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April 13, 2017
File: 2014-3177

Robert Janzen
Project Manager
Open Space Infrastructure Delivery, Integrated Infrastructure Services
10th Floor, CN Tower
10004-104 Ave NW
Edmonton, AB T5J 2R7
cc: Anton Goulko

Re: SOUTH WHITEMUD BOARDWALK RESTORATION - ENVIRONMENTAL IMPACT ASSESSMENT

Dear Mr. Janzen:

Associated Environmental Consultants Inc. is pleased to provide you with this Environmental Impact Assessment for the South Whitemud Boardwalk project. This report presents the environmental sensitivities identified and proposed mitigation strategies to reduce potential environmental impact from the project.

With your approval, the Report will be forwarded to Parks and Biodiversity for review and comment, before it is finalized.

Please do not hesitate to contact Sandra or myself should you require any additional information.

Yours truly,

April Strekies, B.Sc., BIT
Environmental Scientist

Sandra Meidinger, P.Biol, R.P.Bio.
Manager, Environmental

AS

Associated Environmental

REPORT

City of Edmonton

Whitemud Creek Boardwalk Replacement Environmental Impact Assessment

April 2017

ISO 9001 and 14001 Certified | An Associated Engineering Company

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1 Introduction

The City of Edmonton is planning to replace a damaged boardwalk in Whitemud Ravine, adjacent to the Whitemud Creek and within the City of Edmonton (**Figure 1-1**). The boardwalk is part of an extensive trail system maintained and operated by the City. The new alignment will be located 15 m west of the existing boardwalk, which will also be further away from Whitemud Creek.

The Whitemud Ravine is part of the North Saskatchewan River Valley and any new work in the river valley is protected under the North Saskatchewan River Area Redevelopment Plan, Bylaw No. 7188 (City of Edmonton 2014). A per the project's Bylaw 7188 progress outlined in Section 3.1.1, Parks and Biodiversity determined that an Environmental Impact Assessment should be completed and accepted prior to project construction.

1.1 OBJECTIVE OF ASSESSMENT

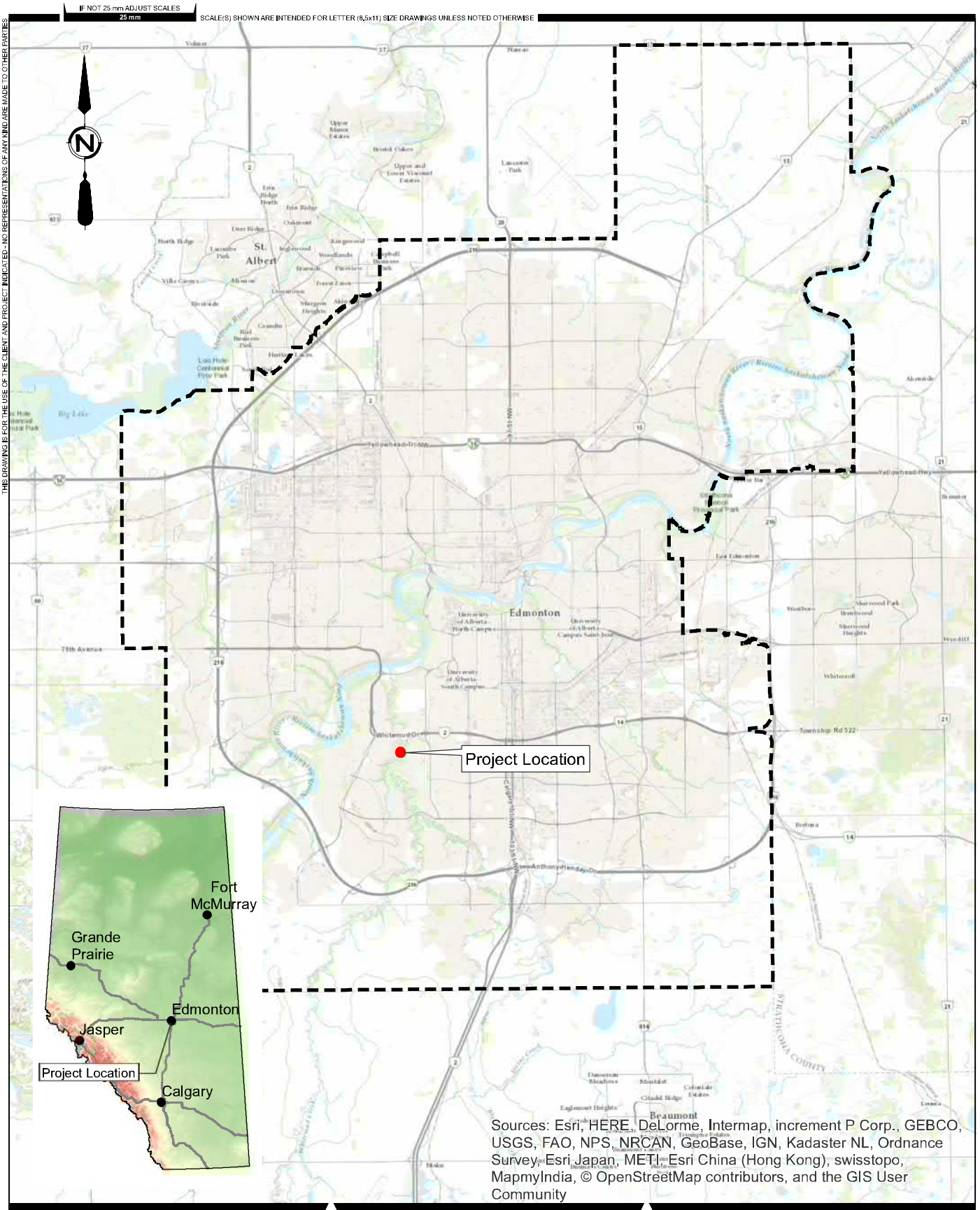
The objective of this report is to assess the potential environmental impacts of the boardwalk construction and develop strategies to avoid, minimize, or mitigate impacts. This report:

- Describes the proposed project;
- Characterizes the baseline environment;
- Identifies the potential environmental impacts of the construction, operation, and maintenance of the road;
- Describes the mitigation strategies and procedures to avoid or reduce environmental impacts; and
- Identifies any residual environmental impacts that cannot be reasonably mitigated.

1.2 PROJECT RATIONALE AND SITE LOCATION

In spring 2014, the boardwalk sustained damage from ice jams. Replacement of the existing boardwalk and stairs, with the design for a boardwalk-only, will improve accessibility through an important wet area crossing site, connecting the north and south portions of the Whitemud Ravine trail system. Existing damage, accessibility, erosion of the north bank, and proximity to Whitemud Creek all factored into the new alignment. Benefits of the new alignment are as follows:

- Located further away from Whitemud Creek;
- Avoids two mature white spruce trees (*Picea glauca*);
- Avoids a local chipmunk (*Tamias* genus) burrows, which are important to local naturalists;
- Improves accessibility (< 8% grade as compared to existing stairs) for diverse users (e.g., wheel chairs, strollers, etc.);
- Reduced on-ground footprint with the raised boardwalk and platform; and
- Improved opportunity for wildlife viewing through the addition of a viewing platform.



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DATE: 2/17/2017

Associated Engineering

0 1,000 2,000 4,000 6,000 8,000 Meters

AE PROJECT No.	2014-3177
DATE	2017 FEBRUARY
SCALE	1:200,000
COORD. SYSTEM	NAD 1983 CSRS 3TM 114
REV	
DESCRIPTION	ISSUED FOR REPORT

FIGURE No. 1-1

WHITEMUD CREEK RAVINE SOUTH OXBOW SITE BOARDWALK REPLACEMENT

PROJECT LOCATION

1.3 STUDY AREA AND CONTEXT

For the purpose of this report, the study area includes two designated areas: Project Footprint and Project Area (**Table 1-1**).

Table 1-1
Spatial Boundaries of Environmental Assessment

Area Designation	Definition
Project Footprint	The area that will be directly disturbed within the boardwalk alignment.
Project Area	The area within 100 m radius of the project footprint including Whitemud Creek; the immediate area that may be directly affected by the project.

2 Project Description

2.1 REGIONAL SETTING

Whitemud Ravine provides opportunities for year-round recreation, including viewing platforms, hiking, fishing, cross-country skiing, and equestrian trials in select areas. Whitemud Creek meanders through the Whitemud Ravine and is part of the North Saskatchewan River Valley watershed. It is slightly sloped making this area highly desirable to recreationalists and naturalists of varying skill levels. The area is also surrounded by residential development and roadway infrastructure; increasing accessibility to these trail systems.

The ravine provides a corridor for wildlife movement to and from the North Saskatchewan River, and optimal refuge areas within the continuous riparian areas.

2.2 BOARDWALK REPLACEMENT

The new boardwalk will span an oxbow of Whitemud Creek (“the oxbow”) and will be approximately 10m west of the damaged boardwalk and stairs, and 20m west of Whitemud Creek.

Site Description: 700 m south of Whitemud Drive
Land-legal: NW 12-52-25-4 W4M
Approximate GPS Location: 53.476363, -113.555448
Nearest watercourses: Whitemud Creek 20 m west; within the oxbow of Whitemud Creek.

2.2.1 Materials and Dimensions

Preliminary designs of the new boardwalk are provided **Appendix A** and summarized in **Table 2-1.** In general, it will have the following features:

- A new gravel approach, connecting to the existing gravel trail, with a 3% gradient at the trail connections and an 8% gradient along the boardwalk over the oxbow.
- Rip rap armoring on the west embankment of the trail, consisting of Class I and Class II rock (50 – 300 mm).
- A new boardwalk and rails, with a height of 2.6 m from the oxbow surface.
- 36 cast in place concrete piles.
- Restoration of the areas surrounding the trail and boardwalk.

Table 2-1
Project Footprint Dimensions

Component	Details	Area
Boardwalk		
Instream Concrete Piles (x 10)	400 mm diameter, 6 m depth	3 m^2
Non-instream Concrete Piles (x 22)	400 mm diameter, 6 m depth	6 m^2
Deck	2.6 m above water level, 3 x 6 planks, ¼" spacing; 45 m x 3.4 m	153 m^2
Viewing platform		150 m^2
Gravel Approach (north and south connection)	18 m x 3.4 m	62 m^2
Riprap armoring (north embankment)	Class I and Class II – 100/200 mm to 500 mm; 25 m x 4 m	100 m^2

2.2.2 Work Site Isolation

The concrete piles will be installed using a cast-in-place method. A sub-set of the piles will be installed within the oxbow (instream piles). For the instream piles, the work area will need to be isolated from the remaining water column, to protect fish within the oxbow and water quality. Isolation measures may include caissons driven into the oxbow at pile installation locations, but the exact isolation technique will be determined by the contractor. The isolation will contain turbid water within the construction area and allow the sediments to settle out of the water column before demobilization. In addition, it should be designed to ensure the concrete will not leave the isolation area, impact the surrounding water by altering pH levels and impacting resident fish.

2.2.3 Laydown and Staging areas

Staging for the project area will be located approximately 1 km north of the project area, in the parking area off Rainbow Valley Road. Two other areas have been identified for the contractor to use as laydown areas: 1) an area next to the viewing platform on the north bank (~ 25 m^2); and 2) a 100 m^2 (5 m by 20 m) area adjacent to the trail on the south side.

The laydown area on the south side of the trail will require significant vegetation removal.

2.2.4 Construction Schedule

Construction is anticipated to start in July 2017, and will require approximately 10 weeks for construction of the new boardwalk. Demolition of the damaged boardwalk (and stairs) and site restoration will be completed following the installation of the new boardwalk.

Anticipated construction sequence, with associated timelines is as follows:

- Grubbing of the trail areas (~ 1 week).
- Pilings installation (~ 2 weeks).
- Timber piers and deck beam installation (~ 1.5 week).
- Decking – placement of the bridge planks on the beams (~ 1 week).
- Handrail installation (this will take place alongside decking work (~1 to 2 weeks).
- Final site grading (~1 week).
- Demolition of the remaining damaged boardwalk structure and restoration of surrounding area.

Please note that construction timelines will likely increase depending on the ability to implement trail closures.

2.3 PUBLIC CONSULTATION

An initial public consultation will be completed prior to the start of construction. The City will present the proposed alignment and design to the public for their input and comments.

Key findings from this report could be used to support various communication activities or other engagement approaches for public consultation. The key findings would expand the public understanding of the project and the mitigation measures that will be undertaken during construction to protect both the public and the environment.

3 Regulatory Framework

A summary of the environmental regulations and legislation that has been considered for this project are included below. **Table 3-1** further outlines a specific summary of the permit/approval applications that are

required for construction of the boardwalk. A comprehensive list of all permits/approvals, as well as applicable legislation should be included in the contractor's ECO Plan[1].

3.1 MUNICIPAL BYLAWS

3.1.1 North Saskatchewan River Valley Area Redevelopment Plan – Bylaw No. 7188

All development in the North Saskatchewan River Valley (including this project) must have specific approval under Bylaw 7188. The following timeline outlines the Bylaw 7188 review process that has taken place so far:

- An Initial Project Review was submitted to Parks and Biodiversity on August 8, 2014 (File No. GB14-57). City review comments, consolidated by Parks and Biodiversity were received on September 9, 2014 (Posse: 159136708-001). The City's Infrastructure Services Department responded to both comments on September 10, 2014, to complete the IPR file.
- Two IPRs were filed for the geotechnical investigations complete at the project site, but are considered closed (GB15-14).
- A Biophysical Assessment was submitted on October 14, 2014 that describes the desktop research and field verification methods and findings of the assessment, and provides environmental recommendations to consider in the design of the boardwalk.

This report is submitted to the Parks and Biodiversity Offices to fulfill follow-up Bylaw 7188 requirements for File No. GB14-57.

3.1.2 Corporate Tree Management Policy C456A

The purpose of the Corporate Tree Management Policy C456A is to protect the tree canopy within the City of Edmonton from destruction, loss, or damage. Where salvage of trees is not possible, the City of Edmonton determines the financial value of the trees removed based on size and species. Vegetation clearing is not anticipated for the boardwalk construction. Any trees marked for removal to accommodate project work will require evaluation by the City under this policy.

3.1.3 Community Standards Bylaw, Bylaw 14600

The Community Standards Bylaw, Bylaw 14600 (City of Edmonton 2016) regulates noise within the City of Edmonton. The Bylaw also restricts construction activity to between 7 a.m. and 9 p.m. on any day other than Sunday or a holiday and between 9 a.m. and 7 p.m. on Sunday or holiday. Construction planning should consider the timing restrictions detailed in this Bylaw.

[1] As required under the 2017 ECO Plan Framework, **Section 3.2**.

3.2 PROVINCIAL LEGISLATION

3.2.1 Water Act

Work in or near a waterbody, including wetlands, is regulated under the provincial *Water Act* (R.S.A. 2000, C. W-3). A notification must be submitted to Alberta Environment and Parks under the Code of Practice for Watercourse Crossings at least 14 days prior to the start of construction.

3.2.2 Public Lands Act

All Crown land, including the bed and shore of permanent and naturally occurring waterbodies, is regulated under the provincial *Public Lands Act (*R.S.A. 2000, C. P-40). Occupation of Crown land requires a disposition.

A disposition has been obtained for the occupation of the new boardwalk footprint on Crown land (bed and shore of the oxbow): DLO150027. This Licence expires August 9, 2040.

3.2.3 Historical Resources Act

Archaeological and paleontological resources are regulated under the provincial *Historical Resources Act* (R.S.A. 2000, C. H-9). The project area is located in an area that has high potential for archaeological and paleontological resources (Historical Resource Value: 5, archaeological and palaeontological), and as a result requires Clearance from Alberta Culture and Tourism (ACT).

A Clearance application was submitted to ACT in 2014. During their review, ACT determined that the project has a high potential to affect Quaternary (ice age) palaeontological resources, given the steep sedimentary exposures on the northern side of the oxbow crossing. Therefore, ACT required a Historical Resources Impact Assessment to be completed for the new trail by a palaeontologist qualified to hold a "Permit to Excavate Palaeontological Resources (Mitigative)" within the Province of Alberta. This Paleontology HRIA was completed on October 1, 2014 and approved by ACT with standard conditions on February 5, 2016.

Historical resources are further discussed in Section 5.6**.**

3.2.4 Wildlife Act

The provincial *Wildlife Act* (R.S.A. 2000, c. W-10) prohibits the wilful molestation, disruption, or destruction of wildlife, or a house, nest, or den of wildlife.

If bird surveys are carried out as part of construction mitigation activities, or if any animal relocation is planned, a permit under this Act will be required (Research Permit/Collection Licence).

