1**	**16**

Appendix A

Natural Heritage Review

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www.aecom.com

Memorandum

To	Project File	Page	1
CC			
Subject	Teeterville Dam Stability and Condition Assessment; Natural Heritage Background Review		
From	Casey O'Driscoll and Jillian deMan		
Date	December 23, 2015	60439243	

1. Introduction

AECOM Ltd. was retained by the Long Point Region Conservation Authority (LPRCA) to complete a Dam Stability and Condition Assessment on Teeterville Dam in Teeterville, Ontario. The study area includes the Teeterville Dam located at the Teeterville Road crossing and extends downstream to the railroad crossing in the town of Delhi, Ontario. Refer to **Figure 1 Attachment 'A'** for the Teeterville Dam study area.

This memorandum (hereafter referred to as memo) outlines the methods and results of a preliminary review of background information for the Teeterville Dam study area. Additionally, this memo identifies any gaps in data and summarizes requests made to relevant agencies.

2. Methods

A desktop review of background information was completed for both terrestrial and aquatic heritage features known within the Teeterville Dam study area. The following secondary sources were used during the background information review:

- Ontario Ministry of Natural Resources and Forestry (MNRF) Make-a-Map: Natural Heritage Areas Application;
- Norfolk County Official Plan (2011);
- LPRCA Watershed Reports;
- MNRF Land Information Ontario (LIO) Mapping;
  MNRF Natural Heritage Information Center (NHIC) Species at Risk (SAR) and Rare Species Records; and
- Fisheries and Oceans Canada (DFO) Aquatic Species at Risk Mapping.

2.1 Agency Correspondence

Information requests were submitted to the Long Point Region Conservation Authority (LPRCA), Ministry of Natural Resources and Forestry (MNRF) and Fisheries and Oceans Canada (DFO) for data gaps that were identified during the background information review as well as to ensure that the information **provided** in this memo is correct and up to date.

A copy of agency correspondence can be found in **Attachment B.**

2.1.1 MNRF

A data request was sent to MNRF Planner Andrea Fleischhauer on November 25, 2015 requesting following information:

- Presence of Natural areas (ESA, PSW, ANSI, significant woodlands, Provincial Parks, Conservation Reserves and Wildlife Management Areas);
- Natural Area Reports;
- Species at Risk records/occurrences;
- Presences of critical habitat (Bobolink, etc.);
- Species at Risk Recovery strategies (specifically for Bobolink);
- Thermal and flow regime classification of watercourses GIS data;
- In-water timing window restrictions; and
- Fish Collection Records.

On December 21st 2015 a response was received with the following information supplied:

- The study area encompasses a large section of the BC 31 Complex Provincially Significant Wetland
- Records/occurrences of the following terrestrial SAR within the study area; Chimney Swift, Barn Swallow, Bobolink, Eastern Meadowlark, Wood Thrush, American Badger and Snapping Turtle
- Presence of critical habitat for all species listed above within the study area
- The thermal regime of Big Creek which is classified as a coldwater fishery; and
- Fish collection records

2.1.2 LPRCA

A data request was sent to LPRCA Lands & Waters Supervisor, Paul Gagnon on November 26th, 2015 requesting following information:

- Presence of Natural areas (ESA, PSW, ANSI, significant woodlands, Provincial Parks, Conservation Reserves and Wildlife Management Areas)
- Natural Area Reports
- Species at Risk records/occurrences
- Presences of critical habitat (i.e., Bobolink, etc.)
- Species at Risk Recovery strategies (specifically for Bobolink)
- Thermal and flow regime classification of watercourses GIS data

- In-water timing window restrictions
- Fish Collection Records

On December 1st 2015 a response was received with the following information supplied:

- The thermal regime of Big Creek which is classified as a coldwater stream
- Microsoft Excel tables containing temperature data and graphs for Big Creek

2.1.3 DFO

A data request was sent to DFO Fisheries Protection on November 25, 2015 requesting following information:
Confirmation of the presence/absence of the following aquatic SAR identified on DFO SAR Mapping in respects to the study area:

- Silver Lamprey (Great Lakes/Upper St. Lawrence
- Grass Pickerel
- Northern Brook Lamprey (Great Lakes/Upper St. Lawrence)
- River Redhorse
- Silver Chub (Great Lakes/Upper St. Lawrence)
- Warmouth

On November 26th 2015 a response was received with the following information supplied:

Andrew Geraghty, the Fisheries Protection Program Biologist for DFO confirmed that none of the aquatic SAR listed above were present within the portion of Big Creek within the study area. However, immediately downstream of the study area the presence of the following aquatic SAR has been confirmed:

- Silver Lamprey
- Grass Pickerel
- Northern Brook Lamprey
- Warmouth
- Eastern Sand Darter
- Pugnose Shiner
- Lake Chubsucker (potentially extirpated)

3. Results

Available background information obtained during the background review pertaining to both aquatic and terrestrial aspects is summarized in the following sections.

3.1 Aquatic Background Results

3.1.1 Watersheds

The study area falls within the Big Creek watershed, which drains an area of approximately 725 km^2(LPRCA, 2007). The Big Creek watershed primarily drains one major physiographic region, the

Norfolk Sand Plain and also drains a small section of two other physiographic regions; the Horseshoe Moraine located in the northwest section of the watershed and a small section of the Haldimand Clay Plain located at the southern tip of the watershed (LPRCA, 2007). The Big Creek watershed drains directly into Lake Erie (LPRCA, 2007).

Surrounding land-use within the Big Creek watershed is estimated to be approximately 71% agricultural production, especially in the northern half of the watershed (LPRCA, 2007). The southern half of the watershed has a much lower percentage of agricultural land use and contains a much higher percentage of forest cover and natural areas (LPRCA, 2007).

There are several groundwater fed creeks and streams within the Big Creek water shed that provide several significant coldwater fisheries in the area (LPRCA, 2007). Many of these smaller coldwater creeks and streams within the watershed are tributaries of Big Creek and therefore contribute to the large coldwater fishery associated with Big Creek (LPRCA, 2007).

3.1.2 Water Quality

Despite the high percentage of agricultural land use within the Big Creek watershed, water quality tends to be quite good and most streams and rivers within the watershed including Big Creek, have been classified as significant coldwater watercourses which provide habitat for both resident and migratory coldwater species (LPRCA, 2005). Water quality reports were obtained using desk top review only, no field investigations were conducted.

3.1.3 Fish Species

Fish records retrieved from MNRF LIO Mapping and through correspondence with MNRF indicate that the following species are known to occur within Big Creek and therefore potentially within the portion of Big Creek within the study area:

- Rock Bass (*Ambloplites rupestris*)
- White Sucker (*Catostomus commersonii*)
- Brook Stickleback (*Culaea inconstans*)
- Rainbow Darter (*Etheostoma caeruleum*)
- Brassy Minnow (*Hybognathus hakinsoni*)
- Northern Hog Sucker (*Hypentelium nigricans*)
- Pumpkinseed (*Lepomis gibbosus*)
- Hornyhead Chub (*Nocomis biguttatus*)
- Common Shiner (*Luxilus cornutus*)
- Blacknose Shiner (*Notropis heterolepis*)
- Rainbow Trout (*Oncorhynchus mykiss*)- Resident population
- Blackside Darter (*Percina maculate*)
- Bluntnose Minnow (*Pimephales notatus*)
- Fathead Minnow (Pimephales promelas)
- Eastern Blacknose Dace (*Rhinichthys atratulus*)
- Brown Trout (*Salmo trutta*)- Resident population
- American Brook Lamprey (*Lethenteron appendix*)
- Mottled Sculpin (*Cottus bairdii*)

- Brook Trout (*Salvelinus fontinalis*)
- Johnny Darter (*Etheostoma nigrum*)
- Emerald Shiner (*Notropis atherinoides*)
- Central Mudminnow (*Umbra limi*)
- Creek Chub (*Semotilus atromaculatus*)

Results from fish community surveys performed by LPRCA from 2002- 2005 show that Big Creek receives a healthy run of migratory Rainbow Trout and Chinook Salmon (*Oncorhynchus tshawytscha)*(LPRCA, 2005).

Field investigations were not conducted to further determine the presence/absence and distribution of the fish species listed above throughout the watercourse.

3.1.4 SAR

DFO Aquatic SAR Mapping (DFO, 2015) did not identify any fish or mussel SAR the portion of Big Creek that falls within the study area. Further consultation with DFO Fisheries Protection confirmed the absence of any fish or mussel SAR from Teeterville Dam downstream to the town of Delhi.

It should be noted that the reaches of Big Creek immediately downstream from the southern limit of the study area in Delhi have records of several fish SAR which include:

- Silver Lamprey (*Ichthyomyzon unicuspis*)- Great Lakes/ Upper St. Lawrence Population
- Grass Pickerel (*Esox americanus vermiculatus*)
- Northern Brook Lamprey (*Ichthyomyzon fossor*)- Great Lakes/ Upper St. Lawrence Population
- River Redhorse (*Moxostoma carinatum*)
- Silver Chub (*Machrybopis storeriana*)- Great Lakes/ Upper St. Lawrence Population
- Warmouth (*Lepomis gulosus*)
- Eastern Sand Darter (*Ammocrypta pellucida*)
- Pugnose Shiner (*Notropis Anogenus*)
- Lake Chubsucker (*Erimyzon sucetta*)

4. Terrestrial Background Results

4.1 Designated Natural Areas

The *Make-a-map: Natural Heritage Areas Application* (MNRF, 2015) as well as the *Norfolk County Official Plan* (Norfolk County, 2011) were used to collect background information on existing natural features located within and/or in close proximity to the study area. The search results are summarized in the following sections. It should be noted that all work was conducted using desk top only, no field investigations were conducted.

4.1.1 Provincial Parks and Conservation Reserves

No provincial parks or conservation reserves have been identified within the study area.

4.1.2 Significant Wetlands

BC31 Provincially Significant Wetland Complex (BC 31) is present throughout the majority of the study area. This wetland contains both swamp and marsh communities.

4.1.3 Areas of Natural and Scientific Interest (ANSI)

Several Life Science and ANSI sites were identified within the study area and/or in close proximity to the study area. The list of Life Science and ANSI sites identified are as follows; La Salette Woods (Life Science Site) is located within 1 km of the study area, Delhi Swamp (Life Science Site) is located within the study area, Delhi Big Creek Valley (Life Science & ANSI) is located within the study area, Delhi Big Creek Valley (Carolinian Canada Site) is located within the study area, and Quance Bush (Life Science Site) is located within 1 km of the study area.

4.1.4 Environmentally Significant Areas (ESA)

No ESAs were identified within the study area or in close proximity to the study area.

4.2 Norfolk County Official Plan

The Norfolk County Official Plan identifies provincially significant wetlands within the study area as mapped on Schedule B1, a Significant Natural area located in the southern reach of the study area as mapped on Schedule C4 and Significant Woodlands as mapped on Schedule C1.

4.3 Long Point Region Conservation Authorities Regulated Areas

The study area is located within the jurisdiction of LPRCA. Big Creek, the main watercourse throughout the study area is located within the regulated area limits.

4.4 SAR

The *Make-a-map: Natural Heritage Areas Application* (MNRF, 2015) was used to search for NHIC rare species and species at risk records within the study area. A total of 28 1 km UTM Grid Squares intersected throughout the study area and records were retrieved from each 1km Grid. Results from the search identified a total of 17 provincially rare species which included three Threatened species, two Endangered species and one species of Special Concern (see **Table 1**).

Table 1. NHIC Rare Species Records Within the Study Area

Taxon	Common Name	Scientific Name	S-Rank	COSEWIC Status	COSSARO Status	Year Last Observed
Bird	Bobolink	Dolichonyx oryzivorus	S4B	Threatened	Threatened	2002
Reptile	Blanding's Turtle	Emydoidea blandingii	S3	Threatened	Threatened	2005
Mammal	American Badger	Taxidea taxus	S2	Endangered/ Threatened	Endangered	2006
Plant	American Water-willow	Justicia americana	S1	Threatened	Threatened	1954
Reptile	Massasauga Rattlesnake	Sistrurus catenatus	S1	Endangered	Endangered	1969
Plant	Green Dragon	Arisaema dracontium	S3	Special Concern	Special Concern	1901
Plant	Woodland Muhly	Muhlenbergia sylvatica	S2	N/A	N/A	1986
Plant	Ohio Spiderwort	Tradescantia ohiensis	S2	N/A	N/A	1901
Plant	Palmate-leaved Violet	Viola palmata	S2S3	N/A	N/A	1986
Plant	Hairy Pinweed	Lechea mucronata	S3	N/A	N/A	1955
Plant	Sundial Lupine	Lupinus perennis	S3	N/A	N/A	1958
Plant	Woodland Flax	Linum virginianum	S2	N/A	N/A	1937
Plant	Shellbark Hickory	Carya laciniosa	S3	N/A	N/A	1971
Plant	Northern Pin Oak	Quercues ellipsoidalis	S3	N/A	N/A	1986
Plant	Forked Panicgrass	Dichanthelium dichotomum	S2	N/A	N/A	1986
Plant	Deer-tongue Panicgrass	Dichanthelium clandestium	S2	N/A	N/A	1985
Plant	Fall Crabgrass	Digitaria cognata	S1	N/A	N/A	1986

Field investigations were not conducted to further determine the presence or absence of any of the above listed SAR.

5. Species at Risk

Through a species at risk screening it was determined that 15 SAR species are likely to be present within the study area including:

- Bobolink
- Northern Brook Lamprey
- River Redhorse
- Silver Chub
- Silver Lamprey
- Warmouth
- American Badger
- American Water-willow
- Green Dragon
- Blanding's Turtle
- Massasauga Rattlesnake
- Eastern Sand Darter
- Pugnose Shiner
- Lake Chubsucker
- Grass Pickerel

Field investigations were not conducted to further determine the presence or absence of the above listed SAR or the presence of suitable habitat for each species.

The following section provides a description of the preferred habitat for the SAR listed above.

Bobolink: Nests primarily in forage crops, particularly hayfields and pastures, dominated by a variety of species such as clover, tall grasses and broadleaved plants; also occurs in wet prairie, graminoid, peatlands and abandoned fields; generally requires tracts of grassland >5 ha. Also nests in lightly grazed pastures, fallow and abandoned fields and shallow grassy marshes. This species can be associated with the following ELC communities: TPO, TPS, CUM1 and MAM2.

Northern Brook Lamprey: Generally inhabits clear, coolwater streams with areas of soft substrates such as sand and silt to facilitate burrowing of juveniles. Adults are generally found in areas of fast flowing riffles with a rock/gravel substrate. This species can typically be associated with the following ELC communities: OAO characterized as clear, coolwater streams with silt and sand substrates.

River Redhorse: Primarily inhabits medium to large size rivers with substantial flows. In the early summer months (May-June) adults migrate from deep, slow moving pool and run habitat to shallow riffle-run habitats with coarse substrate and moderate to swift flows. This species can typically be associated with the following ELC communities: OAO characterized as medium to large-sized rivers with substantial flow.

Silver Chub: Preferred habitat throughout most of North American range consists of medium to large rivers with areas of substantial flow and a mix of sand, silt and/or gravel substrates. In Ontario this species is only found in the Great Lakes usually in areas with depths between 7 and 12 meters. This species can typically be associated with the following ELC communities: OAO characterized as medium to large rivers with a substantial current with silt, sand or gravel substrate or lake habitat.

Silver Lamprey: The adult life stage of this species requires clean, fast flowing streams and rivers with small amounts of sand and other materials for eggs to adhere to during spawning. Lakes and/or rivers with healthy populations of fish hosts are also required. Larval life stages require deep, slow moving areas of large streams and rivers with soft substrate such as sand and silt for burrowing.

Warmouth: Preferred habitat consists of silt-free marshes, ponds and lakes with an abundance of aquatic plants and mucky substrates. This species has been classified as a warm-water species.

American Badger: This species can be found in a variety of habitats such as tall grass prairies, sand barrens and farm lands as these habitats provide badgers with small prey and areas to construct dens. This species can typically be associated with the following ELC communities: TPS1, CUM1, CUS and SBO with dry sandy soil.

American Water-willow: This species prefers to grow along the shores of rivers, streams and lakes. It can also be found growing in the waters of rivers, streams, lakes, ditches and occasionally wetlands. This species also requires periodic flooding and wave action in the areas in which it is growing in order to reduce competition from other aquatic plants.

Green Dragon: This species is generally found growing in wet deciduous forests along streams and rivers. Preferred deciduous forest communities are dominated by maple species, Red Ash and White Elm. This species can typically be associated with the following ELC communities: FOD6, FOD7, FOD8, FOD9 and SWD with moist soils.

Blanding's Turtle: This species lives in shallow waters of large wetlands and shallow lakes with an abundance of aquatic vegetation. From October until the end of April this species is found hibernating in the mud at the bottom of permanent water bodies. This species can typically be associated with the following ELC communities: SWT2, SWT3, SWD, SWM, MAS2, SAS1, SAM1, where open water is present.

Massasauga Rattlesnake: This species can be found in several different types of habitats including tall grass prairies, bogs, marshes, shorelines, forests and alvars. Within these habitats Massasaugas require open areas containing bedrock in order to bask and warm themselves. Pregnant females are often found in dry, open habitats such as rock barrens and forest clearings as temperature plays a big role in the development of offspring. Non-pregnant females and males can generally be found foraging in low land habitats such as grasslands, wetlands, bogs and shorelines of lakes and rivers. Hibernaculum generally consists of crevices of bedrock, sphagnum swamps, tree root cavities and animal burrows where they can get below the frost line but above the water table.

Eastern Sand Darter: This species prefers shallow habitats in lakes, streams and rivers with clean, sandy bottoms. This species can typically be associated with the following ELC communities: OAO with sandy bottoms.

Pugnose Shiner: This species is generally found in lakes and calm areas of rivers and creeks having clear water and bottoms of sand, mud or organic matter. It prefers water bodies with plenty of aquatic vegetation, particularly stonewort (Chara sp.). This species can typically be associated with the following ELC communities: OAO with abundant aquatic vegetation, clear water with sand, mud or organic substrate.

Lake Chubsucker: In Ontario, this species generally lives in marshes and lakes with clear, still, warmer water and plenty of aquatic plants. This habitat is found in bays, channels, ponds, and coastal wetlands. During the breeding season, from April to early June in Ontario, adults move into marshes where eggs are laid among vegetation in shallower water. This species can typically be associated with the following ELC communities: OAO, SAS, SAM, and SAF with clear, still warm water and an abundance of aquatic plants.

Grass Pickerel: This species is found in wetlands, ponds, slow-moving streams and shallow bays of larger lakes with warm, shallow, clear water and an abundance of aquatic plants. This species can typically be associated with the following ELC communities: OAO, SAS, SAM and SAF with warm, shallow, clear water and an abundance of aquatic plants.

6. Summary

Upon completion of the background information review it has been determined that a total of 15 SAR are likely to be present within the study area, nine (9) of them being aquatic SAR and six (6) terrestrial SAR. BC31 Provincially Significant Wetland Complex (BC 31) is located throughout majority of the study area. Several Life Science and ANSI sites were identified within the study area and/or in close proximity to the study area. The list of Life Science and ANSI sites identified are as follows; La Salette Woods (Life Science Site) is located within 1 km of the study area, Delhi Swamp (Life Science Site) is located within the study area, Delhi Big Creek Valley (Life Science & ANSI) is located within the study area, Delhi Big Creek Valley (Carolinian Canada Site) is located within the study area, and Quance Bush (Life Science Site) is located within 1 km of the study area.

7. References

LPRCA. 2007. Water Quality Technical Report: Big Creek Watershed. Long Point Region Conservation Authority, Simcoe ON. Retrieved from: http://www.sourcewater.ca/swp_watersheds_longpoint/LPRCA_WQ_July07_3.pdf

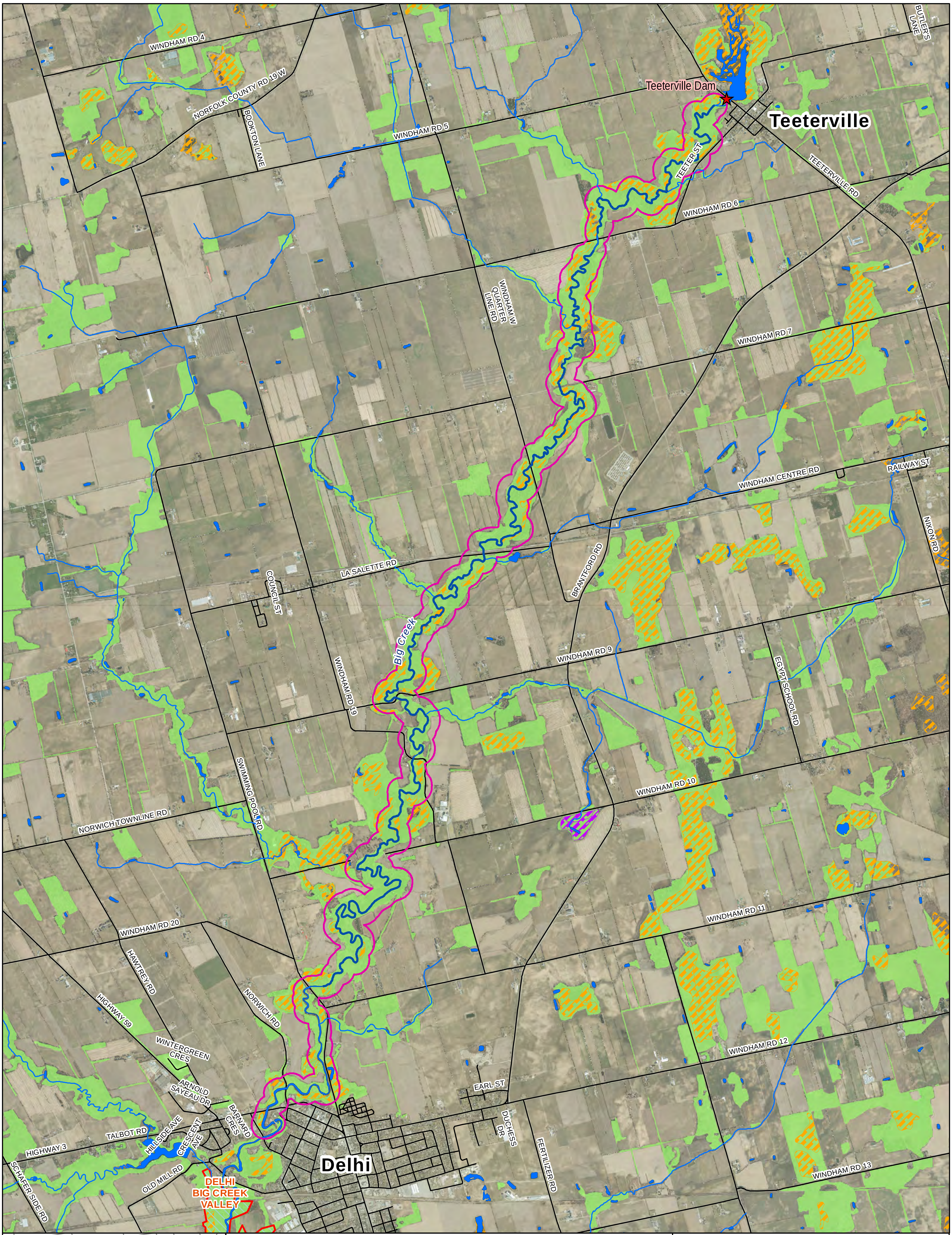
LPRCA. 2005. Establishing Environmental Flow Requirements for Big Creek. Long Point Region Conservation Authority, Simcoe ON. Retrieved from: http://www.conservation-ontario.on.ca/standalone/pdf/Long%20Point.pdf

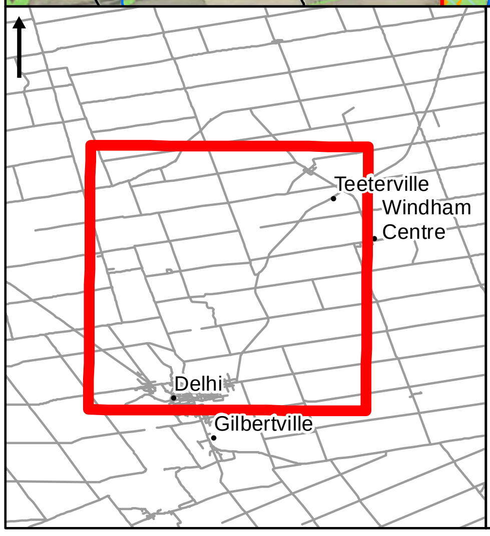
Norfolk County Official Plan. 2011. Retrieved from: http://www.norfolkofficialplan.ca/documents/OP_Maps_January13_2011.pdf

DFO 2015. 2015 Aquatic Species at Risk Mapping. Retrieved from: http://www.dfo-mpo.gc.ca/Library/356763_LongPoint_EN.pdf

Ontario Ministry of Natural Resources and Forestry (MNRF), 2015. Make-a-Map: Natural Heritage Areas Online Tool. Retrieved from: http://www.giscoeapp.lrc.gov.on.ca/web/MNR/NHLUPS/NaturalHeritage/Viewer/Viewer.html

Attachment A: Figures





Legend

- ▬ Big Creek Watercourse
- ─ Watercourses
- ─ Road
- ☐ Study Area (120m)
- ▨ Provincially Significant Life Science ANSI
- ▨ Evaluated Wetland - Provincially Significant
- ▨ Evaluated Wetland - Other
- 🟦 Waterbodies
- 🟩 Wooded Area

↑ N

Teeterville Dam
Stability & Condition Assessment

Natural Heritage Features

March 2016	1:35,000	Datum: NAD 83 Zone 17 Source: LIO
P#: 60439243	V#:	

AECOM Canada Ltd.

Figure 1

0 600 1,200 2,400
Meters

Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Natural_Heritage.mxd
Date Saved: 3/9/2016 8:44:18 AM

Attachment B: Agency Correspondence

From:	Barney, Ted (MNRF) <Ted.Barney@ontario.ca>
Sent:	Monday, December 21, 2015 11:48 AM
To:	O'Driscoll, Casey
Cc:	Fleischhauer, Andrea (MNRF)
Subject:	RE: Teeterville Dam Information Request
Attachments:	2015-05-01 - Long Point Activities Quick Reference Guide_V8_FINAL.pdf

Casey,
Please see below for information that MNRF has on file in regards to the Teeterville Dam Information Request:

- Presence of Natural areas (ESA, PSW, ANSI, significant woodlands, Provincial Parks, Conservation Reserves and Wildlife Management Areas)
  - The study area encompasses a large section of the BC 31 Complex Provincially Significant Wetland.
  - There are LPRCA lands within the general study area. Contacting LPRCA will provide more specific details.

- Natural Area Reports
  - I am unsure of what you mean by “Natural Area Reports”. If you could be more specific, I can try to better answer this question.

- Species at Risk records/occurrences
  - Chimney Swift (Threatened)
  - Barn Swallow (Threatened)
  - Bobolink (Threatened)
  - Eastern Meadowlark (Threatened)
  - Wood Thrush (Special Concern)
  - SAR Fish & Mussels (Endangered & Threatened) – contacting the Department of Fisheries & Oceans likely will help with providing specifics to species occurance
  - American Badger (Endangered)
  - Snapping Turtle (Special Concern)

- Presences of critical habitat (i.e., Bobolink, etc.)
  - There is presence of critical habitat within the study area for all species listed above.

- Species at Risk Recovery strategies (specifically for Bobolink)
  - You can access the recovery strategies for the species listed above through http://www.ontario.ca/environment-and-energy/species-risk-ontario-list

- Thermal and flow regime classification of watercourses GIS data
  - MNRF lists this section of Big Creek as a cold water fishery. However, I would suggest that LPRCA likely has more precise data and would suggest contacting them directly.

- In-water timing window restrictions
  - In general, information for timing windows within Norfolk Count for in-water work are listed (with links to specifics) on the attached file.

- Fish Collection Records
    - American Brook Lamprey
    - Bluntnose Minnow
    - Mottled Sculpin
    - Brook Trout
    - White Sucker
    - Hornyhead Chub
    - Johnny Darter
    - Pumpkinseed
    - Brook Stickleback
    - Northern Hog Sucker
    - Blackside Darter
    - Emerald Shiner
    - Central Minnow
    - Brown Trout
    - Common Shiner
    - Creek Chub
    - Blacknose Shiner
    - Rock Bass
    - Rainbow Trout
    - Brassy Minnow
    - Eastern Blacknose Dace
    - Fathead Minnow

Thank you,
Ted.

Ted Barney, M.Sc.
A/Management Biologist
MNRF Aylmer District
615 John St. N.
Aylmer, ON
N5H 2S8
Phone: 519-773-4723
Fax: 519-773-9014
ted.barney@ontario.ca

From: O'Driscoll, Casey [mailto:Casey.ODriscoll@aecom.com]
Sent: December-03-15 7:45 AM
To: Fleischhauer, Andrea (MNRF)
Subject: RE: Teeterville Dam Information Request

Good morning Andrea,

I have attached a new map with the study area boundaries and location of the dam.

Many thanks,

Casey O’Driscoll
AECOM
Fisheries & Wildlife Ecologist

Casey.ODriscoll@aecom.com
D 519.650.8609 C 226.220.9322

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Unit 290
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Canada
T. 519.650.5313 F. 519.650.3424
www.aecom.com

From: Fleischhauer, Andrea (MNRF) [mailto:Andrea.Fleischhauer@ontario.ca]
Sent: Monday, November 30, 2015 9:58 AM
To: O'Driscoll, Casey
Subject: FW: Teeterville Dam Information Request

HI Casey –

We've received your request.

It would be helpful if you provided a map that more clearly depicted the study area and dam.

FYI - Our response time is 6-8 weeks.

Thanks
Andrea

____
Andrea Fleischhauer
District Planner, Aylmer District
Ministry of Natural Resources and Forestry

P: 519.773.4750
C: 519.765.6455
F: 519.773.9014
E: andrea.fleischhauer@ontario.ca

From: O'Driscoll, Casey [mailto:]
Sent: November-26-15 1:37 PM
To: Riddell, Heather (MNRF)
Subject: Teeterville Dam Information Request

Good afternoon Heather,

AECOM has been retained by the Long Point Region Conservation Authority (LPRCA) to complete a Dam Stability and Condition Assessment on Teeterville Dam located in the town of Teeterville. Please refer to the attached map to see the location and extent of the study area which falls between Teeterville dam and Delhi along Big Creek. The study area falls within the Long Point Region Watershed, which is under the jurisdiction of the Long Point Region Conservation Authority.

AECOM has undertaken a preliminary review of available data within the study area using several available sources which included:

- MNRF Make-A-Map Natural Heritage Areas
- 2015 DFO SAR Mapping
- Norfolk County Official Plan
- MNRF LIO Mapping

Based on this review, we are aware of the presence of several natural areas as well as several terrestrial and aquatic species at risk within the study area:

- Species at Risk:
    - Bobolink
    - Blanding's Turtle
    - American Badger
    - American Water-willow
    - Massasauga Rattlesnake
    - Green Dragon
    - Silver Lamprey (Great Lakes/Upper St. Lawrence)
    - Grass Pickerel
    - Northern Brook Lamprey (Great Lakes/Upper St. Lawrence)
    - River Redhorse
    - Silver Chub (Great Lakes/Upper St. Lawrence)
    - Warmouth
- Natural Areas
    - Teeterville Reservoir Wetland (BC11)- Provincially evaluated wetland
    - BC31 Complex (BC31)- Provincially evaluated wetland
    - Dry Creek Wetland Complex (WIND)- Provincially evaluated wetland
    - La Salette Woods- Life Science Site
    - WI37- Unoffical wetland
    - Delhi Swamp- Life Science Site
    - Delhi Big Creek Valley- Life Science, ANSI, Carolinian Canada Site
    - Quance Bush- Life Science Site

During the preliminary review, AECOM also identified data gaps for which we require additional information. Please consider this as a formal request for the following information with respect to the study area in the attached map. If you could please review the above listed data, and provide us with any additional information, reports and/or GIS data pertaining to:

- Presence of Natural areas (ESA, PSW, ANSI, significant woodlands, Provincial Parks, Conservation Reserves and Wildlife Management Areas)
- Natural Area Reports
- Species at Risk records/occurrences
- Presences of critical habitat (i.e., Bobolink, etc.)
- Species at Risk Recovery strategies (specifically for Bobolink)
- Thermal and flow regime classification of watercourses GIS data
- In-water timing window restrictions
- Fish Collection Records

We understand that not all of the information requested from the list above may be available; however, it would be greatly beneficial if you could please provide a response of what information can be or will be provided.

Should you have any questions or require further information, please do not hesitate to contact me as I would be happy to provide assistance.

Many Thanks,

Casey O'Driscoll
AECOM
Fisheries & Wildlife Ecologist
Casey.ODriscoll@aecom.com
D 519.650.8609 C 226.220.9322

AECOM
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Unit 290
Kitchener , ON N2P 0A4
Canada
T. 519.650.5313 F. 519.650.3424
www.aecom.com

From:	Paul Gagnon <watercare@lprca.on.ca>
Sent:	Tuesday, December 01, 2015 11:12 AM
To:	O'Driscoll, Casey
Cc:	Craig Jacques; Bonnie Bravener; General Mailbox
Subject:	RE: Teeterville Dam Information Request
Attachments:	Teeterville Dam Above Final Temperature Data & Graph 2015.xlsx; Teeterville Dam Below Final Temperature Data & Graph 2015.xlsx; teeterville above.xls; Below Teeterville.xls

Hi Casey,

I've attached our temperature data. Big Creek is a cold water stream, and therefore, cold water timing windows will apply (these windows can be determined by contacting either MNRF or DFO). Craig Jacques in our office has also attached a useful link (below).

Regards,

Paul Gagnon
Lands & Waters Supervisor
Long Point Region Conservation Authority
4 Elm Street
Tillsonburg, ON, N4G 0C4
e-mail: watercare@lprca.on.ca
Phone: (519)842-4242 ex.232/fax: (519)842-7123

From: Craig Jacques
Sent: Thursday, November 26, 2015 2:57 PM
To: Paul Gagnon
Subject: FW: Teeterville Dam Information Request

http://files.ontario.ca/environment-and-energy/species-at-risk/massasauga_map_eng.pdf!

From: General Mailbox
Sent: Thursday, November 26, 2015 2:33 PM
To: Craig Jacques; Bonnie Bravener; Paul Gagnon; Ejay Lai; Dave Holmes

Cc: Lorrie Minshall; Cliff Evanitski
Subject: FW: Teeterville Dam Information Request

Dana McLachlan
Long Point Region Conservation Authority
Head Office
4 Elm St, Tillsonburg ON N4G 0C4
Phone: 519-842-4242 or 1-888-231-5408 ext. 221
Fax: 519-842-7123
Email: conservation@lprca.on.ca

From: O'Driscoll, Casey [mailto:Casey.ODriscoll@aecom.com]
Sent: November 26, 2015 2:26 PM
To: General Mailbox
Subject: Teeterville Dam Information Request

To whom it may concern:

AECOM has been retained by the Long Point Region Conservation Authority (LPRCA) to complete a Dam Stability and Condition Assessment on Teeterville Dam located in the town of Teeterville. Please refer to the attached map to see the location and extent of the study area which falls between Teeterville Dam and Delhi along Big Creek. The location of the study area falls within the Long Point Region Watershed, which is under the jurisdiction of the Long Point Region Conservation Authority.

AECOM has undertaken a preliminary review of available data within the study area using several available sources which included:

- MNRF Make-A-Map Natural Heritage Areas
- 2015 DFO SAR Mapping
- Norfolk County Official Plan
- MNRF LIO Mapping

Based on this review, we are aware of the presence of several natural areas as well as several terrestrial and aquatic species at risk within the study area:

- Species at Risk:
    - Bobolink
    - Blanding’s Turtle
    - American Badger
    - American Water-willow
    - Massasauga Rattlesnake
    - Green Dragon
    - Silver Lamprey (Great Lakes/Upper St. Lawrence)
    - Grass Pickerel
    - Northern Brook Lamprey (Great Lakes/Upper St. Lawrence)

    - River Redhorse
    - Silver Chub (Great Lakes/Upper St. Lawrence)
    - Warmouth
- Natural Areas
    - Teeterville Reservoir Wetland (BC11)- Provincially evaluated wetland
    - BC31 Complex (BC31)- Provincially evaluated wetland
    - Dry Creek Wetland Complex (WIND)- Provincially evaluated wetland
    - La Salette Woods- Life Science Site
    - WI37- Unoffical wetland
    - Delhi Swamp- Life Science Site
    - Delhi Big Creek Valley- Life Science, ANSI, Carolinian Canada Site
    - Quance Bush- Life Science Site

During the preliminary review, AECOM also identified data gaps for which we require additional information. Please consider this as a formal request for the following information with respect to the study area in the attached map. If you could please review the above listed data, and provide us with any additional information, reports and/or GIS data pertaining to:

- Presence of Natural areas (ESA, PSW, ANSI, significant woodlands, Provincial Parks, Conservation Reserves and Wildlife Management Areas)
- Natural Area Reports
- Species at Risk records/occurrences
- Presences of critical habitat (i.e., Bobolink, etc.)
- Species at Risk Recovery strategies (specifically for Bobolink)
- Thermal and flow regime classification of watercourses GIS data
- In-water timing window restrictions
- Fish Collection Records

We understand that not all of the information requested from the list above may be available; however, it would be greatly beneficial if you could please provide a response of what information can be or will be provided.