3.2.5 Fisheries (Alberta) Act

Handling, capturing, relocating fish is regulated under this Act. If fish are trapped during instream work (e.g., following installation of isolation measures), a fish salvage may be required; prior to the fish salvage, the fisheries biologist completing the salvage will need to obtain a Fish Research License under the *Fisheries* (Alberta) *Act*.

3.2.6 Weed Control Act

The *Weed Control Act* (R.S.A., 2008, c. W-5.1) regulates weed species listed in Schedule 1 (prohibited noxious) and Schedule 2 (noxious) of the Act. Project activities must destroy weeds listed in Schedule 1, and control or prevent the spread of weeds listed in Schedule 2.

3.3 FEDERAL LEGISLATION

3.3.1 Fisheries Act

Provisions under the federal *Fisheries Act* (R.S.C., 1985, c. F-14) apply to activities that have the potential to cause serious harm to fish where the focus is on commercial, recreational, or Aboriginal fishery. “Serious harm” is defined as the death of fish or the permanent alteration or destruction of fish habitat.

Fisheries and Oceans Canada (DFO) determined on August 22, 2014 that this project does not require Authorization, given that serious harm to fish can be avoided by following standard measures. The “Measures to avoid causing harm to fish and fish habitat” must be applied during construction. As per the Measures, the instream work area must be isolated, and if trapped, a fish salvage must be completed by a qualified professional (Government of Canada 2013). DFO should be updated prior to the start of work with the new 2017 construction schedule and the updated design drawings/construction methods.

3.3.2 Migratory Birds Convention Act

The federal *Migratory Birds Convention Act, 1994* (S.C. 1994, c. 22) protects migratory birds, their eggs, and their nests. Any project activities that may impact migratory birds, their eggs, or nests, should be considered, and mitigation planned as appropriate (e.g., tree/vegetation clearing timing to avoid the nesting season). Timing constraints are noted in Section 3.2.4 and timing mitigations are further discussed in Section 5.4.

3.3.3 Species at Risk Act

Activities with potential to impact a species at risk or species of concern and/or the habitat are regulated under the federal *Species at Risk Act* (SARA) (S.C. 2002, c. 29).

A permit would be required if any fish or wildlife species listed in Schedule 1 of SARA may be handled during the project; current data indicates no SARA permit will be required for project activities.

Table 3-1
Summary of Permits and Approvals for the South Whitemud Creek Boardwalk

Legislation		Application details		Approval No./ application outcome
Fisheries Act	Regulatory Item	Request for Review		DFO File No. 14-HCAA-01127
	Effective Date	22 August 2014		
	Expiry Date	N/A		
***Water Act* (provincial)**	Regulatory Item	Code of Practice Notification (Boardwalk)		Submit 14 days prior to the start of construction.
	Effective Date	TBD		
	Expiry Date	TBD		
***Public Lands Act* (provincial)**	Regulatory Item	Disposition (Boardwalk)		DLO150027
	Effective Date	10 August 2015		
	Expiry Date	9 August 2040		
***Historical Resources Act* (provincial)**	Regulatory Item	Online clearance	Historical Resources Impact Assessment	OPaC 005786259
	Effective Date	28 August 2014	5 February 2016	
	Expiry Date	N/A	N/A	
North Saskatchewan River Valley Area Redevelopment Plan; Bylaw No. 7188	Regulatory Item	Initial Project Review (IPR)	Environmental Impact Assessment (EIA)	In progress
	Effective Date	13 August 2014	TBD	
	Expiry Date	N/A	N/A	

4 Environmental Assessment Methods

4.1 DATABASE SEARCHES

A review of publicly available data and information was completed to identify potential environmental constraints specific to the project area. Sources of information included:

- Fish and Wildlife Management Information System (FWMIS) (Government of Alberta 2014a);
- Alberta Conservation Information Management System (ACIMS) (Government of Alberta 2013a);
- Historical Resources Act listings (ABADATA 2016);
- Government of Alberta Species at Risk Database (Government of Alberta 2011);
- Species at Risk Public Registry (Government of Canada 2016b); and
- Agricultural Region of Alberta Soil Inventory Database (Government of Alberta 2015).

4.2 LITERATURE REVIEW

Previous studies completed within the project area and reviewed as part of the EIA include:

- Geotechnical Investigation by Golder Associates dated October 6, 2014 and May 12, 2016 (**Appendix B**);
- Paleontological Historical Resource Impact Assessment by Nautilus Paleontology dated October 1, 2014 (**Appendix C**); and,
- A Biophysical Assessment by Associated Engineering Ltd. dated July 29, 2014 (**Appendix D**).

4.3 FIELD VERIFICATION

Two biologists from Associated Engineering's Environmental Science Division, Beckie Rozander, P.Biol., and Jöel Gervais, B.Sc., QAES., conducted a field assessment and rare plant survey on July 29, 2014 to inspect the existing damaged boardwalk and the proposed new boardwalk location; the surrounding area was also surveyed for wildlife and vegetation.

A follow up field verification was completed by Michael Paulsen, P. Eng. (Lead Bridge Designer) and Sandra Meidinger, P. Biol. (AE Project Manager and Lead Biologist) on November 2, 2106 to confirm the new boardwalk alignment.

Field photographs are included in **Appendix E**.

5 Baseline Environmental Conditions

5.1 LAND USE

The project area is located within the North Saskatchewan River valley, in the City of Edmonton. Whitemud Ravine contains a network of existing trails and boardwalks. Per City of Edmonton Bylaw 7188, the protection of the River Valley environment is important in order to provide Edmontonians with a contiguous recreation and open space system as well as to retain the existing designated residential areas (City of Edmonton 2014).

The neighbouring areas are generally residential, and nearby features include the Derrick Golf and Winter Club, and parking for access to the trails and river valley.

5.2 SOILS

The project area lies within the aspen parkland region of Alberta and is characterized by Black Chernozemic soils with Glysolic soils present in low lying areas (Government of Alberta 2013b). Golder Associates conducted a geotechnical survey on September 2, 2014 (**Appendix B**). The methods included drilling four test holes using a 50mm auger at depth ranging from 1.5 to 3.4m below the soil surface.

The results of Golder Associates geotechnical survey showed that on the north embankment mainly consisted of a clayshale bedrock and sand with some gravel. This sand was uniform in the grade. Within the floodplain the bedrock remained the same, however, the subsurface conditions shifted from sand to silty clay. Topsoil depths ranged in depth from the soil surface to 0.1 to 0.2m.

The slope on the north side of the oxbow crossing poses significant erosion potential particularly where the existing stairs and boardwalk are located. Restoration plans should include erosion protection measures for this slope to prevent slope failure and sedimentation to both the oxbow and Whitemud Creek.

5.3 VEGETATION

Vegetation within the project area is generally riparian, with some upland terrestrial vegetation. During the field survey, shrubs and aquatic vegetation were observed (**Table 5-1**). None of the plant species observed on site have conservation listings under the *Species at Risk Act* or provincial *Wildlife Act*, Schedule 6 (Government of Alberta 2011, Government of Canada 2014).

A mature spruce tree was noted during the field visit at the edge of the slope along the existing trail, with a substantial portion of it's root system exposed against the slope. The tree was observed as a potentially unstable safety hazard; however, removal of this tree is not within the project footprint.

Minimal vegetation will be disturbed under the project footprint as shown in **Figure 5-1**. The proposed alignment was chosen to avoid mature vegetation.

Figure 5-1
General boardwalk alignment indicated by the blue arrows

Table 5-1
Plant Species Observed During Field Survey

Common Name	Scientific Name	Habitat	*Species at Risk Act* Status[1]	COSEWIC Status[1]	*Wildlife Act* Schedule 6 Listing[2]	2010 General Status of Wild Species[3]
Trees and Shrubs (riparian, transitional, and upland[2])						
White spruce	*Picea gluaca*	Upland	Not listed	Not listed	Not listed	Secure
Prickly rose	*Rosa acicularis*	Upland	Not listed	Not listed	Not listed	Secure
Green alder	*Alnus crispa*	Transitional	Not listed	Not listed	Not listed	Secure
Manitoba maple	*Acer negundo*	Transitional	Not listed	Not listed	Not listed	Undetermined
Red-osier dogwood	*Cornus stolonifera*	Upland	Not listed	Not listed	Not listed	Secure
Saskatoon	*Amelanchier alnifolia*	Upland	Not listed	Not listed	Not listed	Secure
Wild red raspberry	*Rubus idaeus*	Upland	Not listed	Not listed	Not listed	Secure
Snowberry	*Symphoricarpos albus*	Upland	Not listed	Not listed	Not listed	Secure
High bush cranberry	*Epilobium angustifolium*	Transitional	Not listed	Not listed	Not listed	Secure
Mountain ash	*Sorbus species*	Upland	Not listed	Not listed	Not listed	Secure
Sandbar willow	*Salix exigua*	Riparian	Not listed	Not listed	Not listed	Secure
Wolf willow	*Elaeagnus commutata*	Upland	Not listed	Not listed	Not listed	Secure
Bebb's willow	*Salix bebbiana*	Riparian	Not listed	Not listed	Not listed	Secure
Forbes and Graminoids[3]						
Cattail	*Typha latifolia*	Riparian	Not listed	Not listed	Not listed	Secure
Reed canary grass	*Phalaris arundinacea*	Riparian	Not listed	Not listed	Not listed	Secure

[2] Wilkinson, K.1990. Trees and Shrubs of Alberta. Lone Pine Publishing. Edmonton (AB).
[3] Lahring, H. 2003. Water and Wetland Plants of the Prairie Provinces. University of Regina; Canadian Plains Research Centre. Regina (SK).

Common Name	Scientific Name	Habitat	*Species at Risk Act* Status[1]	COSEWIC Status[1]	*Wildlife Act* Schedule 6 Listing[2]	2010 General Status of Wild Species[3]
Water hemlock	*Cicuta maculata*	Riparian	Not listed	Not listed	Not listed	Secure
Stinging nettle	*Urtica dioica*	Riparian	Not listed	Not listed	Not listed	Secure
Marsh skullcap	*Scutellaria galericulata*	Riparian	Not listed	Not listed	Not listed	Secure
Rare Species						
Lance-leaved loosestrife	*Lysimachia lanceolata*	Riparian	Not listed	Not listed	Not listed	Exotic

[1]Government of Canada. 2016b. Species at Risk Public Registry. *A to Z Species Index.* http://www.sararegistry.gc.ca/sar/index/default_e.cfm. Accessed February 17, 2017.
[2] *Wildlife Regulation*, Alberta Regulation 143/1997, Schedule 6. http://www.qp.alberta.ca/documents/Regs/1997_143.pdf. Accessed February 17, 2017.
[3] Government of Alberta. 2011. Wild Species Status Search. http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. Accessed February 17, 2017.

5.3.1 Rare Species

A search of Alberta Conservation Information Management System (ACIMS) revealed five non-sensitive element occurrences, no protected areas, and no Crown reservations/notations within ATS Section 12-52-25-W4M (Government of Alberta 2013a). These non-sensitive species and their statuses are provided in **Table 5-2** below.

None of the species from the ACIMS desktop search were incidentally observed in the project area during the field visit. However, lance-leaved loosestrife (*Lysimachia lanceolata*) was detected more than 50 m from the site along the west edge of the oxbow (**Figure 5-4**). This plant is listed as an exotic species in Alberta (Government of Alberta 2011) with an ACIMS ecological community ranking of S3 (21 – 80 occurrences; may be rare and local throughout its range, or found locally in a restricted range) and a global ranking of G5 (community is demonstrably widespread and abundant); but is not currently listed under the *Species-at-Risk Act.*

Figure 5-2
Lance-Leaved Loosestrife (Source: Ladybird Johnson Wildflower Center 2013)

Table 5-2
Non-Sensitive Element Occurrences Within 12-52-25-W4M As Noted In A Search Of The Provincial ACIMS Database

Common Name	Scientific Name	Preferred Habitat	ACIMS Rank[1]	*Species At Risk Act* Status[2]	COSEWIC Status[2]	*Wildlife Act* Schedule 6 Listing[3]	2010 General Status of Wild Species[4]
Flat fruited pelt lichen	*Peltigera horizontalis*	Mossy soil, rocks, and logs in forest areas (Brodo et al 2001)	S2S3	Not listed	Not listed	Not listed	May be at risk
Marsh (green) muhly	*Muhlenbergia racemosa*	Dry soil (Mohlenbrock 2001)	S2	Not listed	Not listed	Not listed	May be at risk
Smooth sweet cicely	*Osmorhiza longistylis*	Moist woods (Kershaw et al 2001)	S2	Not listed	Not listed	Not listed	May be at risk
Flat-topped white aster	*Doellingeria umbellata* var. *pubens*	Moist woodland and swampy ground. (Moss and Packer 1983)	S2	Not listed	Not listed	Not listed	May be at risk
Moss	*Rhodobryum ontariense*	Forests, forest edge, rotten longs, tree base. (eFlora 2007)	S2	Not listed	Not listed	Not listed	Sensitive

[1]Rank as listed on ACIMS and defined as "an evaluation of the level of risk of extinction of species and the elimination of ecosystems" (Governement of Alberta 2013; NatureServe)
[2] Government of Canada. 2016b. Species at Risk Public Registry. *A to Z Species Index.* http://www.sararegistry.gc.ca/sar/index/default_e.cfm. Accessed February 17, 2017.
[3] *Wildlife Regulation*, Alberta Regulation 143/1997, Schedule 6. http://www.qp.alberta.ca/documents/Regs/1997_143.pdf. Accessed February 17, 2017.
[4] Government of Alberta. 2011. Wild Species Status Search. http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. Accessed February 17, 2017.

5.3.2 Invasive weeds

Several noxious weeds were observed in the project area during the field visit; non-listed weed species were also noted in the project area (Table 5-3).

Table 5-3
Noxious Weeds Observed Within the Project Area

Common Name	Scientific Name	Habitat	ACIMS Type[1]	*Weed Control Act* Scheduled listing[2]
Scheduled (Noxious) Weeds				
Field bindweed	*Convolvulus arvensis*	Riparian/Disturbed sites	Exotic	Noxious
Canada thistle	*Cirsium arvense*	Disturbed areas	Exotic	Noxious
Common tansy	*Tanacetum vulgare*	Disturbed areas	Exotic	Noxious
White cockle	*Lychnis alba*	Upland	Exotic	Noxious
Perennial sow thistle	*Sonchus arvensis*	Disturbed areas	Exotic	Noxious
Dalmatian toadflax	*Linaria dalmatica*	Disturbed areas	Exotic	Noxious
Tall buttercup	*Ranunculus acris*	Riparian/Disturbed areas	Exotic	Noxious
Non-listed Weeds				
Sweet clover	Genus *Melilotus*	Disturbed areas	Exotic	Not listed
Lambs quarters	*Chenopodium album*	Riparian/Upland	Exotic	Not listed
Flixweed	*Descurainia sophia*	Disturbed areas	Exotic	Not listed

[1] List of Elements in Alberta – Vascular Plants. 2015. ACIMS. http://www.albertaparks.ca/media/6493459/acims-list-of-elements-in-alberta-vascular-plants.xlsx. February 17, 2017.
[2] Weed Control Regulation. Alberta Regulation 19/2010, Part 4 Schedule. www.qp.alberta.ca/documents/Regs/1997_143.pdf. February 17, 2017.

5.4 WILDLIFE

The project falls within two provincial sensitive wildlife zones, “sharp-tailed grouse survey area” and “sensitive raptors range” for bald eagles, *Haliaeetus leucocephalus* (Government of Alberta 2014a). It is located south and outside of the Key Wildlife Biodiversity Zone (**Figure 5-3)**. There are also four documented occurrences of wildlife within a 2 km radius of the boardwalk based on a desktop search (Government of Alberta 2014a); summarized in **Table 5-4**, and further discussed below. Species that were observed during the site visit are discussed in Section 5.4.3 and summarized in **Table 5-5**.

Table 5-4
Wildlife Recorded Within 2km of NW12-52-25-W4M and their Conservation Listings.

Common Name	Scientific Name	Habitat	Species at Risk Act Status[1]	COSEWIC status[1]	*Wildlife Act* Schedule 6 Listing[2]	2010 General Status of Wild Species[3]
Barred Owl	*Strix varia*	Coniferous forests near water sources	Not listed	Not listed	Not listed	Sensitive
Peregrine Falcon	*Flaco peregrinus*	Wetlands/grasslands Dry forests	Special concern – Schedule 1	Special concern	Endangered	At Risk
Canadian Toad	*Anaxyrus hemiophrys*	Various types: Wetlands/pastures/ Forests/grasslands	Not listed	Not at risk	Not listed	May be at Risk
Northern Leopard Frog	*Rana pipiens*	Forests/grasslands Riparian areas	Special concern – Schedule 1	Special concern	Not listed	At Risk

[1] Government of Canada. 2016b. Species at Risk Public Registry. *A to Z Species Index.* http://www.sararegistry.gc.ca/sar/index/default_e.cfm. Accessed February 17, 2017.
[2] *Wildlife Regulation*, Alberta Regulation 143/1997, Schedule 6. http://www.qp.alberta.ca/documents/Regs/1997_143.pdf. Accessed February 17, 2017.
[3] Government of Alberta. 2011. Wild Species Status Search. http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. Accessed February 17, 2017.

5.4.1 Birds

Based the desktop search noted above, Barred owls (*Strix varia*) and Peregrine falcons (*Flaco peregrinus*) have been previously documented within 2km of the project area. Barred owls are generally found in swamps and dense forest. They may move into open areas for nocturnal hunting. This species is a resident of Alberta year round, and it may begin nesting activities in the early spring (Government of Alberta 2016). Peregrine falcons are generally found nesting close to riparian habitat or marsh habitats. They are active from mid-to-late April until they migrate south for the winter, anytime from late August to October (Government of Alberta 2009b).

The project area is located within the migratory nesting zone of B4, which has a nesting period from April 15 to August 31 (Government of Canada 2016a). The nesting period for owls and other birds of prey in this area is from March 1 to August 15 (Government of Alberta 2013). **Table 5-5** further summarizes the guidelines for sensitive timing windows for these species, with setback distances from nesting sites or leks based on the level of disturbance required to complete construction works.

As previously mentioned, the project area is located within the Sharp-tailed grouse survey zone. However, it does not support preferred habitat for Sharp-tailed grouse or their leks, which generally is within brush areas near agricultural fields (Government of Alberta 2009b).

Table 5-5
Sensitive Timing Guidelines and Associated Setback Distances, By Level of Disturbance

Species	Location	Time of Year	Level of Disturbance		
			Low	Medium	High
Sensitive Raptor Species Peregrine falcon, Bald eagle, Golden eagle, Prairie falcon, Ferruginous hawk	Nesting sites	March 15th – July 15th	1000m	1000m	1000m
		July 16th – March 14th	50m	100m	1000m
Sharp-tailed grouse (*Pedioecetes phasianellus*)	Leks	March 15th – July 15th	500m	500m	500m
		July 16th – March 14th	100m	100m	500m
Barred Owl (*Strix varia*)	Nesting sites	March 1st – August 15th	100m	400m	500m
		August 16th – February 28th	N/A	N/A	500m

5.4.2 Amphibians

Documented occurrences of amphibians within 2 km of the project area include the Canadian toad (*Bufo hemiophrys*), active April to September (Government of Alberta 2009a), and the Northern leopard frog (*Rana pipiens*), active April to October (Government of Alberta 2013d). During active periods, the Canadian toad is generally mobile during the day and burrows into the ground at night. The Northern leopard frog is generally active at night, resting during the day in shallow pockets in the soil to absorb moisture and avoid predators.

Given the abundance of riparian habitat, there is a high likelihood of amphibians being present in the project area during the active periods.

5.4.3 Site Observations

A chipmunk (*Tamias* genus) nesting area was observed during the field visit, northwest of the existing boardwalk and stairs (**Figure 5-4**). Chipmunks are active in Alberta from spring to autumn. In winter, they spend the majority of their time in solitary burrows, alternating between bouts of activity and torpor (Government of Alberta 2010). Additional species noted during the field visit are included in **Table 5-6**.

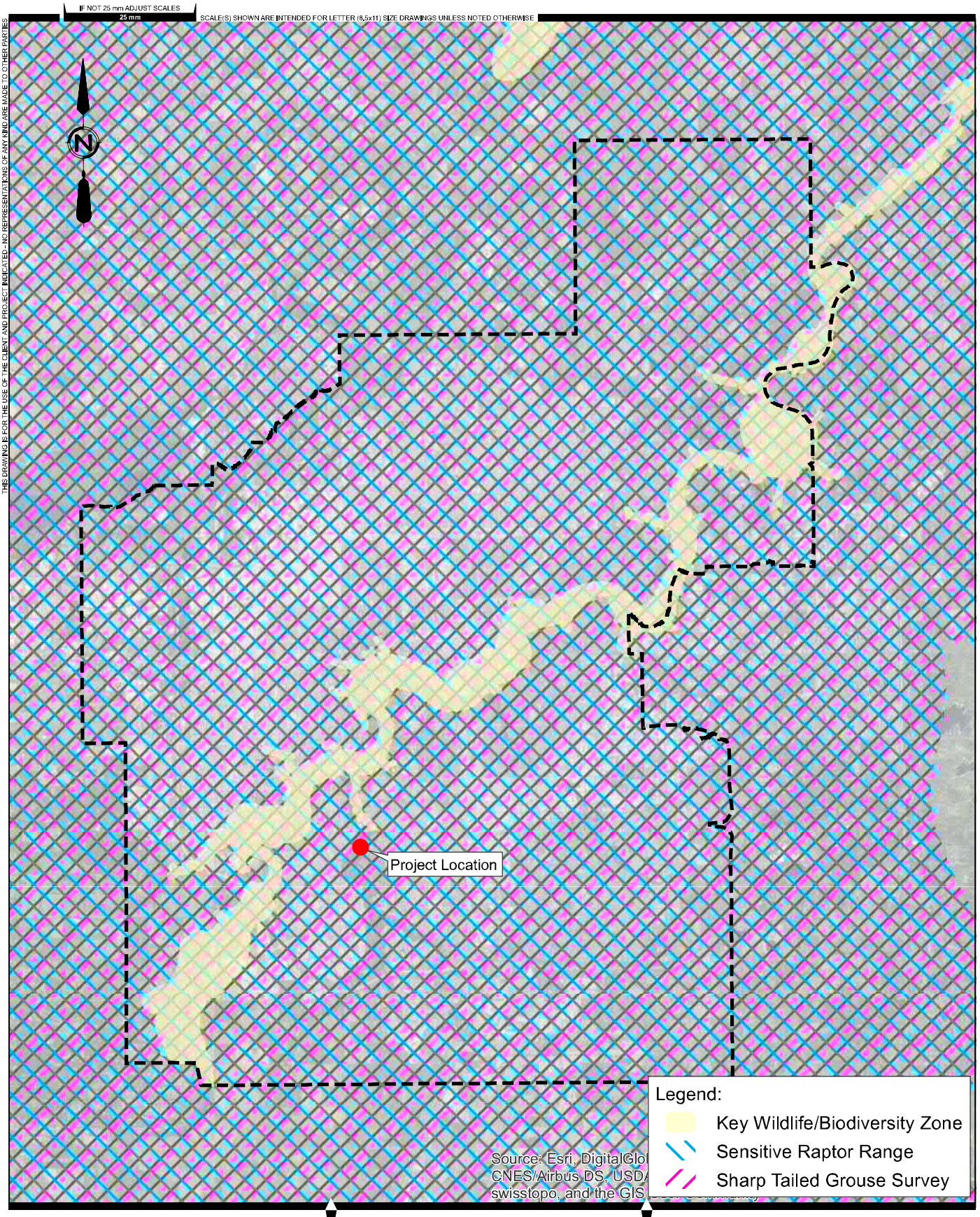
Table 5-6
Wildlife Species Observed During Field Survey

Common Name	Scientific Name	Observation Type	Species at Risk Act Status[1]	COSEWIC status[1]	*Wildlife Act* Schedule 6 Listing[2]	2010 General Status of Wild Species[3]
Garter snake	*Thamnophis* (Genus)	One individual	Unknown	Unknown	Not listed	Sensitive
Chipmunk	*Tamias genus*	Three individuals	Unknown	Unknown	Not listed	Unknown
Red squirrel	*Tamiasciurus hudsonicus*	Two individuals	Not listed	Not listed	Not listed	Secure
Gadwall duck	*Anas strepera*	12 individuals	Not listed	Not listed	Not listed	Secure
Mallard duck	*Anas platyrhynchos*	Three individuals	Not listed	Not listed	Not listed	Secure
Various songbirds	Various species	Individuals	Unknown	Unknown	Not listed	Unknown

Common Name	Scientific Name	Observation Type	Species at Risk Act Status[1]	COSEWIC status[1]	*Wildlife Act* Schedule 6 Listing[2]	2010 General Status of Wild Species[3]
Western screech owl	*Megascops kennicottii*	One individual	Not listed	Not listed	Not listed	Accidental
Black hornet	*Vespa* (Genus)	Nest	Unknown	Unknown	Not listed	Unknown
Coyote	*Canis latrans*	Tracks	Not listed	Not listed	Not listed	Secure
Weasel	*Mustela (Genus)*	Tracks	Unknown	Unknown	Not listed	Unknown
Beaver	*Castor Canadensis*	Activity	Not listed	Not listed	Not listed	Secure

[1] Government of Canada. 2016b. Species at Risk Public Registry. *A to Z Species Index.* http://www.sararegistry.gc.ca/sar/index/default_e.cfm. Accessed February 17, 2017.
[2] *Wildlife Regulation*, Alberta Regulation 143/1997, Schedule 6. http://www.qp.alberta.ca/documents/Regs/1997_143.pdf. Accessed February 17, 2017.
[3] Government of Alberta. 2011. Wild Species Status Search. http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. Accessed February 17, 2017.

IF NOT 25 mm ADJUST SCALES
25 mm
SCALE(S) SHOWN ARE INTENDED FOR LETTER (8.5x11) SIZE DRAWINGS UNLESS NOTED OTHERWISE



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DATE: 2/15/2017, Stephanie Tik

Associated Engineering

AE PROJECT No.	2014-3177
DATE	2017 FEBRUARY
SCALE	1:200,000
COORD. SYSTEM	NAD 1983 3TM 114
REV	
DESCRIPTION	ISSUED FOR REPORT

FIGURE No. 5-3

WHITEMUD CREEK RAVINE SOUTH OXBOW SITE BOARDWALK REPLACEMENT

GOVERNMENT OF ALBERTA SENSITIVE ZONES - RELATIVE TO PROJECT AREA

5.5 AQUATIC RESOURCES AND FISH

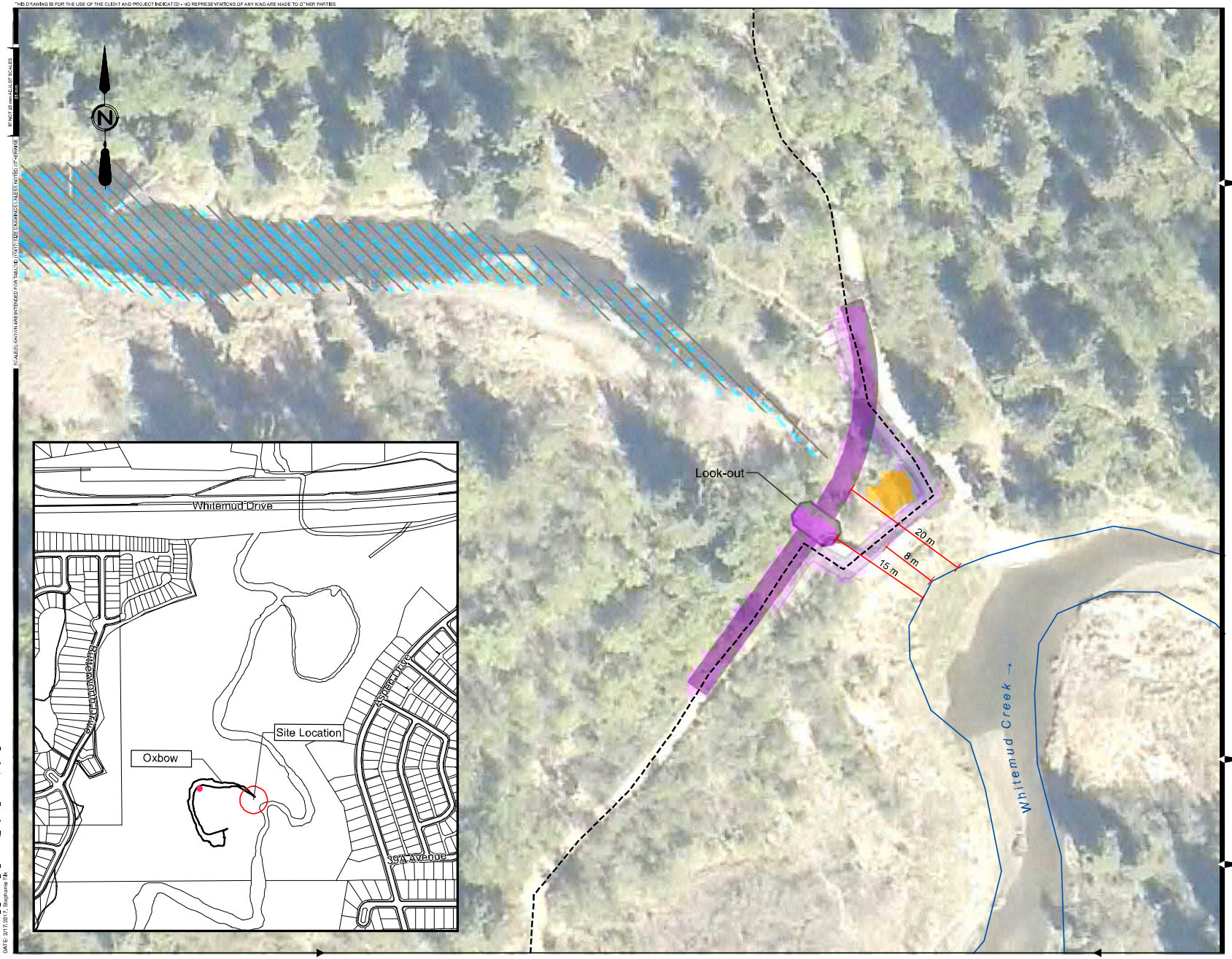
The new boardwalk alignment will cross an oxbow, about 20 m west of the Whitemud Creek channel (see **Figure 5-4**). Although the oxbow is not currently connected to Whitemud Creek, it was noted by a local resident that it has historically been connected during periods of extremely high water (flood events)[4] . This oxbow is approximately 350 m in length (U-bend shape) and about 10 m in width. Whitemud Creek is a tributary to the North Saskatchewan River and spans a length of approximately 11 km. Whitemud Creek and the oxbow are both located on the south side of the North Saskatchewan River.

The oxbow is considered a Class D waterbody because it is not hydrologically connected to Whitemud Creek. Several small fish were visually observed in the oxbow during the 2014 field assessment. The species could not be confirmed but appeared to be fry, cyprinid (family Cyprinidae), stickleback (family Gasterosteidae), or northern pikeminnow (Ptychocheilus oregonensis).

While the boardwalk will not be constructed within the bed and banks of Whitemud Creek, the creek is within close proximity to the project footprint (within 20 m). Whitemud Creek is a Class B watercourse in the Alberta *Water Act* Code of Practice Maps, with a restricted activity period (RAP) from **April 16 to June 30**. It is known to contains important walleye (*Sander vitreus*) spawning habitat (Government of Alberta 2012).

No species at risk for fish were identified in the FWMIS search, either provincially or federally (**Table 5-5**) (*Wildlife Regulation*, A.R. 143/1997, Government of Canada 2014). An aquatic habitat assessment of Whitemud Creek in 2010 specified fine material as the predominant substrate (<2 mm; 36%), followed by small gravel (2 - 16 mm; 28%), large gravel (20%), and cobble (4%) (Government of Alberta 2014a).

[4] According to local knowledge, the oxbow was last connected to Whitemud Creek ~ 4 years ago (J. Gervais personal communication with local residents, 2014).