Should you have any questions or require further information, please do not hesitate to contact me as I would be happy to provide assistance.

Many Thanks,

Casey O'Driscoll
AECOM
Fisheries & Wildlife Ecologist
Casey.ODriscoll@aecom.com
D 519.650.8609 C 226.220.9322

AECOM
50 Sportsworld Crossing Road
Unit 290
Kitchener , ON N2P 0A4
Canada
T. 519.650.5313 F. 519.650.3424
www.aecom.com

From: Fisheries Protection <fisheriesprotection@dfo-mpo.gc.ca>
Sent: Tuesday, December 22, 2015 10:23 AM
To: O'Driscoll, Casey
Subject: RE: Aquatic SAR within Big Creek From Teeterville to Delhi Ontario

Hello Casey,
For the extended study area that you have indicated, we can confirm the presence of the following species in the area:

- Silver Lamprey
- Grass Pickerel
- Northern Brook Lamprey
- Warmouth

As well as:

- Eastern Sand Darter
- Pugnose Shiner
- Lake Chubsucker is potentially extirpated but there are historical records in the area

There are also records for American Brook Lamprey, which is not SAR listed but considered a sensitive species and worth noting.

Cheers,
Andrew Geraghty
Fisheries Protection Program Biologist, Central & Arctic Region
Fisheries and Oceans Canada / Government of Canada
Andrew.Geraghty@dfo-mpo.gc.ca / Tel: 905-336-4560

Biologiste, protection des pêches, Région du Centre et de l'Arctique
Pêches et Océans Canada / Gouvernement du Canada
Andrew.Geraghty@dfo-mpo.gc.ca / Tél. : 905-336-4560

From: O'Driscoll, Casey [mailto:Casey.ODriscoll@aecom.com]
Sent: December-03-15 2:44 PM
To: Geraghty, Andrew
Subject: RE: Aquatic SAR within Big Creek From Teeterville to Delhi Ontario

Hello Andrew,

Thank you for the quick response, it is greatly appreciated.

As our study area has now extended downstream of Delhi to Lake Erie I was wondering if you could please confirm the presence/absence of the following aquatic SAR that were identified on DFO Mapping:

Silver Lamprey (Great Lakes/Upper St. Lawrence
Grass Pickerel
Northern Brook Lamprey (Great Lakes/Upper St. Lawrence)
River Redhorse
Silver Chub (Great Lakes/Upper St. Lawrence)
Warmouth

Many Thanks,

Casey O'Driscoll
AECOM
Fisheries & Wildlife Ecologist
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From: Geraghty, Andrew [mailto:Andrew.Geraghty@dfo-mpo.gc.ca]
Sent: Thursday, November 26, 2015 4:33 PM
To: O'Driscoll, Casey
Subject: RE: Aquatic SAR within Big Creek From Teeterville to Delhi Ontario

Hello Casey,
I have run your question by our SAR coordinator, and he has responded with the answer below. However, we did not receive any attachment with your email referencing a study area; our answer is based off of the location you specified in the subject of your email alone. If you were looking for information on a location outside of what was specified in your subject, please let us know.

Andrew Geraghty
Fisheries Protection Program Biologist, Central & Arctic Region
Fisheries and Oceans Canada / Government of Canada
Andrew.Geraghty@dfo-mpo.gc.ca / Tel: 905-336-4560

Biologiste, protection des pêches, Région du Centre et de l'Arctique
Pêches et Océans Canada / Gouvernement du Canada
Andrew.Geraghty@dfo-mpo.gc.ca / Tél. : 905-336-4560

From: Balint, David
Sent: November-26-15 12:18 PM
To: Geraghty, Andrew
Subject: FW: Aquatic SAR within Big CreekFrom Teeterville to Delhi Ontario

There are no records for SAR from Delhi upstream to Teeterville.

SAR are recorded downstream of Delhi

From: O'Driscoll, Casey [mailto:Casey.ODriscoll@aecom.com]
Sent: November-26-15 9:09 AM
To: Fisheries Protection
Subject: Aquatic SAR within Big CreekFrom Teeterville to Delhi Ontario

Good Morning,

I was wondering if you could please confirm the presence/absence of the following aquatic SAR within the appended study area. The following list of species were identified on DFO Mapping:

Silver Lamprey (Great Lakes/Upper St. Lawrence
Grass Pickerel
Northern Brook Lamprey (Great Lakes/Upper St. Lawrence)
River Redhorse
Silver Chub (Great Lakes/Upper St. Lawrence)
Warmouth

Thank you,

Casey O'Driscoll
AECOM
Fisheries & Wildlife Ecologist
Casey.ODriscoll@aecom.com
D 519.650.8609 C 226.220.9322

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Appendix B

Inspection Form and Photos

Dam Safety Inspection

Location:	Teeterville Dam, Teeterville, Ontario	
Owner:	Long Point Region Conservation Authority	
Date:	September 16, 2015	
Inspection by:	AECOM Canada Sam Mansor, P.Eng. Steve Scott Steven Kohler	
Weather conditions:		
On inspection day:	Sunny	Temperature: ± 25 ºC
Average for 7 days before:		Daily mean temperature: 11 - 20 ºC

Dam

(Concrete structures: spillway, piers, abutments)

Observations:

- Piers:
    - Fair to poor condition
    - Light honeycombing
    - Light to severe spalling
    - Light to medium delamination
    - Medium to severe erosion
    - Exposed reinforcing steel at the toes of the center pier and west pier
    - Several vertical surfaces were refaced and built out from original surfaces
- Support Frame Platform:
    - Fair to good condition
    - Light corrosion
    - Light honeycombing
- Dam Abutments:
    - Fair condition
    - Light to medium scaling, spalls and delaminations
    - Light erosion along the spillway and base of the abutment walls
    - South abutment wall was refaced as part of a past rehabilitation
- Spillway:
    - Limited inspection due to flow of water on downstream side and depth of water on upstream side
    - Horizontal and vertical surfaces of spillway in fair condition with localized poor areas
    - Light to medium erosion, localized light to medium spalling / delamination and light to medium disintegration
- Waterway:
    - Scattered rocks downstream
    - Significant sediment buildup upstream

Gates and Stoplogs

(Gates, stoplogs, gains)

Observations:

- Stop Logs:
    - Fair condition
    - Section loss, some rot decay, checks and splitting
    - Significant amount of water is leaking between the stop logs
    - Nominally measured as 200 mm x 200 mm square sawn timber members
- Stop Log Gains:
    - Limited inspection due to access

Truss Bridge

(Superstructure, bearings, railings)

Observations:

- Bearings:
    - Limited inspection due to debris/ vegetation buildup
    - Severe corrosion and flaking of steel
- Top Chord:
    - Fair to poor condition
    - Medium corrosion
    - Localized medium section loss and flaking of structural steel
    - Light to medium pitting of the surface
    - Gusset plates in fair to poor condition with medium corrosion
- Bottom Chord:
    - Poor condition
    - Medium to severe corrosion
    - Severed (non-continuous) at northwest quadrant
    - Medium to severe section loss and flaking of structural steel
    - Light to medium pitting of the surface
- Truss Cross Bracing:
    - Vertical cross bracing in fair to poor condition with medium corrosion
    - Localized medium section loss and flaking of structural steel and light to medium pitting
    - Gusset plates in fair to poor condition with medium corrosion
- Diagonal Bars:
    - Fair to poor condition with medium corrosion
    - Several were somewhat loose and tightened
- Floor Beams:
    - Fair to poor condition with medium corrosion and pitting
    - Localized section loss
- Stringers:
    - Fair to poor condition with medium corrosion and pitting
    - Minor section loss
    - Northerly three stringers fully exposed and not supporting any decking
    - Southerly four stringers support steel access grating
    - Missing stringer at northeast
- Decking:
    - Galvanized steel grate with galvanized railing
    - Fair to good condition
    - Grating deflects under heavy weight, appears to be undersized
    - Wire fence connected to the truss in fair to poor condition with corrosion

Bridge Substructure

(Substructure, foundation, wingwalls)

Observations:

- Foundation:
    - Lower portions not visible for inspection
- Abutments:
    - Fair to poor condition
    - Medium to severe disintegration
    - Medium scaling and spalling
    - Narrow to wide horizontal cracking with efflorescence staining
    - Light to medium delamination on top of the abutment walls
    - Vegetation growing through cracks
- Wingwalls:
    - Limited inspection due to access
    - Fair condition
    - Light scaling, spalls and delaminations
    - Horizontal narrow cracks with efflorescence staining
- Retaining Wall:
    - Dry stacked soil retaining system at southwest composed of reused concrete slabs and rubble
    - Fair condition with no sign of distress
    - Vegetation was growing through gaps and between the units
- Approaches:
    - Asphalt approaches
    - Fair condition
    - Light to medium cracking and raveling
    - Light to medium localized settlements of the asphalt
    - Grass growing through the cracks and missing sections of the asphalt
- Embankments:
    - Vegetated embankments in fair to good condition
    - Light erosion on the upstream embankments

Photo 1: Dam Elevation

Photo 2: Dam looking East

Photo 3: East Dam Abutment

Photo 4: Concrete Deterioration at Middle Pier

Photo 5: Scaling at North Pier

Photo 6: Dam Stoplogs

Photo 7: Bridge Elevation from Upstream

Photo 8: Missing Stringer on Bridge

Photo 9: Failed Stringer

Photo 10: Loss of Web Section in Stringer

Photo 11: Loss of Section at Connection

Photo 12: Deterioration at Connection

Photo 13: Failed Bottom Chord

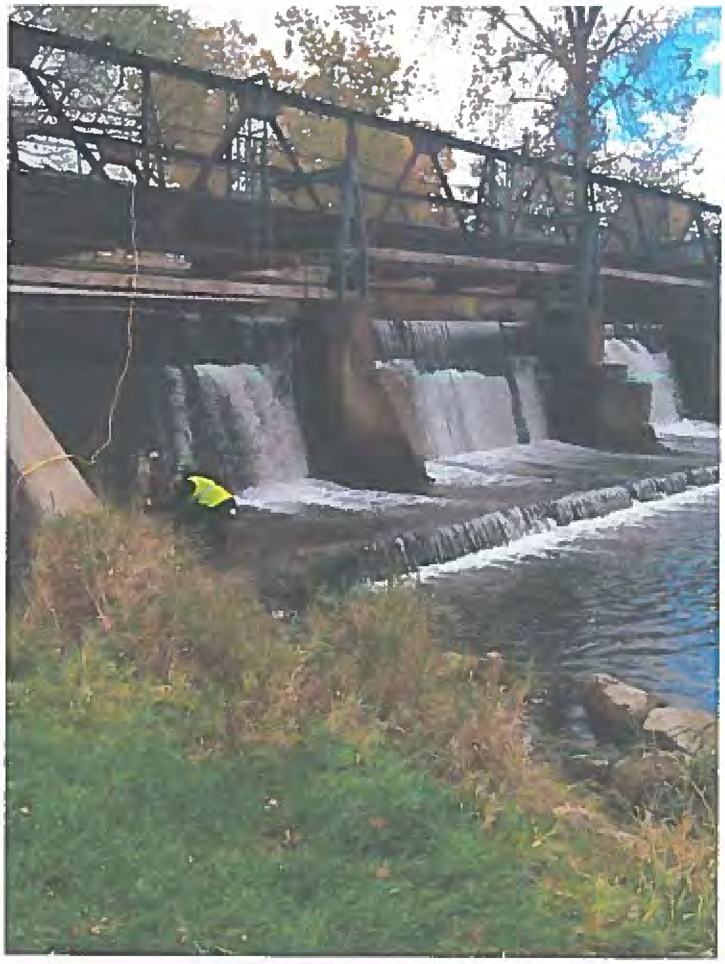
Photo 14: West Bridge Abutment

Photo 15: West Approach

Photo 16: East Approach

Appendix C

Watech Inspection Report



INSPECTION OF TEETERVILLE DAM
TEETERVILLE, ONTARIO

Prepared for:
Aecom Canada Ltd.

Prepared by:

WATECH SERVICES INC.
895 Valetta Street
London, Ontario
N6H 2Z4

October 2015

WSI 15178

TABLE OF CONTENTS

1. INTRODUCTION

WATECH SERVICES INC. was retained by Aecom Canada to carry out inspection and concrete drilling on the structure known as the Teeterville Dam in the Hamlet of Teeterville, Ontario.

The report details the results of our inspection findings and may be used as baseline reference and background information for future inspection and maintenance programs and to assist in future repair work.

2. INSPECTION

2.1. General

Inspection Team:	3 person crew
Location:	Teeterville, Ontario
Date:	October 14, 2015
Weather:	Cloudy, 12°C

The field inspection work was carried out by a WATECH SERVICES INC. inspection team on October 14, 2015.

The inspection was carried out essentially on the downstream spillway of the structure with the main focus of the inspection being the determination of the spillway sill concrete thickness. Concrete cores were obtained and drill holes were drilled to determine concrete thickness and provide initial assessment of concrete quality.

A diver wading in a drysuit downstream of the dam was used to determine the extent of undermining of the downstream sill if present.

3. OBSERVATIONS AND INSPECTION RESULTS

The Teeterville Dam is a primarily concrete structure consisting of 4 stop log controlled spillways spanning the width of Big Creek. An essentially level concrete spillway is in place downstream of the stop logs.

The focus of the inspection work was the spillway. Concrete drilling and coring was carried at the locations shown on Figure 1.

The drilling and coring indicates a spillway slab thickness that is typically 550 to 600 millimetres. The cores indicate some larger aggregate (greater than 19mm) is present in the concrete. The drilling resistance indicated the concrete quality to be fairly good. Significant erosion of the end of the spillway is noted above and below the water level.

The sill is significantly undermined across the full width of the channel. Undermining varies in height from 150 to 500 millimetres and penetrates under the slab up to 3 metres. The approximate extent of the undermining is also shown on Figure 1. The drilling and probing under the sill indicates that loose rock is supporting the slab where it is not undermined.

4. COMMENTS AND RECOMMENDATIONS

The stability of the Teeterville Dam is threatened by the significant undermining of the spillway slab that is noted.

Consideration should be given to restoring the support to the spillway as soon as practical in order to prevent a future failure and possible loss of the structure. A

An effective repair could be completed by installing a vertical steel form at the end of the spillway and pumping grout through core holes into the void. It may also be required to place rock material in front of the steel plates to prevent future erosion of the riverbed in front of the spillway.

INSPECTION OF
TEETERVILLE DAM
Teeterville, Ontario

Aecom Canada Ltd.
October 2015

Photographs

WATECH SERVICES INC.
WSI 15178

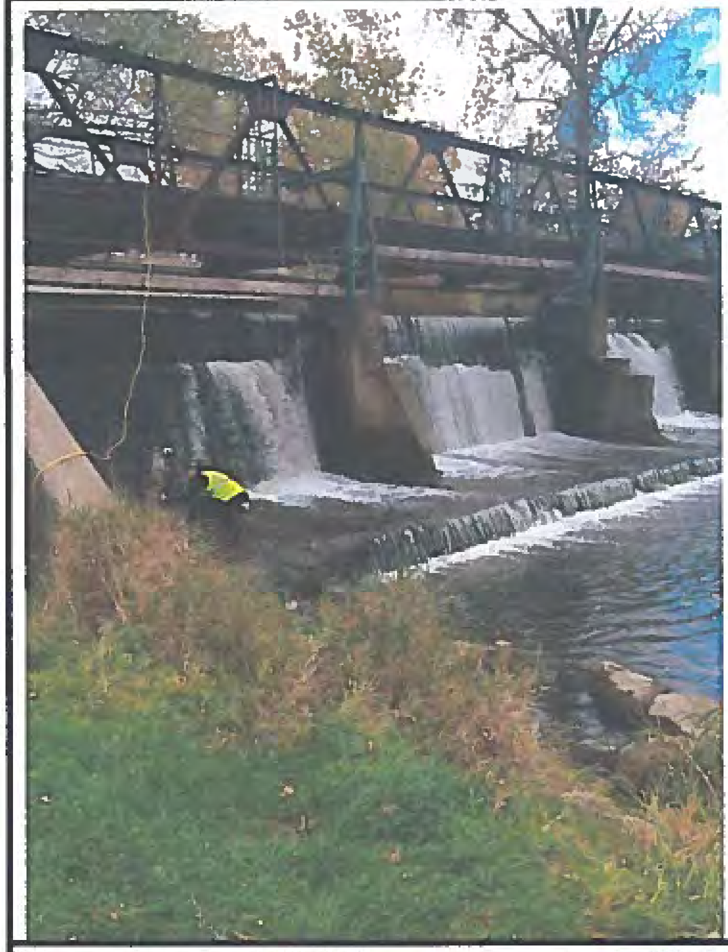


PHOTO # 1

Teeterville Dam from downstream

PHOTO # 2

Workers drilling 19mm test hole

PHOTO # 3

Workers preparing to drill 50mm core

PHOTO # 4

Worker drilling 50mm core

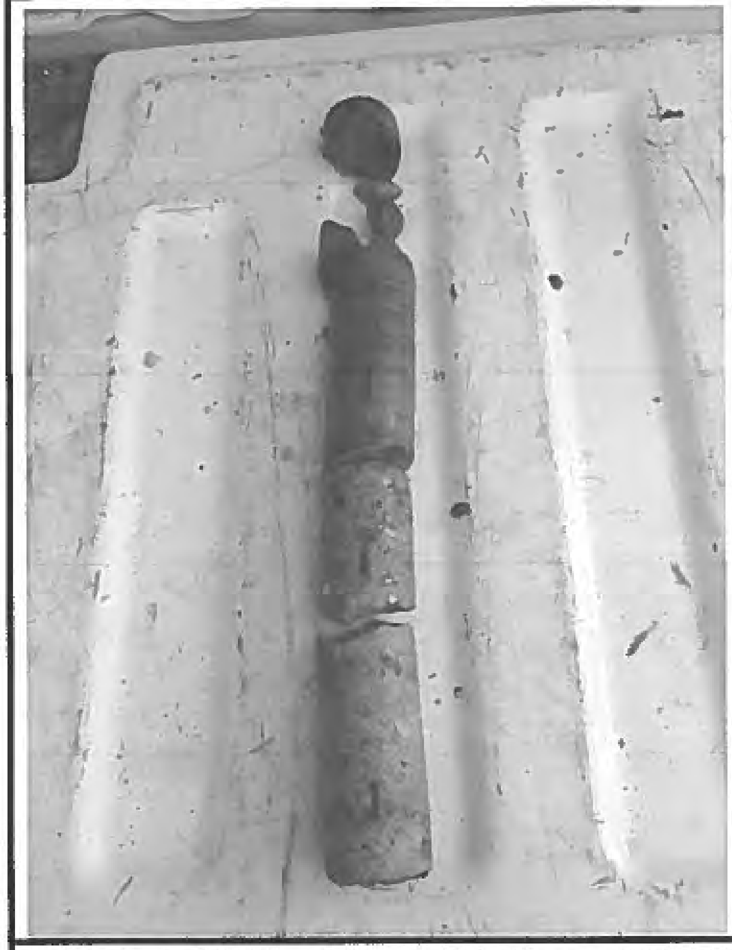


PHOTO # 5

Core Sample 1

PHOTO # 6

Core Sample 1

PHOTO # 7

Core sample 2

PHOTO # 8

Core sample 2

PHOTO # 9

Erosion hole in Bay 2 of spillway sill

PHOTO # 10

Erosion hole in Bay 2 of spillway sill

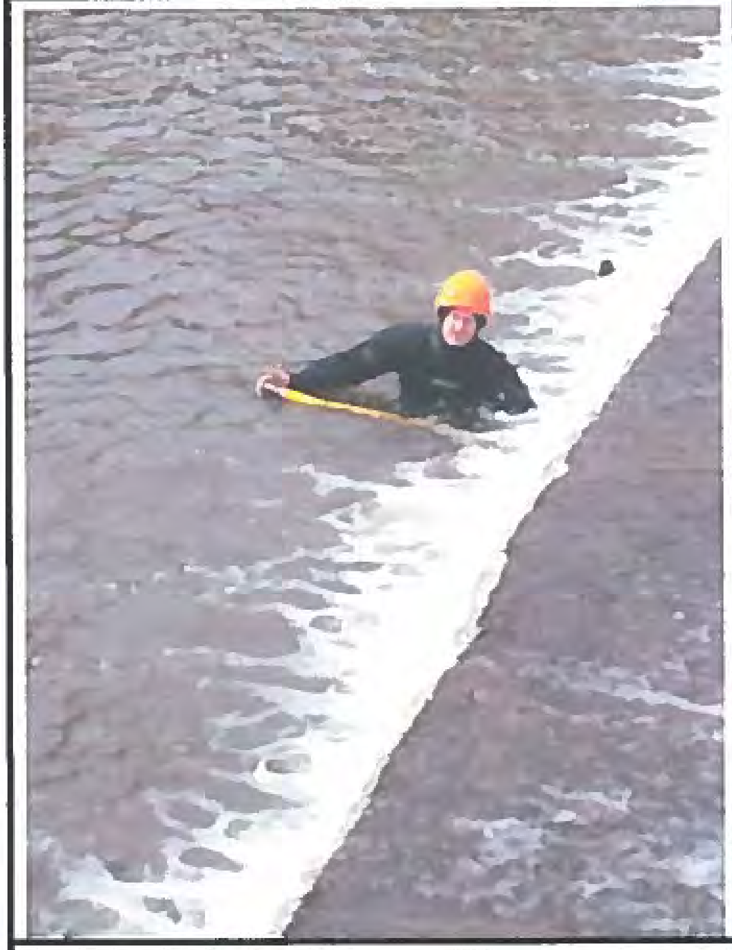


PHOTO # 11

Diver determining depth of undermining

PHOTO # 12

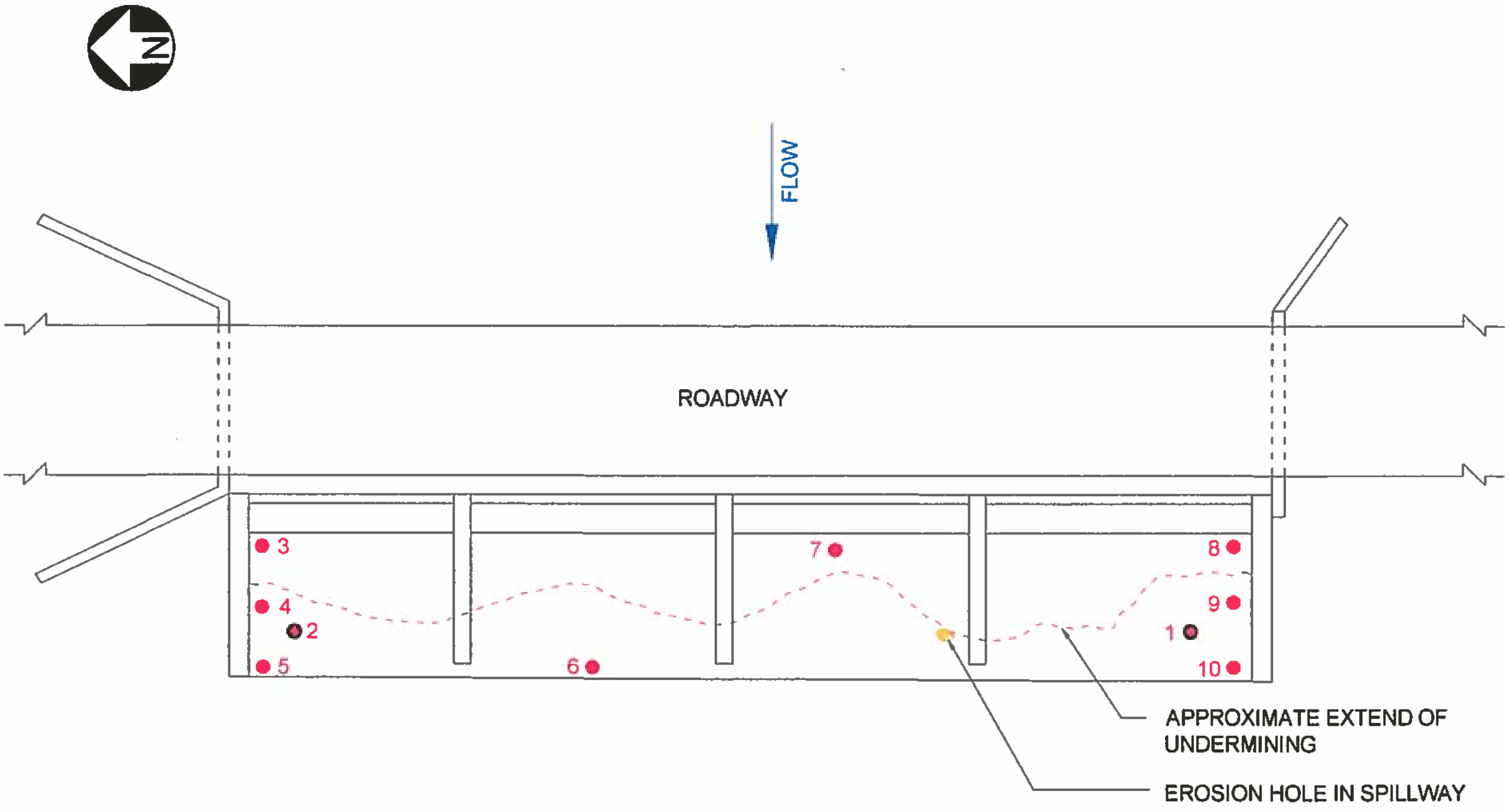
Diver showing depth of undermining

INSPECTION OF
TEETERVILLE DAM
Teeterville, Ontario

Aecom Canada Ltd.
October 2015

Figure 1

WATECH SERVICES INC.
WSI 15178



NOTES

1. THE INSPECTION AND TEST DRILLING WAS COMPLETED ON OCTOBER 14, 2015
2. SEE ATTACHED TABLE 1 FOR SPILLWAY SILL THICKNESS MEASURMENTS
3. UNDERMINING NOTED BELOW SPILLWAY 150MM TO 500MM IN HEIGHT AND UP TO 3.0 METRES HORIZONTALLY.
4. ● DESIGNATES DRILL HOLE LOCATION
5. ● DESIGNATES CORE HOLE LOCATION

AECOM

TEETERVILLE DAM
SPILLWAY SILL INSPECTION

WATECH SERVICES INC.

15178
OCTOBER 2015

Appendix D

Hydrotechnical Analyses

idf_v2-3_2014_12_21_613_ON_6131983_DELHI_CS
Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

```
==============================================================================

 DELHI CS                                              ON        6131983
 (composite)
 Latitude:  42 52'N    Longitude: 80 33'W    Elevation/Altitude: 231        m

 Years/Années :  1962 - 2007          # Years/Années :     42

==============================================================================
```

```
******************************************************************************
```

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

```
******************************************************************************
```

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1962	11.7	13.7	16.3	17.5	17.8	22.1	35.6	40.9	47.8
1963	10.7	13.7	16.3	23.1	33.3	38.9	45.2	64.3	64.8
1964	6.9	10.2	15.2	19.0	25.9	33.5	68.3	73.4	73.9
1965	6.6	8.9	10.7	17.8	29.5	37.1	37.3	38.9	53.8
1966	7.1	9.4	11.9	18.3	21.3	25.1	31.0	42.9	55.9
1967	12.4	16.0	19.6	20.8	21.6	27.7	59.2	62.5	65.3
1968	4.8	8.4	11.9	15.7	20.8	36.3	74.7	91.9	110.0
1969	4.3	6.1	7.6	8.1	14.5	14.5	34.5	52.1	65.0
1970	7.9	11.4	14.5	20.6	22.6	28.4	51.6	51.8	55.6
1971	8.9	12.2	16.0	18.5	20.6	22.1	31.7	31.7	34.5
1972	13.0	14.5	15.5	19.0	21.6	34.8	40.1	46.0	46.5
1974	13.0	14.2	14.5	15.2	16.5	19.3	27.9	28.2	35.3
1975	6.9	11.2	12.2	14.7	19.3	32.8	39.6	42.2	42.2
1976	11.2	13.2	14.7	16.3	17.0	19.8	30.2	32.8	51.1
1977	9.7	15.5	18.8	24.6	24.9	28.4	40.1	40.1	59.4
1978	7.9	11.9	13.9	17.8	22.6	27.4	50.0	51.4	53.5
1979	6.7	10.0	12.0	17.6	23.6	30.1	34.7	37.8	39.0
1980	12.0	16.0	22.2	27.8	30.5	31.3	31.6	37.1	38.6
1981	7.4	9.7	12.9	16.2	18.9	21.7	41.2	57.4	57.4
1982	11.6	14.4	16.2	18.0	23.0	25.7	36.0	69.9	70.6
1983	10.7	16.8	19.9	25.7	35.6	49.9	69.0	78.2	81.6
1984	9.1	16.0	18.2	22.8	27.4	29.6	40.7	45.0	51.9
1985	9.0	11.2	11.6	16.9	18.4	22.9	24.7	40.6	43.1
1986	6.2	9.5	10.4	12.1	17.2	21.2	38.6	39.2	50.1
1987	6.9	8.3	9.4	11.6	17.7	21.2	37.8	38.8	42.2
1988	8.8	17.2	19.2	35.0	38.0	38.8	39.0	61.5	68.0
1989	5.0	8.8	11.9	13.2	14.3	24.2	28.2	29.4	29.9
1990	6.5	10.0	12.9	15.3	17.9	33.4	42.0	42.0	47.6
1991	7.4	12.0	16.9	20.4	28.3	35.4	65.0	117.4	138.8
1992	9.7	15.5	17.5	24.1	24.5	28.9	38.5	54.1	58.6
1993	4.4	7.7	9.6	11.5	14.5	19.2	30.6	30.8	46.2
1994	9.7	13.6	17.5	19.4	31.9	43.7	75.6	77.4	81.6
1995	12.1	16.9	22.5	36.2	37.0	44.1	68.3	83.0	85.0
1998	5.8	7.2	9.4	11.4	14.2	18.4	22.0	39.0	39.4
1999	9.2	16.6	23.0	32.8	38.2	47.6	72.0	72.0	73.8

```
          2000   10.2   15.2   21.8   38.6   43.0   50.4   53.4   73.6   75.2
          2001    7.2   11.2   14.4   15.8   19.2   22.2   29.2   31.6   38.4
          2002    7.8   12.6   17.0   24.6   29.2   31.6   33.0   40.4   40.4
          2003    8.8   14.4   17.2   25.8   33.4   35.2   35.4  -99.9   45.0
          2004    5.6    7.0    7.4    9.4   10.8   14.6   24.2   27.8   33.8
          2005   13.2   18.2   28.2   45.8   57.8   58.8   59.0   62.2   79.6
          2006    7.6   12.2   15.0   18.6   23.6   26.4   28.6   43.0   49.4
          2007    7.2   10.0   10.2   10.4   11.0   11.0   19.6   30.6   40.1
        ---------------------------------------------------------------------
        # Yrs.     43     43     43     43     43     43     43     42     43
        Années
          Mean    8.6   12.3   15.2   20.1   24.4   29.9   42.2   51.2   57.2
       Moyenne
     Std. Dev.    2.5    3.2    4.5    8.0    9.4   10.4   15.3   19.8   21.2
    Écart-type
         Skew.   0.25  -0.04   0.55   1.27   1.29   0.69   0.87   1.24   1.74
   Dissymétrie
      Kurtosis   2.33   2.15   3.55   4.94   5.62   3.51   2.88   4.76   7.44

          *-99.9 Indicates Missing Data/Données manquantes

 Warning: annual maximum amount greater than 100-yr return period amount
 Avertissement : la quantité maximale annuelle excède la quantité
                 pour une période de retour de 100 ans
          Year/Année      Duration/Durée        Data/Données          100-yr/ans
                1991              12 h                 117.4               113.4
                1991              24 h                 138.8               123.8
                2005              30 min                45.8                45.3
                2005               1 h                  57.8                53.8

********************************************************************************

Table 2a : Return Period Rainfall Amounts (mm)
           Quantité de pluie (mm) par période de retour

********************************************************************************

 Duration/Durée        2        5       10       25       50      100   #Years
                  yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   Années
          5 min      8.2     10.4     11.8     13.6     15.0     16.3       43
         10 min     11.8     14.6     16.5     18.8     20.6     22.3       43
         15 min     14.5     18.4     21.1     24.4     26.8     29.3       43
         30 min     18.8     25.9     30.6     36.5     41.0     45.3       43
          1 h       22.9     31.1     36.6     43.6     48.7     53.8       43
          2 h       28.2     37.4     43.5     51.2     57.0     62.6       43
          6 h       39.7     53.2     62.2     73.5     82.0     90.3       43
         12 h       48.0     65.5     77.1     91.7    102.6    113.4       42
         24 h       53.7     72.5     84.9    100.6    112.2    123.8       43

********************************************************************************

Table 2b :

 Return Period Rainfall Rates (mm/h) - 95% Confidence limits
 Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

********************************************************************************

 Duration/Durée        2        5       10       25       50      100   #Years
                  yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   Années
          5 min     98.0    124.3    141.7    163.7    180.0    196.2       43
                +/-  8.2 +/- 13.7 +/- 18.6 +/- 25.0 +/- 29.9 +/- 34.9       43
         10 min     70.6     87.6     98.8    113.0    123.5    133.9       43
```

```
                +/-  5.3 +/-  8.9 +/- 12.0 +/- 16.1 +/- 19.3 +/- 22.5       43
         15 min     57.9     73.7     84.2     97.5    107.3    117.1       43
                +/-  4.9 +/-  8.3 +/- 11.2 +/- 15.1 +/- 18.1 +/- 21.0       43
         30 min     37.5     51.8     61.2     73.1     81.9     90.7       43
                +/-  4.4 +/-  7.4 +/- 10.0 +/- 13.5 +/- 16.2 +/- 18.9       43
          1 h       22.9     31.1     36.6     43.6     48.7     53.8       43
                +/-  2.6 +/-  4.3 +/-  5.9 +/-  7.9 +/-  9.4 +/- 11.0       43
          2 h       14.1     18.7     21.8     25.6     28.5     31.3       43
                +/-  1.4 +/-  2.4 +/-  3.3 +/-  4.4 +/-  5.3 +/-  6.1       43
          6 h        6.6      8.9     10.4     12.3     13.7     15.0       43
                +/-  0.7 +/-  1.2 +/-  1.6 +/-  2.2 +/-  2.6 +/-  3.0       43
         12 h        4.0      5.5      6.4      7.6      8.6      9.4       42
                +/-  0.5 +/-  0.8 +/-  1.0 +/-  1.4 +/-  1.7 +/-  2.0       42
         24 h        2.2      3.0      3.5      4.2      4.7      5.2       43
                +/-  0.2 +/-  0.4 +/-  0.6 +/-  0.7 +/-  0.9 +/-  1.0       43

********************************************************************************

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
 T = Rainfall duration (h) / Durée de la pluie (h)

********************************************************************************

       Statistics/Statistiques      2      5     10     25     50    100
                               yr/ans yr/ans yr/ans yr/ans yr/ans yr/ans
      Mean of RR/Moyenne de RR   34.9   45.0   51.6   60.1   66.3   72.5
    Std. Dev. /Écart-type (RR)   33.9   42.6   48.3   55.6   61.0   66.4
        Std. Error/Erreur-type    6.6    9.1   10.9   13.2   14.9   16.6
               Coefficient (A)   21.4   28.3   32.8   38.5   42.7   46.9
         Exponent/Exposant (B) -0.675 -0.662 -0.656 -0.651 -0.647 -0.645
 Mean % Error/% erreur moyenne    6.6    8.0    8.6    9.1    9.4    9.7
```

OFAT III Results

Watershed Chatacterization Table

OFATID	39459
Area (km^2)	200.60820
Shape Factor	12.662
Mean El. (m)	260.478
Max. El. (m)	340.494
Mean Slope (%)	1.353
Main Channel Length (km)	50.40000
Max. Channel El. (m)	313.19
Min. Channel El. (m)	231.81
Channel Slope (m/km)	1.61
Channel Slope (%)	0.161
Water Area (km^2)	18.37620
Open Water Area (km^2)	0.31230
Wetland Area (km^2)	18.06390
Mean Temp.	8.150
Annual Preciptation (mm)	969.000

Land Cover Table

VALUE	AREA (m^2)	PERCENTAGE	CLASS_NAME
1	139725	0.07	Clear Open Water
5	790650	0.39	Marsh
6	20087800	10.02	Swamp
12	760050	0.38	Treed Upland
13	10171600	5.07	Deciduous Treed
14	2844680	1.42	Mixed Treed
15	66150	0.03	Coniferous Treed
16	843750	0.42	Plantations - Treed Cultivated
17	1081350	0.54	Hedge Rows
25	277200	0.14	Sand/Gravel/Mine Tailings/Extraction
27	6438830	3.21	Community/Infrastructure
28	157007000	78.30	Agriculture and Undifferentiated Rural Land Use