Associated Engineering

THE CITY OF Edmonton

FIGURE No. 5-4

WHITEMUD CREEK RAVINE SOUTH OXBOW SITE BOARDWALK REPLACEMENT

SITE DETAILS

AE PROJECT No.	2014-3177
SCALE	1:500
COORD. SYSTEM	NAD 1983 CSRS 3TM 114
DATE	2017 FEBRUARY
REV	
DESCRIPTION	ISSUED FOR REPORT

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DATE: 2017.01.17, Stephanie Tik

Table 5-7
Fish Species Identified from FWMIS Within A 2km Radius Of NW12-52-25-W4M

Common Name	Scientific Name	*Species at Risk Act* Status[1]	COSEWIC Status[1]	*Wildlife Act* Schedule 6 Listing[2]	2010 General Status of Wild Species[3]
Burbot	*Lota lota*	Not listed	Not listed	Not listed	Secure
Brook Stickleback	*Culaea inconstans*	Not listed	Not listed	Not listed	Secure
Fathead minnow	*Pimephales promelas*	Not listed	Not listed	Not listed	Secure
Lake chub	*Couesius plumbeus*	Not listed	Not listed	Not listed	Secure
Longnose dace	*Rhinichthys cataractae*	Not listed	Not listed	Not listed	Secure
Longnose sucker	*Catostomus catostomus*	Not listed	Not listed	Not listed	Secure
Northern crayfish	*Orconectes virilis*	Not listed	Not listed	Not listed	Not assessed
Pearl dace	*Margariscus margarita*	Not listed	Not listed	Not listed	Undetermined
River shiner	*Notropis blennius*	Not listed	Not listed	Not listed	Undetermined
Spottail shiner	*Notropis hudsonius*	Not listed	Not listed	Not listed	Secure
White sucker	*Catostomus commersoni*	Not listed	Not listed	Not listed	Secure

[1] Government of Canada. 2016b. Species at Risk Public Registry. *A to Z Species Index.* http://www.sararegistry.gc.ca/sar/index/default_e.cfm. Accessed February 17, 2017.
[2] *Wildlife Regulation*, Alberta Regulation 143/1997, Schedule 6. http://www.qp.alberta.ca/documents/Regs/1997_143.pdf. Accessed February 17, 2017.
[3] Government of Alberta. 2011. Wild Species Status Search. http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. Accessed February 17, 2017.

5.6 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

The Whitemud Ravine is part of the North Saskatchewan River Valley, a protected area under Bylaw 7188 as part of Edmonton's valuable open space heritage (City of Edmonton 2014). It is described by the Edmonton Nature Club, a non-profit organization in Edmonton, as giving "a feeling of wilderness in the city" (Edmonton Nature Club 2017).

The Whitemud Boardwalk provides access for recreational users to the river valley trails off the Rainbow Valley Road, to various neighborhoods, including Aspen Gardens. The new boardwalk will allow for the trail system to be more accessible to a variety of recreational users by replacing the existing stairs with a sloped gravel trail, connecting to the new boardwalk.

5.7 HISTORICAL RESOURCES

As mentioned in Section 3, the project is in an area with high potential for archaeological and paleontological resources (Historical Resource Value: 5, archaeological and palaeontological).

The HRIA completed in 2014 determined that the risk of encountering fossil resources during Project construction is minimal. As a result, project Clearance was obtained from ACT. However, if any fossiliferous material is encountered during the project work, contractors must immediately contact the City Project Manager.

6 Impact and Analysis Methods

Observations made during the literature review and field verification guided the assessment of environmental impacts related to the project. The assessment considered:

- the baseline environmental conditions (Section 5);
- planned construction activities;
- the proposed boardwalk upgrade concept; and
- operation of the boardwalk.

Impacts were assessed by comparing the baseline site conditions with the expected final site conditions. Where impacts on the baseline conditions are expected, consideration is given to minimize impacts through mitigation strategies and best management practices (BMPs). Changes expected to have minor impacts or deemed to be easily mitigated were considered negligible impacts.

7 Environmental Impacts and Mitigation Strategies

7.1 SITE-SPECIFIC IMPACTS AND MITIGATION STRATEGIES

The boardwalk replacement has been designed to avoid short and long-term impacts on the surrounding environment and such that impacts can be easily mitigated. The new alignment will avoid mature trees and will be located further away from Whitemud Creek, minimizing its influence on the main channel. Removal of the existing boardwalk will also allow for establishment of erosion and sediment control where the bank is eroding.

The key concerns addressed in this EIA include:

- Loss of instream and upland vegetation within the project footprint;
- Spread of invasive species;
- Wildlife and fish encounters during construction; and
- Indirect impacts on nearby fish habitat in Whitemud creek.

7.1.1 Vegetation and Rare Plants

Loss of vegetation is anticipated within the project footprint. Aquatic vegetation loss will be limited to the area of the instream piles (~3 m^2) and clearing a 1 m wide across the channel (~ 10 m^2) to enable access to the piles.

Disturbance to vegetation should be minimized wherever possible and be limited to the construction area. Delineating the construction area using flagging or fencing prior to construction starting will prevent any unnecessary loss to vegetation.

Vegetation within the proposed laydown areas will primarily be Manitoba maple *(Acer negundo*), alder (*Alnu*s spp.) and red-osier dogwood *(Cornus stolonifera*). However, Urban Forestry Department should be consulted on all vegetation disturbance and protection measures as they directly relate to the project work; the Urban Forestry Department will perform all tree/vegetation removal and maintenance activities. Section 7.1.3 provides mitigation measures relating to the timing of vegetation disturbance, to minimize impact on migratory birds and sensitive owl species.

Lance-leaved loosestrife (rare plant) was observed during the field visit more than 50 m away from the project area. A qualified professional should confirm that this species (and no other rare species) is not present within the project area (particularly the laydown areas) prior to construction. If it is not present, mitigations are not anticipated to be required.

7.1.2 Invasive Species

Under the *Weed Control Act*, the project must "control" listed noxious weeds (see Section 3.2.6). Weed species on site should be re-assessed by a qualified environmental professional prior to construction, and their approximate locations considered for further management and equipment siting. Additionally, the contractor should provide as part of the project ECO Plan, a procedure for the control of Noxious weed species on site.

Additionally, during construction, spread prevention actions should be implemented. For example, all equipment should be cleaned prior to arriving on site and prior to leaving to prevent introduction of weed species from other sites, and to prevent the spread of the weed species known to be present on this site.

Weed identification guides, such as the "Alberta Invasive Plan Identification Guide"[5] should be kept on site for reference by construction personnel. If any prohibited noxious weeds are identified they must be destroyed.

7.1.3 Wildlife

The boardwalk replacement is not expected to change or obstruct the movement of wildlife through the Whitemud Ravine. There are minor changes to the landscape from the existing state and post-construction alignment and wildlife will be able to continue to pass on the west side of the oxbow.

[5] Wheatland County. 2013. Alberta Invasive Plant Identification Guide. http://open.alberta.ca/dataset/8bb61884-bbfb-4640-bd5d-96f6e633d4ee/resource/275f7dbe-8116-4d81-ba95-329df950be7e/download/6740590-2013-Alberta-Invasive-Plant-Identification-Guide-2013-06-13.pdf (accessed 26 October 2016).

The presence of wildlife should be considered during construction planning to avoid harassing or disturbing in accordance with the *Wildlife Act*. Riparian habitat comprises much of the project area. While larger mammals and ungulates will be easily observed within the construction areas, amphibians may go unnoticed. They are most likely to be present within the project footprint during their active periods.

To reduce the impacts on amphibians in the area, the quality of habitat should be protected from the risks of contamination and sedimentation while working near Whitemud Creek and the oxbow. Woody debris should be left alone wherever possible as these are common basking sites for amphibians. During construction, the area should be inspected each morning to ensure wildlife is not trapped within the isolation area or by the ESC measures. Silt fencing, if installed to the correct depth or weighted down at the base, may also work as amphibian exclusion fencing to deter them from entering the project work area. This is generally more effective when implemented prior to the end of hibernation periods (OMNR 2013).

Vegetation clearing should be targeted to occur outside of sensitive wildlife breeding/nesting periods, **March 1 to August 31** (in other words, clear between September 1 and February 28), where possible. The construction schedule as proposed will likely require some clearing and grubbing to occur during this period. Therefore, a qualified environmental professional should be consulted prior to vegetation removal to determine if preferred nesting habitat is present in the project area and, if required, complete a nesting survey 7 days prior to clearing.

Table 7-1 outlines the restricted periods and setbacks for sensitive raptors and sharp-tailed grouse (Government of Alberta 2013c).

7.1.4 Fish and Aquatic Habitat

It is expected that the total instream footprint will be 3 m^2 (or 10 piles) and will have minimal impacts to the aquatic environment within the oxbow. In addition, the height of the boardwalk is expected to be 2.6 m above the substrate; therefore, it is anticipated that there will be no effect on the movement of water and fish within the oxbow. Aquatic vegetation will continue to grow beneath the structure and regulate water temperature and provide nutrients for fish.

During all concrete work for the installation of the piles, compressed CO_2 should be kept nearby, to use in case of spills of liquid concrete into the oxbow. CO2 may be used immediately following a spill to neutralize alkalinity caused by the spill. Additionally, in the event of a spill, the pH of the oxbow should be monitored to determine when the alkalinity is neutralized by the CO_2. Samples from other parts of the oxbow should be used as a baseline for pH.

The oxbow is considered a Class D waterbody and has been identified as containing fish. Work in this waterbody (specifically, any below the high water mark) will require appropriate regulatory permits and mitigation measures such as the use of isolation. Due to the proximity of Whitemud Creek, extra caution when working near the creek should be taken during the Restricted Activity Period for this Class B waterbody (April 16 to June 30).

The Fisheries and Oceans Canada (DFO) guidelines for Measures to Avoid Causing Harm to Fish or Fish Habitat must also be followed (Government of Canada 2013).

7.2 OTHER KEY MITIGATION STRATEGIES AND GENERAL BEST MANAGEMENT PRACTICES

Other key mitigation strategies and best management practices for this project will include:

1. Minimizing the potential for workers and equipment entering the site to introduce or spread weeds. Ensure all equipment is clean and free of debris, and remove existing noxious weed species if encountered on site.
2. Implementing the following potential strategies in the site's plans for erosion and sediment control and reclamation: soil stabilization through planting water-tolerant native seeds, live willow staking, and use of wattle lines and native shrubs. Consider also the potential impact of intense weather events on re-seeding plans.
3. All ESC measures should be free of hay and straw to prevent the spread of non-native seeds and to prevent attracting wildlife;
4. Completing clearing work outside of March 1 and August 31, taking into consideration the nesting periods for migratory birds, sensitive raptors, and barred owls. If any raptor nests are detected on site, specific disturbance buffers may need to be established, as identified in **Table 7-1**.
5. Isolating the work area in the oxbow using caisson or a silt curtain, any trapped fish must be removed from the within the isolation area before proceeding;
6. Removing the isolation curtain in the oxbow once sediment has settled out of the water column;
7. Restoring the site to its original condition upon project completion and seeding disturbed areas with a native seed mix and following the City's Restoration Plan.
8. All areas disturbed during construction will be cleared of construction waste and re-contoured to original conditions;
9. Completing an Environmental Construction Operation (ECO) Plan which details any environmental sensitivities, erosion and sediment control, mitigation strategies and regulatory framework. The plan will include the following details:
    - All machinery will be clean and free of oil and grease and will not be allowed to enter to wetted perimeter of the oxbow or Whitemud Creek;
    - Refuelling of equipment will occur at least 30 m from any surface water feature or at such a distance that petroleum products will not be released into surface drainages;
    - Spill kits, equipped with river booms and absorbent pads, will be kept near the water at all times.
    - All spills will be immediately contained and reported to the appropriate authority; and
    - No construction waste is to be left on-site and the site must be clean of debris upon completion.

7.3 ENVIRONMENTAL MONITORING

A Qualified Aquatic Environmental Specialist (QAES) should be retained as an environmental monitor to provide periodic monitoring during the installation of the concrete piles. The monitor will have the authority

to halt or modify construction activities if some aspect of the work is creating or will result in environmental damage.

7.4 OPERATION AND MAINTENANCE ISSUES

There are no foreseeable operation and maintenance issues once the boardwalk is installed.

8 Summary

The replacement of the Whitemud Boardwalk, is expected to have minor environmental impacts provided the mitigation strategies described above are implemented. Any concerns can be managed by following best management practices and minimizing disturbance where possible as summarized in

City personnel should be notified immediately of any wildlife encounters or other environmental concerns relating to this project. Environmental permits and approvals, the project ECO Plan, and ESC Plan should be adhered to and available on site during all project work. A site inspection is recommended following project completion.

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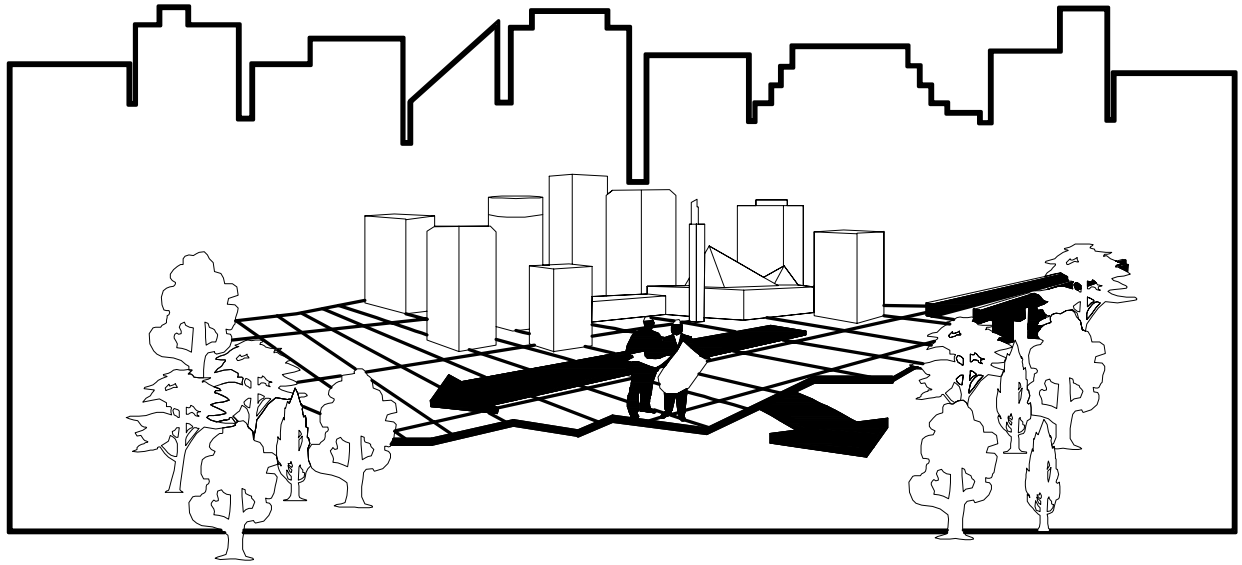
Appendix A – Boardwalk Design

THE CITY OF Edmonton

INTEGRATED INFRASTRUCTURE SERVICES

OPEN SPACE INFRASTRUCTURE DELIVERY



SOUTH WHITEMUD CREEK BOARDWALK REPLACEMENT

FOR 90% SUBMISSION

PROJECT No. 2014-3177

IF NOT 50 mm ADJUST SCALES
50 mm
SCALE(S) SHOWN ARE INTENDED FOR ANSI D (22X34) SIZE DRAWINGS, TABLOID (11X17) SIZE DRAWINGS ARE 1/2 OF SCALE(S) SHOWN UNLESS NOTED OTHERWISE

GENERAL NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE
2. ALL STATIONS AND ELEVATIONS ARE IN METERS
3. THE CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UNDERGROUND AND ABOVE GROUND UTILITIES IN THE FIELD PRIOR TO COMMENCING ANY WORK. THE CONTRACTOR IS RESPONSIBLE FOR ANY TEMPORARY PROTECTION OF EXISTING UTILITIES DURING CONSTRUCTION
4. ALL EXISTING TREES, SHRUBS AND PLANTINGS, NOT IDENTIFIED FOR REMOVAL ARE TO BE PROTECTED. ANY TREES, SHRUBS OR PLANTINGS DAMAGED BY THE CONTRACTORS OPERATIONS SHALL BE REPLACED AT THE CONTRACTOR EXPENSE
5. STRUCTURAL DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ALL OTHER CONTRACT DOCUMENTS
6. REVIEW ALL DRAWINGS AND CHECK DIMENSIONS PRIOR TO IMPLEMENTING THE WORK. REPORT ANY DISCREPANCIES TO THE CONSULTANT FOR CLARIFICATION BEFORE PROCEEDING
7. NOTIFY THE ENGINEER A MINIMUM OF 48 HOURS PRIOR TO ANY REQUIRED SITE REVIEWS
8. ALL REFERENCES TO CODES AND STANDARDS ARE TO THE LATEST ISSUE
9. SEE DRAWINGS FOR DESIGN LOADS. DO NOT EXCEED DURING CONSTRUCTION

DESIGN NOTES

CODES

1. CANADIAN HIGHWAY BRIDGE DESIGN CODE (CHBDC) CSA S6-14
2. ALBERTA BUILDING CODE (ABC)

LOADING

1. DEAD LOADS AS PER CSA S6-06
2. PEDESTRIAN LIVE LOAD AS PER CSA S6-14
3. DESIGN MAINTENANCE VEHICLE IS 1585 Kg WITH DYNAMIC LOAD ALLOWANCE = 0.25
4. WIND, SNOW AND RAIN LOAD AS PER ABC CLIMATIC DATA FOR EDMONTON:

   S_S = 1.7 kPa (a_{snow} = 1.0 IN COMBINATION WITH a_{LL} = 1.5)

   S_r = 0.1 kPa

   Q(1/50) = 0.50 kPa
5. SEISMIC LOADING AS PER ABC DATA FOR EDMONTON:

   SA(0.2) = 0.095

   SA(0.5) = 0.057

   SA(1.0) = 0.026

   SA(2.0) = 0.008

   PGA = 0.036

MATERIAL NOTES

STRUCTURAL STEEL

1. ALL STEEL WORK SHALL CONFORM TO CSA G40.2 1M (GRADE 350MPa)
2. ALL STEEL WORK TO BE HOT DIPPED GALVANIZED IN ACCORDANCE WITH ASTM A123
3. ANY GALVANIZING DAMAGED DURING CONSTRUCTION (INCLUDING DAMAGE DUE TO FIELD WELDING) SHALL BE REPAIRED BY METALIZING AS PER ASTM A780 METHOD 3
4. ALL WELDING SHALL CONFORM TO THE REQUIREMENTS OF CSA W59
5. ALL ANCHOR BOLTS TO CONFORM TO ASTM F.1554
6. ALL WELDS TO BE 6 mm FILLET WELDS U.N.O.
7. HIGH STRENGTH BOLTS, NUTS AND WASHERS ASTM STANDARD A325, STANDARD SPECIFICATION FOR STRUCTURAL BOLTS, STEEL
8. JOIST HANGERS AND POST CAPS TO BE SPECIFIED SIMPSON STRING TIE OR EQUIVALENT

TIMBER

1. WOOD COMPONENTS SHALL CONFORM TO CSA O141
2. WOOD PRESSURE TREATMENT SHALL CONFORM TO CSA O80
3. TREATED WOOD MEMBERS SHALL BE SPF No. 1 GRADE ACQ TREATED
4. TOP RAIL AND HANDRAIL WOOD SHALL BE ALASKAN YELLOW CEDAR GRADE 20f - E BENDING GRADE, APPEARANCE GRADE: COMMERCIAL
5. DECK MEMBERS TO BE S4S
6. MEMBERS TO BE FASTENED IN ACCORDANCE WITH CSA O86
7. DIMENSIONS SHOWN ARE NOMINAL FINISHED DIMENSIONS
8. JOIST HANGERS TO BE GALVANIZED SADDLE TYPE ONLY, NAILED PER THE MANUFACTURER'S RECOMMENDATIONS TO DEVELOP FULL CAPACITY OF HANGER

CONCRETE

1. ALL CONCRETE SHALL HAVE 28 DAY STRENGTH OF 35 MPa
2. CONCRETE SHALL HAVE A SLUMP OD 80 mm +/- 20 mm
3. MAXIMUM AGGREGATE SHALL BE 19.0 mm
4. WATER FOR CONCRETE SHALL BE ACCORDING TO CSA A23.1 CLAUSE 4.2.2
5. THE CONTRACTOR SHALL USE ONLY CHEMICAL ADMIXTURES SPECIFIED IN THE CONTRACT DOCUMENTS. SPECIALTY CHEMICAL ADMIXTURES MAY BE USED WHEN APPROVED BY THE OWNER

CAST-IN-PLACE REINFORCED CONCRETE

1. CONCRETE MATERIALS, QUALITY, MIXING, PLACING, FORMWORK AND OTHER CONSTRUCTION PRACTICES TO CONFORM TO CSA - A23.1
2. NOTIFY CONSULTANT 24 HOURS PRIOR TO CONCRETE POURS TO ALLOW FOR REVIEW OF REINFORCEMENT
3. FIELD AND LABORATORY TESTING OF CONCRETE TO BE COMPLETED BY A THIRD PARTY TESTING AND INSPECTION AGENCY APPROVED BY AND RESPONSIBLE TO THE ENGINEER. TESTING AGENCY SHALL BE CERTIFIED TO CSA - A283 AND TESTING TO BE COMPLETED IN ACCORDANCE WITH CSA - A23.2. TESTING PAID BY CONTRACTOR
4. SITE BATCHED CONCRETE INSTALLED AS PER MANUFACTURERS REQUIREMENTS IS ACCEPTABLE.

FOUNDATION

1. REMOVE ALL LOOSE OR SATURATED MATERIAL AND GROUNDWATER FROM THE BASE OF FOOTING EXCAVATION BY APPROVED METHODS PRIOR TO PLACING FOUNDATIONS
2. PROTECT EXCAVATIONS FOR FOOTING FROM RAIN, SNOW, FREEZING TEMPERATURES, STANDING WATER, LOSS OF MOISTURE AND DEGRADATION BY APPROVED METHODS

GEOTECHNICAL

1. ALL GEOTECHNICAL WORK TO BE CARRIED OUT IN ACCORDANCE WITH GOLDER ASSOCIATES GEOTECHNICAL INVESTIGATION REPORT NUMBER 1404541 "OXFORD BOARDWALK WHITEMUD CREEK WALKING TRAIL EDMONTON, ALBERTA" DATED MAY 12, 2016

DEMOLITION

1. CONTRACTOR SHALL PROVIDE A DEMOLITION PLAN STAMPED BY A PROFESSIONAL ENGINEER PRIOR TO START OF DEMOLITION
2. ALL MATERIAL SALVAGED SHALL BE DISPOSED OF IN AN ENVIRONMENTALLY FRIENDLY MANNER

Associated Engineering
BEST MANAGED COMPANIES Platinum Member

PRELIMINARY/
FOR DISCUSSION
NOT FOR CONSTRUCTION
DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
B	2017MAR17	M. PAULSEN	A. REES	ISSUED FOR 90% REVIEW
A	2017FEB17	M. PAULSEN	A. REES	ISSUED FOR 60% REVIEW

CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

SCALE: AS SHOWN

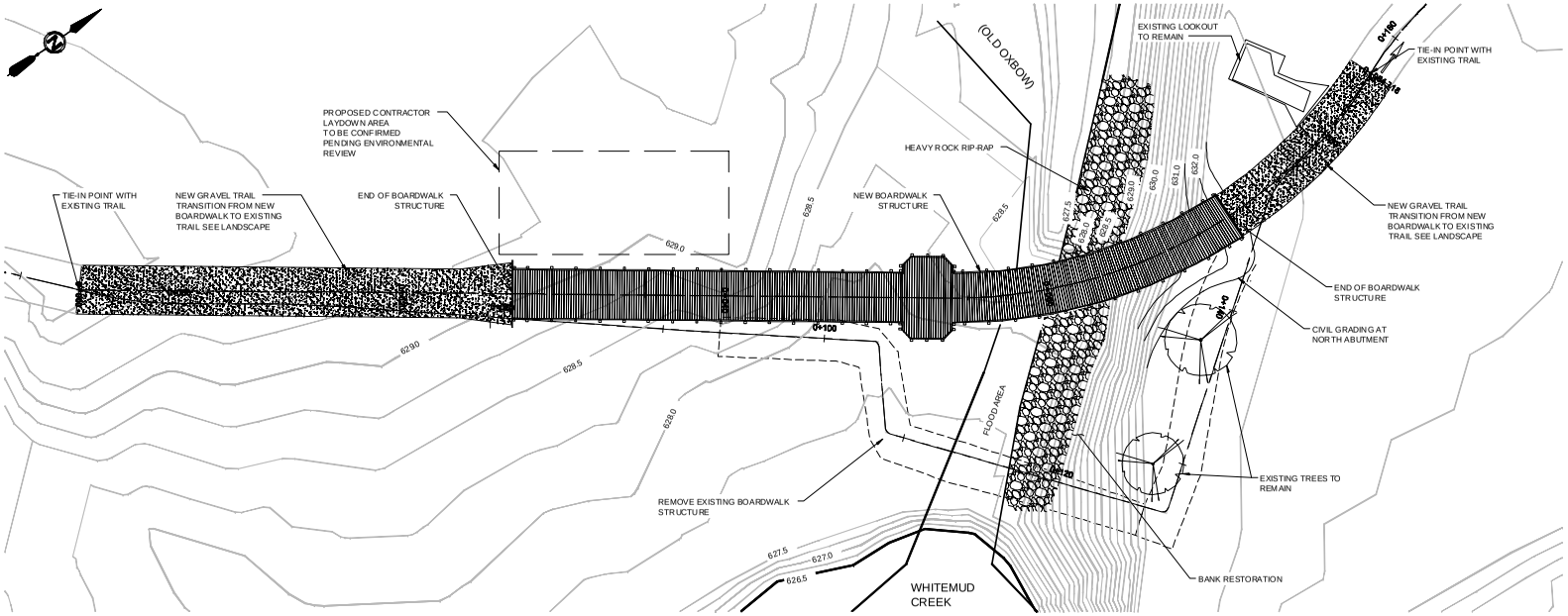
THE CITY OF Edmonton COMMUNITY SERVICES

STRUCTURES
BOARDWALK
GENERAL NOTES

DRAWING	REVISION	SHEET
3177-00-S-002	B	2 / 9

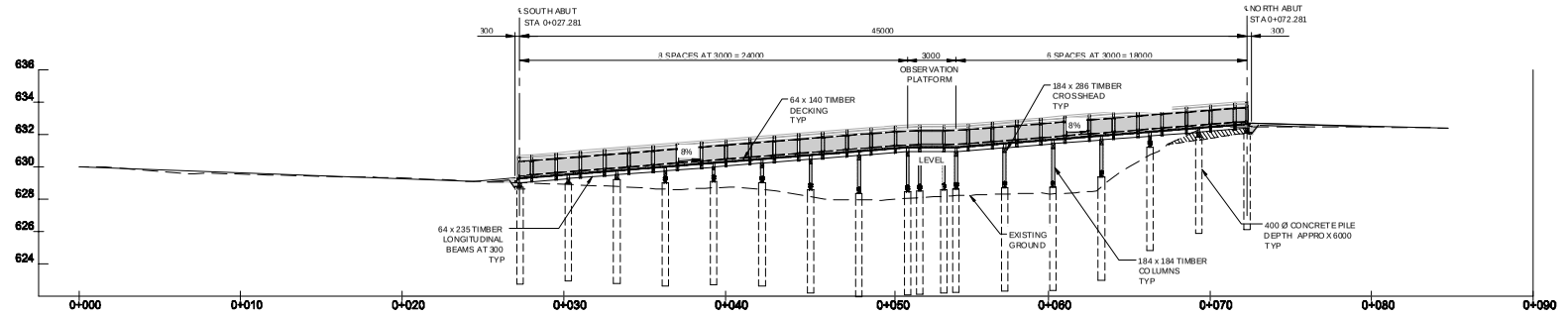
IF NOT 50 mm ADJUST SCALES

SCALE(S) SHOWN ARE INTENDED FOR ANSI D (22X34) SIZE DRAWINGS, TABLOID (11X17) SIZE DRAWINGS ARE 1/2 OF SCALE(S) SHOWN UNLESS NOTED OTHERWISE



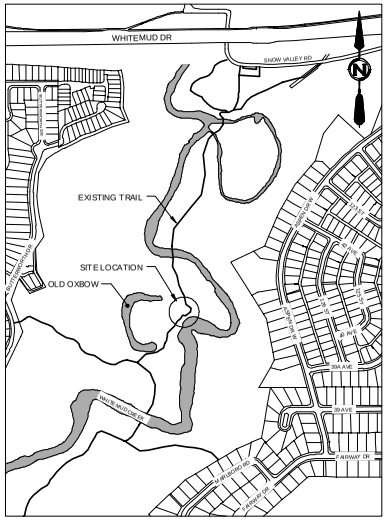
PLAN 1:150

GENERAL LAYOUT



ELEVATION 1:150

LOOKING WEST



PLAN NTS

SITE LOCATION

PRELIMINARY/ FOR DISCUSSION
NOT FOR CONSTRUCTION
DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
B	2017MAR17	M. PAULSEN	A. REES	ISSUED FOR 90% REVIEW
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CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

SCALE: AS SHOWN

COMMUNITY SERVICES

STRUCTURES
BOARDWALK
GENERAL LAYOUT

DRAWING	REVISION	SHEET
3177-00-S-101	B	3 / 9

Associated Engineering

\\cs-edm-fs-02\projects\20143177\00_S_Whitemud_Ck_Bvd\Working_Dwgs\300_Structural\02_detail design\3177-00-S-101.dwg
DATE: 2017-03-20, Aden Rees

IF NOT 50 mm ADJUST SCALES
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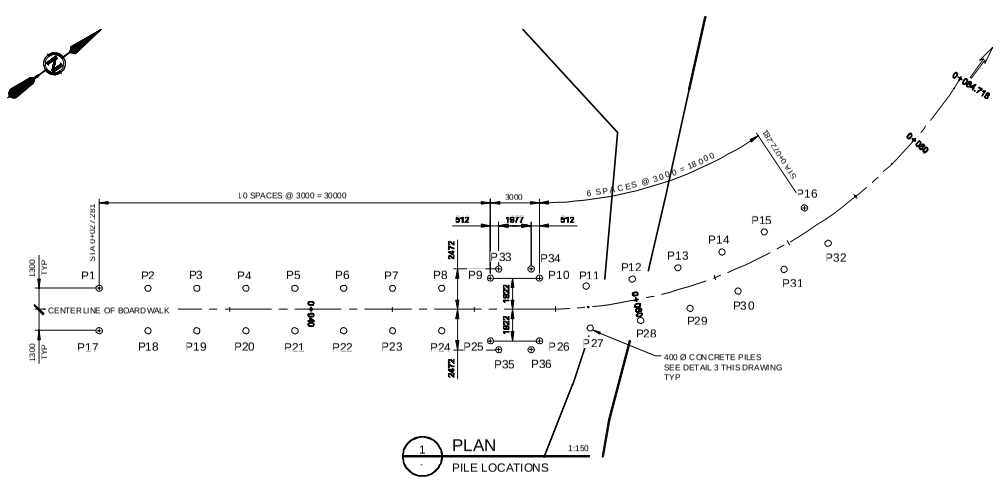
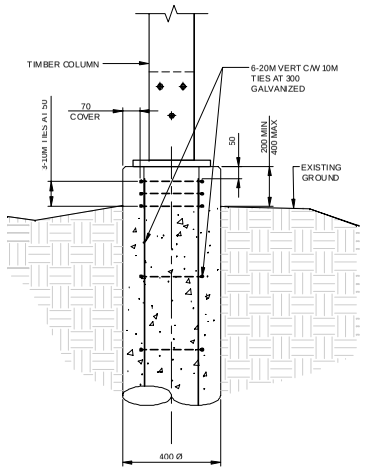


1 PLAN 1:150
PILE LOCATIONS

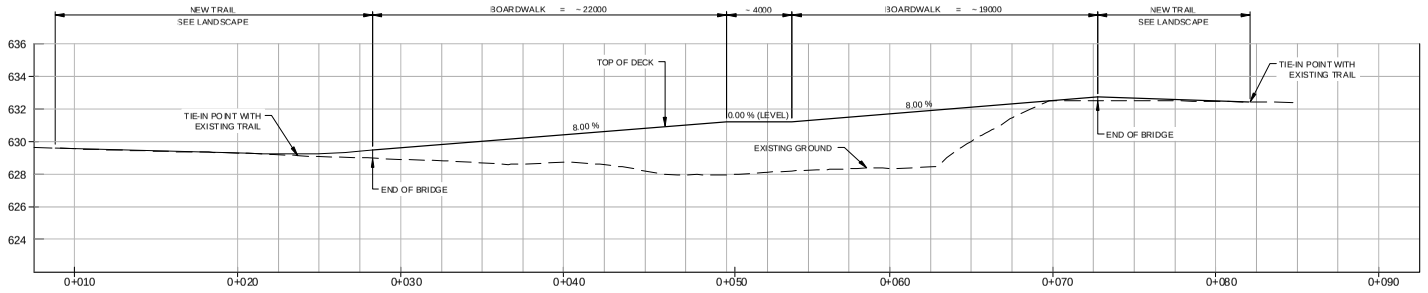


NOTE:

- REFER TO PILE SCHEDULE FOR PILE LENGTH AND LOCATION

3 DETAIL 1:10
TYPICAL PILE

PILE SCHEDULE				
NO.	NORTHING	EASTING	CUT OFF EL	TIP EL
P1	5927103544.4548	29495067.9288	628.751	622.751
P2	5927105973.0324	29496829.1815	628.991	622.899
P3	5927108401.6099	29498590.4342	629.231	622.767
P4	5927110830.1875	29500351.6869	629.005	622.604
P5	5927113258.7650	29502112.9396	629.095	622.695
P6	5927115687.3426	29503874.1923	629.024	622.624
P7	5927118115.9201	29505635.4450	628.587	622.187
P8	5927120544.4977	29507396.6977	628.367	621.967
P9	5927123338.4614	29508654.1223	628.452	622.052
P10	5927125767.0389	29510415.3750	628.633	622.233
P11	5927127805.9603	29512489.1792	628.720	622.320
P12	5927130352.2926	29513816.4692	628.745	622.345
P13	5927133016.2342	29514888.3468	629.372	622.972
P14	5927135772.2403	29515694.5337	631.228	624.828
P15	5927138593.8830	29516227.2993	631.871	625.871
P16	5927141454.1052	29516481.5347	632.111	626.111
P17	5927102018.0358	29497172.6960	628.751	622.751
P18	5927104446.6134	29498933.9487	628.991	622.899
P19	5927106875.1909	29500695.2014	629.231	622.767
P20	5927109303.7685	29502456.4541	629.005	622.604
P21	5927111732.3460	29504217.7068	629.095	622.695
P22	5927114160.9236	29505978.9595	629.024	622.624
P23	5927116589.5011	29507740.2122	628.587	622.187
P24	5927119018.0786	29509501.4649	628.367	621.967
P25	5927121081.2700	29511766.5458	628.452	622.052
P26	5927123509.8475	29513527.7985	628.633	622.233
P27	5927126492.7205	29514733.1491	628.720	622.320
P28	5927129264.8246	29516178.1240	628.745	622.345
P29	5927132164.9661	29517345.0402	629.372	622.972
P30	5927135165.3349	29518222.7081	631.228	624.828
P31	5927138237.1600	29518802.7116	631.871	625.871
P32	5927141350.9854	29519079.4889	632.111	626.111
P33	5927124075.3367	29508509.4725	628.504	622.104
P34	5927125675.6107	29509670.0230	628.583	622.183
P35	5927121172.6983	29512511.8978	628.095	622.104
P36	5927122772.9722	29513672.4483	628.583	622.183



2 PROFILE 1:150
ALONG CENTERLINE

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DATE: 2017-03-20, Aiden Rees

Associated Engineering
BEST MANAGED COMPANIES Platinum Member

PRELIMINARY/
FOR DISCUSSION
NOT FOR CONSTRUCTION
DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
B	2017MAR17	M. PAULSEN	A. REES	ISSUED FOR 90% REVIEW
A	2017FEB17	M. PAULSEN	A. REES	ISSUED FOR 60% REVIEW

CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

SCALE: AS SHOWN

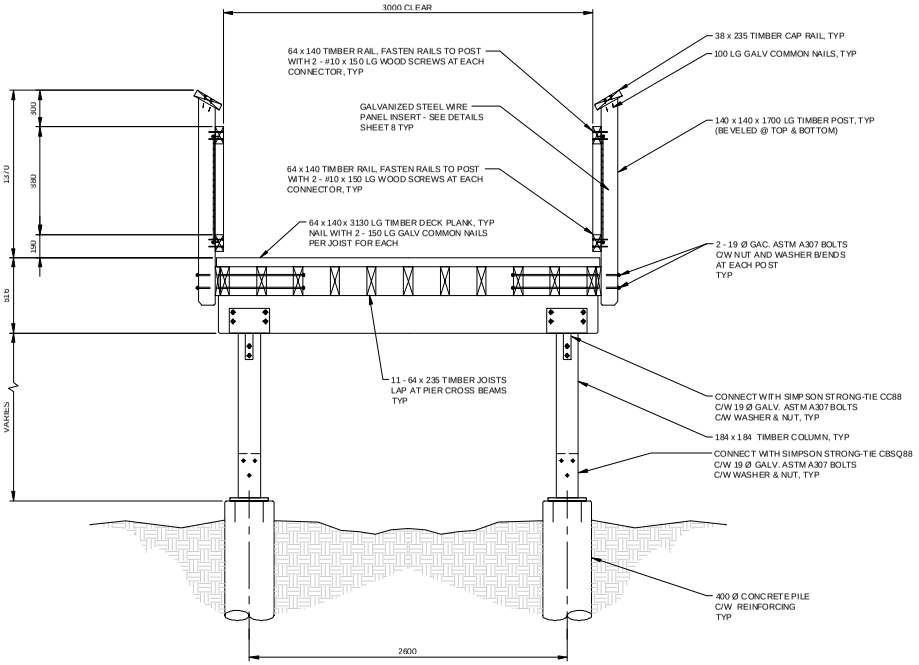
THE CITY OF Edmonton COMMUNITY SERVICES

STRUCTURES
BOARDWALK
PILE LAYOUT AND PROFILE

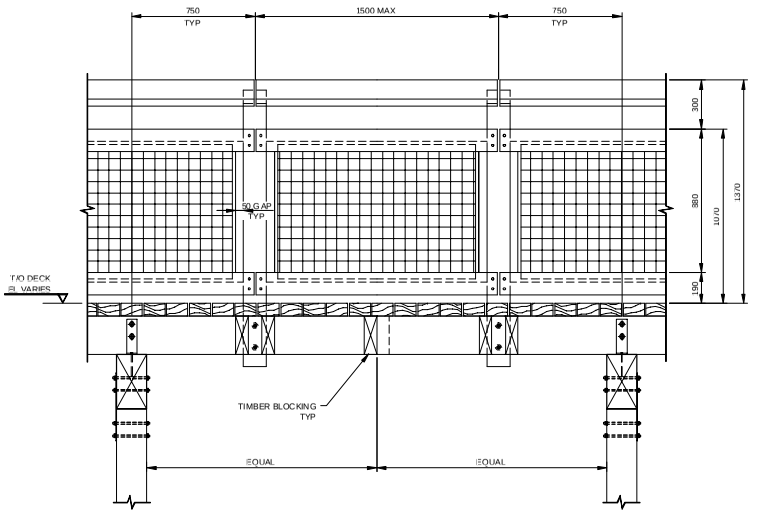
DRAWING	REVISION	SHEET
3177-00-S-102	B	4 / 9

IF NOT 50 mm ADJUST SCALES
50 mm

SCALE(S) SHOWN ARE INTENDED FOR ANSI D (22X34) SIZE DRAWINGS, TABLOID (11X17) SIZE DRAWINGS ARE 1/2 OF SCALE(S) SHOWN UNLESS NOTED OTHERWISE



1 SECTION 1:20
TYPICAL OBSERVATION PLATFORM (SIMILAR)



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TYPICAL

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DATE: 2017-03-20, Adam Rees

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Best Managed Companies Platinum Member

PRELIMINARY/ FOR DISCUSSION
NOT FOR CONSTRUCTION
DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
B	2017MAR17	M. PAULSEN	A. REES	ISSUED FOR 90% REVIEW
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CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

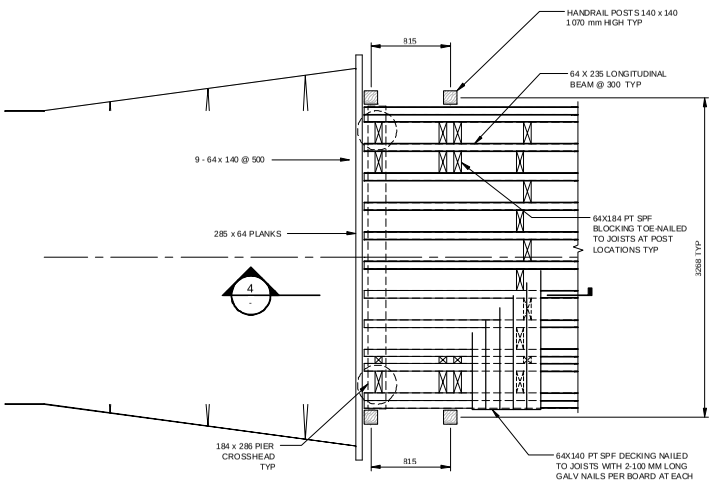
SCALE: AS SHOWN

The City of Edmonton COMMUNITY SERVICES

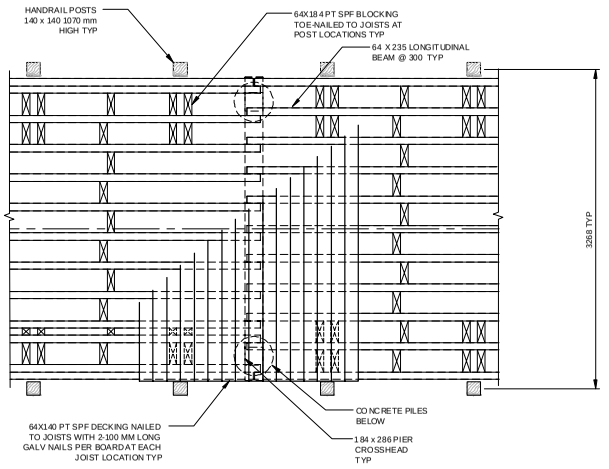
STRUCTURES
BOARDWALK
TYPICAL SECTIONS

DRAWING	REVISION	SHEET
3177-00-S-301	B	5 / 9

IF NOT 50 mm ADJUST SCALES
50 mm
SCALE(S) SHOWN ARE INTENDED FOR ANSI D (22X34) SIZE DRAWINGS, TABLOID (11X17) SIZE DRAWINGS ARE 1/2 OF SCALE(S) SHOWN UNLESS NOTED OTHERWISE



1 - PLAN 1:25
SOUTH ABUTMENT



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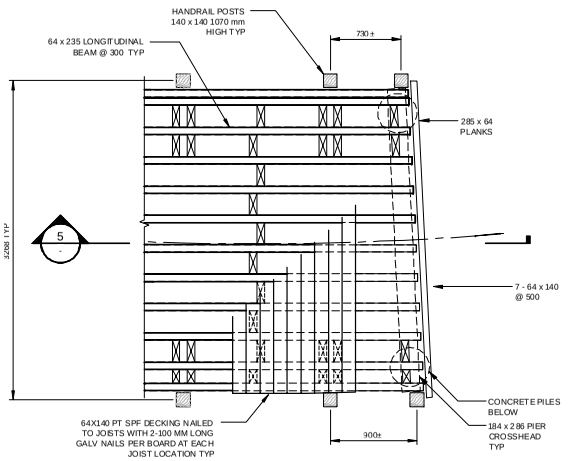
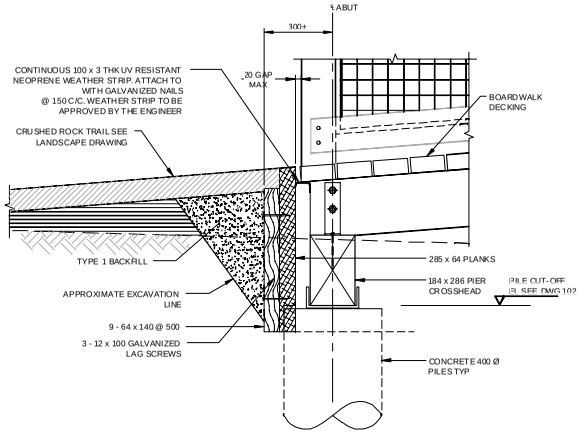
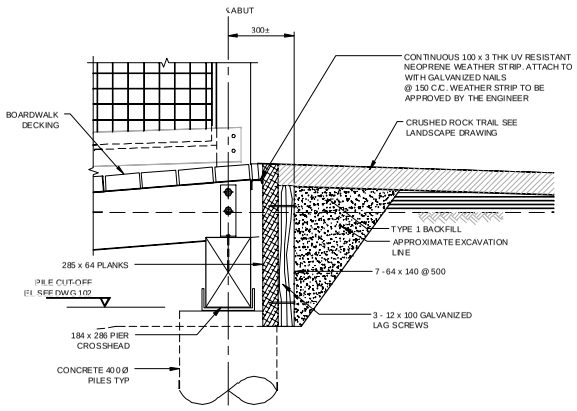


3 - PLAN 1:25
NORTH ABUTMENT



4 - SECTION 1:10
SOUTH ABUTMENT



5 - SECTION 1:10
NORTH ABUTMENT

Associated Engineering
BEST MANAGED COMPANIES Platinum Member

PRELIMINARY/
FOR DISCUSSION
NOT FOR CONSTRUCTION
DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
B	2017MAR17	M. PAULSEN	A. REES	ISSUED FOR 90% REVIEW
A	2017FEB17	M. PAULSEN	A. REES	ISSUED FOR 60% REVIEW

CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

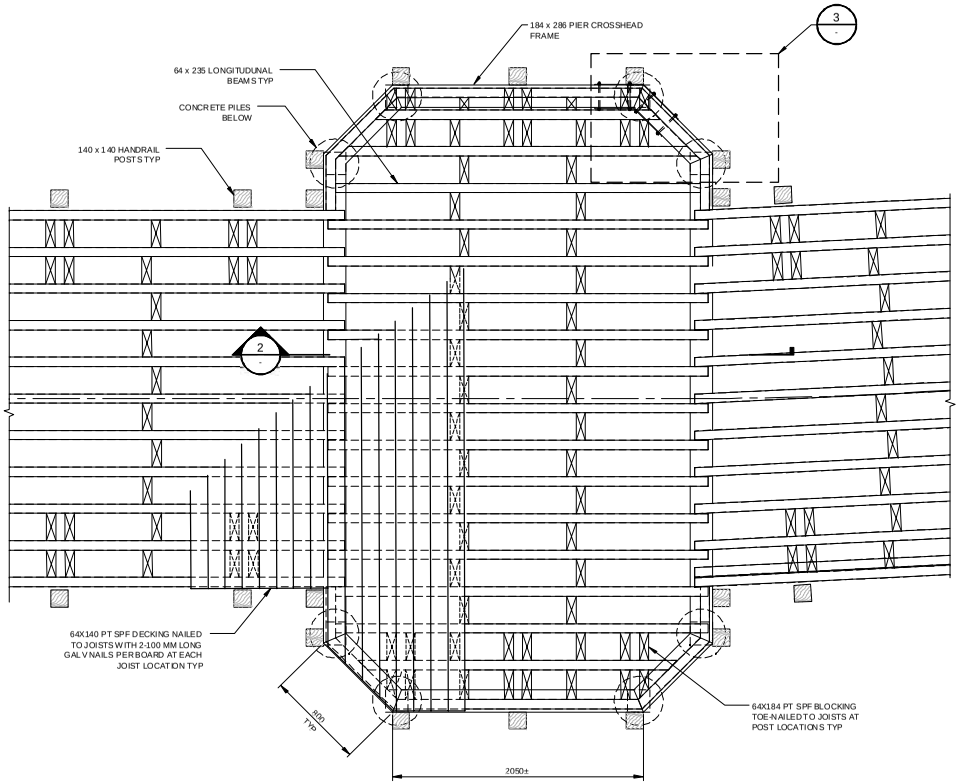
SCALE: AS SHOWN

THE CITY OF Edmonton COMMUNITY SERVICES

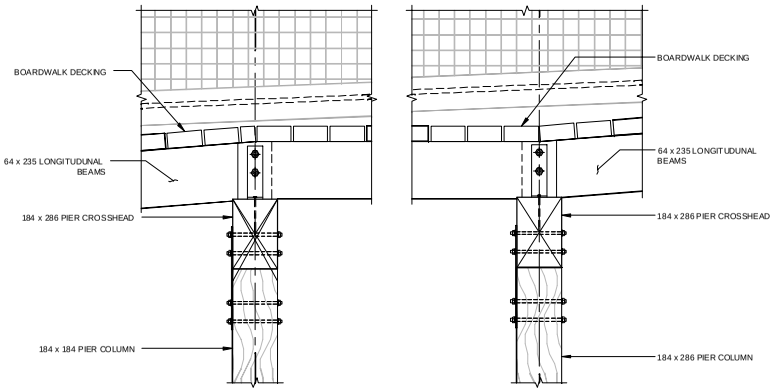
STRUCTURES
BOARDWALK
ABUTMENT DETAILS

DRAWING	REVISION	SHEET
3177-00-S-401	B	6 / 9

IF NOT 50 mm ADJUST SCALES
50 mm
SCALE(S) SHOWN ARE INTENDED FOR ANSI D (22X34) SIZE DRAWINGS, TABLOID (11X17) SIZE DRAWINGS ARE 1/2 OF SCALE(S) SHOWN UNLESS NOTED OTHERWISE