OFAT III Results

OFATID	39459
Model	Mean Annual Flow (MNR2003)
Units	cms
MAF	2.349405

Model	Moin & Shaw 85 Primary Multiple Regresssion Flood
Units	cms
RngQ2Q20	Parameters DA, SLP, ACLS, BFI, MAR are in the range used to create this model.
RngQ50Q1	Parameters DA, SLP, ACLS, BFI, MAR are in range used to create this model.
FF_Q2	29.953834
FF_Q5	45.277358
FF_Q10	56.343108
FF_Q20	67.362630
FF_Q50	78.650730
FF_Q100	89.769881

Model	Moin & Shaw 85 Index Flood with Expected Probability Adjustment
Units	cms
AreaLimit	Drainage Area Parameter in range for model.
FF_Q1.25	26.410000
FF_Q2	29.410000
FF_Q5	42.880000
FF_Q10	53.850000
FF_Q20	67.790000
FF_Q50	87.730000
FF_Q100	111.670000
FF_Q200	117.640000
FF_Q500	138.580000

Statistical Flow Analysis

HYDAT ID	02GC011	
Name	Big Creek Near Calvin	
Gauge Watershed	146.806	sq.km
Dam Watershed	200.608	sq.km
Adam/Agauge	1.366484	

Return Period	Gauge Flow (cms)	Dam Flow* (cms)
2	30.2	38.2
2.33	32.99	41.7
5	44.3	56.0
10	52.7	66.6
20	60.3	76.2
25	62.59	79.1
50	69.5	87.8
100	76.1	96.2
200	82.5	104.3
500	90.7	114.6

*Qdam = Qgauge x $(\text{Adam}/\text{Agauge})^{0.75}$

```
   OPEN STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.910)

      Modified from official EPA SWMM5.1.010 by CHI

Modifications include: seasonal hydrologic modeling, conduit max. volume statistics,
and bug fixes.

When not using the new seasonal modeling capabilities, this
SWMM engine should produce output and report files identical
to EPA SWMM5.1.010, warts and all. As such, this SWMM engine
is provided "as is", without warranty of any kind, and should not be
construed as an endorsement or validation of the output of either
version. CHI accepts no liability for any direct or indirect loss
arising out of its use.

For more information: https://www.openswmm.org/OS51910
--------------------------------------------------------------

WARNING 09: time series interval greater than recording interval for Rain Gage Delhi100yr

*************
Element Count
*************
Number of rain gages ...... 4
Number of subcatchments ... 1
Number of nodes ........... 1
Number of links ........... 0
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Raingage Summary
****************
                                                    Data       Recording
Name                 Data Source                    Type       Interval
------------------------------------------------------------------------
AES_1h_Southern_Ontario_103.78mm AES_12h_Southern_Ontario_103.78mm VOLUME      60 min.
Delhi100yr           AES12hr100yr                   VOLUME       5 min.
Hurricane_Hazel_(Southern_Ontario) Hurricane_Hazel_(Southern_Ontario) VOLUME      60 min.
SCS_24h_Type_II_103.78mm SCS_24h_Type_II_103.78mm       VOLUME       5 min.


********************
Subcatchment Summary
```

```
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------------------
Teeterville            20060.82   3980.32      2.25    1.3530 SCS_24h_Type_II_103.78mm OF1


************
Node Summary
************
                                         Invert      Max.    Ponded    External
Name                 Type                 Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
OF1                  OUTFALL               0.00      0.00       0.0



*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... NO
  Water Quality .......... NO
Infiltration Method ...... GREEN_AMPT
Starting Date ............ NOV-10-2015 00:00:00
Ending Date .............. NOV-11-2015 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:01:00
Dry Time Step ............ 00:01:00


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......      2082.044       103.787
```

```
  Evaporation Loss .........         0.000         0.000
  Infiltration Loss ........      2035.198       101.451
  Surface Runoff ...........        45.000         2.243
  Final Storage ............         1.852         0.092
  Continuity Error (%) .....        -0.000


  **************************        Volume        Volume
  Flow Routing Continuity        hectare-m      10^6 ltr
  **************************     ---------     ---------
  Dry Weather Inflow .......         0.000         0.000
  Wet Weather Inflow .......        44.996       449.962
  Groundwater Inflow .......         0.000         0.000
  RDII Inflow ..............         0.000         0.000
  External Inflow ..........         0.000         0.000
  External Outflow .........        44.996       449.962
  Flooding Loss ............         0.000         0.000
  Evaporation Loss .........         0.000         0.000
  Exfiltration Loss ........         0.000         0.000
  Initial Stored Volume ....         0.000         0.000
  Final Stored Volume ......         0.000         0.000
  Continuity Error (%) .....         0.000


  ***************************
  Subcatchment Runoff Summary
  ***************************

  --------------------------------------------------------------------------------------------------------
                            Total      Total      Total      Total      Total       Total     Peak  Runoff
                           Precip      Runon       Evap      Infil     Runoff      Runoff   Runoff   Coeff
  Subcatchment                 mm         mm         mm         mm         mm    10^6 ltr      CMS
  --------------------------------------------------------------------------------------------------------
  Teeterville              103.79       0.00       0.00     101.45       2.24      450.01    93.73   0.022


  Analysis begun on:  Wed Nov 11 08:47:33 2015
  Analysis ended on:  Wed Nov 11 08:47:33 2015
  Total elapsed time: < 1 sec
```

HEC-RAS Plan: SunnyDay   River: Big Creek   Reach: R1   Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	23857	Max WS	0.37	234.93	236.03		236.03	0.000000	0.01	24.68	37.75	0.01
R1	23700	Max WS	0.37	234.91	236.03		236.03	0.000000	0.01	51.25	166.89	0.00
R1	23512	Max WS	0.37	235.30	236.03		236.03	0.000000	0.00	147.69	319.56	0.00
R1	23330	Max WS	0.37	234.83	236.03		236.03	0.000000	0.00	276.50	347.01	0.00
R1	23170	Max WS	0.37	234.33	236.03		236.03	0.000000	0.00	227.88	216.20	0.00
R1	23142	Max WS	0.37	234.30	236.03		236.03	0.000001	0.03	13.27	14.33	0.01
R1	23126	Max WS	0.37	234.29	236.03		236.03	0.000000	0.01	25.53	21.41	0.00
R1	23120	Max WS	0.37	234.59	236.03		236.03	0.000000	0.02	22.49	23.23	0.01
R1	23112	Max WS	0.37	234.87	236.03	235.00	236.03	0.000000	0.01	28.22	31.00	0.00
R1	23107		Inl Struct									
R1	23098	Max WS	1.27	231.69	232.11		232.11	0.000368	0.22	5.80	22.96	0.14
R1	23024	Max WS	1.26	231.43	232.09		232.09	0.000137	0.19	6.68	15.61	0.09
R1	22953	Max WS	1.25	231.36	231.93		231.96	0.004118	0.82	1.53	4.59	0.46
R1	22850	Max WS	1.24	231.25	231.71		231.72	0.000834	0.42	2.96	7.89	0.22
R1	22740	Max WS	1.18	231.14	231.57		231.59	0.001552	0.57	2.06	5.46	0.30
R1	22511	Max WS	1.07	230.91	231.40		231.40	0.000281	0.27	3.92	8.73	0.13
R1	22235	Max WS	1.06	230.64	231.36		231.36	0.000035	0.12	8.83	14.23	0.05
R1	21904	Max WS	1.05	230.30	231.16		231.18	0.001247	0.55	1.92	4.45	0.27
R1	21778	Max WS	1.05	230.17	230.96		230.98	0.002056	0.66	1.58	4.00	0.34
R1	21612	Max WS	1.05	230.01	230.80		230.80	0.000189	0.27	3.86	6.08	0.11
R1	21325	Max WS	1.04	229.72	230.57		230.59	0.001490	0.58	1.80	4.23	0.28
R1	21078	Max WS	1.04	229.47	230.32		230.33	0.000822	0.45	2.32	5.43	0.22
R1	20877	Max WS	1.04	229.27	230.13		230.14	0.001189	0.52	2.00	4.64	0.25
R1	20690	Max WS	1.04	229.08	229.93		229.94	0.001158	0.52	1.99	4.69	0.26
R1	20421	Max WS	1.04	228.81	229.70		229.71	0.000771	0.45	2.32	5.22	0.21
R1	20291	Max WS	1.03	228.68	229.52		229.55	0.002069	0.68	1.53	3.62	0.33
R1	19795	Max WS	1.01	228.18	229.08		229.08	0.000006	0.06	16.97	19.46	0.02
R1	19677	Max WS	1.01	228.06	229.04		229.05	0.000573	0.41	2.48	5.06	0.18
R1	19639	Max WS	1.01	228.02	229.04	228.34	229.04	0.000021	0.10	10.54	17.02	0.04
R1	19624		Bridge									
R1	19617	Max WS	1.01	228.38	229.03		229.03	0.000054	0.13	7.59	14.65	0.06
R1	19582	Max WS	1.01	228.35	228.91		228.97	0.007716	1.04	0.97	3.44	0.63
R1	19465	Max WS	1.01	228.24	228.57		228.58	0.000798	0.36	2.83	9.45	0.21
R1	19256	Max WS	1.01	228.04	228.41		228.42	0.001169	0.41	2.47	9.11	0.25
R1	18999	Max WS	0.99	227.81	228.16		228.17	0.001173	0.43	2.30	7.75	0.25
R1	18716	Max WS	0.99	227.54	228.01		228.01	0.000097	0.16	6.03	13.04	0.08
R1	18402	Max WS	0.99	227.25	227.63		227.65	0.003505	0.55	1.80	9.45	0.40
R1	18112	Max WS	0.98	226.98	227.22		227.22	0.000856	0.31	3.15	13.72	0.21
R1	17727	Max WS	0.98	226.62	227.07		227.07	0.000193	0.22	4.44	10.08	0.11
R1	17455	Max WS	0.97	226.37	227.04		227.04	0.000035	0.12	8.05	12.81	0.05

HEC-RAS Plan: SunnyDay River: Big Creek Reach: R1 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	17274	Max WS	0.97	226.20	226.98		226.99	0.000548	0.35	2.76	7.05	0.18
R1	17187	Max WS	0.97	226.12	226.93		226.95	0.001095	0.50	2.24	21.07	0.25
R1	17146	Max WS	0.97	226.08	226.91		226.92	0.000424	0.32	3.07	7.36	0.16
R1	17101	Max WS	0.97	226.04	226.89		226.90	0.000715	0.42	2.32	5.48	0.20
R1	16906	Max WS	0.97	225.86	226.70		226.71	0.001436	0.56	1.72	4.11	0.28
R1	16528	Max WS	0.97	225.51	226.27		226.28	0.001014	0.45	2.13	5.63	0.24
R1	16336	Max WS	0.97	225.33	226.14		226.14	0.000460	0.33	2.96	7.23	0.16
R1	16069	Max WS	0.97	225.08	225.96		225.97	0.001003	0.50	1.95	4.45	0.24
R1	15771	Max WS	0.97	224.81	225.76		225.77	0.000508	0.38	2.57	5.42	0.17
R1	15633	Max WS	0.91	224.68	225.41		225.44	0.003706	0.81	1.13	3.09	0.43
R1	15570	Max WS	0.89	224.62	225.32	224.87	225.32	0.000095	0.16	5.53	12.27	0.08
R1	15566		Bridge									
R1	15558	Max WS	0.89	224.65	225.32		225.32	0.000081	0.15	6.01	13.87	0.07
R1	15524	Max WS	0.89	224.62	225.32		225.32	0.000033	0.12	7.43	11.23	0.05
R1	15248	Max WS	0.89	224.38	225.28		225.28	0.000221	0.28	3.21	5.68	0.12
R1	14901	Max WS	0.88	224.08	225.24		225.24	0.000035	0.14	6.07	7.06	0.05
R1	14671	Max WS	0.88	223.88	225.24		225.24	0.000006	0.07	12.60	12.71	0.02
R1	14348	Max WS	0.88	223.60	225.22		225.22	0.000089	0.20	4.27	5.27	0.07
R1	14214	Max WS	0.88	223.49	225.21		225.22	0.000033	0.12	8.96	28.40	0.05
R1	13925	Max WS	0.87	223.24	225.21		225.21	0.000006	0.07	21.02	52.79	0.02
R1	13821	Max WS	0.87	223.15	225.21		225.21	0.000008	0.08	12.04	15.47	0.02
R1	13794	Max WS	0.87	223.12	224.23	224.22	224.50	0.074737	2.32	0.38	0.68	1.00
R1	13777	Max WS	0.87	223.11	223.66	223.38	223.66	0.000429	0.25	3.50	12.65	0.15
R1	13773		Bridge									
R1	13766	Max WS	0.87	223.15	223.65		223.65	0.000321	0.24	3.69	11.89	0.13
R1	13738	Max WS	0.87	223.12	223.60		223.62	0.002512	0.65	1.35	4.32	0.37
R1	13481	Max WS	0.87	222.80	223.17		223.19	0.001189	0.46	1.91	5.86	0.26
R1	13254	Max WS	0.87	222.52	222.93		222.95	0.001218	0.48	1.83	5.36	0.26
R1	12826	Max WS	0.87	221.99	222.57		222.57	0.000702	0.42	2.07	4.67	0.20
R1	12361	Max WS	0.87	221.41	222.18		222.19	0.001033	0.47	1.86	4.81	0.24
R1	12107	Max WS	0.87	221.10	221.94		221.95	0.001005	0.47	1.84	4.38	0.23
R1	11898	Max WS	0.87	220.84	221.77		221.78	0.000773	0.47	1.87	3.64	0.21
R1	11664	Max WS	0.87	220.55	221.36		221.39	0.002778	0.80	1.09	1.85	0.34
R1	11437	Max WS	0.87	220.27	221.05		221.05	0.000211	0.27	3.24	5.77	0.12
R1	11259	Max WS	0.87	220.05	220.85		220.87	0.002062	0.65	1.35	3.40	0.33
R1	11018	Max WS	0.87	219.75	220.56		220.56	0.000609	0.42	2.10	4.24	0.19
R1	10912	Max WS	0.87	219.62	220.53	219.88	220.53	0.000035	0.12	7.31	11.67	0.05
R1	10905		Bridge									
R1	10899	Max WS	0.87	219.84	220.53		220.53	0.000128	0.18	4.91	11.95	0.09
R1	10863	Max WS	0.87	219.77	220.42		220.46	0.005922	0.93	0.94	2.90	0.52

HEC-RAS Plan: SunnyDay   River: Big Creek   Reach: R1   Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	10758	Max WS	0.87	219.57	220.12		220.13	0.001882	0.51	1.71	6.25	0.31
R1	10496	Max WS	0.87	219.07	219.69		219.71	0.002261	0.61	1.44	4.62	0.35
R1	10264	Max WS	0.87	218.63	219.28		219.30	0.002176	0.60	1.46	4.46	0.34
R1	9975	Max WS	0.87	218.08	218.80		218.81	0.001760	0.57	1.54	4.30	0.30
R1	9680	Max WS	0.87	217.51	218.37		218.38	0.001486	0.58	1.50	3.52	0.28
R1	9636	Max WS	0.87	217.43	218.34	217.78	218.35	0.000207	0.26	3.37	6.45	0.11
R1	9633		Bridge									
R1	9626	Max WS	0.87	217.64	218.34		218.34	0.000172	0.24	3.60	8.52	0.11
R1	9593	Max WS	0.87	217.61	218.33		218.33	0.000459	0.31	2.86	7.95	0.16
R1	9531	Max WS	0.87	217.53	218.32		218.32	0.000084	0.18	4.74	7.65	0.07
R1	9294	Max WS	0.87	217.35	218.02		218.04	0.002803	0.68	1.28	3.83	0.38
R1	8978	Max WS	0.87	217.07	217.40		217.42	0.002129	0.54	1.61	5.96	0.33
R1	8768	Max WS	0.87	216.88	217.13		217.14	0.001443	0.41	2.15	9.21	0.27
R1	8457	Max WS	0.87	216.61	216.86		216.87	0.000923	0.33	2.61	10.66	0.22
R1	8134	Max WS	0.87	216.32	216.60		216.60	0.001346	0.41	2.12	8.42	0.26
R1	7982	Max WS	0.87	216.19	216.44		216.45	0.001398	0.41	2.11	8.52	0.26
R1	7854	Max WS	0.87	216.07	216.31		216.32	0.001406	0.40	2.17	9.27	0.26
R1	7297	Max WS	0.87	215.58	215.74		215.75	0.001165	0.29	3.02	18.45	0.23
R1	6668	Max WS	0.87	215.02	215.23		215.23	0.000807	0.28	3.09	14.88	0.20
R1	6443	Max WS	0.87	214.82	215.00		215.01	0.001740	0.38	2.30	12.53	0.28
R1	5556	Max WS	0.87	214.04	214.30		214.30	0.000299	0.20	4.39	16.86	0.12
R1	4951	Max WS	0.87	213.50	213.79		213.80	0.002071	0.51	1.72	6.95	0.33
R1	4631	Max WS	0.87	213.22	213.42		213.43	0.001165	0.33	2.64	13.32	0.24
R1	4357	Max WS	0.87	212.98	213.20		213.20	0.001040	0.33	2.67	12.41	0.22
R1	4198	Max WS	0.87	212.84	213.12		213.12	0.000331	0.22	4.01	14.52	0.13
R1	4132	Max WS	0.87	212.78	213.06	212.97	213.07	0.003806	0.49	1.79	12.30	0.41
R1	4120		Bridge									
R1	4109	Max WS	0.87	212.78	213.00		213.03	0.015358	0.83	1.05	9.21	0.79
R1	4060	Max WS	0.87	212.72	212.87		212.87	0.001734	0.33	2.63	17.79	0.27
R1	3694	Max WS	0.87	212.26	212.45		212.46	0.000790	0.26	3.30	17.29	0.19
R1	3381	Max WS	0.87	211.88	212.12		212.13	0.002390	0.45	1.92	10.25	0.33
R1	3007	Max WS	0.87	211.41	211.66		211.67	0.001353	0.39	2.20	9.38	0.26
R1	2542	Max WS	0.86	210.83	211.44		211.44	0.000035	0.11	7.73	14.12	0.05
R1	2286	Max WS	0.86	210.52	211.43		211.43	0.000036	0.11	7.86	14.99	0.05
R1	2232	Max WS	0.86	210.45	211.43	210.67	211.43	0.000009	0.06	14.96	26.26	0.02
R1	2222		Bridge									
R1	2212	Max WS	0.86	210.45	211.43		211.43	0.000009	0.06	13.78	26.25	0.03
R1	2155	Max WS	0.86	210.50	211.43		211.43	0.000016	0.08	11.26	20.78	0.03
R1	2084	Max WS	0.86	210.55	211.42		211.42	0.000063	0.13	6.77	15.96	0.06
R1	1956	Max WS	0.86	210.65	211.42		211.42	0.000062	0.14	6.13	12.17	0.06

HEC-RAS Plan: SunnyDay River: Big Creek Reach: R1 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	1884	Max WS	0.86	210.72	211.15	211.05	211.18	0.007395	0.76	1.14	6.52	0.58
R1	1866		Bridge									
R1	1848	Max WS	0.86	210.72	211.05	211.05	211.14	0.022946	1.31	0.66	3.93	1.02
R1	1806	Max WS	0.86	210.44	210.57		210.59	0.011714	0.73	1.19	10.37	0.69
R1	1471	Max WS	0.86	208.30	208.52		208.55	0.004879	0.66	1.30	6.78	0.48
R1	1276	Max WS	0.86	207.06	208.22		208.22	0.000016	0.08	10.54	16.87	0.03
R1	1221	Max WS	0.86	207.37	208.22	207.66	208.22	0.000087	0.15	5.70	12.98	0.07
R1	1206		Bridge									
R1	1192	Max WS	0.86	207.94	208.20		208.22	0.004931	0.53	1.63	11.98	0.46
R1	1139	Max WS	0.86	207.82	208.09		208.11	0.008048	0.66	1.31	9.85	0.57
R1	1038	Max WS	0.86	207.58	207.95		207.95	0.000248	0.18	4.84	19.21	0.11
R1	875	Max WS	0.86	207.20	207.62		207.64	0.004590	0.68	1.27	6.07	0.47
R1	557	Max WS	0.86	206.46	206.95		206.95	0.000669	0.33	2.61	8.44	0.19
R1	500	Max WS	0.86	206.54	206.91	206.74	206.92	0.001273	0.31	2.75	16.00	0.24
R1	482		Bridge									
R1	465	Max WS	0.86	206.54	206.77		206.81	0.015264	0.87	0.99	8.13	0.79
R1	397	Max WS	0.86	206.31	206.57		206.59	0.004060	0.47	1.84	14.09	0.41
R1	115	Max WS	0.86	205.51	206.05		206.07	0.003323	0.67	1.29	4.81	0.41
R1	5	Max WS	0.86	205.19	205.74	205.59	205.77	0.003842	0.74	1.17	4.24	0.45

HEC-RAS Plan: 100yr   River: Big Creek   Reach: R1   Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	23857	Max WS	37.64	234.93	236.74		236.76	0.000231	0.53	132.25	192.86	0.15
R1	23700	Max WS	32.96	234.91	236.73		236.73	0.000045	0.19	182.76	210.36	0.06
R1	23512	Max WS	32.85	235.30	236.72		236.72	0.000008	0.09	375.90	338.20	0.03
R1	23330	Max WS	32.63	234.83	236.72		236.72	0.000003	0.06	540.43	414.62	0.02
R1	23170	Max WS	32.46	234.33	236.72		236.72	0.000004	0.09	381.19	225.94	0.02
R1	23142	Max WS	32.44	234.30	236.68		236.77	0.001694	1.35	24.08	19.02	0.38
R1	23126	Max WS	32.44	234.29	236.72		236.75	0.000362	0.81	40.37	21.78	0.19
R1	23120	Max WS	32.44	234.59	236.71		236.75	0.000455	0.84	39.95	27.66	0.21
R1	23112	Max WS	32.44	234.87	236.72	235.59	236.74	0.000285	0.65	50.06	31.94	0.16
R1	23107		Inl Struct									
R1	23098	Max WS	31.59	231.69	233.75		233.77	0.000234	0.67	58.13	37.38	0.15
R1	23024	Max WS	31.52	231.43	233.73		233.75	0.000241	0.68	74.82	79.54	0.16
R1	22953	Max WS	30.12	231.36	233.56		233.72	0.002405	1.87	23.67	25.30	0.46
R1	22850	Max WS	30.01	231.25	233.48		233.52	0.000575	0.96	49.77	43.41	0.23
R1	22740	Max WS	29.28	231.14	233.41		233.45	0.000788	1.04	53.76	68.09	0.26
R1	22511	Max WS	28.47	230.91	233.25		233.29	0.000641	1.02	48.32	102.20	0.24
R1	22235	Max WS	27.96	230.64	233.13		233.15	0.000414	0.70	40.30	31.85	0.19
R1	21904	Max WS	27.08	230.30	232.82		232.89	0.001391	1.36	42.70	94.77	0.35
R1	21778	Max WS	26.74	230.17	232.68		232.73	0.001160	1.22	53.40	117.69	0.32
R1	21612	Max WS	26.68	230.01	232.42		232.53	0.001651	1.48	20.37	21.02	0.36
R1	21325	Max WS	25.92	229.72	232.07		232.11	0.001173	1.13	50.40	78.41	0.31
R1	21078	Max WS	24.62	229.47	231.89		231.91	0.000611	0.91	72.04	157.23	0.23
R1	20877	Max WS	23.82	229.27	231.74		231.78	0.000924	1.08	58.78	168.60	0.28
R1	20690	Max WS	23.56	229.08	231.53		231.60	0.001251	1.23	24.59	22.50	0.33
R1	20421	Max WS	23.34	228.81	231.29		231.34	0.000777	1.07	42.15	59.70	0.27
R1	20291	Max WS	23.22	228.68	231.10		231.17	0.001984	1.38	26.17	28.71	0.39
R1	19795	Max WS	23.11	228.18	230.63		230.64	0.000107	0.48	48.80	21.94	0.10
R1	19677	Max WS	23.10	228.06	230.46		230.56	0.001851	1.49	20.69	25.84	0.40
R1	19639	Max WS	23.09	228.02	230.48	228.98	230.50	0.000209	0.62	37.27	45.11	0.14
R1	19624		Bridge									
R1	19617	Max WS	23.09	228.38	230.46		230.49	0.000341	0.71	32.74	20.61	0.18
R1	19582	Max WS	23.02	228.35	230.24		230.46	0.005362	2.10	12.34	19.55	0.65
R1	19465	Max WS	23.01	228.24	230.00		230.06	0.001038	1.07	21.57	16.31	0.30
R1	19256	Max WS	22.89	228.04	229.83		229.88	0.000722	0.90	25.55	19.47	0.25
R1	18999	Max WS	22.75	227.81	229.53		229.60	0.001417	1.21	18.84	15.22	0.35
R1	18716	Max WS	22.38	227.54	229.26		229.31	0.000713	0.97	23.19	14.64	0.24
R1	18402	Max WS	22.13	227.25	229.09		229.12	0.000499	0.75	31.16	26.20	0.21
R1	18112	Max WS	21.88	226.98	228.99		229.01	0.000271	0.67	34.03	23.77	0.16
R1	17727	Max WS	21.44	226.62	228.81		228.86	0.000525	0.91	23.87	13.60	0.21
R1	17455	Max WS	21.39	226.37	228.73		228.76	0.000227	0.65	33.58	25.79	0.14

HEC-RAS Plan: 100yr River: Big Creek Reach: R1 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	17274	Max WS	21.24	226.20	228.60		228.67	0.000819	1.17	19.60	15.44	0.28
R1	17187	Max WS	21.23	226.12	228.60		228.60	0.000193	0.51	73.51	46.31	0.13
R1	17146	Max WS	21.23	226.08	228.57		228.60	0.000486	0.87	34.09	21.48	0.21
R1	17101	Max WS	21.23	226.04	228.52		228.57	0.000814	1.11	23.21	16.66	0.28
R1	16906	Max WS	21.20	225.86	228.33		228.38	0.001205	1.18	27.06	26.09	0.32
R1	16528	Max WS	21.12	225.51	227.95		228.01	0.000787	1.11	22.80	17.00	0.27
R1	16336	Max WS	21.09	225.33	227.85		227.89	0.000462	0.91	28.80	22.77	0.21
R1	16069	Max WS	20.76	225.08	227.65		227.71	0.000947	1.15	22.41	18.43	0.29
R1	15771	Max WS	20.47	224.81	227.40		227.46	0.000794	1.09	23.89	20.93	0.27
R1	15633	Max WS	9.60	224.68	227.07		227.10	0.000702	0.78	17.02	86.70	0.23
R1	15570	Max WS	9.34	224.62	227.06	225.25	227.06	0.000043	0.31	39.84	29.09	0.07
R1	15566		Bridge									
R1	15558	Max WS	9.34	224.65	227.06		227.06	0.000040	0.30	37.14	24.79	0.06
R1	15524	Max WS	9.34	224.62	227.06		227.06	0.000054	0.31	38.79	179.41	0.07
R1	15248	Max WS	8.67	224.38	227.04		227.04	0.000094	0.40	30.11	26.29	0.09
R1	14901	Max WS	8.28	224.08	227.02		227.02	0.000024	0.22	75.57	70.57	0.05
R1	14671	Max WS	8.27	223.88	227.02		227.02	0.000015	0.21	63.53	60.80	0.04
R1	14348	Max WS	8.13	223.60	227.01		227.01	0.000008	0.12	158.69	110.54	0.02
R1	14214	Max WS	8.13	223.49	227.01		227.01	0.000004	0.10	196.72	136.80	0.02
R1	13925	Max WS	8.12	223.24	227.01		227.01	0.000002	0.08	277.27	190.39	0.02
R1	13821	Max WS	8.12	223.15	227.01		227.01	0.000019	0.23	51.64	29.41	0.04
R1	13794	Max WS	8.12	223.12	225.48	225.80	226.62	0.114144	4.75	1.71	1.45	1.40
R1	13777	Max WS	8.11	223.11	224.56	223.73	224.58	0.000269	0.52	16.57	15.71	0.15
R1	13773		Bridge									
R1	13766	Max WS	8.11	223.15	224.56		224.57	0.000293	0.56	15.99	14.86	0.16
R1	13738	Max WS	8.11	223.12	224.50		224.55	0.001620	0.97	8.83	12.42	0.35
R1	13481	Max WS	8.08	222.80	224.20		224.24	0.000855	0.80	10.06	10.01	0.26
R1	13254	Max WS	8.05	222.52	224.03		224.06	0.000768	0.77	10.60	15.53	0.24
R1	12826	Max WS	7.96	221.99	223.72		223.75	0.000783	0.80	9.91	8.94	0.24
R1	12361	Max WS	7.85	221.41	223.49		223.50	0.000298	0.55	20.54	35.48	0.16
R1	12107	Max WS	7.84	221.10	223.44		223.45	0.000144	0.40	36.29	51.70	0.11
R1	11898	Max WS	7.83	220.84	223.38		223.40	0.000366	0.59	16.35	19.37	0.17
R1	11664	Max WS	7.83	220.55	222.68		222.81	0.005916	1.63	4.82	5.67	0.54
R1	11437	Max WS	7.83	220.27	222.14		222.16	0.000406	0.64	14.23	16.62	0.18
R1	11259	Max WS	7.83	220.05	221.90		221.95	0.001870	1.08	7.26	7.87	0.36
R1	11018	Max WS	7.82	219.75	221.47		221.53	0.001527	1.02	7.69	7.94	0.33
R1	10912	Max WS	7.82	219.62	221.42	220.25	221.43	0.000145	0.43	19.14	15.11	0.11
R1	10905		Bridge									
R1	10899	Max WS	7.82	219.84	221.41		221.43	0.000213	0.49	17.13	15.98	0.14
R1	10863	Max WS	7.82	219.77	221.21		221.35	0.006756	1.69	4.63	6.45	0.64

HEC-RAS Plan: 100yr River: Big Creek Reach: R1 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	10758	Max WS	7.82	219.57	220.90		220.93	0.001042	0.84	10.77	15.48	0.28
R1	10496	Max WS	7.82	219.07	220.53		220.58	0.001781	0.98	8.36	15.95	0.36
R1	10264	Max WS	7.82	218.63	220.16		220.21	0.001624	0.96	9.04	16.73	0.34
R1	9975	Max WS	7.82	218.08	219.78		219.82	0.001152	0.88	10.45	17.10	0.29
R1	9680	Max WS	7.81	217.51	219.32		219.38	0.002058	1.12	8.09	14.61	0.38
R1	9636	Max WS	7.81	217.43	219.29	218.36	219.32	0.000599	0.71	11.05	10.05	0.22
R1	9633		Bridge									
R1	9626	Max WS	7.81	217.64	219.28		219.30	0.000497	0.70	11.13	13.06	0.21
R1	9593	Max WS	7.81	217.61	219.27		219.29	0.000359	0.52	15.21	16.85	0.17
R1	9531	Max WS	7.81	217.53	219.25		219.27	0.000290	0.56	16.16	19.55	0.16
R1	9294	Max WS	7.81	217.35	218.85		218.93	0.002912	1.20	6.50	8.65	0.44
R1	8978	Max WS	7.80	217.07	218.16		218.20	0.001892	0.97	8.03	11.13	0.37
R1	8768	Max WS	7.80	216.88	217.88		217.91	0.000973	0.74	10.48	13.08	0.27
R1	8457	Max WS	7.80	216.61	217.63		217.65	0.000673	0.67	11.67	12.92	0.22
R1	8134	Max WS	7.80	216.32	217.33		217.37	0.001154	0.80	9.79	12.35	0.29
R1	7982	Max WS	7.79	216.19	217.12		217.16	0.001552	0.96	8.14	9.35	0.33
R1	7854	Max WS	7.79	216.07	216.92		216.96	0.001687	0.94	8.30	10.93	0.34
R1	7297	Max WS	7.78	215.58	216.29		216.30	0.000752	0.59	13.10	18.73	0.23
R1	6668	Max WS	7.77	215.02	215.84		215.86	0.000703	0.62	12.47	15.96	0.23
R1	6443	Max WS	7.77	214.82	215.64		215.67	0.000995	0.74	10.53	13.26	0.26
R1	5556	Max WS	7.75	214.04	215.13		215.14	0.000222	0.42	18.53	17.16	0.13
R1	4951	Max WS	7.74	213.50	214.46		214.51	0.001982	0.98	7.94	11.52	0.37
R1	4631	Max WS	7.74	213.22	214.05		214.08	0.000822	0.68	11.45	14.54	0.24
R1	4357	Max WS	7.74	212.98	213.80		213.83	0.001046	0.75	10.34	13.13	0.27
R1	4198	Max WS	7.74	212.84	213.67		213.69	0.000726	0.64	12.18	15.28	0.23
R1	4132	Max WS	7.74	212.78	213.56	213.26	213.60	0.002133	0.87	8.92	16.50	0.38
R1	4120		Bridge									
R1	4109	Max WS	7.74	212.78	213.44		213.50	0.004219	1.10	7.06	15.37	0.52
R1	4060	Max WS	7.73	212.72	213.36		213.38	0.001123	0.68	11.39	18.09	0.27
R1	3694	Max WS	7.73	212.26	213.08		213.09	0.000518	0.54	14.32	17.92	0.19
R1	3381	Max WS	7.72	211.88	212.81		212.84	0.001111	0.79	9.75	12.28	0.28
R1	3007	Max WS	7.72	211.41	212.41		212.44	0.000960	0.74	10.41	12.75	0.26
R1	2542	Max WS	7.71	210.83	212.12		212.13	0.000201	0.42	18.22	16.38	0.13
R1	2286	Max WS	7.70	210.52	212.07		212.08	0.000211	0.42	18.18	17.07	0.13
R1	2232	Max WS	7.70	210.45	212.07	210.98	212.07	0.000057	0.23	32.90	29.13	0.07
R1	2222		Bridge									
R1	2212	Max WS	7.70	210.45	212.07		212.07	0.000070	0.27	28.70	29.11	0.08
R1	2155	Max WS	7.70	210.50	212.06		212.06	0.000105	0.31	25.20	23.17	0.09
R1	2084	Max WS	7.69	210.55	212.04		212.05	0.000267	0.45	17.20	17.73	0.14
R1	1956	Max WS	7.69	210.65	211.99		212.01	0.000429	0.54	14.11	15.53	0.18

HEC-RAS Plan: 100yr River: Big Creek Reach: R1 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	1884	Max WS	7.69	210.72	211.92	211.47	211.95	0.001234	0.75	10.19	15.37	0.30
R1	1866		Bridge									
R1	1848	Max WS	8.60	210.72	211.49	211.50	211.70	0.018868	2.04	4.23	11.18	1.06
R1	1806	Max WS	8.55	210.44	210.94		211.04	0.009190	1.36	6.27	17.76	0.73
R1	1471	Max WS	8.34	208.30	209.14		209.21	0.003575	1.18	7.05	12.03	0.49
R1	1276	Max WS	8.26	207.06	208.84		208.84	0.000158	0.37	22.12	19.57	0.11
R1	1221	Max WS	8.25	207.37	208.81	208.11	208.83	0.000482	0.59	14.10	14.80	0.19
R1	1206		Bridge									
R1	1192	Max WS	8.25	207.94	208.69		208.74	0.002387	0.95	8.68	14.96	0.40
R1	1139	Max WS	8.22	207.82	208.58		208.61	0.002558	0.85	9.66	20.72	0.40
R1	1038	Max WS	8.21	207.58	208.44		208.45	0.000643	0.56	14.62	20.89	0.21
R1	875	Max WS	8.15	207.20	208.19		208.23	0.002367	0.83	9.85	21.16	0.39
R1	557	Max WS	8.13	206.46	207.47		207.52	0.002317	0.99	8.19	12.83	0.40
R1	500	Max WS	8.12	206.54	207.40	207.04	207.42	0.001210	0.68	11.88	20.61	0.29
R1	482		Bridge									
R1	465	Max WS	8.12	206.54	207.32		207.35	0.001942	0.80	10.20	20.12	0.36
R1	397	Max WS	8.08	206.31	207.26		207.27	0.000555	0.51	15.72	23.24	0.20
R1	115	Max WS	8.07	205.51	206.83		206.89	0.002355	1.03	7.86	11.94	0.40
R1	5	Max WS	8.06	205.19	206.53	206.17	206.60	0.002953	1.17	6.92	10.30	0.45

HEC-RAS Plan: 100yrB   River: Big Creek   Reach: R1   Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	23857	Max WS	37.64	234.93	236.74		236.76	0.000231	0.53	132.25	192.86	0.15
R1	23700	Max WS	37.17	234.91	236.73		236.73	0.000058	0.22	182.76	210.36	0.07
R1	23512	Max WS	33.06	235.30	236.72		236.72	0.000008	0.09	375.69	338.19	0.03
R1	23330	Max WS	33.01	234.83	236.72		236.72	0.000003	0.06	540.18	414.56	0.02
R1	23170	Max WS	32.98	234.33	236.72		236.72	0.000004	0.09	381.05	225.93	0.02
R1	23142	Max WS	32.39	234.30	236.68		236.77	0.001690	1.35	24.07	19.02	0.38
R1	23126	Max WS	32.38	234.29	236.72		236.75	0.000361	0.81	40.35	21.78	0.19
R1	23120	Max WS	32.38	234.59	236.71		236.75	0.000454	0.84	39.93	27.66	0.21
R1	23112	Max WS	32.37	234.87	236.72	235.59	236.74	0.000284	0.65	50.02	31.94	0.16
R1	23107		Inl Struct									
R1	23098	Max WS	32.36	231.69	233.77		233.79	0.000235	0.67	59.09	37.52	0.16
R1	23024	Max WS	32.34	231.43	233.76		233.78	0.000239	0.68	76.88	79.89	0.16
R1	22953	Max WS	31.49	231.36	233.58		233.75	0.002509	1.93	24.20	25.77	0.47
R1	22850	Max WS	30.51	231.25	233.50		233.54	0.000567	0.96	50.67	43.50	0.23
R1	22740	Max WS	30.44	231.14	233.43		233.47	0.000810	1.06	55.08	69.13	0.26
R1	22511	Max WS	28.90	230.91	233.27		233.31	0.000627	1.02	50.30	104.64	0.24
R1	22235	Max WS	28.79	230.64	233.14		233.17	0.000422	0.71	40.84	33.61	0.19
R1	21904	Max WS	27.51	230.30	232.83		232.91	0.001358	1.35	44.19	96.39	0.35
R1	21778	Max WS	27.44	230.17	232.69		232.75	0.001139	1.22	55.34	118.11	0.31
R1	21612	Max WS	27.24	230.01	232.44		232.55	0.001671	1.50	20.66	21.44	0.36
R1	21325	Max WS	26.24	229.72	232.08		232.12	0.001154	1.13	51.21	78.59	0.31
R1	21078	Max WS	25.28	229.47	231.90		231.92	0.000639	0.94	73.71	171.59	0.24
R1	20877	Max WS	24.40	229.27	231.75		231.79	0.000909	1.07	61.05	169.44	0.28
R1	20690	Max WS	24.09	229.08	231.55		231.62	0.001263	1.25	24.92	23.08	0.33
R1	20421	Max WS	23.84	228.81	231.31		231.35	0.000779	1.07	43.03	60.54	0.27
R1	20291	Max WS	23.71	228.68	231.11		231.19	0.001984	1.38	26.60	28.77	0.39
R1	19795	Max WS	23.58	228.18	230.65		230.66	0.000109	0.48	49.14	21.98	0.10
R1	19677	Max WS	23.57	228.06	230.47		230.58	0.001847	1.50	21.08	25.96	0.40
R1	19639	Max WS	23.55	228.02	230.50	228.99	230.52	0.000211	0.63	37.57	45.92	0.14
R1	19624		Bridge									
R1	19617	Max WS	23.55	228.38	230.48		230.50	0.000343	0.71	33.05	20.67	0.18
R1	19582	Max WS	23.49	228.35	230.25		230.47	0.005329	2.12	12.61	19.85	0.65
R1	19465	Max WS	23.37	228.24	230.01		230.07	0.001033	1.07	21.84	16.37	0.30
R1	19256	Max WS	23.36	228.04	229.85		229.89	0.000723	0.90	25.87	19.52	0.25
R1	18999	Max WS	23.05	227.81	229.55		229.62	0.001398	1.21	19.08	15.26	0.34
R1	18716	Max WS	22.85	227.54	229.27		229.32	0.000720	0.98	23.42	14.68	0.24
R1	18402	Max WS	22.35	227.25	229.11		229.13	0.000491	0.75	31.59	26.35	0.21
R1	18112	Max WS	22.09	226.98	229.00		229.03	0.000268	0.67	34.42	23.95	0.16
R1	17727	Max WS	21.86	226.62	228.83		228.87	0.000532	0.92	24.08	13.67	0.21
R1	17455	Max WS	21.78	226.37	228.75		228.77	0.000230	0.66	33.99	29.42	0.15

HEC-RAS Plan: 100yrB   River: Big Creek   Reach: R1   Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	17274	Max WS	21.62	226.20	228.62		228.69	0.000826	1.18	19.83	16.33	0.28
R1	17187	Max WS	21.60	226.12	228.61		228.62	0.000194	0.51	74.23	49.44	0.13
R1	17146	Max WS	21.60	226.08	228.58		228.61	0.000488	0.88	34.41	21.53	0.21
R1	17101	Max WS	21.59	226.04	228.53		228.59	0.000817	1.12	23.46	17.70	0.28
R1	16906	Max WS	21.51	225.86	228.34		228.40	0.001202	1.19	27.45	27.17	0.32
R1	16528	Max WS	21.45	225.51	227.96		228.02	0.000792	1.12	23.00	17.05	0.27
R1	16336	Max WS	21.40	225.33	227.86		227.90	0.000466	0.91	29.05	22.87	0.21
R1	16069	Max WS	21.05	225.08	227.65		227.72	0.000956	1.16	22.56	18.50	0.29
R1	15771	Max WS	20.69	224.81	227.41		227.47	0.000797	1.10	24.06	20.98	0.27
R1	15633	Max WS	9.79	224.68	227.09		227.12	0.000656	0.76	19.21	88.03	0.22
R1	15570	Max WS	9.52	224.62	227.08	225.26	227.09	0.000042	0.31	40.55	29.22	0.07
R1	15566		Bridge									
R1	15558	Max WS	9.52	224.65	227.08		227.09	0.000039	0.30	37.77	25.01	0.06
R1	15524	Max WS	9.52	224.62	227.08		227.09	0.000053	0.31	43.34	180.66	0.07
R1	15248	Max WS	8.83	224.38	227.06		227.07	0.000093	0.40	30.79	27.18	0.09
R1	14901	Max WS	8.45	224.08	227.05		227.05	0.000024	0.22	77.39	71.27	0.05
R1	14671	Max WS	8.44	223.88	227.04		227.04	0.000015	0.21	65.09	61.63	0.04
R1	14348	Max WS	8.41	223.60	227.04		227.04	0.000008	0.12	161.52	110.65	0.03
R1	14214	Max WS	8.38	223.49	227.04		227.04	0.000004	0.11	200.23	137.19	0.02
R1	13925	Max WS	8.32	223.24	227.04		227.04	0.000002	0.08	282.14	190.80	0.02
R1	13821	Max WS	8.30	223.15	227.03		227.04	0.000019	0.23	52.40	29.59	0.04
R1	13794	Max WS	8.30	223.12	225.49	225.82	226.66	0.114921	4.79	1.73	1.46	1.40
R1	13777	Max WS	8.30	223.11	224.58	223.73	224.59	0.000272	0.52	16.76	15.74	0.15
R1	13773		Bridge									
R1	13766	Max WS	8.30	223.15	224.57		224.58	0.000297	0.56	16.18	14.96	0.16
R1	13738	Max WS	8.29	223.12	224.51		224.56	0.001612	0.98	8.98	12.57	0.35
R1	13481	Max WS	8.26	222.80	224.22		224.25	0.000859	0.81	10.22	10.07	0.26
R1	13254	Max WS	8.23	222.52	224.05		224.08	0.000762	0.77	10.87	17.58	0.24
R1	12826	Max WS	8.14	221.99	223.74		223.77	0.000786	0.81	10.07	9.01	0.24
R1	12361	Max WS	8.03	221.41	223.51		223.52	0.000293	0.55	21.22	36.04	0.16
R1	12107	Max WS	8.02	221.10	223.46		223.47	0.000141	0.40	37.31	51.83	0.11
R1	11898	Max WS	8.01	220.84	223.40		223.42	0.000363	0.60	16.74	19.42	0.17
R1	11664	Max WS	8.01	220.55	222.70		222.83	0.005809	1.63	4.93	5.93	0.54
R1	11437	Max WS	8.01	220.27	222.16		222.18	0.000405	0.64	14.54	16.69	0.18
R1	11259	Max WS	8.01	220.05	221.91		221.97	0.001867	1.08	7.39	7.94	0.36
R1	11018	Max WS	8.01	219.75	221.49		221.54	0.001544	1.03	7.79	7.99	0.33
R1	10912	Max WS	8.00	219.62	221.43	220.26	221.44	0.000148	0.44	19.33	15.16	0.11
R1	10905		Bridge									
R1	10899	Max WS	8.00	219.84	221.43		221.44	0.000215	0.50	17.33	16.03	0.14
R1	10863	Max WS	8.00	219.77	221.22		221.37	0.006791	1.70	4.70	6.50	0.64

HEC-RAS Plan: 100yrB   River: Big Creek   Reach: R1   Profile: Max WS (Continued)

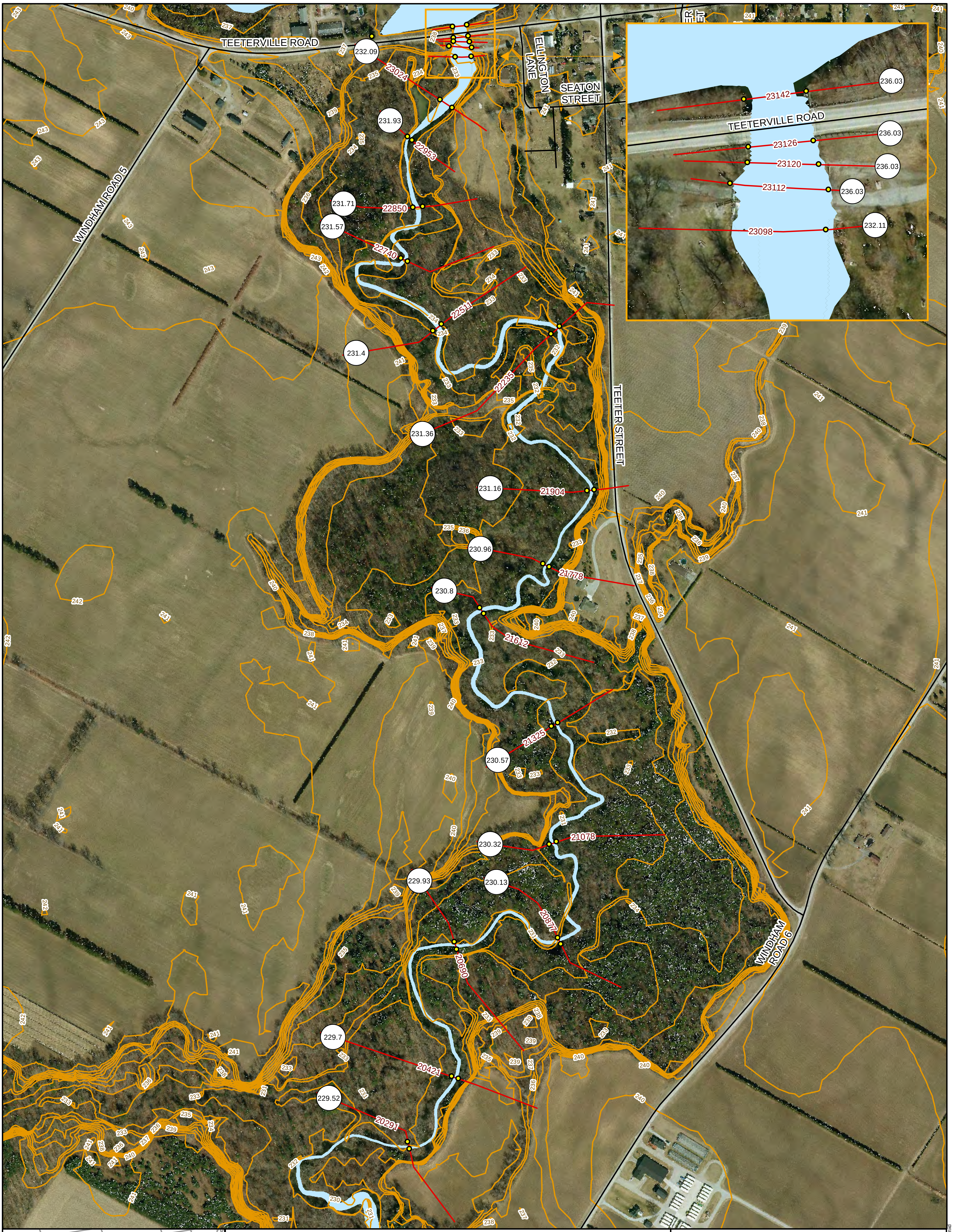
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	10758	Max WS	8.00	219.57	220.91		220.95	0.001044	0.84	10.94	15.54	0.28
R1	10496	Max WS	8.00	219.07	220.54		220.59	0.001775	0.99	8.53	15.98	0.36
R1	10264	Max WS	8.00	218.63	220.17		220.22	0.001621	0.97	9.22	16.76	0.34
R1	9975	Max WS	8.00	218.08	219.80		219.84	0.001152	0.88	10.67	17.13	0.29
R1	9680	Max WS	7.99	217.51	219.33		219.40	0.002055	1.13	8.30	14.92	0.38
R1	9636	Max WS	7.99	217.43	219.31	218.36	219.33	0.000605	0.71	11.19	10.08	0.22
R1	9633		Bridge									
R1	9626	Max WS	7.99	217.64	219.29		219.31	0.000501	0.71	11.26	13.13	0.21
R1	9593	Max WS	7.99	217.61	219.29		219.30	0.000358	0.53	15.44	16.87	0.17
R1	9531	Max WS	7.99	217.53	219.26		219.28	0.000293	0.57	16.43	19.58	0.16
R1	9294	Max WS	7.99	217.35	218.86		218.94	0.002929	1.21	6.60	8.72	0.44
R1	8978	Max WS	7.99	217.07	218.17		218.22	0.001898	0.98	8.15	11.21	0.37
R1	8768	Max WS	7.98	216.88	217.89		217.92	0.000971	0.75	10.66	13.15	0.27
R1	8457	Max WS	7.98	216.61	217.65		217.67	0.000670	0.67	11.86	12.96	0.22
R1	8134	Max WS	7.98	216.32	217.35		217.38	0.001154	0.80	9.95	12.42	0.29
R1	7982	Max WS	7.98	216.19	217.13		217.18	0.001560	0.97	8.25	9.36	0.33
R1	7854	Max WS	7.97	216.07	216.93		216.98	0.001692	0.95	8.42	10.96	0.34
R1	7297	Max WS	7.97	215.58	216.30		216.32	0.000749	0.60	13.30	18.73	0.23
R1	6668	Max WS	7.95	215.02	215.85		215.87	0.000703	0.63	12.65	15.98	0.23
R1	6443	Max WS	7.95	214.82	215.66		215.68	0.000993	0.74	10.69	13.28	0.26
R1	5556	Max WS	7.93	214.04	215.15		215.16	0.000223	0.42	18.77	17.17	0.13
R1	4951	Max WS	7.92	213.50	214.47		214.52	0.001979	0.98	8.08	11.60	0.38
R1	4631	Max WS	7.92	213.22	214.06		214.09	0.000826	0.68	11.60	14.56	0.24
R1	4357	Max WS	7.92	212.98	213.81		213.84	0.001055	0.76	10.46	13.14	0.27
R1	4198	Max WS	7.92	212.84	213.68		213.70	0.000736	0.64	12.30	15.30	0.23
R1	4132	Max WS	7.92	212.78	213.57	213.26	213.61	0.002120	0.87	9.07	16.54	0.38
R1	4120		Bridge									
R1	4109	Max WS	7.92	212.78	213.45		213.51	0.004169	1.10	7.21	15.53	0.51
R1	4060	Max WS	7.92	212.72	213.37		213.39	0.001112	0.68	11.59	18.10	0.27
R1	3694	Max WS	7.91	212.26	213.09		213.11	0.000516	0.54	14.55	17.93	0.19
R1	3381	Max WS	7.91	211.88	212.82		212.86	0.001114	0.80	9.89	12.32	0.28
R1	3007	Max WS	7.85	211.41	212.41		212.44	0.000996	0.75	10.49	13.01	0.27
R1	2542	Max WS	7.77	210.83	212.13		212.14	0.000202	0.43	18.27	16.38	0.13
R1	2286	Max WS	7.75	210.52	212.07		212.08	0.000212	0.43	18.22	17.07	0.13
R1	2232	Max WS	7.74	210.45	212.07	210.98	212.08	0.000058	0.23	32.97	29.15	0.07
R1	2222		Bridge									
R1	2212	Max WS	7.74	210.45	212.07		212.07	0.000070	0.27	28.74	29.12	0.08
R1	2155	Max WS	7.73	210.50	212.06		212.07	0.000106	0.31	25.24	23.18	0.09
R1	2084	Max WS	7.72	210.55	212.04		212.05	0.000267	0.45	17.23	17.73	0.15
R1	1956	Max WS	7.71	210.65	211.99		212.01	0.000429	0.55	14.13	15.54	0.18

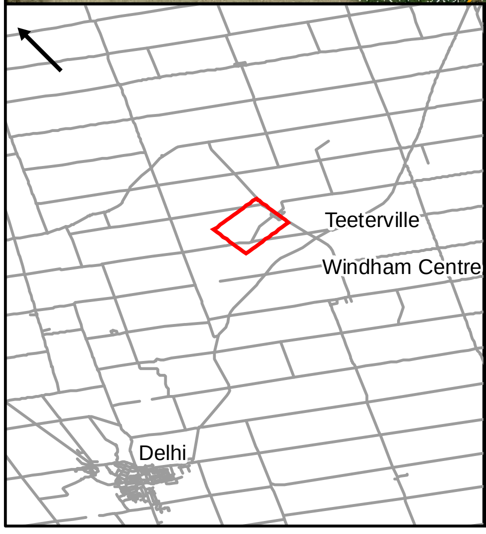
HEC-RAS Plan: 100yrB River: Big Creek Reach: R1 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
R1	1884	Max WS	7.70	210.72	211.92	211.47	211.95	0.001230	0.75	10.21	15.38	0.30
R1	1866		Bridge									
R1	1848	Max WS	8.65	210.72	211.49	211.50	211.70	0.018922	2.04	4.24	11.19	1.06
R1	1806	Max WS	8.60	210.44	210.94		211.04	0.009194	1.37	6.29	17.77	0.73
R1	1471	Max WS	8.39	208.30	209.14		209.21	0.003580	1.18	7.08	12.05	0.49
R1	1276	Max WS	8.32	207.06	208.84		208.85	0.000158	0.38	22.18	19.57	0.11
R1	1221	Max WS	8.31	207.37	208.81	208.10	208.83	0.000483	0.59	14.15	14.81	0.19
R1	1206		Bridge									
R1	1192	Max WS	8.31	207.94	208.70		208.74	0.002370	0.95	8.73	14.97	0.40
R1	1139	Max WS	8.30	207.82	208.58		208.62	0.002551	0.85	9.73	20.75	0.40
R1	1038	Max WS	8.24	207.58	208.44		208.46	0.000639	0.56	14.69	20.90	0.21
R1	875	Max WS	8.23	207.20	208.20		208.23	0.002359	0.83	9.93	21.24	0.39
R1	557	Max WS	8.20	206.46	207.47		207.52	0.002326	1.00	8.23	12.85	0.40
R1	500	Max WS	8.20	206.54	207.40	207.04	207.43	0.001213	0.69	11.94	20.63	0.29
R1	482		Bridge									
R1	465	Max WS	8.18	206.54	207.32		207.35	0.001919	0.79	10.29	20.14	0.36
R1	397	Max WS	8.17	206.31	207.26		207.27	0.000556	0.52	15.83	23.28	0.20
R1	115	Max WS	8.14	205.51	206.84		206.89	0.002336	1.03	7.93	11.96	0.40
R1	5	Max WS	8.13	205.19	206.54	206.17	206.61	0.002944	1.17	6.97	10.34	0.45

Appendix E

Inundation Maps





Legend

● Bank Point

Cross Section

Road

Sunny Day Failure Inundation

xx Sunny Day Flailure Water Surface Elevation

N

Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	Figure 1

AECOM Canada Ltd

0 85 170 340
Meters

Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_SunnyDay.mxd
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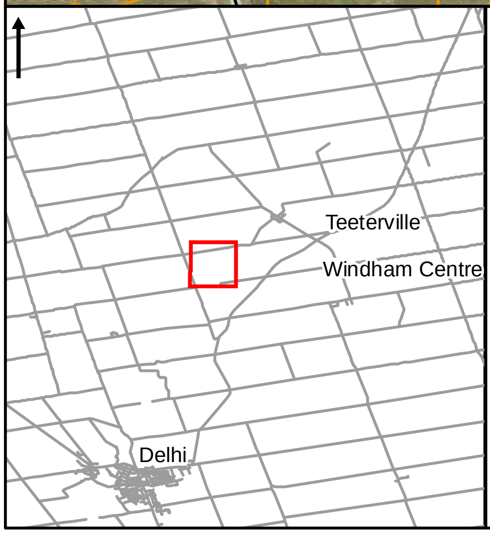


Legend

- ● Bank Point
- Cross Section
- Road
- 🟦 Sunny Day Failure Inundation
- ○ XX Sunny Day Flailure Water Surface Elevation

N

Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015

1:5,000

Datum: NAD 83 Zone 17
Source:

P#: 60439243

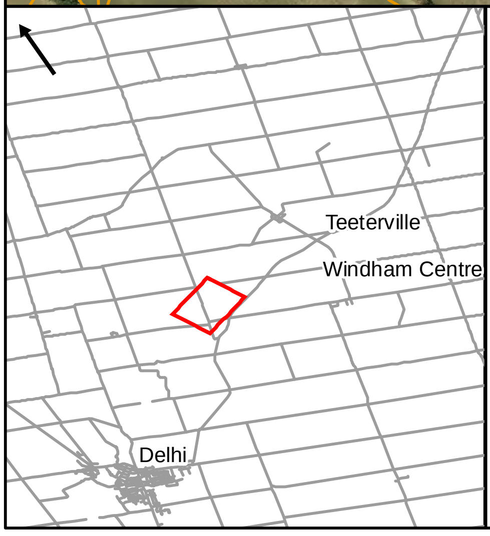
V#:

AECOM
AECOM Canada Ltd

Figure 2

0 85 170 340
Meters

Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_SunnyDay.mxd
Date Saved: 11/26/2015 4:05:29 PM



Legend

● Bank Point

— Cross Section

— Road

▭ Sunny Day Failure Inundation

○ XX Sunny Day Flailure Water Surface Elevation

N

Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	
AECOM Canada Ltd		Figure 3

0 85 170 340
Meters

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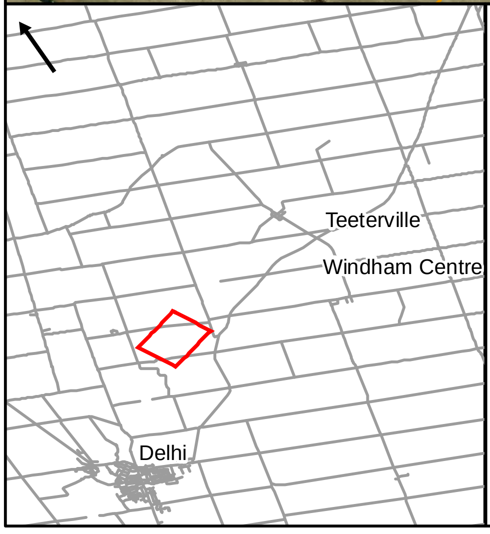

Legend

● Bank Point

Cross Section

Road

🟦 Sunny Day Failure Inundation

○ XX Sunny Day Flailure Water Surface Elevation

N

Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	**Figure 4**

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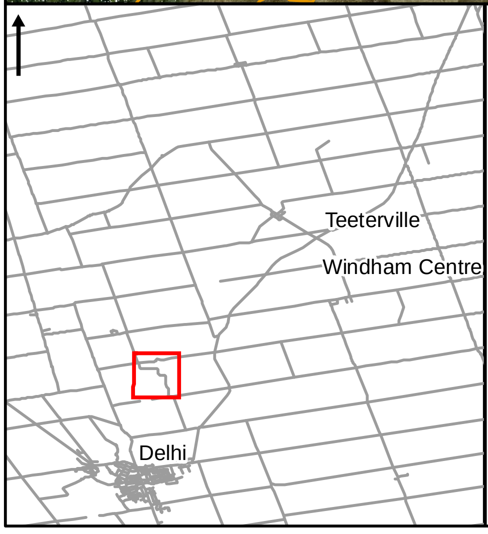

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● Bank Point

— Cross Section

— Road

▬ Sunny Day Failure Inundation

○ xx Sunny Day Flailure Water Surface Elevation

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Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	

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Figure 5

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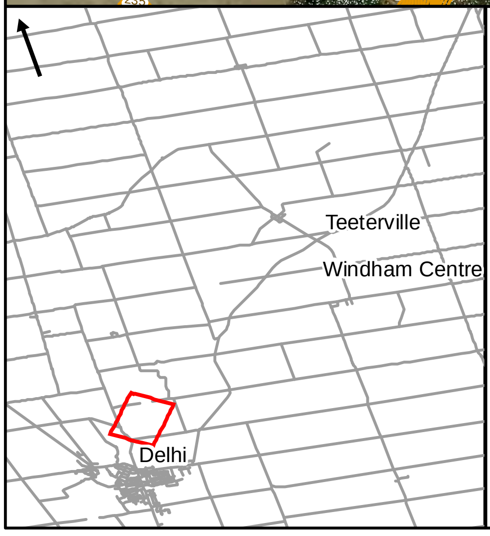

Legend

- ● Bank Point
- — Cross Section
- — Road
- 🟦 Sunny Day Failure Inundation
- XX Sunny Day Flailure Water Surface Elevation

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Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	

AECOM Canada Ltd

Figure 6

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Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_SunnyDay.mxd
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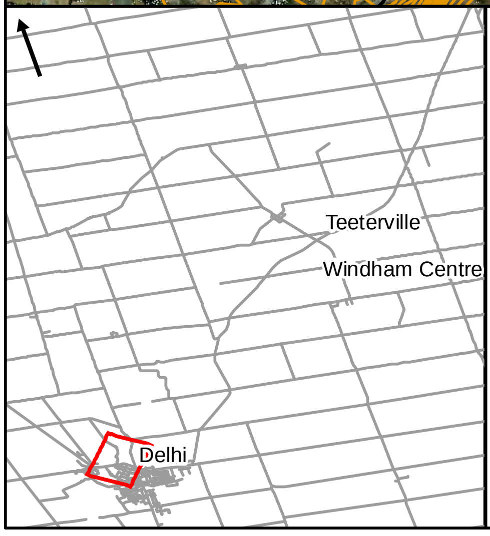

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● Bank Point

Cross Section

Road

🟦 Sunny Day Failure Inundation

○ xx Sunny Day Flailure Water Surface Elevation

N

Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	Figure 7

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AECOM Canada Ltd

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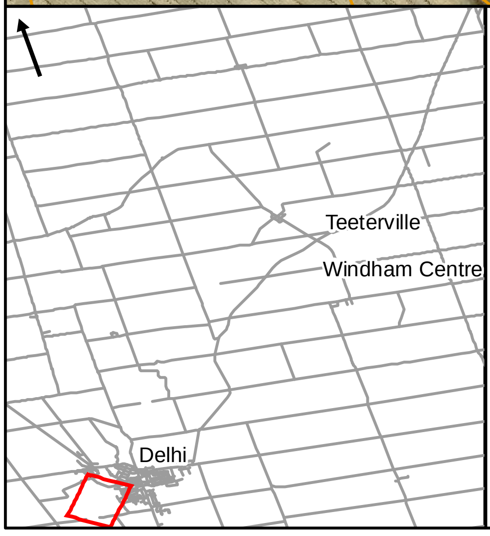

Legend

- ● Bank Point
- Cross Section
- Road
- Sunny Day Failure Inundation
- XX Sunny Day Flailure Water Surface Elevation

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Teeterville Dam Break Analysis

Sunny Day Failure Inundation Map

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
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AECOM
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Figure 8

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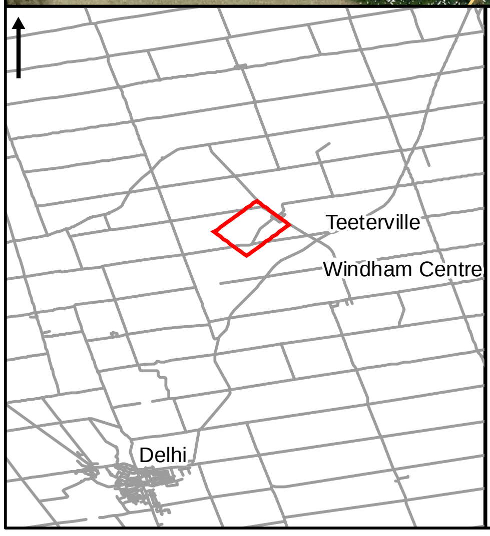

Legend

- ● Bank Point
- Cross Section
- Road
- 🟦 100 Year Flood Inundation
- 🟦 100 Year Flood with Dam Failure inundation
- xx 100 Year Water Surface Elevation
- xx 100 Year with Dam Failure Water Surface Elevation

Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	**Figure 1**

AECOM
AECOM Canada Ltd

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Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_100YR.mxd
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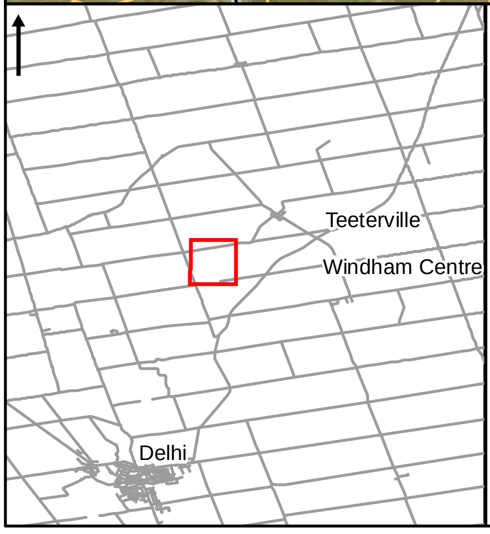

Legend

- ● Bank Point
- Cross Section
- Road
- 100 Year Flood Inundation
- 100 Year Flood with Dam Failure inundation
- xx 100 Year Water Surface Elevation
- xx 100 Year with Dam Failure Water Surface Elevation

N

Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	
AECOM AECOM Canada Ltd		**Figure 2**

0 85 170 340
Meters

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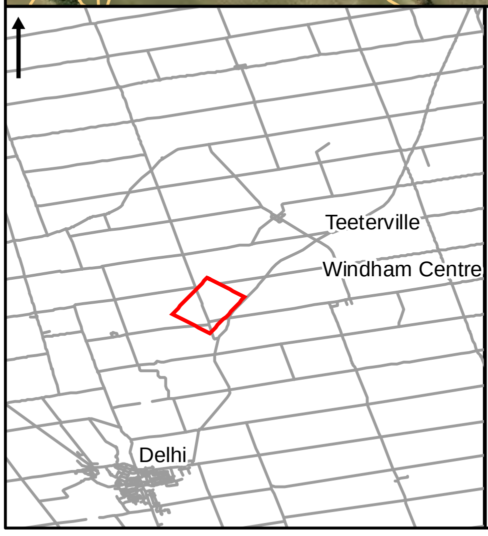

Legend

- ● Bank Point
- — Cross Section
- — Road
- ▨ 100 Year Flood Inundation
- ▨ 100 Year Flood with Dam Failure inundation
- xx 100 Year Water Surface Elevation
- xx 100 Year with Dam Failure Water Surface Elevation

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Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	Figure 3

AECOM
AECOM Canada Ltd

0 85 170 340
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Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_100YR.mxd
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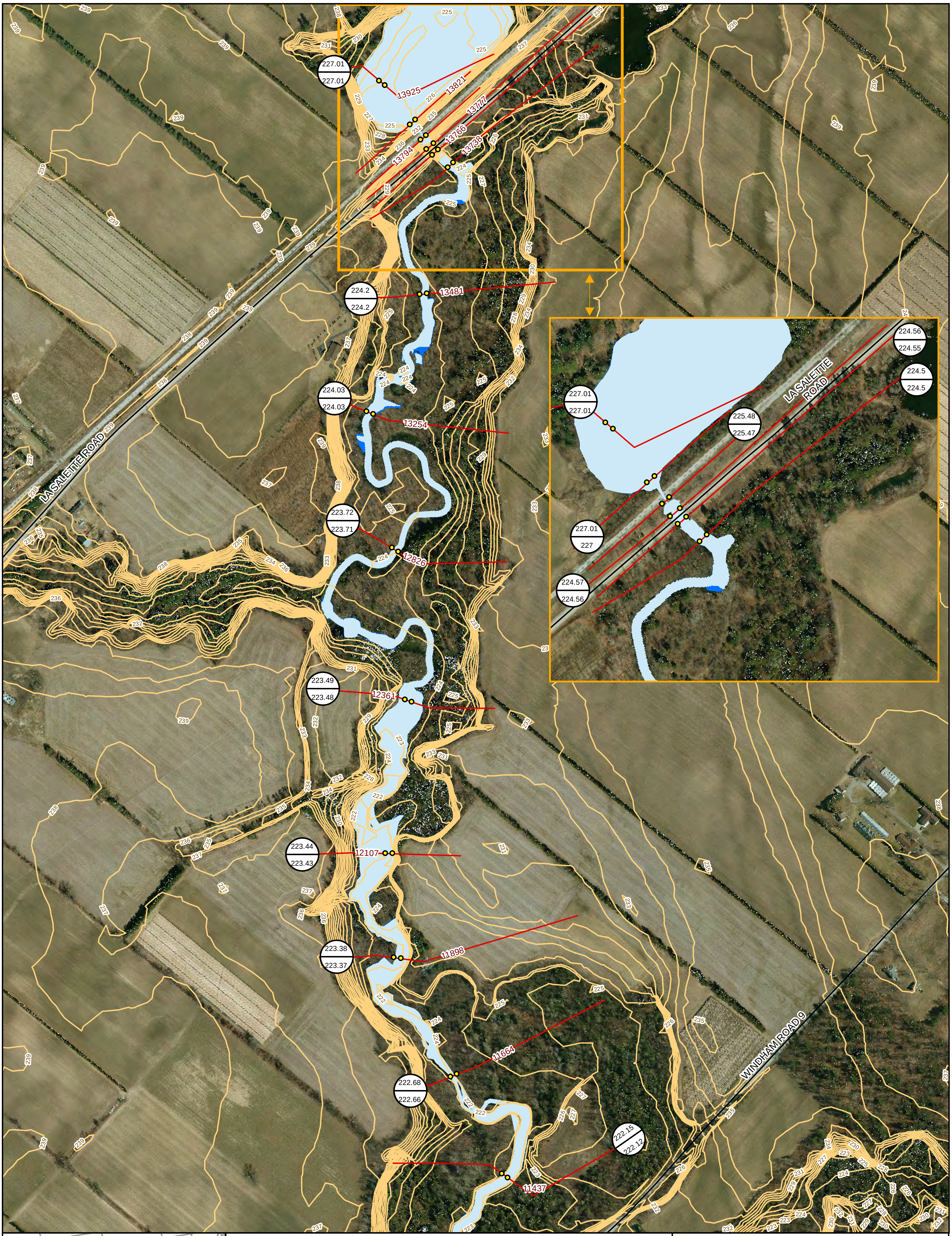

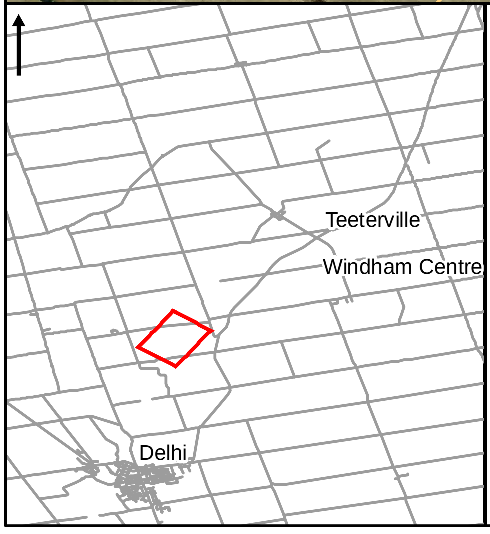

Legend

- ● Bank Point
- — Cross Section
- — Road
- ▨ 100 Year Flood Inundation
- ▨ 100 Year Flood with Dam Failure inundation
- xx 100 Year Water Surface Elevation
- xx 100 Year with Dam Failure Water Surface Elevation

N

Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	
AECOM AECOM Canada Ltd		Figure 4

0 85 170 340
Meters

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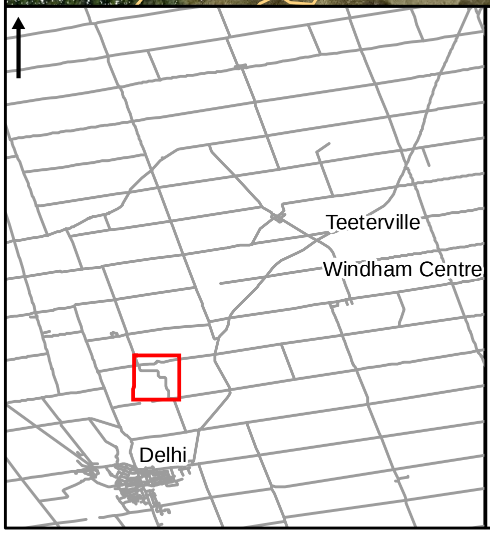

Legend

● Bank Point

— Cross Section

— Road

▢ 100 Year Flood Inundation

🟦 100 Year Flood with Dam Failure inundation

xx / xx 100 Year Water Surface Elevation / 100 Year with Dam Failure Water Surface Elevation

N

Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015

1:5,000

Datum: NAD 83 Zone 17
Source:

P#: 60439243

V#:

AECOM
AECOM Canada Ltd.