1 PLAN 1:20
OBSERVATION PLATFORM FRAMING



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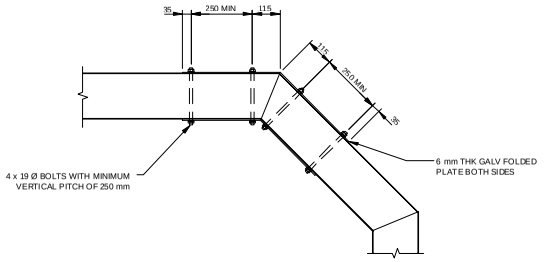

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DATE: 2017-03-20, Aidan Rees

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DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
B	2017MAR17	M. PAULSEN	A. REES	ISSUED FOR 90% REVIEW
A	2017FEB17	M. PAULSEN	A. REES	ISSUED FOR 60% REVIEW

CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

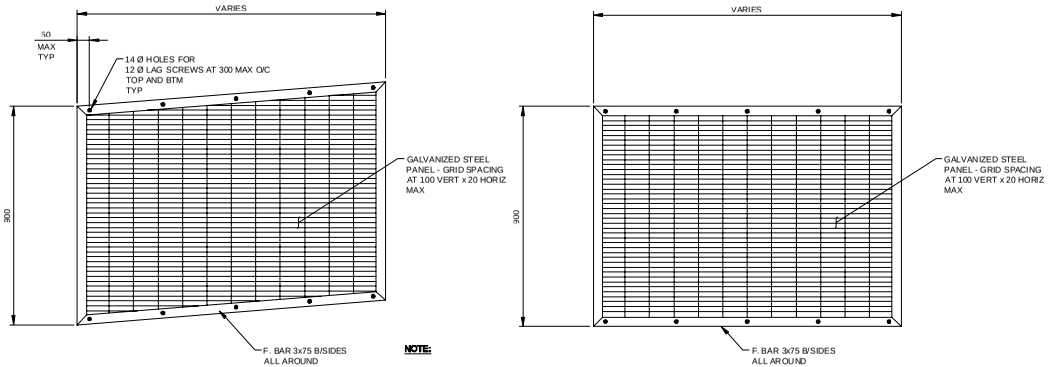
SCALE: AS SHOWN

THE CITY OF Edmonton COMMUNITY SERVICES

STRUCTURES
BOARDWALK
OBSERVATION PLATFORM

DRAWING	REVISION	SHEET
3177-00-S-402	B	7 / 9

IF NOT 50 mm ADJUST SCALES
50 mm
SCALE(S) SHOWN ARE INTENDED FOR ANSI D (22X34) SIZE DRAWINGS, TABLOID (11X17) SIZE DRAWINGS ARE 1/2 OF SCALE(S) SHOWN UNLESS NOTED OTHERWISE



ELEVATION 1:10
TYPICAL PANEL AT SLOPE
(AS NOTED)

NOTE:

ELEVATION 1:10
TYPICAL PANEL AT OBSERVATION PLATFORM
(AS NOTED)

1 / - DETAIL 1:10
HANDRAIL INSERT PANELS

\\s-edm-fs-02\projects\2014\3177\00_S_Whitemud_Ck_Bridl\Working_Dwgs\300_Structural\02_detail design\3177-00-S-501.dwg
DATE: 2017-03-20, Aidan Rees

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NOT FOR CONSTRUCTION
DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
B	2017MAR17	M. PAULSEN	A. REES	ISSUED FOR 90% REVIEW
A	2017FEB17	M. PAULSEN	A. REES	ISSUED FOR 60% REVIEW

CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

SCALE: AS SHOWN

THE CITY OF Edmonton COMMUNITY SERVICES

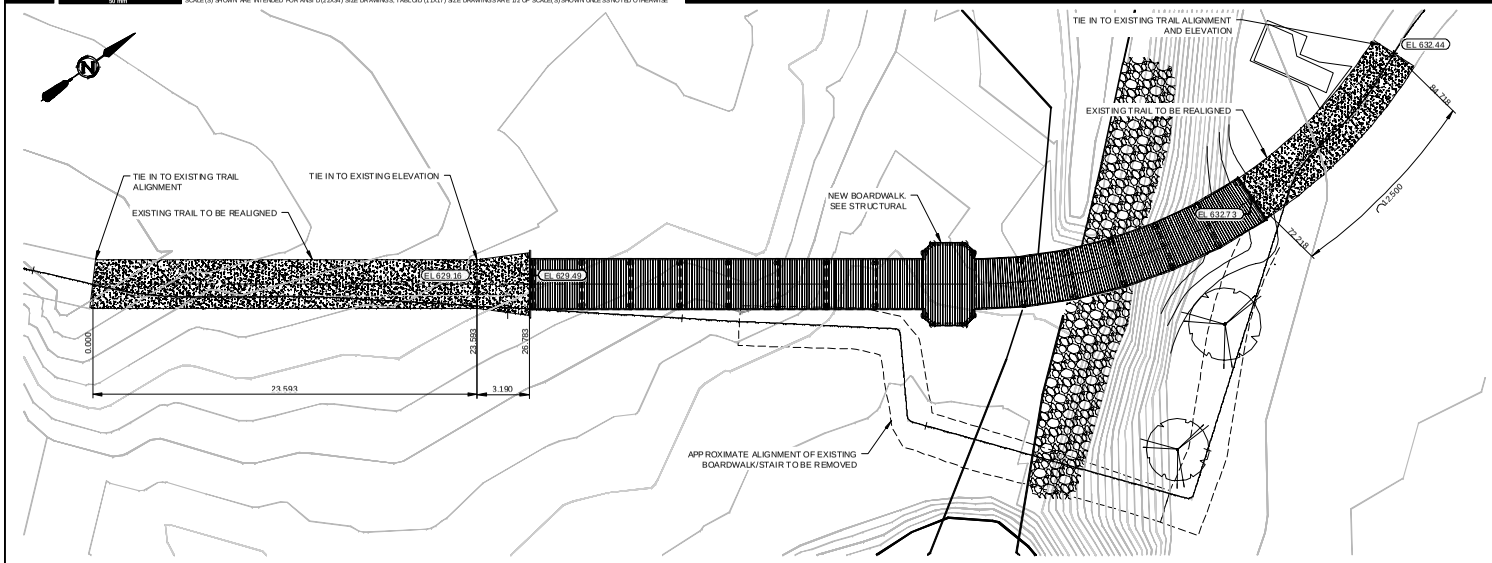
STRUCTURES
BOARDWALK
DETAILS

DRAWING	REVISION	SHEET
3177-00-S-501	B	8 / 9

IF NOT 50 mm ADJUST SCALES

50 mm

SCALE(S) SHOWN ARE INTENDED FOR ANSI D (22X34) SIZE DRAWINGS, TABLOID (11X17) SIZE DRAWINGS ARE 1/2 OF SCALE(S) SHOWN UNLESS NOTED OTHERWISE



1 PLAN 1:150
TRAIL REALIGNMENT

NOTES:

SITE WORK
- THE CONTRACTOR TO CALL ALBERTA ONE- CALL AT 1-800-242-3447 TO LOCATE AND STAKE EXISTING UTILITIES PRIOR TO START OF ANY CONSTRUCTION.
- THE CONTRACTOR IS TO VISIT THE SITE TO CONFIRM ALL SITE CONDITIONS PRIOR TO SUBMITTING BIDS. ANY DISCREPANCIES ARE TO BE REPORTED TO THE CONSULTANT FOR CLARIFICATION.
- THE CONTRACTOR IS RESPONSIBLE FOR THE HOARDING OF ALL TREES WITHIN OR ADJACENT TO CONSTRUCTION AREAS AS PER CITY OF EDMONTON STANDARD DETAILS.
- THE CONTRACTOR IS RESPONSIBLE FOR HAULING OF ALL EXCESS MATERIALS OFF THE SITE TO A LOCATION DESIGNATED BY THE CONSULTANT.
- THE CONTRACTOR IS RESPONSIBLE FOR GENERAL SITE CLEAN UP.
- THE CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGE TO LANDSCAPED AREAS AND MUST MAKE ALL NECESSARY RESTORATIONS AND REPAIRS.

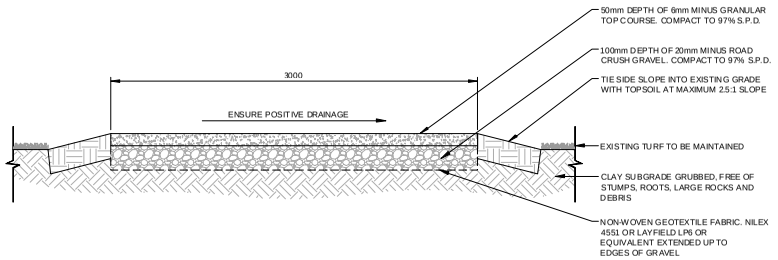
PERMITS AND STANDARDS
- ALL ANCILLARY WORK NORMALLY ASSOCIATED WITH THIS TYPE OF CONSTRUCTION SHALL BE DEEMED TO BE PART OF THE CONTRACT.
- ALL WORK IS TO CONFORM TO THE CITY OF EDMONTON STANDARD SPECIFICATIONS.

MATERIALS
- THE CONTRACTOR SHALL SUPPLY ALL MATERIALS IN QUANTITIES SUFFICIENT TO COMPLETE THE WORK SHOWN ON THE DRAWINGS. ANY DISCREPANCIES IN QUANTITIES SHALL BE REPORTED TO THE CONSULTANT FOR DIRECTION.
- NO SUBSITUTIONS OF MATERIALS, PRODUCTS, OR QUANTITIES SHALL BE PERMITTED WITHOUT PRIOR CONSENT OF THE CONSULTANT.

GENERAL
- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE CITY OF EDMONTON STANDARD SPECIFICATIONS, DRAWINGS, AND DETAILS FOR THE PROJECT.
- ANY AMBIGUITY IN THIS DRAWING OR ACCOMPANYING DETAILS IS TO BE REPORTED TO THE CONSULTANT FOR DIRECTION. THE CONTRACTOR IS NOT TO PROCEED IN UNCERTAINTY.
- LIMITS OF THE WORK ARE TO BE CLEARLY UNDERSTOOD BY THE CONTRACTOR PRIOR TO ANY WORK TAKING PLACE ON SITE. THE CONTRACTOR IS TO CONTACT THE CONSULTANT FOR CLARIFICATION IF REQUIRED.
- THE CONTRACTOR IS TO VERIFY ALL DIMENSIONS AND REPORT ANY DISCREPANCIES TO CONSULTANT.
- ON-SITE LAYOUT IS TO BE APPROVED BY CONSULTANT PRIOR TO START OF CONSTRUCTION.
- ALL MEASUREMENTS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.

LEGEND

GRANULAR TRAIL AS PER SECTION 2/-



NOTES:
- DIMENSIONS OF GRANULAR WALKWAY OR PLAZA AS PER LAYOUT DRAWING.
- ENSURE GRANULAR SURFACE IS FLUSH WITH FINAL GRADE.
- ENSURE POSITIVE DRAINAGE OFF GRANULAR AT ALL LOCATIONS.
- 20mm MINUS GRANULAR - SECTION **2000 AGGREGATE** DESIGNATION 3, CLASS 20A, COMPACT TO 97% S.P.D.

2 SECTION N.T.S.
TYPICAL GRANULAR WALKWAY

\\s-edm-fs-02\projects\2013\43177\00_S_Whitemud_Ck_Bsn\Working_Dwgs\175_Landscape\3177-00-L-101.dwg
DATE: 2017-03-20, Aiden Rees

Associated Engineering

PRELIMINARY/ FOR DISCUSSION
NOT FOR CONSTRUCTION
DRAFT

REV	DATE	DESIGN	DRAWN	DESCRIPTION
A	2017MAR20	B. OBRADOVIC	T. BUCKLEY	ISSUED FOR 90% REVIEW

CITY OF EDMONTON
COMMUNITY SERVICES

WHITEMUD CREEK RAVINE SOUTH
OXBOW SITE
BOARDWALK REPLACEMENT
20143177-00

SCALE: AS SHOWN

THE CITY OF Edmonton COMMUNITY SERVICES

LANDSCAPE
BOARDWALK
PLAN AND DETAILS

DRAWING	REVISION	SHEET
3177-00-L-101	A	9 / 9

Appendix B – Geotechnical Report

DRAFT REPORT

May 12, 2016

DRAFT GEOTECHNICAL INVESTIGATION REPORT

Oxbow Boardwalk
Whitemud Creek Walking Trail
Edmonton, Alberta

Submitted to:
Sandra Meidinger, P.Biol, R.P. Bio.
Associated Engineering
500, 9888 Jasper Avenue
Edmonton, AB T5J 5C6

Report **Number:** 1404541
Distribution:

1 Electronic Copy - Associated Engineering
1 Copy - Golder Associates Ltd.

Golder Associates

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APPENDIX A Record of Test Hole Sheets from Previous Investigation

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Associated Engineering (AE) on behalf of the City of Edmonton (the City) to provide geotechnical engineering services for the proposed replacement of the existing staircase and boardwalk along the walking trail located in the Whitemud Creek ravine, approximately 700 m south of Whitemud Drive in Edmonton, Alberta. The trail will be shifted approximately 10 m to the west to cross an oxbow lake and a new raised boardwalk will be constructed.

Golder previously carried out a preliminary geotechnical investigation for the boardwalk on September 2, 2014; a draft preliminary geotechnical report was submitted to AE in October 2014. After reviewing the preliminary geotechnical report, the City requested a detailed geotechnical investigation be carried out at the Site.

The professional services for this report address only the geotechnical (physical) aspects of the subsurface conditions at this Site. The geo-environmental (chemical) aspects for the projects are outside the terms of reference for this geotechnical study and have not been investigated or addressed herein.

The purpose of this investigation was to obtain information on the subsurface soil and groundwater conditions at the site and, based on our interpretation of this information, provide geotechnical engineering recommendations pertaining to foundations and slope stability issues for the design and construction of proposed realigned boardwalk. The scope of work for this project was outlined in Golder's proposal submitted to AE dated November 2, 2015.

The factual data, interpretations and recommendations provided in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within eighteen months of the date of the report, Golder should be given an opportunity to confirm that the recommendations are still valid.

Use of this report is subject to the conditions outlined in the *Important Information and Limitations of this Report* that follows the main text and forms an integral part of this document. The readers' attention is specifically drawn to this information, as it is essential for the proper use and interpretation of the report.

2.0 SITE LOCATION AND DESCRIPTION

It is understood that the City of Edmonton is planning to replace an existing staircase and boardwalk along the walking trail within the Whitemud Creek ravine, approximately 700 m south of Whitemud Drive (see Figure 1). The trail will be shifted approximately 10 m to the west in order to cross an old oxbow of the creek, and a new raised boardwalk will be constructed.

The existing boardwalk traverses a narrow stretch of land between the oxbow and the creek, which is prone to flooding during high water events. Based on the concept plan (Whitemud Creek Oxbow Site Stair and Boardwalk Replacement Concept Plan, dated Dec. 2012) provided to Golder by AE, the north section of the realigned trail will traverse a steep slope requiring a small amount of cut and fill along the 4.5 m high north slope, tying into the existing trail at the top of the slope. This portion of the trail will be graded at 8 per cent with a 3 per cent cross fall. The boardwalk is to have a grade of 2.5 per cent and will tie in with the existing trail to the south. Screw piles with a 2.4 m centre-to-centre spacing were noted on the concept plan as the preferred foundation support for the boardwalk.

Based on the revised design drawings provided to Golder by AE on April 25, 2016, the preferred foundation support for the boardwalk are concrete cast-in-place piles.

3.0 FIELD INVESTIGATION

The field geotechnical investigation for the boardwalk was carried out on April 8 and March 11, 2016. Four boreholes were advanced at the site at the locations shown on Figure 1. Borehole BH16-01 was advanced to a depth of 5.8 m, Borehole BH16-02 was advanced to 4.6 m and Boreholes BH16-03 and BH16-04 were advanced to 4.9 m below existing ground surface. All boreholes terminated due to auger refusal in the sandstone bedrock.

Borehole BH16-01 was advanced using a M2.5T track mounted drill rig at the crest of the slope and Boreholes BH16-02 to BH16-04 were advanced using a M4T track mounted drill rig at the base of the slope; both drill rigs were supplied and operated by Mobile Augers and Research Ltd. of Edmonton, Alberta. The boreholes were advanced using 152 mm diameter solid stem augers, with soil samples obtained at 1.5 m intervals of depth using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586-11 Standard Test Method for Standard Penetration Test). Bulk samples were also obtained from the auger flights.