Figure 5

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Meters

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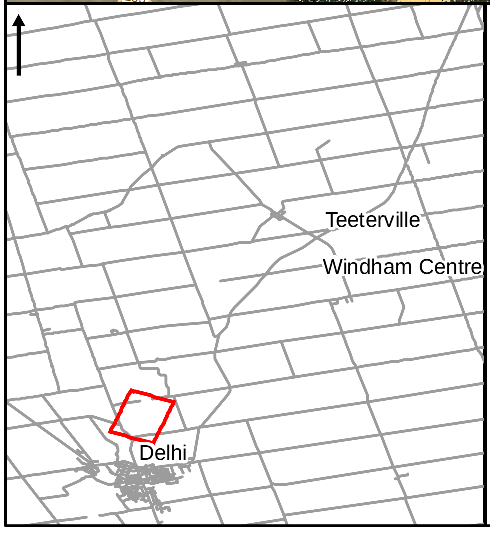

Legend

- ● Bank Point
- ▬ Cross Section
- ▬ Road
- 🟦 100 Year Flood Inundation
- 🟦 100 Year Flood with Dam Failure inundation
- xx 100 Year Water Surface Elevation
- xx 100 Year with Dam Failure Water Surface Elevation

N

Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	
AECOM AECOM Canada Ltd		**Figure 6**

0 85 170 340
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Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_100YR.mxd
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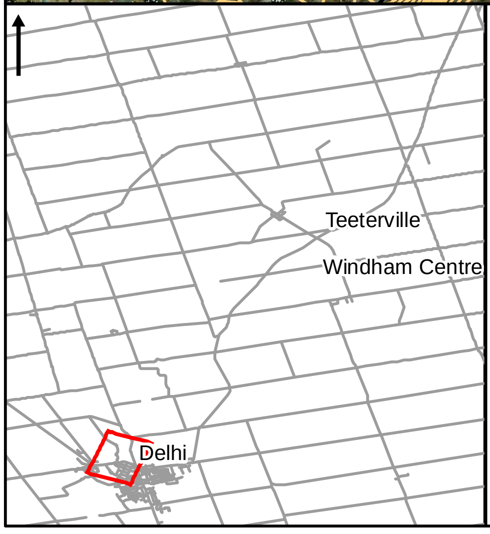

Legend

● Bank Point

Cross Section

Road

🟦 100 Year Flood Inundation

🟦 100 Year Flood with Dam Failure inundation

xx 100 Year Water Surface Elevation

xx 100 Year with Dam Failure Water Surface Elevation

N

Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015

1:5,000

Datum: NAD 83 Zone 17
Source:

P#: 60439243
V#:

AECOM
AECOM Canada Ltd.

Figure 7

0 85 170 340
Meters

Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_100YR.mxd
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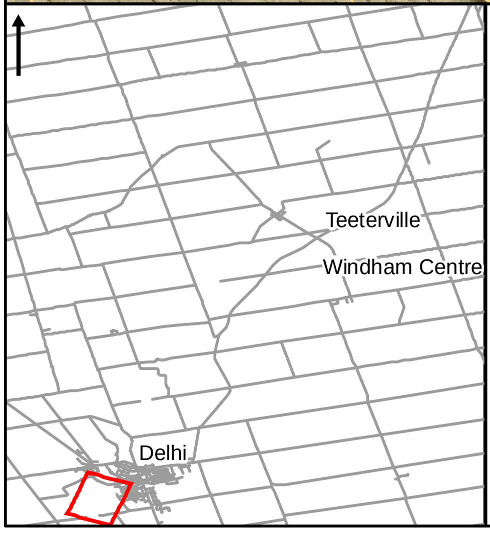

Legend

- ● Bank Point
- Cross Section
- Road
- 100 Year Flood Inundation
- 100 Year Flood with Dam Failure inundation
- xx 100 Year Water Surface Elevation
- xx 100 Year with Dam Failure Water Surface Elevation

N

Teeterville Dam Break Analysis

Inflow Design Flood (100 Year) with Inundation

November 2015	1:5,000	Datum: NAD 83 Zone 17 Source:
P#: 60439243	V#:	
AECOM Canada Ltd		**Figure 8**

0 85 170 340
Meters

Map location: P:\60439243 Teeterville\900-Work\920-929 (GIS-Graphics)\Design\Floodline_Map_100YR.mxd
Date Saved: 11/25/2015 9:10:42 AM

Appendix F

Geotechnical Investigation Report

THURBER ENGINEERING LTD.

GEOTECHNICAL INVESTIGATION
TEETERVILLE DAM STABILITY AND CONDITION ASSESSMENT
LONG POINT REGION CONSERVATION AUTHORITY
TEETERVILLE, ONTARIO

Report

to

AECOM

LICENSED PROFESSIONAL ENGINEER
M Farrant
M.E. FARRANT
100053767
March 9, 2016
PROVINCE OF ONTARIO

Mark. Farrant, P.Eng.
Project Engineer

LICENSED PROFESSIONAL ENGINEER
S. M. SATHER
100052476
Mar 9/16
PROVINCE OF ONTARIO

Date: March 9, 2016
File: 19-5438-141

Steve Sather, P. Eng.
Review Engineer

TABLE OF CONTENTS

1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by Thurber Engineering Limited (Thurber) on the Teeterville Dam located immediately south of County Road 25 (Teeterville Road) in Teeterville, Ontario. Thurber's investigation was completed for the earthern berm portion of the dam, as part of a Dam Stability and Condition Assessment being conducted by AECOM for the Long Point Region Conservation Authority (LPRCA). Thurber's scope of work for this investigation was outlined in Section 6.3.2 of AECOM's proposal to LPRCA, dated June, 2015 and amended as described in AECOM's Request for Clarifications on Scope response document dated June 25, 2015.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SCOPE OF WORK

The scope of work of the investigation included a review of existing documentation and drawings provided by LPRCA, a visual inspection of the dam to assess areas of potential instability, internal erosion and seepage discharge at the toe of the dam, and an intrusive investigation consisting of drilling one borehole through the roadway immediately south of the dam. The borehole was drilled to 11.3 m depth to allow for samples of the embankment and foundation soils to be collected and to install a monitoring well to facilitate the collection of groundwater levels in the dam.

3. BACKGROUND

3.1 Site Description

The Teeterville Dam is located on Big Creek near the village of Teeterville in Norfolk County, Ontario. The dam is oriented in a general northwest-southeast direction and consists of an earthern berm structure and a central concrete spillway containing wooden stop logs. In the past, the berm served as a road embankment for Old County Road 25 (County Road 6) and with the dam abutments, supported a steel truss bridge to facilitate traffic flow over the concrete spillway structure. In recent years, realignment of the roadway and construction of a new bridge upstream of the existing dam have resulted in the abandonment of the old roadway and bridge.

The area surrounding the dam and reservoir is mainly treed, with some residential and agricultural properties located along County Road 25 to the northwest and southeast of the site. The new bridge, roadway and associated embankments separate the dam from the reservoir to the northeast.

The downslope of the earthern dam on the east side of the creek is adjacent to a residential property with a combination of trees, gardens, and a manicured lawn. The downslope area to the west side of the creek is a LPRCA Conservation area that is mainly treed with a lawn area adjacent to the dam. To the south and downstream of the dam, Big Creek meanders in a general southwest direction towards Lake Erie.

The earthern berm portion of the dam is approximately 80 m long, and the concrete structure is about 30 m long.

3.2 Site History and Existing Documentation

The available records indicate that the Teeterville Dam was originally built in the early 1900s but the exact date is unknown. The dam was modified sometime around 1962 to include concrete piers on the downstream face to facilitate the use of winches to install stop logs to raise the water level in the reservoir by approximately 1 m. The piers segment the spillway into 4 bays that can hold 3 stop logs each. The LPRCA took ownership of the dam in 1970 and have been responsible for its operation since. The winch system was fully replaced in 1997. Currently, the pond is used for recreation, agriculture and as a water supply for fire trucks.

The existing documentation provided by LPRCA includes pre-construction drawings for the modifications to Teeterville Dam from 1962, a pre-construction drawing of the new bridge and road realignment upstream of the dam from 1971, and a Dam Inspection report by Riggs Engineering from 2014. The 1962 drawings show a plan of the existing spillway and the proposed stop log hoist. The 1971 plan and profile drawing shows the proposed new road alignment of County Road 25 and bridge location. No construction details for the earthern berm are provided in either drawing.

The 2014 Dam Inspection report notes seepage through the left and right downstream wingwalls and at the interface of the concrete piers at the Teeterville Dam spillway structure. The upstream wingwalls have since been buried by the construction of County Road 25 or covered with stacked blocks. Where visible on the left (facing downstream) upstream wingwall, a crack greater than 10 mm in width was identified. The report noted that the upstream embankment face for the earthern portion of the dam no longer abuts the reservoir, and that southern side of the County Road 25 embankment renders it obsolete. The downstream embankment slope was in good condition with no evidence of cracks or settlement with the exception of local voids adjacent to the grouted concrete at the right downstream wingwall. Wetness was observed at the left wingwall at the bank interface but the cause is unknown.

During a September 9, 2015 site visit and meeting, LPRCA staff familiar with the history of the dam stated that there is minimal concern with the earthen berm as there are no known seepage issues.

3.3 Site Observations

A visual inspection of the dam and site area was carried out on September 9, 2015 by M. Farrant, P.Eng. of Thurber, accompanied by LPRCA and AECOM staff. Selected photographs from the inspection are included in Appendix A and site observations are shown on Drawing 19-5438-141-1 in Appendix B.

The embankment that carries County Road 25 over Big Creek upstream of Teeterville Dam is connected and elevated relative to the original earth berm (Photo 1 and 2). Although this extension of the earthern berm now abuts the reservoir, no evidence of seepage or sinkholes was observed between the road embankment and the berm. In addition, no evidence of sinkholes or seepage was identified on the downstream side of the berm on either side of the spillway structure (Photos 3 and Photo 4). The downstream slope on the east side of the structure is vegetated with shrubs and tall grass.

The northwest downstream slope shows evidence of erosion from run-off at the crest of the slope (Photo 5 and 6). A loss of material was also observed at the downstream wingwall on the northwest side as a result of run-off (Photo 7). Seepage between the concrete wingwall and pier was also observed at this location (Photo 8).

Large trees with approximately 2 foot diameter trunks were present at both abutments and consisted of Poplar on the northwest side and Willow on the southeast side.

A separate diver inspection completed for AECOM by Watech Services Inc. entitled, “Inspection of Teeterville Dam, Teeterville, Ontario, WSI 15178”, dated October 2015, reported voids beneath the downstream slab of the spillway structure.

4. INVESTIGATION PROCEDURES

Following the visual inspection, a borehole investigation was carried out to obtain preliminary information on subsurface materials in the dam and relative piezometric pressures below the dam. Altech Drilling and Investigation Services Limited (Altech) of Elmira, Ontario was subcontracted by Thurber to complete the investigation. The drilling was carried out on October 9th, 2015 and consisted of drilling one (1) borehole (identified as 15-01) immediately south of the concrete spillway structure. Prior to drilling, the borehole location was cleared for underground utilities and a road excavation permit was acquired from Norfolk County. The location of the borehole was established relative to existing site features. The coordinates and elevation of the borehole were estimated based on survey information provided by AECOM. The approximate location of the borehole is shown on Drawing No. 19-5438-141-1, Borehole Location Plan, in Appendix B.

The borehole was advanced to a depth of 11.3 m using a truck-mounted, Diedrich D-120 drill rig. Full time supervision of the subsurface investigation activities was carried out by Thurber's drilling inspector. Soil samples of the embankment fill and native overburden soils were retrieved with a split spoon sampler during standard penetration tests (SPT) completed at routine intervals within the boreholes. Subsurface conditions were logged in the field and representative soil samples were collected and returned to Thurber's laboratory in Oakville, Ontario for geotechnical laboratory testing.

A 50 mm diameter monitoring well was installed in the borehole to allow for measurement of the groundwater level in the dam. The LPRCA was responsible for obtaining water level measurements, under direction by Thurber staff.

Details of the conditions encountered during drilling are summarized on the Record of Borehole sheet in Appendix C.

5. SITE CONDITIONS

5.1 Regional Geologic Conditions

The Teeterville Dam is located within the Norfolk Sand Plain physiographic region. The geology generally comprises older to modern alluvial deposits including clay, silt, sand and organic material (OGS Map P. 1054, Quaternary Geology, Simcoe Area, 1976). The deep bedrock (greater than 30 m deep) in the area comprises Devonian limestone of the Onondaga Formation (OGS Map P. 2234, 1975). Recently, agriculture, dam, and road construction activities in the area have resulted in placement of anthropogenic (fill) deposits in some areas.

5.2 Soil Conditions

General descriptions of the soil conditions are given below. The attached Record of Borehole sheet in Appendix C provides detailed descriptions of the soil conditions encountered during the investigation and must be used in preference to the generalized descriptions provided in this section.

The borehole was advanced through the abandoned roadway immediately south of the concrete spillway structure. The stratigraphy encountered in Borehole 15-01 consisted of a surficial layer of asphalt underlain by a sand fill. Native silty sand was encountered below the fill, and was further underlain by a layer of sandy silt. The borehole was terminated in a sand deposit.

5.2.1 Asphalt

Asphalt was encountered at the ground surface in Borehole 15-01 with a thickness of 140 mm.

5.2.2 Sand Fill

The fill material underlying the asphalt consisted of sand and contained trace to some silt and trace amounts of clay and gravel. Occasional rootlets and other organic material was also encountered within the fill. The total thickness of the fill was 5.3 m at the borehole location.

SPT N-values in the fill ranged from 6 to 9 blows per 0.3 m penetration indicating a loose relative density. A very loose zone was encountered at a depth of 3.96 m which correlated to the water level at the time of drilling. A 50 mm piece of wood was encountered at a depth of 4.7 m which gave an uncharacteristically high N-value. The moisture content of samples from the fill ranged from 3% to 22%.

The results of grain size distribution analyses conducted on samples of the fill are shown on Figure D1 in Appendix D.

5.2.3 Silty Sand

Native silty sand was encountered below the fill and extended to a depth of 6.8 m (Elevation 231.0 m). The silty sand contained some gravel and trace clay. Some rootlets and other organic material was also encountered within the silty sand.

Two SPT N-values were recorded in the native silty sand at 9 blows per 0.3 m, indicating a loose density. The silty sand was wet, with a moisture content of 19%.

5.2.4 Sandy Silt

A sandy silt layer was encountered underlying the silty sand and extended to a depth of 8.9 m (Elevation 228.9 m). The sandy silt contained trace amounts of gravel and clay. Trace clay seams were observed throughout the sample.

SPT N-values in the sandy silt ranged from 9 to 15 blows per 0.3 m penetration indicating a loose to compact relative density. The moisture contents of samples from the sandy silt ranged from 21% to 29%.

The results of a grain size distribution analysis conducted on a sample of the sandy silt is shown on Figure D2 in Appendix D.

5.2.5 Sand

A sand layer was encountered underlying the sandy silt and extended to the borehole termination depth of 11.3 m (Elevation 226.5 m). The sand contained some silt and trace amounts of clay. SPT N-values in the sandy silt ranged from 24 to 25 blows per 0.3 m penetration indicating a compact relative density. The moisture contents of samples from the sand ranged from 19% to 21%.

The results of a grain size distribution analysis conducted on a sample of the sand is shown on Figure D3 in Appendix D.

5.2.6 Groundwater

A monitoring well was installed in Borehole 15-01 to monitor the groundwater elevation at the Teeterville Dam. Details of the monitoring well installation are shown on the Record of Borehole sheet included in Appendix C. In addition to the well, a groundwater level measurement was taken upon completion of drilling. This is an unstabilized reading and therefore gives an approximate elevation of the groundwater at the time of drilling. The groundwater levels measured are summarized in the following table.

Borehole	Date	Depth to Groundwater (m)	Groundwater Elevation (m)	Comment
15-01	October 9, 2015	4.1	233.7	Open Borehole
	October 22, 2015	4.5	233.3	Monitoring Well
	November 6, 2015	4.5	233.3	Monitoring Well

The water level measurements should be expected to vary seasonally and with significant weather events.

6. GEOTECHNICAL ASSESSMENT

6.1 Foundation Conditions

Based on the subsurface stratigraphy found in Borehole 15-01, which was drilled through the embankment at the southeast end of the dam structure, the dam and the earthern berm are likely founded on loose to compact silty sand to sandy silt, with an estimated angle of internal friction of approximately 28 to 30 degrees. The estimated bearing resistance at the downstream toe of the embankment will vary depending on base width, elevation, and seepage conditions. It is recommended that a specific geometry be selected prior to calculation of this parameter.

Based on the results of the inspection of the concrete spillway structure completed by Watech Services Inc, we understand that the structure is likely founded on an aggregate material, such as rock fill, which has been significantly undermined.

6.2 Embankment Stability

A preliminary stability analysis was carried out for the dam using Slope/W of the GeoStudio software package which calculates limit equilibrium stability conditions based on the Morgenstern-Price method. The configuration of the dam used in the analysis was based on the survey information provided by AECOM as well as visual observations and existing map data. Soil parameters used in the analysis were based on the borehole data obtained from the drilling investigation. The piezometric surface was approximated using survey measurements of the reservoir and creek water levels, and the water levels measured in the piezometer installed at Borehole 15-01.

Based on an approximate embankment configuration consisting of a 4 m high berm with a 2 H : 1V downstream side slope, adjacent to the existing roadway embankment, a Factor of Safety of 1.9 for the downstream slope was obtained from the analysis (Figure E1 in Appendix E). This is above the recommended minimum Factor of Safety of 1.5 for a stable embankment slope under long-term steady-state conditions with normal reservoir level (based on Ministry of Natural Resources Technical Bulletin for Geotechnical Design and Factors of Safety, August 2011).

6.3 Internal Erosion

Aside from undermining of the base slab, localized seepage at the interface with the concrete wingwalls, and localized erosion at the crest of the dam due to runoff, the history of site observations does not include significant reported evidence of internal erosion occurring at the site.

The embankment fill and underlying native soils are generally fine-grained, poorly graded, uniform sands and silts, with low plasticity. These soil types are considered to be extremely erodible and offer little piping resistance. Depending on seepage conditions within the berm, there is a potential for the loss of fine soil particles, and internal erosion or piping. Therefore, the site conditions indicate that there is a risk that internal erosion issues may develop under high water conditions.

7. REMEDIAL OPTIONS AND RECOMMENDATIONS

Some measures that may be taken to reduce the potential for future internal erosion issues include the following:

- Installing an impermeable cut-off or upstream blanket to reduce the seepage pressures through the berm and reduce the potential for loss of fine soil particles;
- Trees should be removed from the surface of the dam, particularly on the downslope area;
- Divert stormwater runoff away from the spillway and original dam surface to reduce potential erosion at the crest of the embankment berm; and
- Conduct regular observations of the berm and the downstream soil to note the presence of potential indicators of erosion. This may include sinkholes, depressions, stream bank erosion, or deposition of material downstream.

Further investigation and analysis would be required to carry out a detailed assessment of the embankment stability and potential for internal erosion, and development of detailed remedial measures.

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

APPENDIX A

Site Photographs

Photo 1: Looking northwest at Teeterville Dam
Note: County Road 25 upstream of dam

Photo 2: Looking southeast at Teeterville Dam
Note: County Road 25 upstream of dam

Photo 3: Looking northwest along downstream slope
Note: Highly vegetated southeast slope; Non-vegetated northwest slope

Photo 4: Looking southeast along downstream slope
Note: Highly vegetated southeast slope

Photo 5: Looking north at northwest downstream slope
Note: Eroded patches in the grass due to run-off

Photo 6: Looking north at northwest downstream slope
Note: Close up image of erosion

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Photo 7: Looking north at northwest downstream wingwall
Note: material loss at top corner; Slump at bottom of slope

Photo 8: Looking north at northwest downstream wingwall
Note: Seepage between concrete wingwall and pier

APPENDIX B

Borehole Location Plan

Source: “Ontario.” 545200.00 m E 4754999.00 m N. **Google Earth**.
September 27, 2013. January 27, 2016.

⌖ APPROX. BOREHOLE LOCATION

AECOM

TEETERVILLE DAM
STABILITY AND CONDITION ASSESMENT
GEOTECHNICAL INVESTIGATION

BOREHOLE LOCATION PLAN

JOB# 19-5438-141

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
MEF	MFA	SMS
DATE :	SCALE :	DRAWING No.
JANUARY 2016	1:800	19-5438-141-1

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APPENDIX C

Record of Borehole Sheet

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT(1) ‘N’ VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT “N” VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample
WS Wash Sample
AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample
TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure
PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight
RC Rock Core
SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT ‘N’ Value Standard Penetration Test ‘N’ Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to “A” size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

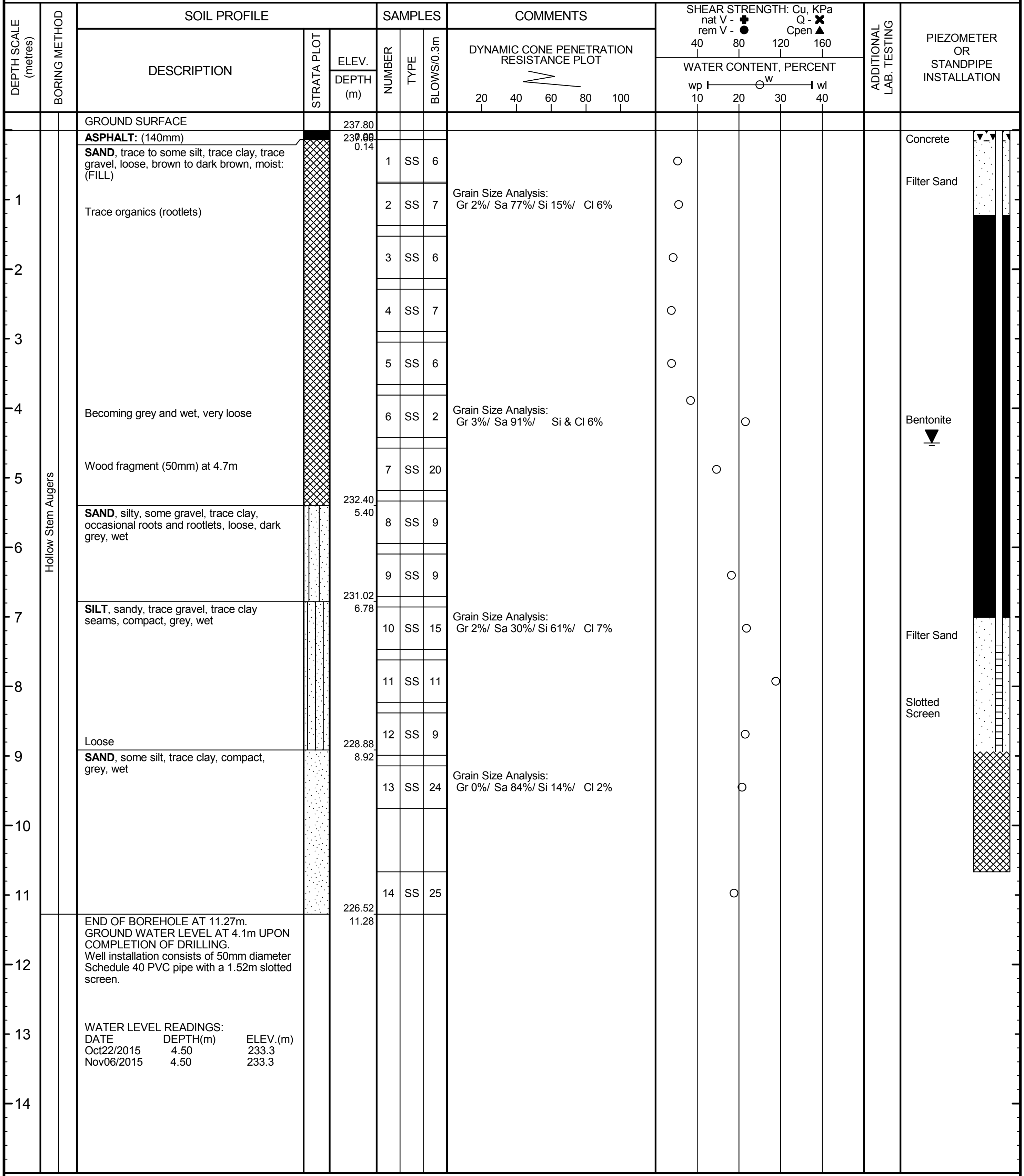
UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE 15-01

PROJECT : Teeterville Dam - Stability and Condition Assessment
LOCATION : Teeterville, ON
STARTED : October 9, 2015
COMPLETED : October 9, 2015
N 4 754 999.0 E 545 200.0

Project No. 19-5438-141
SHEET 1 OF 1
DATUM



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	237.80
ASPHALT: (140mm)	237.66 0.00
SAND, trace to some silt, trace clay, trace gravel, loose, brown to dark brown, moist: (FILL)	0.14
Trace organics (rootlets)	
Becoming grey and wet, very loose	
Wood fragment (50mm) at 4.7m	
SAND, silty, some gravel, trace clay, occasional roots and rootlets, loose, dark grey, wet	232.40 5.40
SILT, sandy, trace gravel, trace clay seams, compact, grey, wet	231.02 6.78
Loose	
SAND, some silt, trace clay, compact, grey, wet	228.88 8.92
END OF BOREHOLE AT 11.27m.	226.52 11.28

NUMBER	TYPE	BLOWS/0.3m	COMMENTS
1	SS	6	
2	SS	7	Grain Size Analysis: Gr 2%/ Sa 77%/ Si 15%/ Cl 6%
3	SS	6	
4	SS	7	
5	SS	6	
6	SS	2	Grain Size Analysis: Gr 3%/ Sa 91%/ Si & Cl 6%
7	SS	20	
8	SS	9	
9	SS	9	
10	SS	15	Grain Size Analysis: Gr 2%/ Sa 30%/ Si 61%/ Cl 7%
11	SS	11	
12	SS	9	
13	SS	24	Grain Size Analysis: Gr 0%/ Sa 84%/ Si 14%/ Cl 2%
14	SS	25	

END OF BOREHOLE AT 11.27m.
GROUND WATER LEVEL AT 4.1m UPON COMPLETION OF DRILLING.
Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
Oct22/2015	4.50	233.3
Nov06/2015	4.50	233.3

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : DJP
CHECKED : MEF

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APPENDIX D

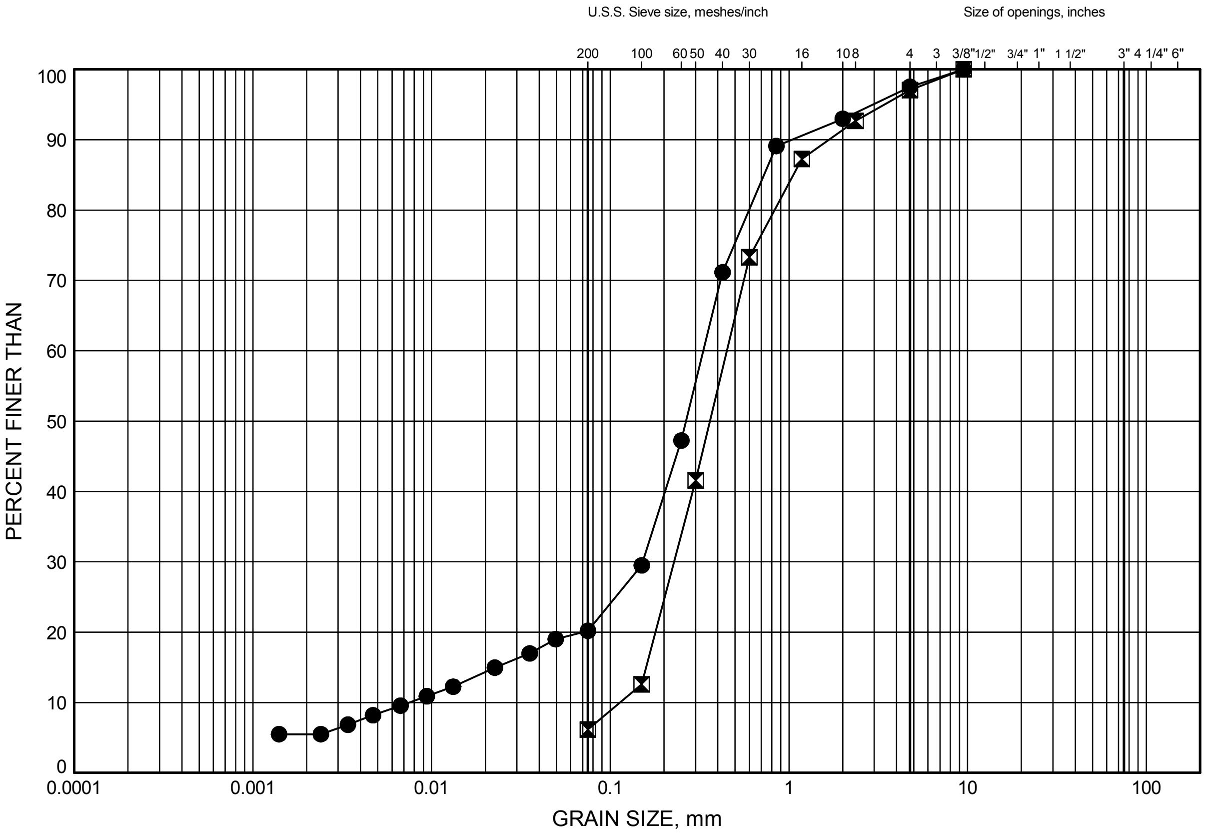
Geotechnical Laboratory Test Results

Teeterville Dam - Stability and Condition Assessment

GRAIN SIZE DISTRIBUTION

FIGURE D1

SAND Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	1.07	236.73
☒	15-01	4.19	233.61

Date January 2016

Project 19-5438-141

THURBER

Prep'd MFA

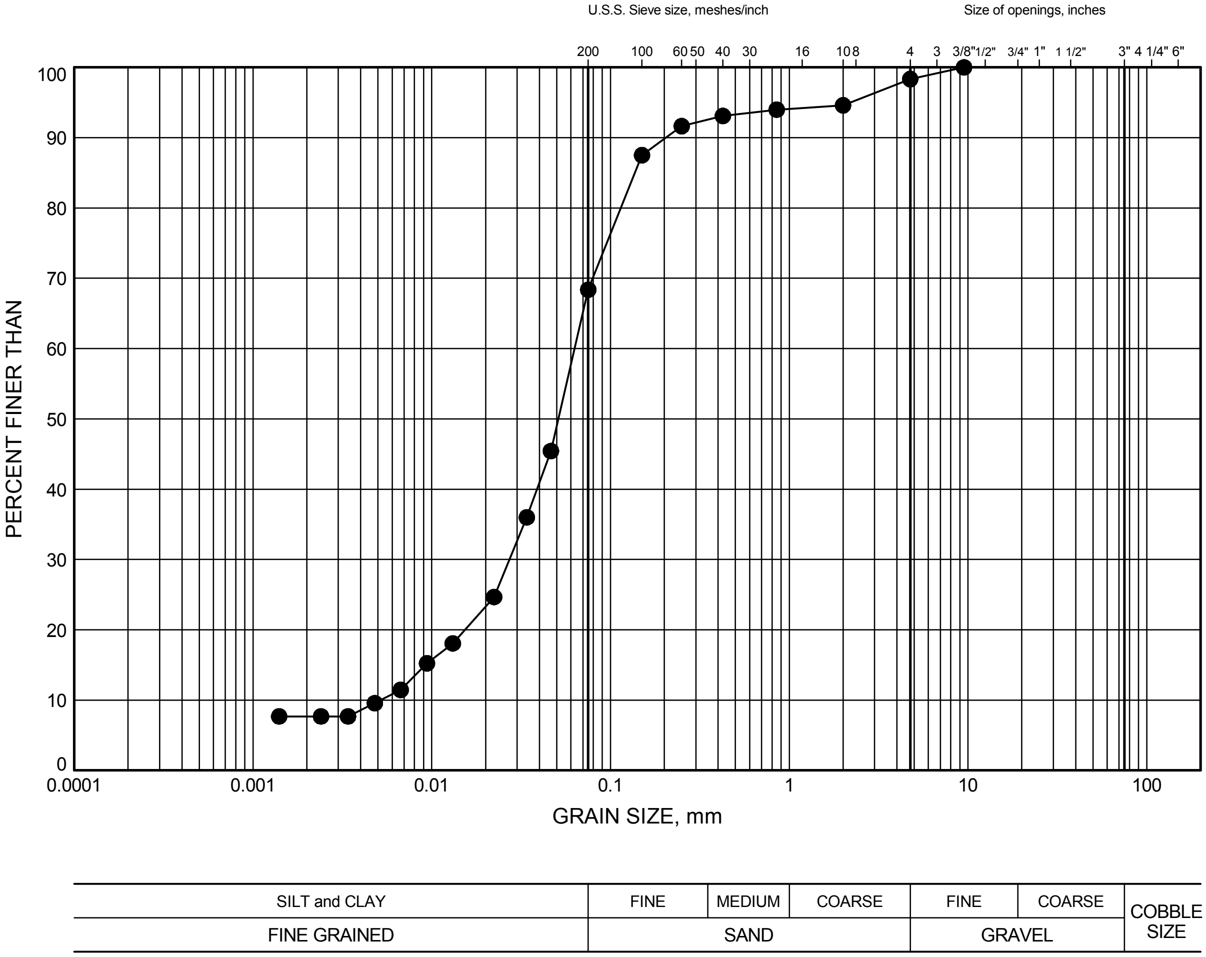
Chkd. MEF

Teeterville Dam - Stability and Condition Assessment

GRAIN SIZE DISTRIBUTION

FIGURE D2

Sandy SILT



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	7.16	230.64

Date January 2016

Project 19-5438-141

THURBER

Prep'd MFA

Chkd. MEF

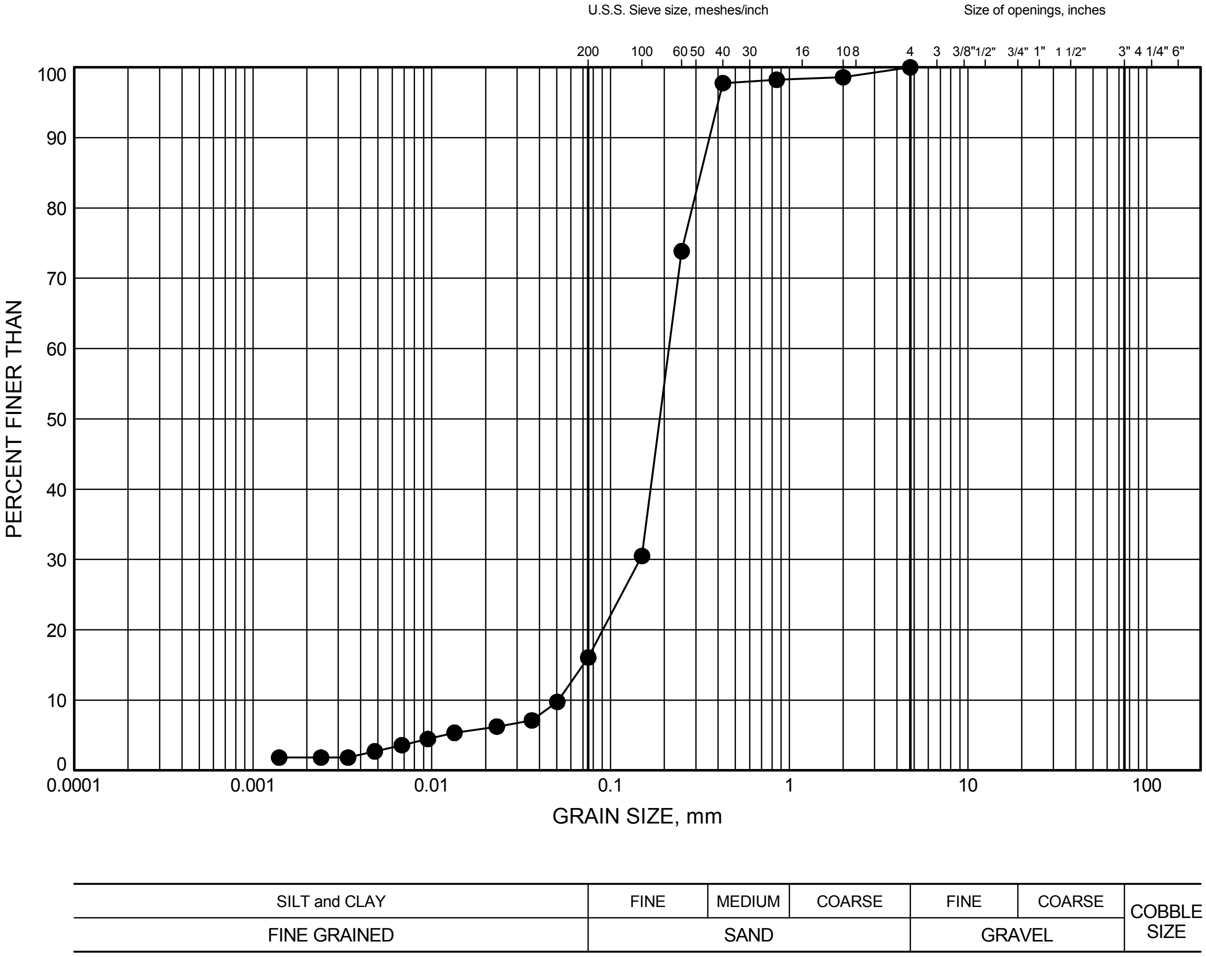
GRAIN SIZE DISTRIBUTION - THURBER 8141.GPJ 1/27/16

Teeterville Dam - Stability and Condition Assessment

GRAIN SIZE DISTRIBUTION

FIGURE D3

SAND



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	9.45	228.35

GRAIN SIZE DISTRIBUTION - THURBER 8141.GPJ 1/27/16

Date January 2016

Project 19-5438-141

THURBER

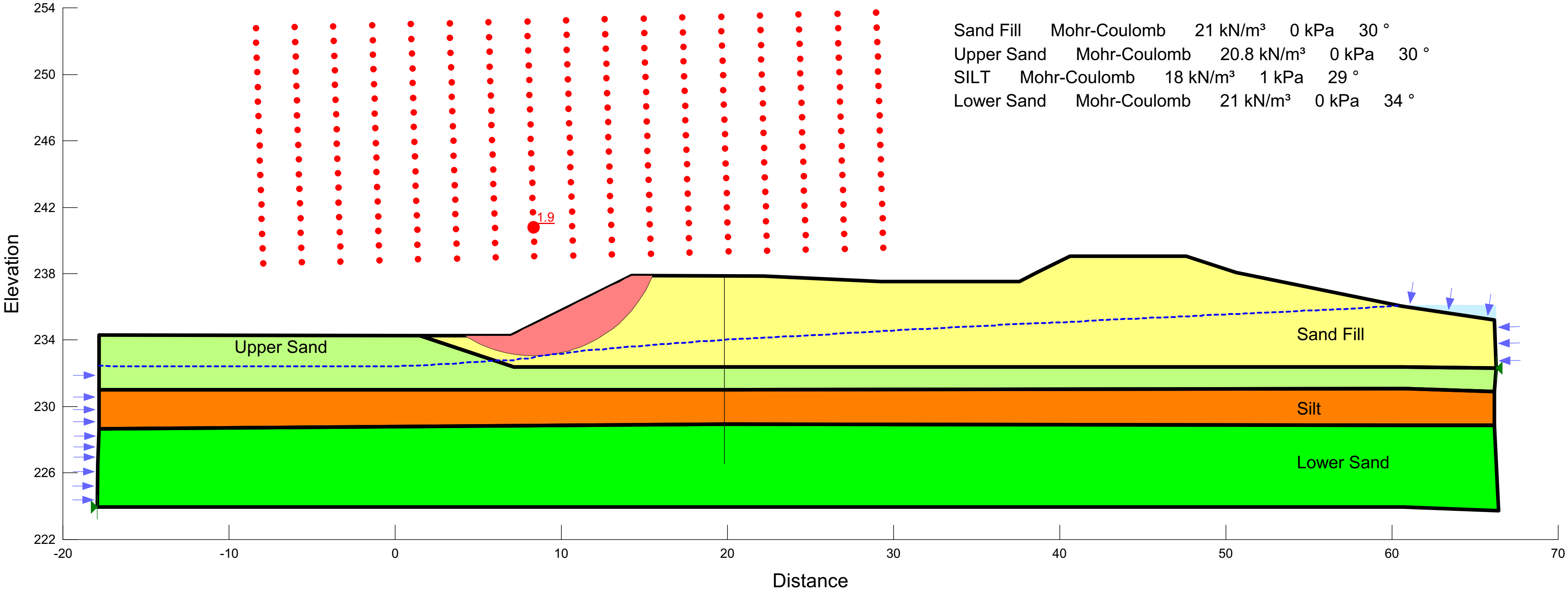
Prep'd MFA

Chkd. MEF

APPENDIX E

Figure

Teeterville Dam Embankment Stability Assessment
Figure E1
19-5438-141



Appendix G

Structural Stability Calculations

Summary of Performance Indicators

Abutment

Load Case	Description	Sliding Safety Factor		Position of Resultant	Contact Base Pressures (kPa)	
		Calculated	Required	(Middle: Yes/No)	Toe	Heel
1	Usual Load (Summer)	0.46	1.5	No	31.41	-7.32
2	Usual Load (Winter)	0.44	1.5	No	46.57	-18.55
3	Unusual Load (Flood)	0.19	1.3	No	37.74	-25.04

Pier

Load Case	Description	Sliding Safety Factor		Position of Resultant	Contact Base Pressures (kPa)	
		Calculated	Required	(Middle: Yes/No)	Toe	Heel
1	Usual Load (Summer)	0.25	1.5	No	23.20	-10.91
2	Usual Load (Winter)	0.27	1.5	No	38.35	-22.14
3	Unusual Load (Flood)	0.05	1.3	No	31.06	-28.12

Abutment Dead Load

Section 1

Height = **0.6** m
Width = **4.8** m
Area = 2.8 m^2

Section 2

Height = **2.0** m
Width = **0.4** m
Area = 0.8 m^2

Section 3

Height = **2.0** m
Width = **0.4** m
Area = 0.4 m^2

Section 4

Height = **1.0** m
Width = **0.4** m
Area = 0.2 m^2

Section 5

Height = **1.0** m
Width = **2.3** m
Area = 2.3 m^2

Section 6

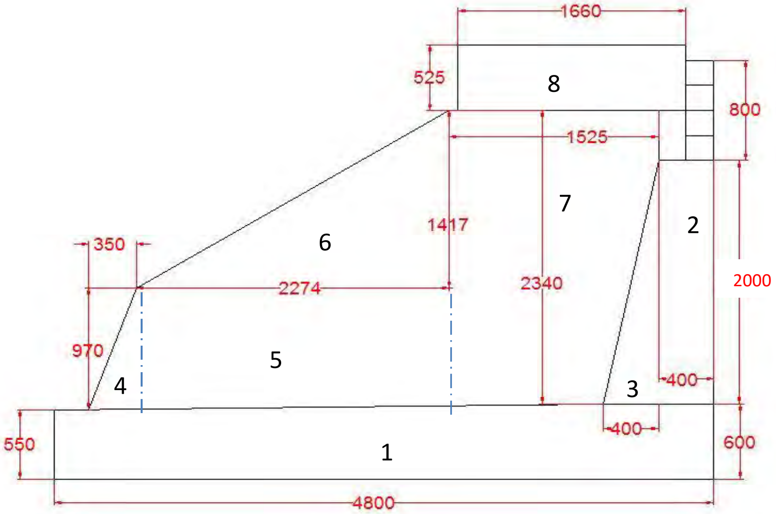
Height = **1.4** m
Width = **2.3** m
Area = 1.7 m^2

Section 7

Height = **2.3** m
Width = **1.5** m
Area = 3.6 m^2

Section 8

Height = **0.5** m
Width = **1.7** m
Area = 0.9 m^2



PROJECT: Teeterville Dam
PN: 60439243
Date: December 2015

AECOM

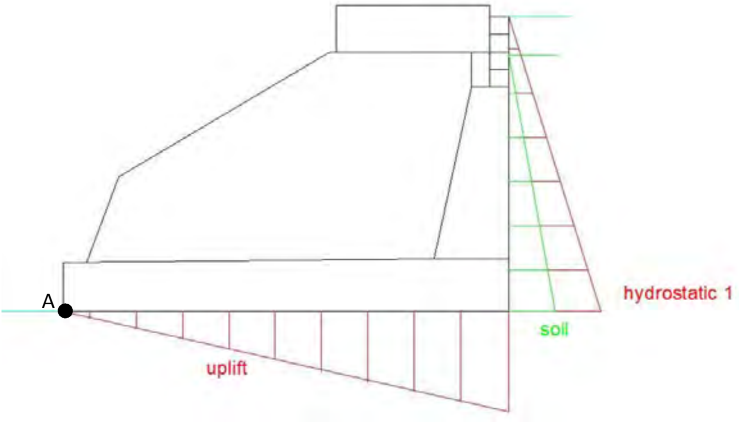
Abutment Load Case 1 Usual Load (Summer)

Upstream Water Elevation	**236.00**	m
Downstream Water Elevation	**232.33**	m
Upstream Soil Elevation	**235.56**	m
Bottom of Dam Elevation	**232.60**	m

Soil Parameters

γ =	**20.5**	kN/m3
γ' =	10.69	kN/m3
ϕ =	**30.0**	°
tan ϕ =	0.577	
Ka =	0.33	
Kp =	3.0	

Base Dimension, B =	4.8	m
B / 3 =	1.60	m
2 B / 3 =	3.20	m



Applied Moments	Label	ρ (kN/m^3)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (m)	MA↺ (kN-m)
Hydrostatic Pressure 1	Pa1	**9.81**	**3.40**		**3.09**	33.354	175.010	1.1	198.34
Uplift 1 (Σ V↑)	Pa2	**9.81**	**0.0**	**4.80**	**3.09**	0.000	0.000	2.4	0.00
Uplift 2 (Σ V↑)	Pa3	**9.81**		**4.80**	**3.09**	33.354	247.073	3.2	790.63
Soil Pressure 1 (active)	Pa4	**10.69**	**2.96**		**3.09**	10.547	48.181	1.0	47.54
Extra	Pa5						0.000	0.0	0.00
						Σ V↑ =	247.07	Σ Mo =	1,036.52
						ΣH←=	223.19		

Resisting Moments	Label	ρ (kN/m^3)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (ft)	↻MA (ft-kip/ft)
Section 1 - Concrete	Pp1	**24.0**	**0.58**	**4.80**	**3.09**		204.450	2.4	490.68
Section 2 - Concrete	Pp2	**24.0**	**2.0**	**0.40**	**3.09**		59.261	4.6	272.60
Section 3 - Concrete	Pp3	**24.0**	**2.0**	**0.4**	**2.39**		22.910	4.3	97.75
Section 4 - Concrete	Pp4	**24.0**	**1.0**	**0.35**	**0.80**		3.259	0.5	1.58
Section 5 - Concrete	Pp5	**24.0**	**1.0**	**2.27**	**0.80**		42.351	1.7	73.61
Section 6 - Concrete	Pp6	**24.0**	**1.4**	**2.27**	**0.70**		27.067	2.1	57.30
Section 7 - Concrete	Pp7	**24.0**	**2.3**	**1.53**	**0.70**		59.951	3.6	218.07
Section 8 - Concrete	Pp8	**24.0**	**0.5**	**1.66**	**0.30**		6.275	3.8	23.66
Hydrostatic Pressure 2	Pp9	**9.81**				0	0.000	0.0	0.00
Water Loading on Heel	Pp10	**9.81**					0.000		0.00
Extra	Pp11								
						Σ V↓ =	425.524	Σ Mr =	1,235.24
						ΣH→=	0.000		

Σ V = 178.45 kN ↓ Σ H = 223.19 kN ←
Σ M = 198.7 kNm ↻

Factors of Safety
Overturning ⇨ ΣMr / ΣMo= **1.19**
Sliding ⇨ ΣV tanϕ / ΣH= **0.46**
Uplift ⇨ Σ V↓ / ΣV↑= **1.72**

Location of Resultant

e_a = ΣM / ΣV
= 1.114 m Outside Middle Third

ec = B/2 - e_a = 1.286 m σ = ΣV / B w x (1 +/- 6 ec / B)
w = **3.09** m σ1 = 31.413 kN/m^2
σ2 = -7.323 kN/m^2

PROJECT: Teeterville Dam
PN: 60439243
Date: December 2015

AECOM

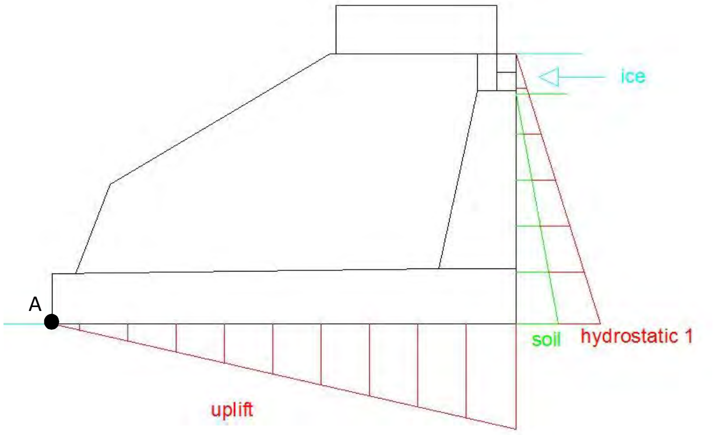
Abutment Load Case 2 Usual Load (Winter)

Upstream Water Elevation	**235.60**	m
Downstream Water Elevation	**232.33**	m
Upstream Soil Elevation	**235.56**	m
Bottom of Dam Elevation	**232.60**	m

Soil Parameters

γ = **20.5** kN/m3
γ' = 10.69 kN/m3
ϕ = **30.0** °
tan ϕ = 0.577
Ka = 0.33
Kp = 3.0

Base Dimension, B = 4.8 m
B / 3 = 1.60 m
2 B / 3 = 3.20 m



Applied Moments	Label	ρ (kN/m³)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (m)	MA↺ (kN-m)
Hydrostatic Pressure 1	Pa1	**9.81**	**3.00**		**3.09**	29.430	136.254	1.0	136.25
Uplift 1 (Σ V↑)	Pa2	**9.81**	**0.0**	**4.80**	**3.09**	0.000	0.000	2.4	0.00
Uplift 2 (Σ V↑)	Pa3	**9.81**		**4.80**	**3.09**	29.430	218.006	3.2	697.62
Soil Pressure 1 (active)	Pa4	**10.69**	**2.96**		**3.09**	10.547	48.181	1.0	47.54
Ice Load (29kN/m)	Pa5				**3.09**		89.509	2.7	241.67
						Σ V↑ =	218.01	Σ Mo =	1,123.08
						ΣH←=	273.94		

Resisting Moments	Label	ρ (kN/m³)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (ft)	↻MA (ft-kip/ft)
Section 1 - Concrete	Pp1	**24.0**	**0.58**	**4.80**	**3.09**		204.450	2.4	490.68
Section 2 - Concrete	Pp2	**24.0**	**2.0**	**0.40**	**3.09**		59.261	4.6	272.60
Section 3 - Concrete	Pp3	**24.0**	**2.0**	**0.4**	**2.39**		22.910	4.3	97.75
Section 4 - Concrete	Pp4	**24.0**	**1.0**	**0.35**	**0.80**		3.259	0.5	1.58
Section 5 - Concrete	Pp5	**24.0**	**1.0**	**2.27**	**0.80**		42.351	1.7	73.61
Section 6 - Concrete	Pp6	**24.0**	**1.4**	**2.27**	**0.70**		27.067	2.1	57.30
Section 7 - Concrete	Pp7	**24.0**	**2.3**	**1.53**	**0.70**		59.951	3.6	218.07
Section 8 - Concrete	Pp8	**24.0**	**0.5**	**1.66**	**0.30**		6.275	3.8	23.66
Hydrostatic Pressure 2	Pp9	**9.81**				0	0.000	0.0	0.00
Water Loading on Heel	Pp10	**9.81**					0.000		0.00
Extra	Pp11								
						Σ V↓ =	425.524	Σ Mr =	1,235.24
						ΣH→=	0.000		

Σ V = 207.52 kN ↓ Σ H = 273.94 kN ←
Σ M = 112.2 kNm ↻

Factors of Safety

Overturning ⇨ ΣMr / ΣMo= **1.10**
Sliding ⇨ ΣV tanϕ / ΣH= **0.44**
Uplift ⇨ Σ V↓ / ΣV↑= **1.95**

Location of Resultant

e_a = ΣM / ΣV
= 0.540 m Outside Middle Third

ec = B/2 - e_a = 1.860 m $\sigma = \Sigma V / B \times (1 +/- 6\ ec / B)$

w = **3.09** m

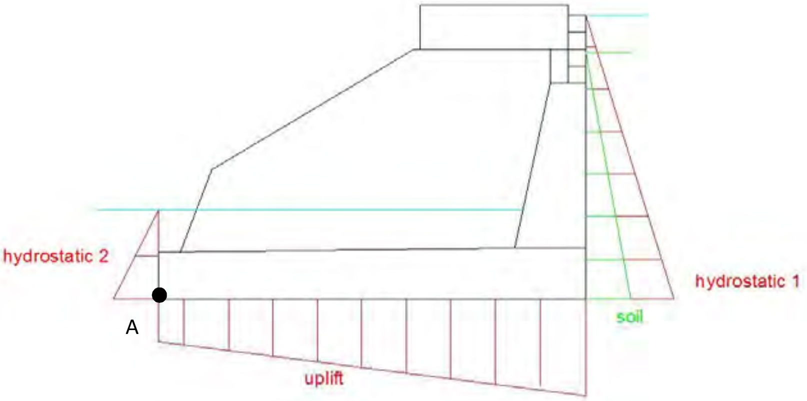
σ_1 = 46.565 kN/m^2
σ_2 = -18.551 kN/m^2

PROJECT: Teeterville Dam
PN: 60439243
Date: December 2015

AECOM

Abutment Load Case 3 Unusual Load (Flood)

Upstream Water Elevation	236.72	m
Downstream Water Elevation	233.75	m
Upstream Soil Elevation	235.56	m
Bottom of Dam Elevation	232.60	m



Soil Parameters

γ = 20.5 kN/m3
γ' = 10.69 kN/m3
ϕ = 30.0 °
tan ϕ = 0.577
Ka = 0.33
Kp = 3.0

Base Dimension, B = 4.8 m
B / 3 = 1.60 m
2 B / 3 = 3.20 m

Applied Moments	Label	ρ (kN/m³)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (m)	MA↺ (kN-m)
Hydrostatic Pressure 1	Pa1	9.81	4.12		3.09	40.417	256.980	1.4	352.92
Uplift 1 (Σ V↑)	Pa2	9.81	1.2	4.80	3.09	11.282	167.138	2.4	401.13
Uplift 2 (Σ V↑)	Pa3	9.81		4.80	3.09	29.136	215.826	3.2	690.64
Soil Pressure 1 (active)	Pa4	10.69	2.96		3.09	10.547	48.181	1.0	47.54
Extra	Pa5						0.000	0.0	0.00
						Σ V↑ =	382.96	Σ Mo =	1,492.23
						ΣH←=	305.16		

Resisting Moments	Label	ρ (kN/m³)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (ft)	↻MA (ft-kip/ft)
Section 1 - Concrete	Pp1	24.0	0.58	4.80	3.09		204.450	2.4	490.68
Section 2 - Concrete	Pp2	24.0	2.0	0.40	3.09		59.261	4.6	272.60
Section 3 - Concrete	Pp3	24.0	2.0	0.4	2.39		22.910	4.3	97.75
Section 4 - Concrete	Pp4	24.0	1.0	0.35	0.80		3.259	0.5	1.58
Section 5 - Concrete	Pp5	24.0	1.0	2.27	0.80		42.351	1.7	73.61
Section 6 - Concrete	Pp6	24.0	1.4	2.27	0.70		27.067	2.1	57.30
Section 7 - Concrete	Pp7	24.0	2.3	1.53	0.70		59.951	3.6	218.07
Section 8 - Concrete	Pp8	24.0	0.5	1.66	0.30		6.275	3.8	23.66
Hydrostatic Pressure 2	Pp9	9.81	1.2		3.09	11.2815	20.022	0.4	7.67
Water Loading on Heel	Pp10	9.81	0.6	4.00	2.39		51.505	2.0	103.01
Extra	Pp11								
						Σ V↓ =	477.029	Σ Mr =	1,345.93
						ΣH→=	20.022		

Σ V = 94.07 kN ↓ Σ H = 285.14 kN ←
Σ M = -146.3 kNm ↻

Factors of Safety

Overturning ⇨ ΣMr / ΣMo= **0.90**
Sliding ⇨ ΣV tanϕ / ΣH= **0.19**
Uplift ⇨ Σ V↓ / ΣV↑= **1.25**

Location of Resultant

e_a = ΣM / ΣV
= -1.555 m Outside Middle Third

ec = B/2 - e_a = 3.955 m σ = ΣV / B x (1 +/- 6 ec / B)

w = 3.09 m

σ1 = 37.741 kN/m^2
σ2 = -25.042 kN/m^2

PROJECT: Teeterville Dam
PN: 60439243
Date: December 2015

Pier Dead Load

Section 1

Height = **0.6** m
Width = **4.8** m
Area = 2.8 m^2

Section 2

Height = **1.9** m
Width = **0.4** m
Area = 0.8 m^2

Section 3

Height = **1.9** m
Width = **0.4** m
Area = 0.4 m^2

Section 4

Height = **1.9** m
Width = **2.1** m
Area = 3.9 m^2

Section 5

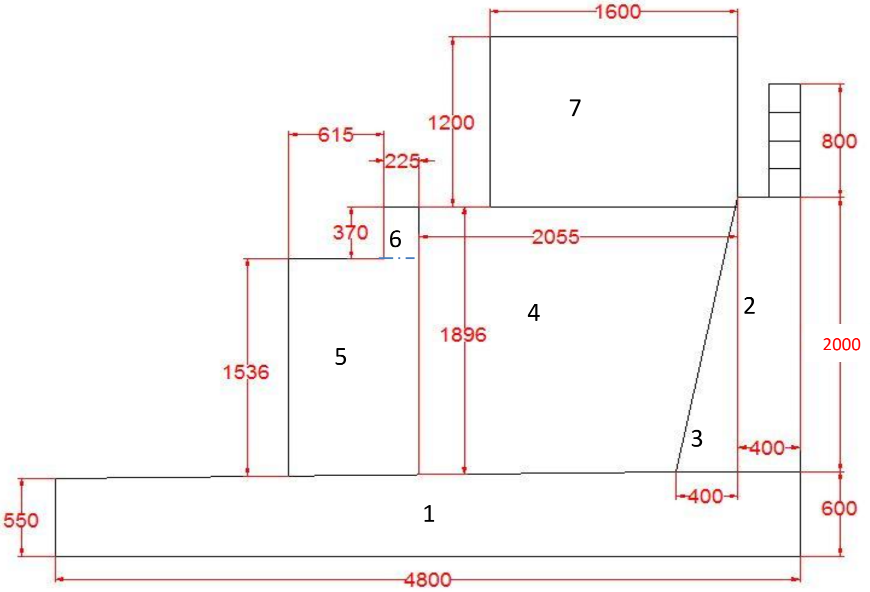
Height = **1.5** m
Width = **0.8** m
Area = 1.3 m^2

Section 6

Height = **0.4** m
Width = **0.2** m
Area = 0.1 m^2

Section 7

Height = **1.2** m
Width = **1.6** m
Area = 2.0 m^2

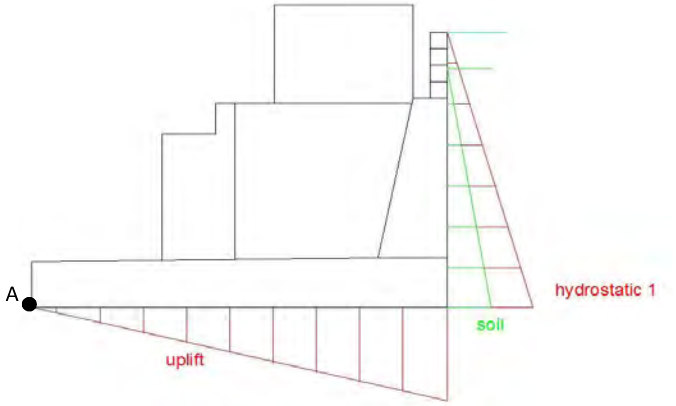


PROJECT: Teeterville Dam
PN: 60439243
Date: December 2015

AECOM

Pier Load Case 1 Usual Load (Summer)

Upstream Water Elevation **236.00** m
Downstream Water Elevation **232.33** m
Upstream Soil Elevation **235.05** m
Bottom of Dam Elevation **232.60** m



Soil Parameters

γ = **20.5** kN/m3
γ' = 10.69 kN/m3
ϕ = **30.0** °
tan ϕ = 0.577
Ka = 0.33
Kp = 3.0

Base Dimension, B = 4.8 m
B / 3 = 1.60 m
2 B / 3 = 3.20 m

Applied Moments	Label	ρ (kN/m³)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (m)	MA↺ (kN-m)
Hydrostatic Pressure 1	Pa1	**9.81**	**3.40**		**7.49**	33.354	424.470	1.1	481.07
Uplift 1 (Σ V↑)	Pa2	**9.81**	**0.0**	**4.80**	**7.49**	0.000	0.000	2.4	0.00
Uplift 2 (Σ V↑)	Pa3	**9.81**		**4.80**	**7.49**	33.354	599.251	3.2	1,917.60
Soil Pressure 1 (active)	Pa4	**10.69**	**2.45**		**7.49**	8.730	80.059	0.8	65.38
Extra	Pa5						0.000	0.0	0.00
						Σ V↑ =	599.25	Σ Mo =	2,464.05
						ΣH←=	504.53		

Resisting Moments	Label	ρ (kN/m³)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (ft)	↻MA (ft-kip/ft)
Section 1 - Concrete	Pp1	**24.0**	**0.58**	**4.80**	**7.49**		495.873	2.4	1,190.09
Section 2 - Concrete	Pp2	**24.0**	**2.0**	**0.40**	**7.49**		143.731	4.6	661.16
Section 3 - Concrete	Pp3	**24.0**	**2.0**	**0.40**	**6.69**		64.186	4.3	273.86
Section 4 - Concrete	Pp4	**24.0**	**1.9**	**2.06**	**0.80**		74.809	3.4	252.29
Section 5 - Concrete	Pp5	**24.0**	**1.5**	**0.84**	**0.42**		13.006	1.9	25.04
Section 6 - Concrete	Pp6	**24.0**	**0.4**	**0.23**	**0.42**		0.839	2.2	1.87
Section 7 - Concrete	Pp7	**24.0**	**1.2**	**1.60**	**0.60**		27.648	3.6	99.53
Hydrostatic Pressure 2	Pp8	**9.81**				0	0.000	0.0	0.00
Water Loading on Heel	Pp9	**9.81**					0.000		0.00
Extra	Pp10								
						Σ V↓ =	820.091	Σ Mr =	2,503.85
						ΣH→=	0.000		

Σ V = 220.84 kN ↓ Σ H = 504.53 kN ←
Σ M = 39.8 kNm ↻

Factors of Safety

Overturning ⇨ ΣMr / ΣMo= **1.02**
Sliding ⇨ ΣV tanϕ / ΣH= **0.25**
Uplift ⇨ Σ V↓ / ΣV↑= **1.37**

Location of Resultant

e_a = ΣM / ΣV
= 0.180 m Outside Middle Third

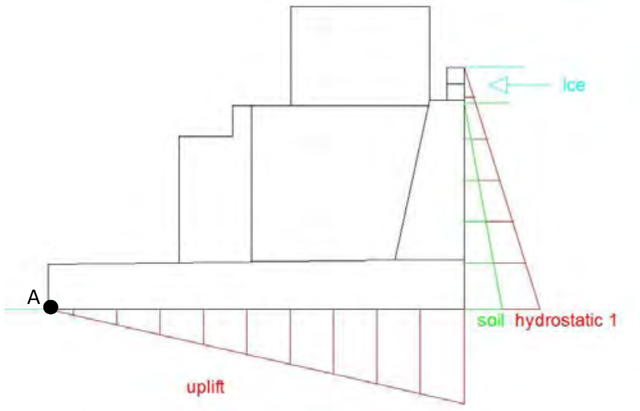
ec = B/2 - e_a = 2.220 m σ = ΣV / B x (1 +/- 6 ec / B)

w = **7.49** m σ1 = 23.199 kN/m^2
σ2 = -10.907 kN/m^2

PROJECT: Teeterville Dam
PN: 60439243
Date: December 2015

Pier Load Case 2 Usual Load (Winter)

Upstream Water Elevation	**235.60**	m
Downstream Water Elevation	**232.33**	m
Upstream Soil Elevation	**235.05**	m
Bottom of Dam Elevation	**232.60**	m



Soil Parameters

γ =	**20.5**	kN/m3
γ' =	10.69	kN/m3
ϕ =	**30.0**	°
tan ϕ =	0.577	
Ka =	0.33	
Kp =	3.0	

Base Dimension, B =	4.8	m
B / 3 =	1.60	m
2 B / 3 =	3.20	m

Applied Moments	Label	ρ	Depth	Width	Length	Pressure	Force	Arm	MA↺
		(kN/m^3)	(m)	(m)	(m)	(kN/m2)	(kN)	(m)	(kN-m)
Hydrostatic Pressure 1	Pa1	**9.81**	**3.00**		**7.49**	29.430	330.469	1.0	330.47
Uplift 1 (Σ V↑)	Pa2	**9.81**	**0.0**	**4.80**	**7.49**	0.000	0.000	2.4	0.00
Uplift 2 (Σ V↑)	Pa3	**9.81**		**4.80**	**7.49**	29.430	528.751	3.2	1,692.00
Soil Pressure 1 (active)	Pa4	**10.69**	**2.45**		**7.49**	8.730	80.059	0.8	65.38
Ice Load (29kN/m)	Pa5				**7.49**		217.094	2.7	586.15
						Σ V↑ =	528.75	Σ Mo =	2,674.01
						ΣH←=	627.62		

Resisting Moments	Label	ρ	Depth	Width	Length	Pressure	Force	Arm	↻MA
		(kN/m^3)	(m)	(m)	(m)	(kN/m2)	(kN)	(ft)	(ft-kip/ft)
Section 1 - Concrete	Pp1	**24.0**	**0.58**	**4.80**	**7.49**		495.873	2.4	1,190.09
Section 2 - Concrete	Pp2	**24.0**	**2.0**	**0.40**	**7.49**		143.731	4.6	661.16
Section 3 - Concrete	Pp3	**24.0**	**2.0**	**0.40**	**6.69**		64.186	4.3	273.86
Section 4 - Concrete	Pp4	**24.0**	**1.9**	**2.06**	**0.80**		74.809	3.4	252.29
Section 5 - Concrete	Pp5	**24.0**	**1.5**	**0.84**	**0.42**		13.006	1.9	25.04
Section 6 - Concrete	Pp6	**24.0**	**0.4**	**0.23**	**0.42**		0.839	2.2	1.87
Section 7 - Concrete	Pp7	**24.0**	**1.2**	**1.60**	**0.60**		27.648	3.6	99.53
Hydrostatic Pressure 2	Pp8	**9.81**				0	0.000	0.0	0.00
Water Loading on Heel	Pp9	**9.81**					0.000		0.00
Extra	Pp10								
						Σ V↓ =	820.091	Σ Mr =	2,503.85
						ΣH→=	0.000		

Σ V = 291.34 kN ↓ Σ H = 627.62 kN ←
Σ M = -170.2 kNm ↻

Factors of Safety

Overturning ⇨	ΣMr / ΣMo=	**0.94**
Sliding ⇨	ΣV tanϕ / ΣH=	**0.27**
Uplift ⇨	Σ V↓ / ΣV↑=	**1.55**

Location of Resultant

e_a = ΣM / ΣV
= -0.584 m Outside Middle Third

ec = B/2 - e_a = 2.984 m σ = ΣV / B x (1 +/- 6 ec / B)

w = **7.49** m σ1 = 38.351 kN/m^2

σ2 = -22.135 kN/m^2

PROJECT: Teeterville Dam
PN: 60439243
Date: December 2015

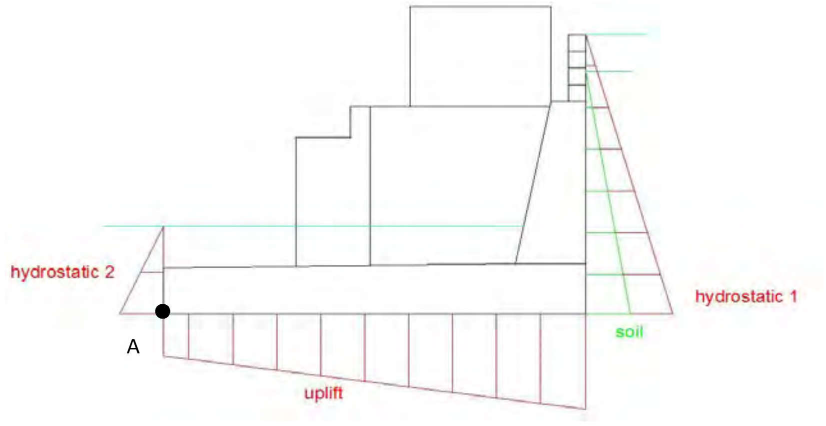
Pier   Load Case 3   Unusual Load (Flood)

Upstream Water Elevation	**236.72**	m
Downstream Water Elevation	**233.75**	m
Upstream Soil Elevation	**235.05**	m
Bottom of Dam Elevation	**232.60**	m

Soil Parameters

γ =	**20.5**	kN/m3
γ' =	10.69	kN/m3
ϕ =	**30.0**	°
tan ϕ =	0.577	
Ka =	0.33	
Kp =	3.0	

Base Dimension, B =	4.8	m
B / 3 =	1.60	m
2 B / 3 =	3.20	m



Applied Moments	Label	ρ (kN/m^3)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (m)	MA↺ (kN-m)
Hydrostatic Pressure 1	Pa1	**9.81**	**4.12**		**7.49**	40.417	623.280	1.4	855.97
Uplift 1 (Σ V↑)	Pa2	**9.81**	**1.2**	**4.80**	**7.49**	11.282	405.376	2.4	972.90
Uplift 2 (Σ V↑)	Pa3	**9.81**		**4.80**	**7.49**	29.136	523.464	3.2	1,675.08
Soil Pressure 1 (active)	Pa4	**10.69**	**2.45**		**7.49**	8.730	80.059	0.8	65.38
Extra	Pa5						0.000	0.0	0.00
						Σ V↑ =	928.84	Σ Mo =	3,569.34
						ΣH←=	703.34		

Resisting Moments	Label	ρ (kN/m^3)	Depth (m)	Width (m)	Length (m)	Pressure (kN/m2)	Force (kN)	Arm (ft)	↻MA (ft-kip/ft)
Section 1 - Concrete	Pp1	**24.0**	**0.58**	**4.80**	**7.49**		495.873	2.4	1,190.09
Section 2 - Concrete	Pp2	**24.0**	**2.0**	**0.40**	**7.49**		143.731	4.6	661.16
Section 3 - Concrete	Pp3	**24.0**	**2.0**	**0.40**	**6.69**		64.186	4.3	273.86
Section 4 - Concrete	Pp4	**24.0**	**1.9**	**2.06**	**0.80**		74.809	3.4	252.29
Section 5 - Concrete	Pp5	**24.0**	**1.5**	**0.84**	**0.42**		13.006	1.9	25.04
Section 6 - Concrete	Pp6	**24.0**	**0.4**	**0.23**	**0.42**		0.839	2.2	1.87
Section 7 - Concrete	Pp7	**24.0**	**1.2**	**1.60**	**0.60**		27.648	3.6	99.53
Hydrostatic Pressure 2	Pp8	**9.81**	**1.2**		**7.49**	11.2815	48.561	0.4	18.61
Water Loading on Heel	Pp9	**9.81**	**0.6**	**4.00**	**7.49**		161.563	2.0	323.13
Extra	Pp10								
						Σ V↓ =	981.654	Σ Mr =	2,845.59
						ΣH→=	48.561		

Σ V =	52.81 kN ↓	Σ H =	654.78 kN ←
Σ M =	-723.7 kNm ↻		

Factors of Safety

Overturning ⇨	ΣMr / ΣMo=	**0.80**
Sliding ⇨	ΣV tanϕ / ΣH=	**0.05**
Uplift ⇨	Σ V↓ / ΣV↑=	**1.06**

Location of Resultant

e_a = ΣM / ΣV

= -13.704 m   Outside Middle Third

e_c = B/2 - e_a = 16.104 m   σ = ΣV / B x (1 +/- 6 e_c / B)

w = **7.49** m

σ1 = 31.056 kN/m^2

σ2 = -28.117 kN/m^2

Appendix H

Sediment Quality and Quantity Analyses

AECOM CANADA LTD. - KITCHENER
ATTN: Steve Scott
50 Sportsworld Crossing Road
Suite 290
KITCHENER ON N2P 0A4

Date Received: 18-SEP-15
Report Date: 07-OCT-15 13:56 (MT)
Version: FINAL

Client Phone: 519-650-5313

Certificate of Analysis

Lab Work Order #: L1675401
Project P.O. #: NOT SUBMITTED
Job Reference: 60439243
C of C Numbers:
Legal Site Desc:

Pires

Mary-Lynn Pires
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-1 TV-1							
Sampled By: CLIENT on 17-SEP-15 @ 15:40							
Matrix: SOIL							
Metals,Hg,Cr6+,B(HWE) 153/04 (July 2011)							
Boron-HWE-O.Reg 153/04 (July 2011)							
Boron (B), Hot Water Ext.	0.44		0.10	ug/g	20-SEP-15	22-SEP-15	R3272957
Hexavalent Chromium in Soil							
Chromium, Hexavalent	<0.20		0.20	ug/g	21-SEP-15	22-SEP-15	R3274550
Mercury in Soil by CVAAS							
Mercury (Hg)	0.0143		0.0050	ug/g	20-SEP-15	21-SEP-15	R3271390
Metals in Soil by CRC ICPMS							
Antimony (Sb)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Arsenic (As)	2.8		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Barium (Ba)	46.9		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Beryllium (Be)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Boron (B)	<5.0		5.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Cadmium (Cd)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Chromium (Cr)	8.6		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Cobalt (Co)	2.4		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Copper (Cu)	5.9		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Lead (Pb)	4.9		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Molybdenum (Mo)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Nickel (Ni)	4.6		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Selenium (Se)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Silver (Ag)	<0.20		0.20	ug/g	20-SEP-15	22-SEP-15	R3273013
Thallium (Tl)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Uranium (U)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Vanadium (V)	13.6		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Zinc (Zn)	34.6		5.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Miscellaneous Parameters							
% Moisture	40.4		0.10	%	21-SEP-15	22-SEP-15	R3272609
1+2-Methylnaphthalenes	<0.042		0.042	ug/g		24-SEP-15	
Bulk Density	925		50	kg/m3		05-OCT-15	R3283597
Xylenes (Total)	<0.050		0.050	ug/g		22-SEP-15	
PAH-O.Reg 153/04 (July 2011)							
1-Methylnaphthalene	<0.030		0.030	ug/g	21-SEP-15	24-SEP-15	R3274531
2-Methylnaphthalene	<0.030		0.030	ug/g	21-SEP-15	24-SEP-15	R3274531
Acenaphthene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Acenaphthylene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Anthracene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(a)anthracene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(a)pyrene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(b)fluoranthene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(g,h,i)perylene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(k)fluoranthene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Chrysene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Dibenzo(ah)anthracene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Fluoranthene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Fluorene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Indeno(1,2,3-cd)pyrene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Naphthalene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Phenanthrene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Pyrene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Surrogate: 2-Fluorobiphenyl	94.0		50-140	%	21-SEP-15	24-SEP-15	R3274531
Surrogate: p-Terphenyl d14	95.5		50-140	%	21-SEP-15	24-SEP-15	R3274531

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-1 TV-1							
Sampled By: CLIENT on 17-SEP-15 @ 15:40							
Matrix: SOIL							
OC Pesticides Reg 153/04 (July 2011)							
Chlordane Total sums							
Chlordane (Total)	<0.028		0.028	ug/g		30-SEP-15	
DDD, DDE, DDT sums							
Total DDD	<0.028		0.028	ug/g		30-SEP-15	
Total DDE	<0.028		0.028	ug/g		30-SEP-15	
Total DDT	<0.028		0.028	ug/g		30-SEP-15	
Endosulfan Total sums							
Endosulfan (Total)	<0.028		0.028	ug/g		30-SEP-15	
OC Pesticides-O.Reg 153/04 (July 2011)							
Aldrin	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
a-chlordane	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
g-chlordane	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
op-DDD	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDD	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
o,p-DDE	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDE	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
op-DDT	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDT	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Dieldrin	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Endosulfan I	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Endosulfan II	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Endrin	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
gamma-hexachlorocyclohexane	<0.010		0.010	ug/g	21-SEP-15	30-SEP-15	R3278400
Heptachlor	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Heptachlor Epoxide	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachlorobenzene	<0.010		0.010	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachlorobutadiene	<0.010		0.010	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachloroethane	<0.010		0.010	ug/g	21-SEP-15	30-SEP-15	R3278400
Methoxychlor	<0.020		0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Surrogate: 2-Fluorobiphenyl	94.3		50-140	%	21-SEP-15	30-SEP-15	R3278400
Surrogate: d14-Terphenyl	86.0		50-140	%	21-SEP-15	30-SEP-15	R3278400
VOC,F1-F4-O.Reg 153/04 (July 2011)							
F1-F4 Hydrocarbon Calculated Parameters							
F1-BTEX	<5.0		5.0	ug/g		24-SEP-15	
F2-Naphth	<10		10	ug/g		24-SEP-15	
F3-PAH	<50		50	ug/g		24-SEP-15	
Total Hydrocarbons (C6-C50)	<72		72	ug/g		24-SEP-15	
F1-O.Reg 153/04 (July 2011)							
F1 (C6-C10)	<5.0		5.0	ug/g	18-SEP-15	22-SEP-15	R3272994
Surrogate: 3,4-Dichlorotoluene	95.0		60-140	%	18-SEP-15	22-SEP-15	R3272994
F2-F4-O.Reg 153/04 (July 2011)							
F2 (C10-C16)	<10		10	ug/g	19-SEP-15	23-SEP-15	R3274928
F3 (C16-C34)	<50		50	ug/g	19-SEP-15	23-SEP-15	R3274928
F4 (C34-C50)	<50		50	ug/g	19-SEP-15	23-SEP-15	R3274928
Chrom. to baseline at nC50	YES				19-SEP-15	23-SEP-15	R3274928
Surrogate: 2-Bromobenzotrifluoride	79.1		60-140	%	19-SEP-15	23-SEP-15	R3274928
Regulation 153 VOCs							
1,3-Dichloropropene (cis & trans)	<0.042		0.042	ug/g		22-SEP-15	
VOC-O.Reg 153/04 (July 2011)							
1,1,1,2-Tetrachloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,2,2-Tetrachloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,1-Trichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-1 TV-1							
Sampled By: CLIENT on 17-SEP-15 @ 15:40							
Matrix: SOIL							
VOC-O.Reg 153/04 (July 2011)							
1,1,2-Trichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1-Dichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1-Dichloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dibromoethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichloropropane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,3-Dichlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,4-Dichlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Acetone	<0.50		0.50	ug/g	18-SEP-15	22-SEP-15	R3272994
Benzene	<0.0068		0.0068	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromodichloromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromoform	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromomethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Carbon tetrachloride	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Chlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Chloroform	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
cis-1,2-Dichloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
cis-1,3-Dichloropropene	<0.030		0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Dibromochloromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Dichlorodifluoromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Ethylbenzene	<0.018		0.018	ug/g	18-SEP-15	22-SEP-15	R3272994
n-Hexane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Methylene Chloride	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
MTBE	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
m+p-Xylenes	<0.030		0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Methyl Ethyl Ketone	<0.50		0.50	ug/g	18-SEP-15	22-SEP-15	R3272994
Methyl Isobutyl Ketone	<0.50		0.50	ug/g	18-SEP-15	22-SEP-15	R3272994
o-Xylene	<0.020		0.020	ug/g	18-SEP-15	22-SEP-15	R3272994
Styrene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Tetrachloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Toluene	<0.080		0.080	ug/g	18-SEP-15	22-SEP-15	R3272994
trans-1,2-Dichloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
trans-1,3-Dichloropropene	<0.030		0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Trichloroethylene	<0.010		0.010	ug/g	18-SEP-15	22-SEP-15	R3272994
Trichlorofluoromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Vinyl chloride	<0.020		0.020	ug/g	18-SEP-15	22-SEP-15	R3272994
Surrogate: 1,4-Difluorobenzene	100.6		70-130	%	18-SEP-15	22-SEP-15	R3272994
Surrogate: 4-Bromofluorobenzene	98.6		70-130	%	18-SEP-15	22-SEP-15	R3272994
L1675401-2 TV-2							
Sampled By: CLIENT on 17-SEP-15 @ 14:30							
Matrix: SOIL							
Metals,Hg,Cr6+,B(HWE) 153/04 (July 2011)							
Boron-HWE-O.Reg 153/04 (July 2011)							
Boron (B), Hot Water Ext.	0.58		0.10	ug/g	20-SEP-15	22-SEP-15	R3272957
Hexavalent Chromium in Soil							
Chromium, Hexavalent	<0.20		0.20	ug/g	21-SEP-15	22-SEP-15	R3274550
Mercury in Soil by CVAAS							
Mercury (Hg)	0.0288		0.0050	ug/g	20-SEP-15	21-SEP-15	R3271390
Metals in Soil by CRC ICPMS							
Antimony (Sb)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-2 TV-2							
Sampled By: CLIENT on 17-SEP-15 @ 14:30							
Matrix: SOIL							
Metals in Soil by CRC ICPMS							
Arsenic (As)	6.6		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Barium (Ba)	67.7		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Beryllium (Be)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Boron (B)	5.2		5.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Cadmium (Cd)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Chromium (Cr)	9.1		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Cobalt (Co)	3.7		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Copper (Cu)	12.1		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Lead (Pb)	9.2		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Molybdenum (Mo)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Nickel (Ni)	7.2		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Selenium (Se)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Silver (Ag)	<0.20		0.20	ug/g	20-SEP-15	22-SEP-15	R3273013
Thallium (Tl)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Uranium (U)	1.1		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Vanadium (V)	16.9		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Zinc (Zn)	47.9		5.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Miscellaneous Parameters							
% Moisture	50.6		0.10	%	21-SEP-15	22-SEP-15	R3272609
1+2-Methylnaphthalenes	<0.064		0.064	ug/g		24-SEP-15	
Bulk Density	819		50	kg/m3		05-OCT-15	R3283597
Xylenes (Total)	<0.054		0.054	ug/g		22-SEP-15	
PAH-O.Reg 153/04 (July 2011)							
1-Methylnaphthalene	<0.045	DLHM	0.045	ug/g	21-SEP-15	24-SEP-15	R3274531
2-Methylnaphthalene	<0.045	DLHM	0.045	ug/g	21-SEP-15	24-SEP-15	R3274531
Acenaphthene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Acenaphthylene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Anthracene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(a)anthracene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(a)pyrene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(b)fluoranthene	0.106	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(g,h,i)perylene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(k)fluoranthene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Chrysene	0.076	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Dibenzo(ah)anthracene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Fluoranthene	0.171	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Fluorene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Indeno(1,2,3-cd)pyrene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Naphthalene	<0.075	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Phenanthrene	0.081	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Pyrene	0.123	DLHM	0.075	ug/g	21-SEP-15	24-SEP-15	R3274531
Surrogate: 2-Fluorobiphenyl	92.2		50-140	%	21-SEP-15	24-SEP-15	R3274531
Surrogate: p-Terphenyl d14	92.2		50-140	%	21-SEP-15	24-SEP-15	R3274531
OC Pesticides Reg 153/04 (July 2011)							
Chlordane Total sums							
Chlordane (Total)	<0.042		0.042	ug/g		30-SEP-15	
DDD, DDE, DDT sums							
Total DDD	<0.042		0.042	ug/g		30-SEP-15	
Total DDE	<0.042		0.042	ug/g		30-SEP-15	
Total DDT	<0.042		0.042	ug/g		30-SEP-15	
Endosulfan Total sums							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-2 TV-2							
Sampled By: CLIENT on 17-SEP-15 @ 14:30							
Matrix: SOIL							
Endosulfan Total sums							
Endosulfan (Total)	<0.042		0.042	ug/g		30-SEP-15	
OC Pesticides-O.Reg 153/04 (July 2011)							
Aldrin	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
a-chlordane	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
g-chlordane	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
op-DDD	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDD	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
o,p-DDE	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDE	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
op-DDT	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDT	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Dieldrin	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Endosulfan I	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Endosulfan II	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Endrin	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
gamma-hexachlorocyclohexane	<0.015	DLHM	0.015	ug/g	21-SEP-15	30-SEP-15	R3278400
Heptachlor	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Heptachlor Epoxide	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachlorobenzene	<0.015	DLHM	0.015	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachlorobutadiene	<0.015	DLHM	0.015	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachloroethane	<0.015	DLHM	0.015	ug/g	21-SEP-15	30-SEP-15	R3278400
Methoxychlor	<0.030	DLHM	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Surrogate: 2-Fluorobiphenyl	99.1		50-140	%	21-SEP-15	30-SEP-15	R3278400
Surrogate: d14-Terphenyl	98.0		50-140	%	21-SEP-15	30-SEP-15	R3278400
VOC,F1-F4-O.Reg 153/04 (July 2011)							
F1-F4 Hydrocarbon Calculated Parameters							
F1-BTEX	<7.5		7.5	ug/g		24-SEP-15	
F2-Naphth	<15		15	ug/g		24-SEP-15	
F3-PAH	<75		75	ug/g		24-SEP-15	
Total Hydrocarbons (C6-C50)	<110		110	ug/g		24-SEP-15	
F1-O.Reg 153/04 (July 2011)							
F1 (C6-C10)	<7.5	DLHM	7.5	ug/g	18-SEP-15	22-SEP-15	R3272994
Surrogate: 3,4-Dichlorotoluene	97.8		60-140	%	18-SEP-15	22-SEP-15	R3272994
F2-F4-O.Reg 153/04 (July 2011)							
F2 (C10-C16)	<15	DLHM	15	ug/g	19-SEP-15	23-SEP-15	R3274928
F3 (C16-C34)	<75	DLHM	75	ug/g	19-SEP-15	23-SEP-15	R3274928
F4 (C34-C50)	<75	DLHM	75	ug/g	19-SEP-15	23-SEP-15	R3274928
Chrom. to baseline at nC50	YES				19-SEP-15	23-SEP-15	R3274928
Surrogate: 2-Bromobenzotrifluoride	80.6		60-140	%	19-SEP-15	23-SEP-15	R3274928
Regulation 153 VOCs							
1,3-Dichloropropene (cis & trans)	<0.064		0.064	ug/g		22-SEP-15	
VOC-O.Reg 153/04 (July 2011)							
1,1,1,2-Tetrachloroethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,2,2-Tetrachloroethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,1-Trichloroethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,2-Trichloroethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1-Dichloroethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1-Dichloroethylene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dibromoethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichlorobenzene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichloroethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichloropropane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-2 TV-2							
Sampled By: CLIENT on 17-SEP-15 @ 14:30							
Matrix: SOIL							
VOC-O.Reg 153/04 (July 2011)							
1,3-Dichlorobenzene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
1,4-Dichlorobenzene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Acetone	<0.75	DLHM	0.75	ug/g	18-SEP-15	22-SEP-15	R3272994
Benzene	<0.010	DLHM	0.010	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromodichloromethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromoform	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromomethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Carbon tetrachloride	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Chlorobenzene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Chloroform	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
cis-1,2-Dichloroethylene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
cis-1,3-Dichloropropene	<0.045	DLHM	0.045	ug/g	18-SEP-15	22-SEP-15	R3272994
Dibromochloromethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Dichlorodifluoromethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Ethylbenzene	<0.027	DLHM	0.027	ug/g	18-SEP-15	22-SEP-15	R3272994
n-Hexane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Methylene Chloride	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
MTBE	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
m+p-Xylenes	<0.045	DLHM	0.045	ug/g	18-SEP-15	22-SEP-15	R3272994
Methyl Ethyl Ketone	<0.75	DLHM	0.75	ug/g	18-SEP-15	22-SEP-15	R3272994
Methyl Isobutyl Ketone	<0.75	DLHM	0.75	ug/g	18-SEP-15	22-SEP-15	R3272994
o-Xylene	<0.030	DLHM	0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Styrene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Tetrachloroethylene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Toluene	<0.12	DLHM	0.12	ug/g	18-SEP-15	22-SEP-15	R3272994
trans-1,2-Dichloroethylene	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
trans-1,3-Dichloropropene	<0.045	DLHM	0.045	ug/g	18-SEP-15	22-SEP-15	R3272994
Trichloroethylene	<0.015	DLHM	0.015	ug/g	18-SEP-15	22-SEP-15	R3272994
Trichlorofluoromethane	<0.075	DLHM	0.075	ug/g	18-SEP-15	22-SEP-15	R3272994
Vinyl chloride	<0.030	DLHM	0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Surrogate: 1,4-Difluorobenzene	100.3		70-130	%	18-SEP-15	22-SEP-15	R3272994
Surrogate: 4-Bromofluorobenzene	98.0		70-130	%	18-SEP-15	22-SEP-15	R3272994
L1675401-3 TV-3							
Sampled By: CLIENT on 18-SEP-15 @ 09:30							
Matrix: SOIL							
Metals,Hg,Cr6+,B(HWE) 153/04 (July 2011)							
Boron-HWE-O.Reg 153/04 (July 2011)							
Boron (B), Hot Water Ext.	<0.10		0.10	ug/g	20-SEP-15	22-SEP-15	R3272957
Hexavalent Chromium in Soil							
Chromium, Hexavalent	<0.20		0.20	ug/g	21-SEP-15	22-SEP-15	R3274550
Mercury in Soil by CVAAS							
Mercury (Hg)	<0.0050		0.0050	ug/g	20-SEP-15	21-SEP-15	R3271390
Metals in Soil by CRC ICPMS							
Antimony (Sb)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Arsenic (As)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Barium (Ba)	16.8		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Beryllium (Be)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Boron (B)	<5.0		5.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Cadmium (Cd)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Chromium (Cr)	5.3		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Cobalt (Co)	1.5		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-3 TV-3							
Sampled By: CLIENT on 18-SEP-15 @ 09:30							
Matrix: SOIL							
Metals in Soil by CRC ICPMS							
Copper (Cu)	3.7		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Lead (Pb)	2.9		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Molybdenum (Mo)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Nickel (Ni)	3.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Selenium (Se)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Silver (Ag)	<0.20		0.20	ug/g	20-SEP-15	22-SEP-15	R3273013
Thallium (Tl)	<0.50		0.50	ug/g	20-SEP-15	22-SEP-15	R3273013
Uranium (U)	<1.0		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Vanadium (V)	13.9		1.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Zinc (Zn)	17.9		5.0	ug/g	20-SEP-15	22-SEP-15	R3273013
Miscellaneous Parameters							
% Moisture	19.3		0.10	%	21-SEP-15	22-SEP-15	R3272609
1+2-Methylnaphthalenes	<0.042		0.042	ug/g		24-SEP-15	
Bulk Density	1490		50	kg/m3		05-OCT-15	R3283597
F4G-SG (GHH-Silica)	900		250	mg/kg	21-SEP-15	21-SEP-15	R3274493
Xylenes (Total)	<0.050		0.050	ug/g		22-SEP-15	
PAH-O.Reg 153/04 (July 2011)							
1-Methylnaphthalene	<0.030		0.030	ug/g	21-SEP-15	24-SEP-15	R3274531
2-Methylnaphthalene	<0.030		0.030	ug/g	21-SEP-15	24-SEP-15	R3274531
Acenaphthene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Acenaphthylene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Anthracene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(a)anthracene	0.199		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(a)pyrene	0.172		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(b)fluoranthene	0.331		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(g,h,i)perylene	0.132		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Benzo(k)fluoranthene	0.096		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Chrysene	0.272		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Dibenzo(ah)anthracene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Fluoranthene	0.578		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Fluorene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Indeno(1,2,3-cd)pyrene	0.156		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Naphthalene	<0.050		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Phenanthrene	0.240		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Pyrene	0.441		0.050	ug/g	21-SEP-15	24-SEP-15	R3274531
Surrogate: 2-Fluorobiphenyl	92.8		50-140	%	21-SEP-15	24-SEP-15	R3274531
Surrogate: p-Terphenyl d14	96.0		50-140	%	21-SEP-15	24-SEP-15	R3274531
OC Pesticides Reg 153/04 (July 2011)							
Chlordane Total sums							
Chlordane (Total)	<0.057		0.057	ug/g		30-SEP-15	
DDD, DDE, DDT sums							
Total DDD	<0.057		0.057	ug/g		30-SEP-15	
Total DDE	<0.057		0.057	ug/g		30-SEP-15	
Total DDT	<0.057		0.057	ug/g		30-SEP-15	
Endosulfan Total sums							
Endosulfan (Total)	<0.057		0.057	ug/g		30-SEP-15	
OC Pesticides-O.Reg 153/04 (July 2011)							
Aldrin	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
a-chlordane	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
g-chlordane	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
op-DDD	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-3 TV-3							
Sampled By: CLIENT on 18-SEP-15 @ 09:30							
Matrix: SOIL							
OC Pesticides-O.Reg 153/04 (July 2011)							
pp-DDD	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
o,p-DDE	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDE	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
op-DDT	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
pp-DDT	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
Dieldrin	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
Endosulfan I	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
Endosulfan II	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
Endrin	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
gamma-hexachlorocyclohexane	<0.030	DLQ	0.030	ug/g	21-SEP-15	30-SEP-15	R3278400
Heptachlor	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
Heptachlor Epoxide	<0.040	DLM	0.040	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachlorobenzene	<0.020	DLM	0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachlorobutadiene	<0.020	DLM	0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Hexachloroethane	<0.020	DLM	0.020	ug/g	21-SEP-15	30-SEP-15	R3278400
Methoxychlor	<0.34	DLQ	0.34	ug/g	21-SEP-15	30-SEP-15	R3278400
Surrogate: 2-Fluorobiphenyl	96.7		50-140	%	21-SEP-15	30-SEP-15	R3278400
Surrogate: d14-Terphenyl	96.4		50-140	%	21-SEP-15	30-SEP-15	R3278400
Note: DLM:Extract was run at a dilution due to high sample matrix background.							
VOC,F1-F4-O.Reg 153/04 (July 2011)							
F1-F4 Hydrocarbon Calculated Parameters							
F1-BTEX	<5.0		5.0	ug/g		24-SEP-15	
F2-Naphth	<10		10	ug/g		24-SEP-15	
F3-PAH	54		50	ug/g		24-SEP-15	
Total Hydrocarbons (C6-C50)	166		72	ug/g		24-SEP-15	
F1-O.Reg 153/04 (July 2011)							
F1 (C6-C10)	<5.0		5.0	ug/g	18-SEP-15	22-SEP-15	R3272994
Surrogate: 3,4-Dichlorotoluene	86.8		60-140	%	18-SEP-15	22-SEP-15	R3272994
F2-F4-O.Reg 153/04 (July 2011)							
F2 (C10-C16)	<10		10	ug/g	21-SEP-15	22-SEP-15	R3273918
F3 (C16-C34)	56		50	ug/g	21-SEP-15	22-SEP-15	R3273918
F4 (C34-C50)	111		50	ug/g	21-SEP-15	22-SEP-15	R3273918
Chrom. to baseline at nC50	NO				21-SEP-15	22-SEP-15	R3273918
Surrogate: 2-Bromobenzotrifluoride	81.0		60-140	%	21-SEP-15	22-SEP-15	R3273918
Regulation 153 VOCs							
1,3-Dichloropropene (cis & trans)	<0.042		0.042	ug/g		22-SEP-15	
VOC-O.Reg 153/04 (July 2011)							
1,1,1,2-Tetrachloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,2,2-Tetrachloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,1-Trichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1,2-Trichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1-Dichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,1-Dichloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dibromoethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichloroethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,2-Dichloropropane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,3-Dichlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
1,4-Dichlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Acetone	<0.50		0.50	ug/g	18-SEP-15	22-SEP-15	R3272994
Benzene	<0.0068		0.0068	ug/g	18-SEP-15	22-SEP-15	R3272994

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1675401-3 TV-3							
Sampled By: CLIENT on 18-SEP-15 @ 09:30							
Matrix: SOIL							
VOC-O.Reg 153/04 (July 2011)							
Bromodichloromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromoform	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Bromomethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Carbon tetrachloride	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Chlorobenzene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Chloroform	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
cis-1,2-Dichloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
cis-1,3-Dichloropropene	<0.030		0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Dibromochloromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Dichlorodifluoromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Ethylbenzene	<0.018		0.018	ug/g	18-SEP-15	22-SEP-15	R3272994
n-Hexane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Methylene Chloride	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
MTBE	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
m+p-Xylenes	<0.030		0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Methyl Ethyl Ketone	<0.50		0.50	ug/g	18-SEP-15	22-SEP-15	R3272994
Methyl Isobutyl Ketone	<0.50		0.50	ug/g	18-SEP-15	22-SEP-15	R3272994
o-Xylene	<0.020		0.020	ug/g	18-SEP-15	22-SEP-15	R3272994
Styrene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Tetrachloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Toluene	0.089		0.080	ug/g	18-SEP-15	22-SEP-15	R3272994
trans-1,2-Dichloroethylene	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
trans-1,3-Dichloropropene	<0.030		0.030	ug/g	18-SEP-15	22-SEP-15	R3272994
Trichloroethylene	<0.010		0.010	ug/g	18-SEP-15	22-SEP-15	R3272994
Trichlorofluoromethane	<0.050		0.050	ug/g	18-SEP-15	22-SEP-15	R3272994
Vinyl chloride	<0.020		0.020	ug/g	18-SEP-15	22-SEP-15	R3272994
Surrogate: 1,4-Difluorobenzene	100.6		70-130	%	18-SEP-15	22-SEP-15	R3272994
Surrogate: 4-Bromofluorobenzene	98.4		70-130	%	18-SEP-15	22-SEP-15	R3272994

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLHM	Detection Limit Adjusted: Sample has High Moisture Content
DLM	Detection Limit Adjusted due to sample matrix effects.
DLQ	Detection Limit raised due to co-eluting interference. GCMS qualifier ion ratio did not meet acceptance criteria.
DLUI	Detection Limit Raised: Unknown Interference generated an apparent false positive test result.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

<table>
<tr><th>ALS Test Code</th><th>Matrix</th><th>Test Description</th><th>Method Reference**</th></tr>
<tr><td>B-HWS-R511-WT</td><td>Soil</td><td>Boron-HWE-O.Reg 153/04 (July 2011)</td><td>HW EXTR, EPA 6010B</td></tr>
<tr><td colspan="4">A dried solid sample is extracted with calcium chloride, the sample undergoes a heating process. After cooling the sample is filtered and analyzed by ICP/OES.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).</td></tr>
<tr><td>CHLORDANE-T-CALC-WT</td><td>Soil</td><td>Chlordane Total sums</td><td>CALCULATION</td></tr>
<tr><td colspan="4">Aqueous sample is extracted by liquid/liquid extraction with a solvent mix. After extraction, a number of clean up techniques may be applied, depending on the sample matrix and analyzed by GC/MS.</td></tr>
<tr><td>CR-CR6-IC-WT</td><td>Soil</td><td>Hexavalent Chromium in Soil</td><td>SW846 3060A/7199</td></tr>
<tr><td colspan="4">This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Method 7199, published by the United States Environmental Protection Agency (EPA). The procedure involves analysis for chromium (VI) by ion chromatography using diphenylcarbazide in a sulphuric acid solution.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).</td></tr>
<tr><td>DDD-DDE-DDT-CALC-WT</td><td>Soil</td><td>DDD, DDE, DDT sums</td><td>CALCULATION</td></tr>
<tr><td colspan="4">Aqueous sample is extracted by liquid/liquid extraction with a solvent mix. After extraction, a number of clean up techniques may be applied, depending on the sample matrix and analyzed by GC/MS.</td></tr>
<tr><td>DENSITY-BULK-CL</td><td>Soil</td><td>Bulk Density</td><td>ASTM D 5057 - 90</td></tr>
<tr><td colspan="4">Sample is dried at <60C and ground to pass a 2 mm screen using a flail grinder. A known volume of the dry soil is weighed to determine bulk density.</td></tr>
<tr><td>ENDOSULFAN-T-CALC-WT</td><td>Soil</td><td>Endosulfan Total sums</td><td>CALCULATION</td></tr>
<tr><td colspan="4">Aqueous sample is extracted by liquid/liquid extraction with a solvent mix. After extraction, a number of clean up techniques may be applied, depending on the sample matrix and analyzed by GC/MS.</td></tr>
<tr><td>F1-F4-511-CALC-WT</td><td>Soil</td><td>F1-F4 Hydrocarbon Calculated Parameters</td><td>CCME CWS-PHC, Pub #1310, Dec 2001-S</td></tr>
</table>

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

F1-HS-511-WT	Soil	F1-O.Reg 153/04 (July 2011)	E3398/CCME TIER 1-HS

Fraction F1 is determined by extracting a soil or sediment sample as received with methanol, then analyzing by headspace-GC/FID.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011), unless a subset of the Analytical Test Group (ATG) has been requested (the Protocol states that all analytes in an ATG must be reported).

F2-F4-511-WT	Soil	F2-F4-O.Reg 153/04 (July 2011)	MOE DECPH-E3398/CCME TIER 1

Fractions F2, F3 and F4 are determined by extracting a soil sample with a solvent mix. The solvent recovered from the extracted soil sample is dried and treated to remove polar material. The extract is analyzed by GC/FID.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011), unless a subset of the Analytical Test Group (ATG) has been requested (the Protocol states that all analytes in an ATG must be reported).

F4G-ADD-511-WT	Soil	F4G SG-O.Reg 153/04 (July 2011)	MOE DECPH-E3398/CCME TIER 1

F4G, gravimetric analysis, is determined if the chromatogram does not return to baseline at or before C50. A soil sample is extracted with a solvent mix, the solvent is evaporated and the weight of the residue is determined.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

HG-200.2-CVAA-WT	Soil	Mercury in Soil by CVAAS	EPA 200.2/1631E (mod)

Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CVAAS.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

MET-200.2-CCMS-WT	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A (mod)

Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CRC ICPMS.

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. This method does not dissolve all silicate materials and may result in a partial extraction. depending on the sample matrix, for some metals, including, but not limited to Al, Ba, Be, Cr, Sr, Ti, Tl, and V.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011), unless a subset of the Analytical Test Group (ATG) has been requested (the Protocol states that all analytes in an ATG must be reported).

METHYLNAPS-CALC-WT	Soil	ABN-Calculated Parameters	SW846 8270
MOISTURE-WT	Soil	% Moisture	Gravimetric: Oven Dried
PAH-511-WT	Soil	PAH-O.Reg 153/04 (July 2011)	SW846 3510/8270

A representative sub-sample of soil is fortified with deuterium-labelled surrogates and a mechanical shaking techniqueis used to extract the sample with a mixture of methanol and toluene. The extracts are concentrated and analyzed by GC/MS. Depending on the analytical GC/MS column used benzo(j)fluoranthene may chromatographically co-elute with benzo(b)fluoranthene or benzo(k)fluoranthene.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011), unless a subset of the Analytical Test Group (ATG) has been requested (the Protocol states that all analytes in an ATG must be reported).

PEST-OC-511-WT	Soil	OC Pesticides-O.Reg 153/04 (July 2011)	SW846 8270 (511)

Soil sample is extracted in a solvent, after extraction a number of clean up techniques may be applied, depending on the sample matrix and analyzed by GC/MS.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011), unless a subset of the Analytical Test Group (ATG) has been requested (the Protocol states that all analytes in an ATG must be reported).

VOC-1,3-DCP-CALC-WT	Soil	Regulation 153 VOCs	SW8260B/SW8270C
VOC-511-HS-WT	Soil	VOC-O.Reg 153/04 (July 2011)	SW846 8260 (511)

Soil and sediment samples are extracted in methanol and analyzed by headspace-GC/MS.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
XYLENES-SUM-CALC-WT	Soil	Sum of Xylene Isomer Concentrations	CALCULATION

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011), unless a subset of the Analytical Test Group (ATG) has been requested (the Protocol states that all analytes in an ATG must be reported).

Total xylenes represents the sum of o-xylene and m&p-xylene.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

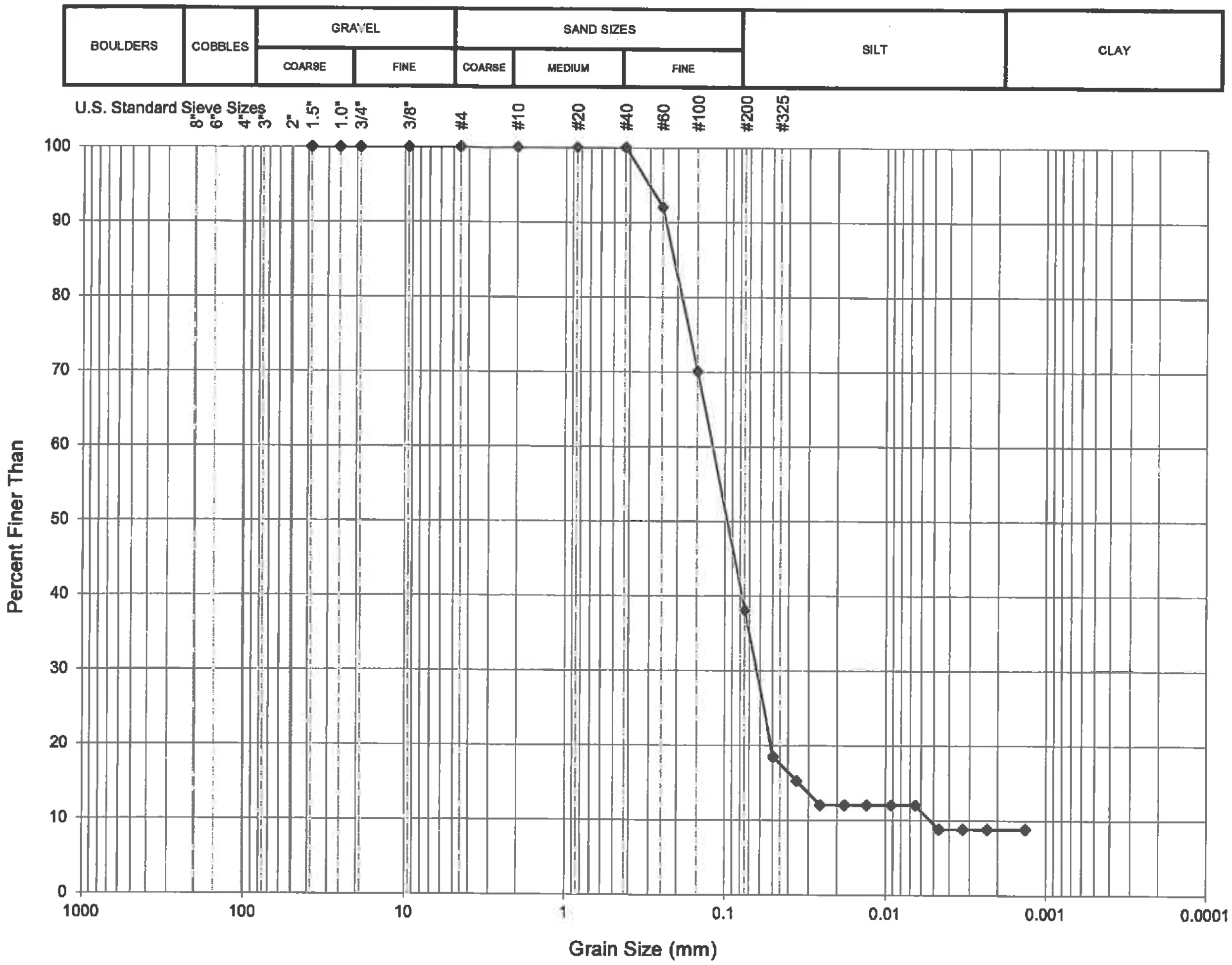
ALS Environmental

WATERLOO

PARTICLE SIZE DISTRIBUTION CURVE

ASTM METHOD D422-63

Project Name:	AECOM CANADA LTD. - KITCHENER
Project Number:	15884
Sample Location:	
Sample Number:	TV-1
Sample Depth:	
Lab ID Number:	L1675401-1
Technician:	MPBH
Sampler:	
Dates:	
Collected On:	9/17/2015
Analyzed:	10/7/2015



DESCRIPTION	**SOIL CLASSIFICATION DESCRIPTIVE MODIFIERS**		**SUMMARY**
SILTY SAND, TRACE CLAY	AND	36 - 50 %	GRAVEL 0 %
	ADJECTIVE (e.g. sandy)	21 - 35 %	SAND 62 %
ESTIMATED HAZEN NUMBER: 2.80E-05 cm/s	WITH	11 - 20 %	SILT + CLAY 38 %
NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM	TRACE	1 - 10 %	

GRAIN SIZE DETERMINATIONS

Project Name: AECOM CANADA LTD. - KITCHENEF
Project Number: 15884
Sampler:
Technician: MPBH
Lab ID Number: L1675401-1

Sample Location:
Sample Number: TV-1
Sample Depth:
Date Sampled: 05/14/2015 9/17/2015
Date Submitted:05/15/2015 9/18/2015
Date Completed: 5/25/15 10/07/15

Total Sample Weight 178 grams
Hydro. Sample Weight 50.000 grams
% Past #10 1.000 * 100
Sub Factor 3.560

Specific Gravity: 2.650
Liquid Specific Gravity: 1.000
Grav Factor: 1.606

Sieve Size	Weight Retained (grams)	Percent Retained	Diameter (mm)	Cum. % Retained	Cum. % Passing
38.1 mm. DIA.:	0.000	0.000	38.100	0.000	100.000
25.4 mm. DIA.:	0.000	0.000	25.400	0.000	100.000
19.0 mm. DIA.:	0.000	0.000	19.000	0.000	100.000
9.5 mm. DIA.:	0.000	0.000	9.500	0.000	100.000
NO. 4 SIEVE :	0.000	0.000	4.500	0.000	100.000
NO. 10 SIEVE :	0.000	0.000	2.000	0.000	100.000
NO. 20 SIEVE :	0.000	0.000	0.850	0.000	100.000
NO. 40 SIEVE :	0.000	0.000	0.425	0.000	100.000
NO. 60 SIEVE :	4.000	8.000	0.250	8.000	92.000
NO. 100 SIEVE:	11.000	22.000	0.150	30.000	70.000
NO. 200 SIEVE:	16.000	32.000	0.075	62.000	38.000

Time (min)	Hydrometer Reading	Temperature (C)	Diameter (mm)	% Suspended (Subsample)	% Suspended (Total Sample)
1.00	8.0	23.2	0.049	18.386	18.386
2.00	7.0	23.2	0.035	15.174	15.174
4.00	6.0	23.2	0.025	11.962	11.962
8.00	6.0	23.2	0.018	11.962	11.962
15.00	6.0	23.2	0.013	11.962	11.962
30.00	6.0	23.2	0.009	11.962	11.962
60.00	6.0	23.2	0.007	11.962	11.962
120.00	5.0	23.2	0.005	8.750	8.750
240.00	5.0	23.2	0.003	8.750	8.750
480.00	5.0	23.2	0.002	8.750	8.750
1440.00	5.0	23.2	0.001	8.750	8.750

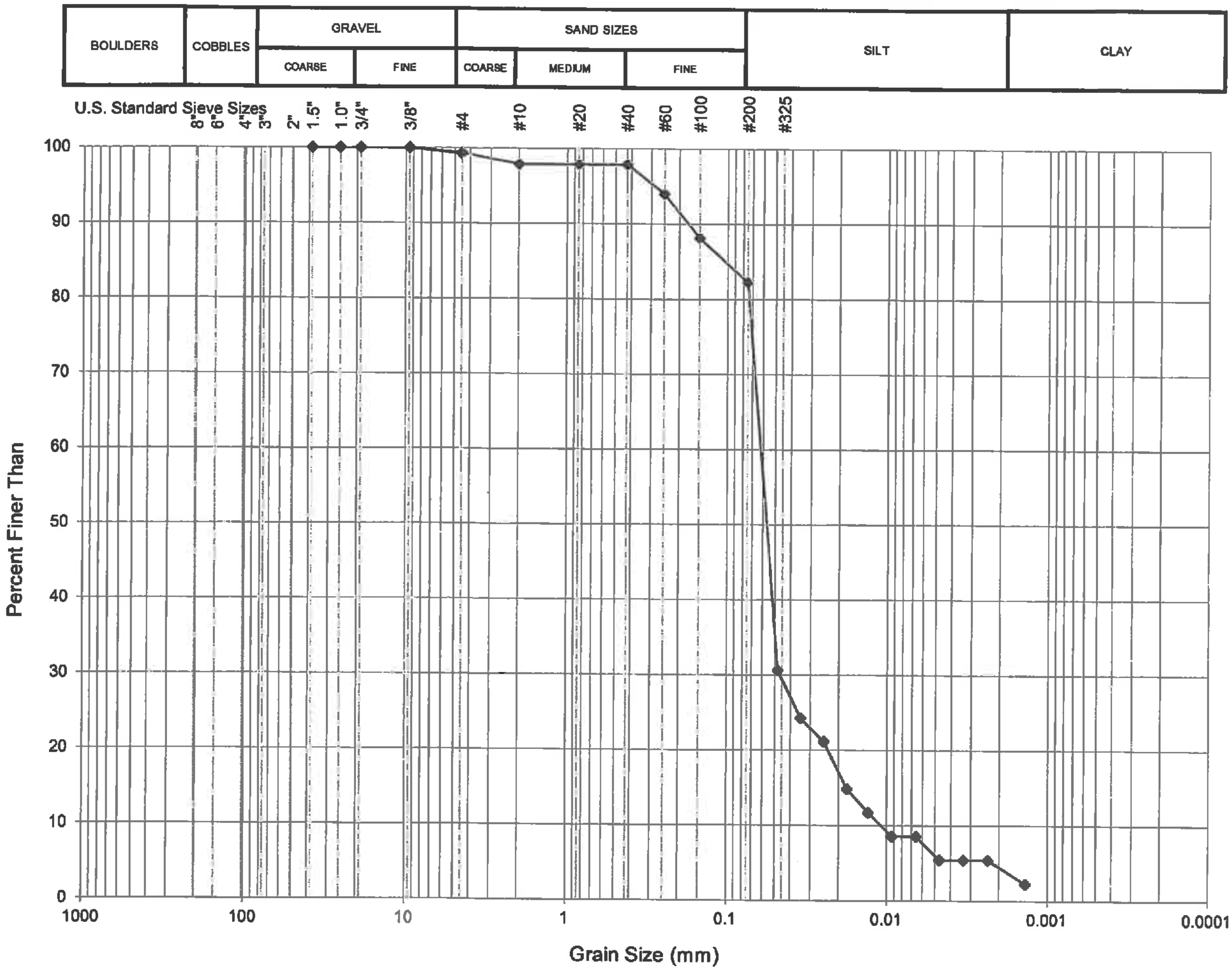
GRAIN SIZE	% BY WT.	DIA. RANGE (mm)
% GRAVEL :	0.00	> 4.5
% COARSE SAND :	0.00	2.0 - 4.5
% MEDIUM SAND :	0.00	0.425 - 2.0
% FINE SAND :	62.00	0.075 - 0.425
% SILT :	29.25	0.075 - 0.002
% CLAY :	8.75	< 0.002
% CLAY :	9.46	< 0.005

ALS Environmental
WATERLOO

PARTICLE SIZE DISTRIBUTION CURVE

ASTM METHOD D422-63

Project Name: AECOM CANADA LTD. - KITCHENER
Project Number: 15884
Sample Location:
Sample Number: TV-2
Sample Depth:
Lab ID Number: L1675401-2
Technician: MPBH
Sampler:
Dates:
Collected On: 9/17/2015
Analyzed: 10/7/2015



DESCRIPTION

SILT WITH SAND, TRACE CLAY

ESTIMATED HAZEN NUMBER: 1.17E-04 cm/s

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SOIL CLASSIFICATION DESCRIPTIVE MODIFIERS

AND	36 - 50 %
ADJECTIVE (e.g. sandy)	21 - 35 %
WITH	11 - 20 %
TRACE	1 - 10 %

SUMMARY

GRAVEL	1	%
SAND	17	%
SILT + CLAY	82	%

GRAIN SIZE DETERMINATIONS

Project Name: AECOM CANADA LTD. - KITCHENEF
Project Number: 15884
Sampler:
Technician: MPBH
Lab ID Number: L1675401-2

Sample Location:
Sample Number: TV-2
Sample Depth:
Date Sampled: 05/14/2015 9/17/2015
Date Submitted:05/15/2015 9/18/2015
Date Completed: 5/25/15 10/07/15

Total Sample Weight 138 grams
Hydro. Sample Weight 50.000 grams
% Past #10 0.978 * 100
Sub Factor 2.700

Specific Gravity: 2.650
Liquid Specific Gravity: 1.000
Grav Factor: 1.606

Sieve Size	Weight Retained (grams)	Percent Retained	Diameter (mm)	Cum. % Retained	Cum. % Passing
38.1 mm. DIA.:	0.000	0.000	38.100	0.000	100.000
25.4 mm. DIA.:	0.000	0.000	25.400	0.000	100.000
19.0 mm. DIA.:	0.000	0.000	19.000	0.000	100.000
9.5 mm. DIA.:	0.000	0.000	9.500	0.000	100.000
NO. 4 SIEVE :	1.000	0.725	4.500	0.725	99.275
NO. 10 SIEVE :	2.000	1.449	2.000	2.174	97.826
NO. 20 SIEVE :	0.000	0.000	0.850	2.174	97.826
NO. 40 SIEVE :	0.000	0.000	0.425	2.174	97.826
NO. 60 SIEVE :	2.000	3.913	0.250	6.087	93.913
NO. 100 SIEVE:	3.000	5.870	0.150	11.957	88.043
NO. 200 SIEVE:	3.000	5.870	0.075	17.826	82.174

Time (min)	Hydrometer Reading	Temperature (C)	Diameter (mm)	% Suspended (Subsample)	% Suspended (Total Sample)
1.00	12.0	23.2	0.048	31.235	30.556
2.00	10.0	23.2	0.034	24.810	24.271
4.00	9.0	23.2	0.024	21.598	21.129
8.00	7.0	23.2	0.018	15.174	14.844
15.00	6.0	23.2	0.013	11.962	11.702
30.00	5.0	23.2	0.009	8.750	8.560
60.00	5.0	23.2	0.007	8.750	8.560
120.00	4.0	23.2	0.005	5.538	5.417
240.00	4.0	23.2	0.003	5.538	5.417
480.00	4.0	23.2	0.002	5.538	5.417
1440.00	3.0	23.2	0.001	2.326	2.275

GRAIN SIZE	% BY WT.	DIA. RANGE (mm)
% GRAVEL :	0.72	> 4.5
% COARSE SAND :	1.45	2.0 - 4.5
% MEDIUM SAND :	0.00	0.425 - 2.0
% FINE SAND :	15.65	0.075 - 0.425
% SILT :	77.67	0.075 - 0.002
% CLAY :	4.51	< 0.002
% CLAY :	6.03	< 0.005

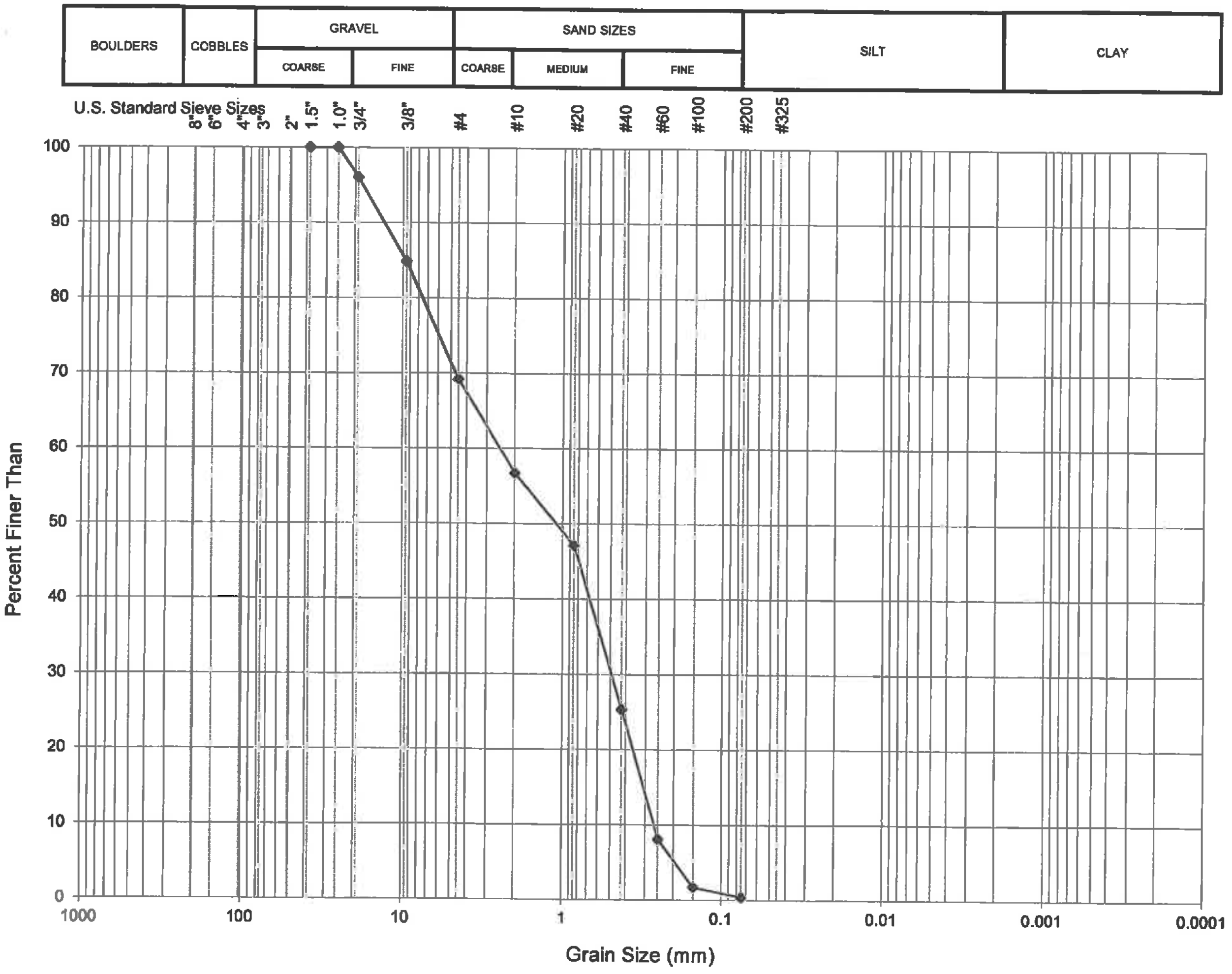
ALS Environmental

WATERLOO

PARTICLE SIZE DISTRIBUTION CURVE

ASTM METHOD D422-63

Project Name:	AECOM CANADA LTD. - KITCHENER
Project Number:	0
Sample Location:	
Sample Number:	TV-3
Sample Depth:	
Lab ID Number:	L1675401-3
Technician:	MPBH
Sampler:	
Dates:	
Collected On:	9/18/2015
Analyzed:	10/7/2015



DESCRIPTION	**SOIL CLASSIFICATION DESCRIPTIVE MODIFIERS**		**SUMMARY**
GRAVELLEY SAND	AND	36 - 50 %	GRAVEL 31 %
	ADJECTIVE (e.g. sandy)	21 - 35 %	SAND 69 %
ESTIMATED HAZEN NUMBER: 7.08E-02 cm/s	WITH	11 - 20 %	SILT + CLAY 0 %
NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM	TRACE	1 - 10 %	

GRAIN SIZE DETERMINATIONS

Project Name:	AECOM CANADA LTD. - KITCHENEI	Sample Location:		
Project Number:		Sample Number:	TV-3	
Sampler:		Sample Depth:		
Technician:	MPBH	Date Sampled: 05/14/2015		9/18/2015
Lab ID Number:	L1675401-3	Date Submitted:05/15/2015		9/18/2015
		Date Completed: 5/25/15	10/07/15	

Total Sample Weight	376 grams	Specific Gravity:	2.650
Hydro. Sample Weight	0.000 grams	Liquid Specific Gravity:	1.000
% Past #10	0.566 * 100	Grav Factor:	1.606
Sub Factor	1.000		

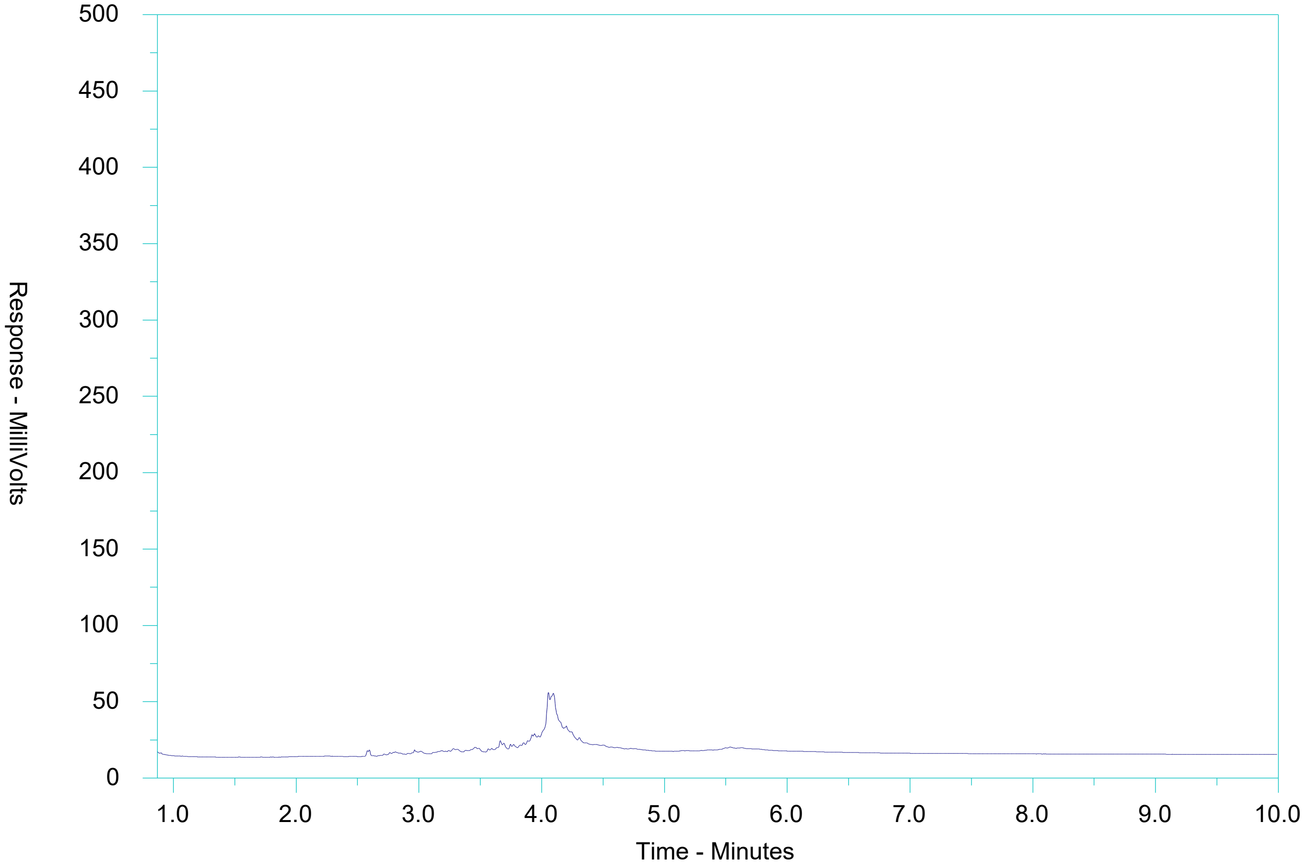
Sieve Size	Weight Retained (grams)	Percent Retained	Diameter (mm)	Cum. % Retained	Cum. % Passing
38.1 mm. DIA.:	0.000	0.000	38.100	0.000	100.000
25.4 mm. DIA.:	0.000	0.000	25.400	0.000	100.000
19.0 mm. DIA.:	15.000	3.989	19.000	3.989	96.011
9.5 mm. DIA.:	42.000	11.170	9.500	15.160	84.840
NO. 4 SIEVE :	59.000	15.691	4.500	30.851	69.149
NO. 10 SIEVE :	47.000	12.500	2.000	43.351	56.649
NO. 20 SIEVE :	36.000	9.574	0.850	52.926	47.074
NO. 40 SIEVE :	82.000	21.809	0.425	74.734	25.266
NO. 60 SIEVE :	65.000	17.287	0.250	92.021	7.979
NO. 100 SIEVE:	24.000	6.383	0.150	98.404	1.596
NO. 200 SIEVE:	5.000	1.330	0.075	99.734	0.266

Time (min)	Hydrometer Reading	Temperature (C)	Diameter (mm)	% Suspended (Subsample)	% Suspended (Total Sample)
1.00			-	-	-
2.00			-	-	-
4.00			-	-	-
8.00			-	-	-
15.00			-	-	-
30.00			-	-	-
60.00			-	-	-
120.00			-	-	-
240.00			-	-	-
480.00			-	-	-
1440.00			-	-	-

GRAIN SIZE	% BY WT.	DIA. RANGE (mm)
% GRAVEL :	30.85	> 4.5
% COARSE SAND :	12.50	2.0 - 4.5
% MEDIUM SAND :	31.38	0.425 - 2.0
% FINE SAND :	25.00	0.075 - 0.425
% SILT & CLAY :	0.27	< 0.075

CCME F2-F4 HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L1675401-1
Client Sample ID: TV-1



◄── F2 ──►	◄── F3 ──►	◄── F4 ──►	
nC10	nC16	nC34	nC50
174°C	287°C	481°C	75°C
346°F	549°F	898°F	1067°F
◄─ Gasoline ─►		◄── Motor Oils/ Lube Oils/ Grease ──►	
◄── Diesel/ Jet Fuels ──►			

The CCME F2-F4 Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

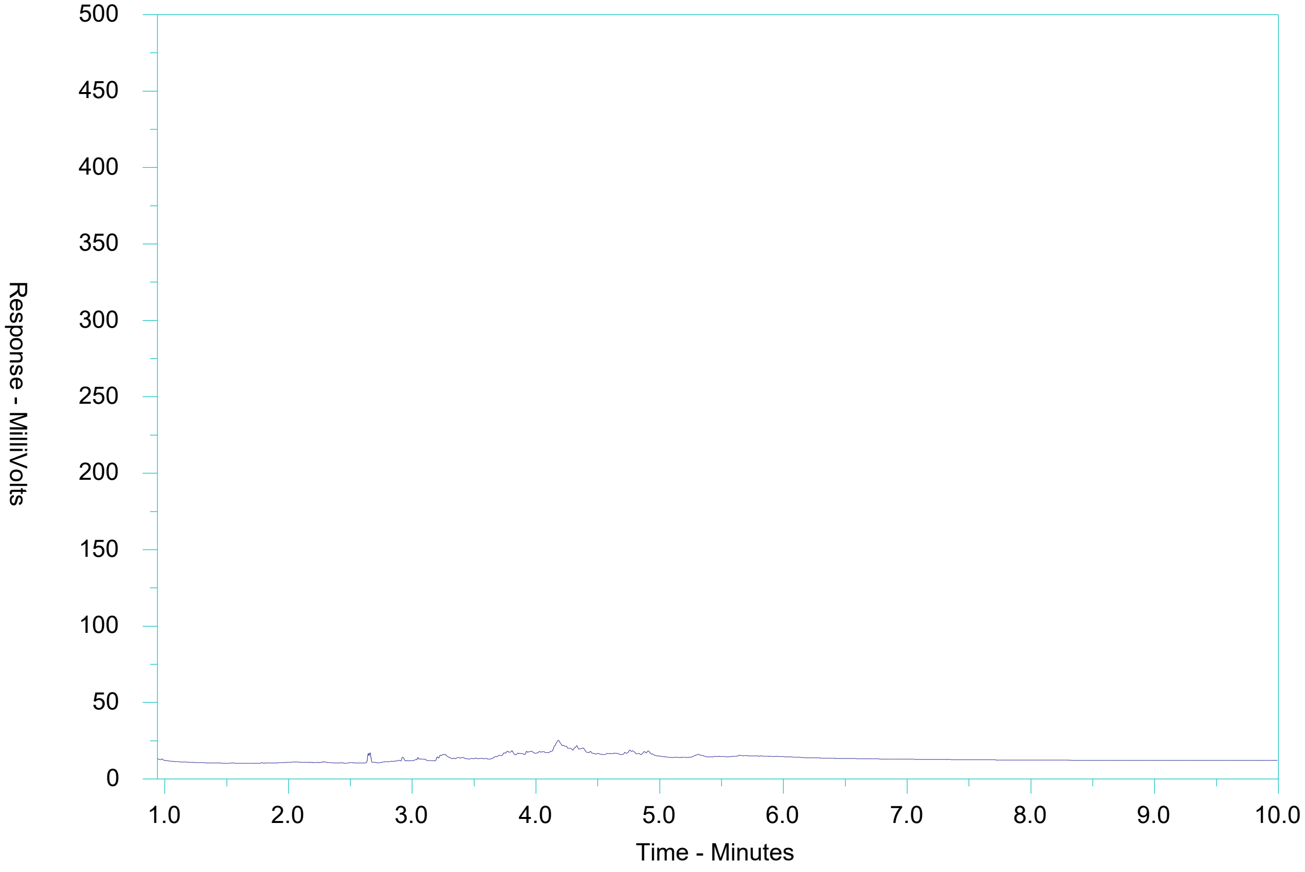
The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and four n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor and the scale at the left.

Note: This chromatogram was produced using GC conditions that are specific to ALS Canada CCME F2-F4 method. Refer to the ALS Canada CCME F2-F4 Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR Library can be found at www.alsglobal.com.

CCME F2-F4 HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L1675401-2
Client Sample ID: TV-2



← F2 →	← F3 →	← F4 →	
nC10	nC16	nC34	nC50
174°C	287°C	481°C	75°C
346°F	549°F	898°F	1067°F
← Gasoline →		← Motor Oils/ Lube Oils/ Grease →	
← Diesel/ Jet Fuels →			

The CCME F2-F4 Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

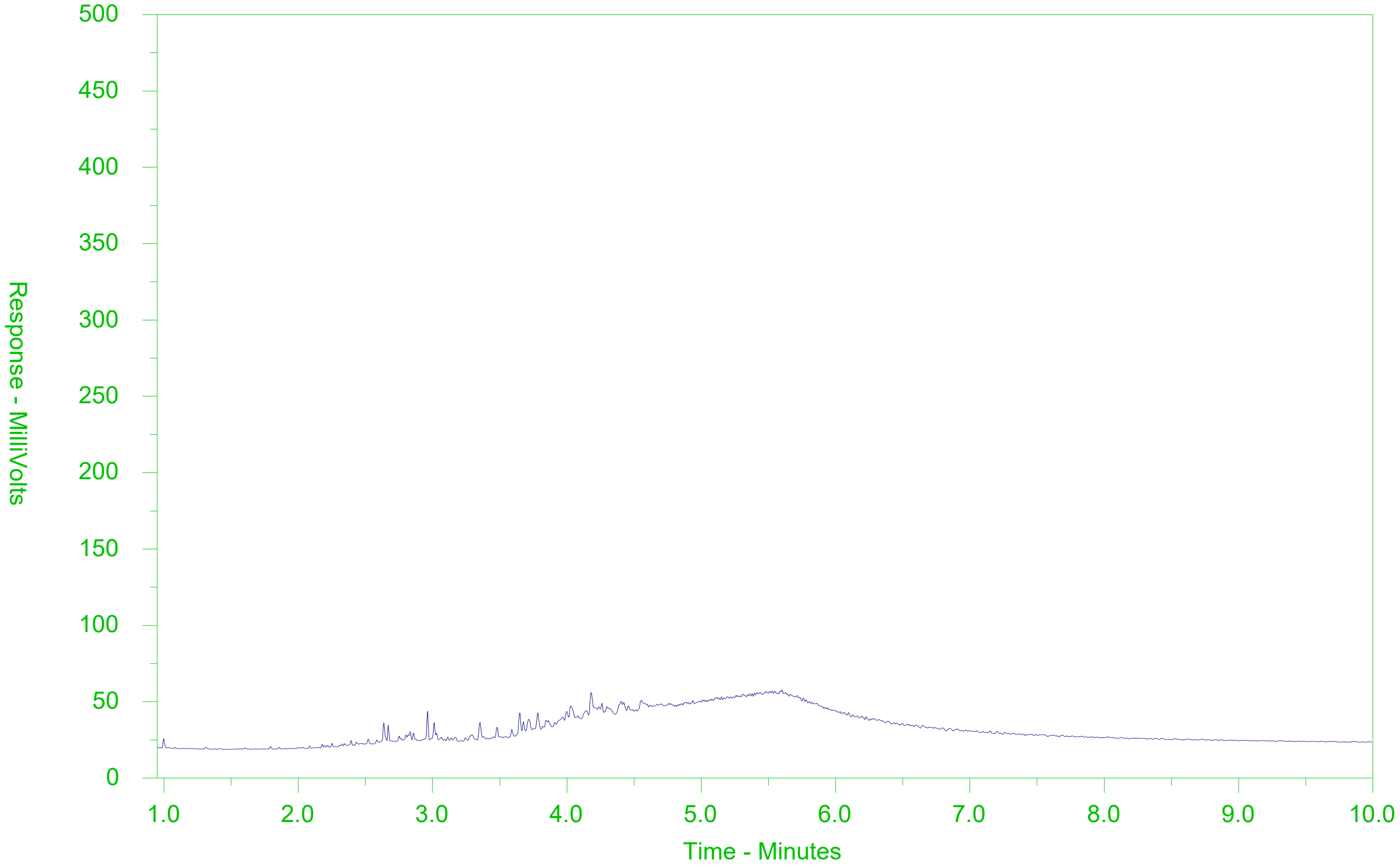
The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and four n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor and the scale at the left.

Note: This chromatogram was produced using GC conditions that are specific to ALS Canada CCME F2-F4 method. Refer to the ALS Canada CCME F2-F4 Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR Library can be found at www.alsglobal.com.

CCME F2-F4 HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L1675401-3
Client Sample ID: TV-3



← F2 →	← F3 →	← F4 →	
nC10	nC16	nC34	nC50
174°C	287°C	481°C	75°C
346°F	549°F	898°F	1067°F
← Gasoline →		← Motor Oils/ Lube Oils/ Grease →	
← Diesel/ Jet Fuels →			

The CCME F2-F4 Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and four n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor and the scale at the left.

Note: This chromatogram was produced using GC conditions that are specific to ALS Canada CCME F2-F4 method. Refer to the ALS Canada CCME F2-F4 Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR Library can be found at www.alsglobal.com.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1675401-COFC

COC Number: 14 -

Page 1 of 1

Report To
Company: AECOM
Contact: Steve Scott
Address: 50 Sportsworld Crossing Road
Kitchener, ON N2P 0A4
Phone: 519-650-5313

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Quality Control (QC) Report with Report ☑ Yes ☐ No
☐ Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax steve.scott2@aecom.com
Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
R ☑ Regular (Standard TAT if received by 3 pm - business days)
P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Specify Date Required for E2,E or P:

Invoice To
Same as Report To ☑ Yes ☐ No
Copy of Invoice with Report ☑ Yes ☐ No
Company:
Contact:

Invoice Distribution
Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax steve.scott2@aecom.com
Email 2 canssc.e-billing@aecom.com

Project Information
ALS Quote #:
Job #: 60439243
PO / AFE:
LSD: Sep-18C

Oil and Gas Required Fields (client use)
Approver ID:
Cost Center:
GL Account:
Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only) L1675401
ALS Contact:
Sampler:

Analysis Request
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Complete Metals	VOC, ~~PHC~~ F1	PAH	OC Pesticides	Grain Size	Bulk Density	F2-F4							Number of Containers
1	TV-1	17-SEP-15	15:40	SOIL	X	X	X	X	X	X	X							7
2	TV-2	17-SEP-15	14:30	SOIL	X	X	X	X	X	X	X							7
3	TV-3	18-SEP-15	09:30	SOIL	X	X	X	X	X	X	X							7

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System?
☐ Yes ☐ No
Are samples for human drinking water use?
☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐
SIF Observations Yes ☐ No ☐
Ice packs Yes ☐ No ☐
Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐
INITIAL COOLER TEMPERATURES °C
FINAL COOLER TEMPERATURES °C 69

SHIPMENT RELEASE (client use)
Released by:
Date:
Time:

INITIAL SHIPMENT RECEPTION (lab use only)
Received by:
Date:
Time:

FINAL SHIPMENT RECEPTION (lab use only)
Received by:
Date: 18/9/15
Time: 17:10

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0326e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

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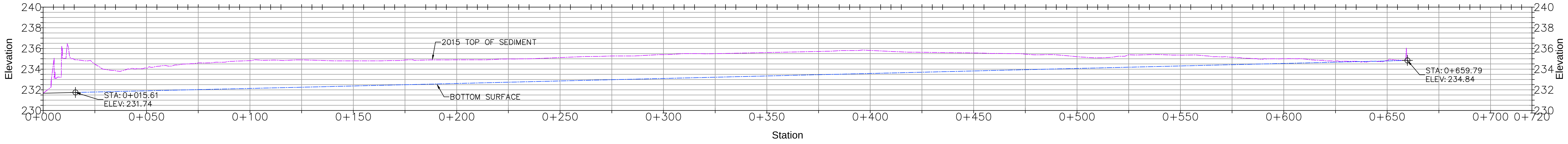
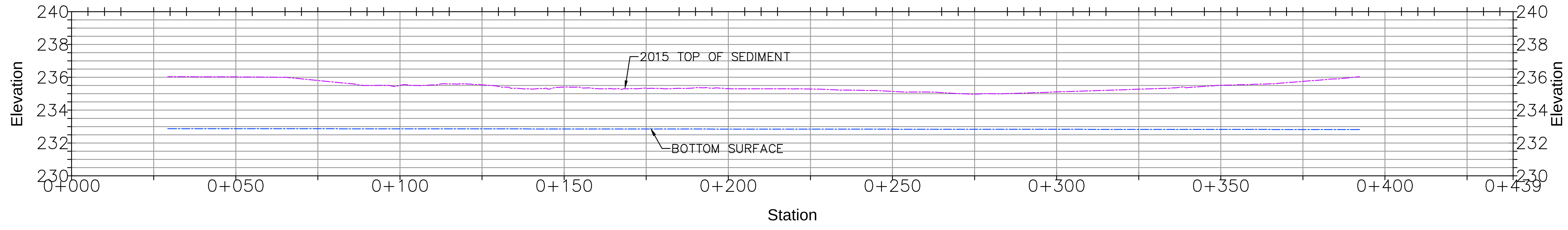
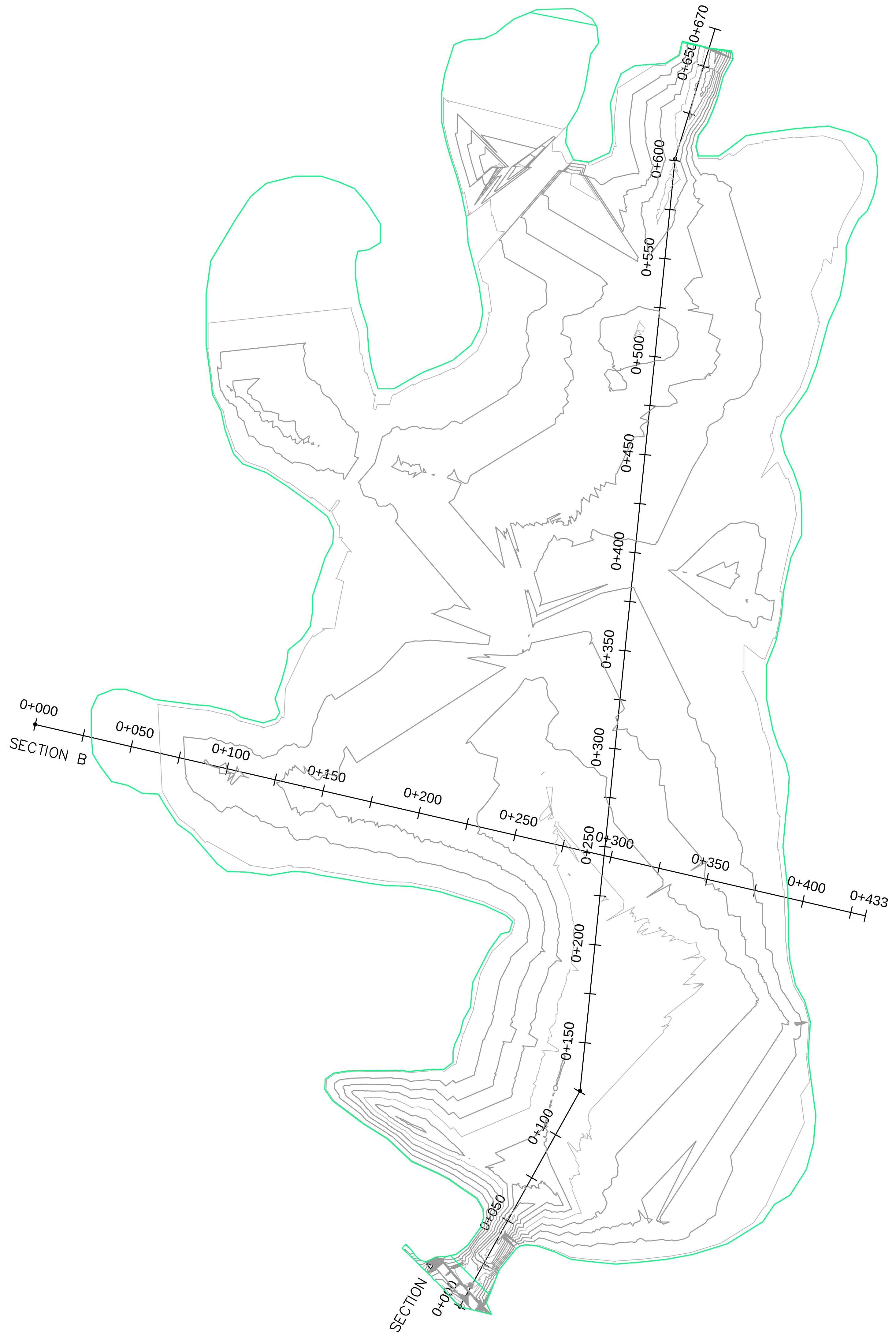
1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

SECTION A



SECTION B





Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
Volume Surface (2015 Top of Sediment ~ Design Bottom)	**1.000**	**1.000**	142588.43sq.m	28.95 Cu. M.	321334.89 Cu. M.	321305.93 Cu. M.<Fill>
Totals			142588.43sq.m	28.95 Cu. M.	321334.89 Cu. M.	321305.93 Cu. M.<Fill>

AECOM

TEETERVILLE DAM
PLAN & SECTIONS

DRN:	DSN:	CHK:	APP:

PROJECT NUMBER: 60430837

SCALE:

FIGURE NUMBER:
FIGURE 1

1:500

About AECOM

AECOM (NYSE: ACM) is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries.

As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges.

From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A Fortune 500 firm, AECOM companies had revenue of approximately US$19 billion during the 12 months ended June 30, 2015.

See how we deliver what others can only imagine at aecom.com and @AECOM.

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