Groundwater conditions were observed in the open boreholes during and immediately following the drilling operations. Standpipes were installed in Boreholes BH16-01 and BH16-03 to permit monitoring of the groundwater levels. The standpipes were constructed of 25 mm diameter PVC pipe, with a slotted screen, filter sand and bentonite seals installed at selected depth intervals above the screen within the boreholes. Standpipe installation details and water level readings are indicated on the Record of Borehole Sheets in Appendix A. Soil cuttings were used to backfill the boreholes above the screened section with a near surface bentonite seal. Excess soil cuttings remaining after backfilling the boreholes were removed from Site following completion of drilling. Boreholes BH16-02 and BH16-04 were backfilled using soil cuttings with a near surface bentonite seal.

Field work was carried out under the full-time supervision of a member of Golder engineering staff who located the boreholes in the field, directed the sampling and in situ testing operations, and logged the boreholes. Samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Edmonton for further examination and laboratory testing. Index and classification tests consisting of water content determinations, Atterberg limits, particle size analyses and soil corrosivity tests were carried out on selected soil samples.

Approximate borehole locations were estimated using a consumer grade handheld global positioning system (GPS) with an expected horizontal accuracy of +/- 5 m. Ground surface elevations were estimated from the site plan provided by AE. The borehole locations, including approximate UTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are presented on the Record of Borehole Sheets and are summarized in the following table.

Table 1: Approximate Borehole Locations and Elevations

Borehole Number	UTM NAD83 Northing (m)	UTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
BH16-01	5,928,311	330,415	633.0	5.8
BH16-02	5,928,297	330,413	631.0	4.6
BH16-03	5,928,294	330,409	631.0	4.9
BH16-04	5,928,284	330,401	632.0	4.9

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on the Alberta Geological Survey Map 143, "*Surficial Geology of Edmonton*", the near surface geological profile in the area of the Site generally consists of erosional features. Erosional features are typically observed near creek valleys like the Whitemud Creek ravine and consist of thin colluvial cover on the valley slopes, thin alluvial materials along the streams, and mixed glacial and bedrock materials near slump areas.

Regionally, the uppermost bedrock unit in the area consists of the Horseshoe Canyon Formation. According to Alberta Geological Survey Map 600, "*Bedrock Geology of Alberta*", the Horseshoe Canyon Formation generally consists of grey, feldspathic, clayey sandstone; grey bentonitic mudstone and carbonaceous shale; concretionary ironstone beds, scattered coal and bentonite beds of variable thickness; and minor limestone beds.

4.2 Subsurface Soil Conditions

Detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the current investigation and the results of in situ and laboratory testing are presented on the Record of Borehole Sheets contained in Appendix A. Results of geotechnical and analytical laboratory testing are presented in Appendix B. The Record of Test Hole Sheets from the previous (2014) investigation are contained in Appendix C.

Soil descriptions provided in this report are based on visual and textural evidence along with accepted standard methods of classification and description routinely used in current geotechnical practice. The stratigraphic boundaries shown on the Record of Borehole Sheets are inferred from observations of drilling progress and from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsurface conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions below the embankment at the north end of the site consist of silty clay and sand, overlaying highly to completely weathered clayshale bedrock, overlaying highly to completely weathered sandstone bedrock. Below the embankment (in the floodplain between the oxbow and Whitemud Creek) the encountered subsurface conditions generally consist of silty clay and sand, overlaying clayey sand, overlying completely weathered sandstone bedrock.

More detailed descriptions of the subsurface conditions encountered in the boreholes are provided in the following sections.

4.2.1 Gravel and Topsoil

A 50 mm thick layer of gravel was encountered in Borehole BH16-01 immediately below the existing ground surface.

Approximately 180 mm to 200 mm of topsoil was encountered immediately below ground surface in Boreholes BH16-02 to BH16-04.

4.2.2 Silty Clay and Sand

A silty clay and sand deposit was encountered underlying the gravel and topsoil in all boreholes. The surface of the deposit was encountered at depths ranging from 0.1 m to 0.2 m, corresponding to Elevations 632.9 m to 630.8 m. The thickness of the deposit varied from 1.3 m to 2.7 m, with the base of the deposit extending to between Elevation 630.2 m and 629.5 m.

The deposit consists of silty clay and sand containing trace organics and plant fibers. Some gravel and inferred cobbles due to grinding of the augers was noted at a depth of 2.3 m in Borehole BH16-01. Results of grain size distribution tests completed on two selected samples of the silty clay and sand deposit are contained in Appendix B.

Atterberg limits testing was conducted on two selected samples of the silty clay and sand deposit and measured plastic limits of 16 and 20 per cent, liquid limits of 31 and 34 per cent and corresponding plasticity indices of 14 and 15 per cent. Plasticity results contained in Appendix B, indicate that the silty clay and sand deposit is of intermediate plasticity. Laboratory water contents measured on selected samples of the silty clay and sand deposit range between about 11 and 47 per cent, with higher water contents observed in the floodplain area.

The Standard Penetration Test (SPT) "N"-values measured within the silty clay and sand were between 1 and 27 blows per 0.3 m of penetration, suggesting a very soft to soft consistency in the floodplain and stiff to very stiff consistency below the embankment. Sloughing was observed within the silty clay and sand deposit in BH16-04 during drilling operations.

4.2.3 Sandy Clayey Silt

A 0.3 m thick interlayer of sandy clayey silt was encountered underlying the silty clay and sand in Borehole BH16-02. The surface of the deposit was encountered at a depth of 1.5 m, corresponding to Elevation 629.5 m.

A laboratory water content measured on one sample of the sandy clayey silt was 44 per cent.

4.2.4 Clayey Sand

A clayey sand deposit was encountered in Boreholes BH16-02 to BH16-04 underlying the silty clay and sand and sandy clayey silt deposits at depths ranging from 1.5 m to 2.4 m, corresponding to Elevations 629.9 m to 629.5 m. The thickness of the deposit varied from 0.6 m to 0.9 m, with the base of the deposit extending to between Elevation 629.0 m and 628.3 m.

The deposit consists of clayey sand containing trace organic pockets and oxidation stains. The sand was typically fine to medium grained. Results of grain size distribution tests completed on two selected samples of the clayey sand deposit are contained in Appendix B.

Laboratory water contents measured on selected samples of the clayey sand deposit were between about 30 and 34 per cent.

One SPT "N"-value measured within the clayey sand was 3 blows per 0.3 m of penetration, indicating a very loose relative density. Sloughing was observed within the clayey sand deposit during drilling operations in all boreholes where it was encountered.

4.2.5 Bedrock

Highly to completely weathered clayshale of the Horseshoe Canyon Formation was encountered underlying the silty clay and sand deposit in Borehole BH16-01 at a depth of 2.7 m, corresponding to Elevation 630.3 m.

The clayshale was highly to completely weathered, massive, grey, non-porous and extremely weak. Laboratory water contents measured on selected samples of the clayshale were between about 18 and 21 per cent. One SPT "N"-value was measured within the clayshale, which showed 43 blows per 0.3 m of penetration suggesting a hard consistency (in terms of a soil).

Highly to completely weathered sandstone bedrock of the Horseshoe Canyon Formation was encountered underlying the clayshale in Borehole BH16-01 and underlying the clayey sand in the remaining boreholes at depths ranging from 2.4 m to 5.2 m, corresponding to Elevations 628.9 m to 627.8 m. All boreholes terminated due to auger refusal within the sandstone, penetrating for thicknesses between 0.6 m and 2.4 m.

The sandstone was typically highly to completely weathered, massive, grey, faintly porous and extremely weak. Oxidation stains were noted in the sandstone in Boreholes BH16-02 and BH16-03. Laboratory water contents measured on selected samples of the sandstone were between about 13 and 24 per cent. The SPT "N"-values measured within the sandstone ranged between 19 blows per 0.3 m of penetration and 50 blows per 0.1 m of penetration, indicating a compact to very dense relative density (in terms of a soil).

4.3 Groundwater Conditions

The observed and recorded water levels in the open boreholes following completion of drilling and in the standpipes are shown on the Record of Borehole sheets and are summarized as follows:

Table 2: Groundwater Conditions

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date
BH16-01	633.0	Dry	-	March 11, 2016 (completion of drilling)
		Dry	-	April 8, 2016 (Drilling of remaining boreholes)

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date
		Dry	-	April 22, 2016 (Two week reading)
BH16-02	631.0	1.8	629.2	April 8, 2016 (completion of drilling)
BH16-03	631.0	3.5	627.5	April 8, 2016 (completion of drilling)
		2.0	629.0	April 22, 2016 (Two week reading)
BH16-04	632.0	1.9	630.1	April 8, 2016 (completion of drilling)

Water levels observed in the open boreholes on completion of drilling may not represent long-term stabilized groundwater levels. Subsurface water levels at the Site are expected to fluctuate seasonally in response to changes in precipitation and snow melt, and should be expected to be higher during the spring and following periods of heavy precipitation.

5.0 GEOTECHNICAL COMMENTS AND RECOMMENDATIONS

This section of the report provides geotechnical engineering comments and recommendations for consideration during design and construction of the boardwalk/staircase replacement. The recommendations are based on Golder's interpretation of factual information obtained from the boreholes advanced as part of the current subsurface investigation at the site and available project information.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

5.1 Frost Susceptibility and Penetration Depth

The anticipated depth of frost penetration was estimated for the average properties for the in-situ soils encountered at the location of the advanced boreholes both based on mean annual Air Freezing Index (AFI) and the 50 year return period Air Freezing Index of about 1450˚C and 2300˚C days, respectively. It was assumed that the near surface soil comprises silty clay and sand with a dry density of 18 kN/m^3 and a gravimetric water content of 27 per cent. The mean annual depth of frost penetration for the cohesive soils present on Site is estimated to be about 1.8 m, and the penetration for a 50-year return period is about 2.1 m. A design frost penetration depth of 2.5 m is recommended. These estimates were determined using the method outlined in the Canadian Foundation Engineering Manual (CFEM) (Canadian Geotechnical Society, 2006).

The U.S. Corps of Engineers have classified the frost susceptibility of soils based on soil type into four groups F1 to F4 in approximate order of increasing frost susceptibility and loss of strength during thaw. Frost effects should be considered in the design of structural elements that are sensitive to post construction movement such as foundations, or buried services that cannot be allowed to freeze. Frost heave is a potentials concern at the bottom of foundation elements (i.e. shallow foundations, slabs-on-grade, grade beams, pile caps and roadways). Based on Atterberg Limits test results, the soils at the Site generally fall into group F3 indicating the soils are highly susceptible to the development of ice lenses and subsequent frost heaves.

5.2 Foundations

Based on the proposed geometry of the boardwalk and the subsurface conditions encountered at the site, both shallow foundations and deep foundations have been considered. The three types of recommended foundation options are further discussed in the following sections. Screw piles are not recommended as they may encounter shallow refusal in the clayshale or sandstone.

5.2.1 Shallow Foundations

Conventional spread and/or shallow foundations founded on the clayshale/sandstone bedrock encountered beneath the soft silty clay and sand and clayey sand deposits may be considered for support of the proposed boardwalk. The surface of the bedrock varies with location, and the following founding elevations are recommended for the boardwalk structure contingent on verification by a qualified geotechnical engineer during construction:

Table 3: Founding Elevation for Shallow Foundations

Foundation Location	Relevant Borehole	Ground Surface Elevation (m)	Surface of Bedrock Elevation (m)	Founding Elevation (m)
Crest of Slope	BH16-01	633.0	630.3	630.0
Base of Slope	BH16-02	631.0	628.3	628.0
	BH16-03	631.0	628.6	628.0
	BH16-04	632.0	629.0	628.5

Shallow foundations should be placed below the frost depth, a minimum of 2.5 m below the final ground surface, to provide protection from frost action. Alternatively, suitably designed insulation may be used to provide protection against frost action.

Strip or spread footings founded at the elevations specified above, the factored geotechnical axial resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS), for 25 mm of settlement are shown in Table 4.

Table 4: Geotechnical Resistance/Reaction Values

Footing Foundation Subgrade	Footing Width (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Resistance at SLS (kPa)
Clayshale	0.3	350	225
	0.5	375	250
	1.0	400	250
Sandstone	0.3	875	575
	0.5	900	600
	1.0	950	625

The geotechnical resistances provided are dependent on the footing size, configuration and applied loads; therefore, the geotechnical resistances should be reviewed if the selected footing width or founding elevation differs from the values given above. The values provided are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account.

A factored coefficient of friction of 0.4 and 0.5 (concrete to soil) is recommended for conventional spread and/or strip foundations founded on the clayshale and sandstone, respectively, which includes a geotechnical resistance factor (ϕ) of 0.8.

The base of each footing excavation must comprise clean, undisturbed bedrock. The founding level for the footings must be inspected by a qualified geotechnical engineer following excavation to verify that all existing fill and other unsuitable material have been removed, as the founding bedrock will be susceptible to disturbance. If the concrete for the footings cannot be poured immediately after excavation and inspection, it is recommended that a concrete working slab be placed on the subgrade within four hours to protect the integrity of the bearing stratum.

5.2.2 Concrete Cast-in-Place Piles

Drilled cast-in-place straight-shaft concrete piles are considered a suitable pile type for the proposed boardwalk replacement. This type of pile was also been used for the two existing pedestrian bridges to the north.

5.2.2.1 Design for Compressive and Uplift Loads

It is expected that the finished grade will be close to the existing grade with no significant cut or fill required. Drilled cast-in-place straight shaft concrete piles subjected to compressive loads should be designed based on the unfactored skin friction values given in Table 5.

Table 5: Unfactored Skin Friction for Drilled Cast-In-Place Straight Shaft Concrete Piles

Depth Below Existing Grade	Major Soil Type	Unfactored Skin Friction (kPa)
0 to 3 m	Clay, Sand	0
Below 3 m	Clay Shale / Sandstone	60

An unfactored unit end bearing resistance of 1000 kPa for piles founded within the sandstone can be included in the design of conventional drilled cast-in-place straight shaft concrete piles if the soil debris at the bottom of the drilled shaft is properly removed.

To determine the Ultimate Limit States (ULS) factored compressive resistance of a pile, a resistance factor (Φ) of 0.4 should be applied to the unfactored resistance determined using the above recommended unfactored skin friction and end bearing values.

The minimum diameter of conventional drilled cast-in-place piles should be 400 mm. The minimum center-to-center spacing between piles should be not less than 2.5 times the pile diameter.

An adfreeze stress of 65 kPa acting along the pile shafts is recommended within the zone that would be subject to frost heave, which should be taken as 2.2 m below ground surface in unheated areas. Where frost jacking and transient uplift loads (such as wind loading) occur simultaneously, these two loads need not be considered together; the larger of the two should be used. A minimum 6 m length will be required to counteract the uplift loads. Straight shaft piles exposed to freezing conditions should have the reinforcing extended to a minimum of 6 m depth below finished grade. Where piles are to be installed to shallower depths than recommended for frost resistance, rigid insulation may be used to reduce the frost penetration depth.

5.2.2.2 Lateral Load Resistance of Piles

The resistance of piles against lateral loads and moments may be calculated using the Method of Broms. Due to the soft nature of the upper clay, it is expected that majority of the lateral resistance will be provided by the underlying clayshale and sandstone for straight shaft vertical piles. For design purpose, it can be conservatively assumed that the pile is cantilevered above the clayshale or sandstone with no lateral resistance from the upper clay.

The recommended values for the Modulus of Subgrade Reaction, k for such soils, are given in Table 6.

Table 6: Modulus of Subgrade Reaction for Laterally Loaded Piles

Loading Condition	Modulus of Subgrade Reaction, k (MN/m^3)
For sustained lateral loads	10/D*
For repetitive lateral loads	8/D*
For transient lateral loads	12/D*

1. *D= Pile Diameter (m)

In design, the lateral resistance of concrete piles is typically limited by a deflection criterion of 6 mm or less. To determine the lateral load, the chart developed by Broms, as illustrated on the attached Figure 2 should be used. The use of the chart requires the calculation of a dimensionless length βL, where:

$$\beta = \sqrt[4]{\frac{kD}{4E_{pile}I_{pile}}}$$

k = Modulus of Subgrade Reaction (MN/m^3, see Table 6)

D = Pile Diameter (m)

E_{pile} = Elastic Modulus of the pile (MPa)

I_{pile} = Moment of Inertia of the pile section (m^4)

L = Pile Length (m)

The y axis of the chart is given in terms of a dimensionless lateral deflection value $y_o kDL/P$, where:

y_o = Lateral Deflection (mm)

P = Lateral Load (kN)

In the calculation for the maximum positive moment for a free-head pile, the point of fixity (f) below surface may be determined by the following, where:

$$f = \frac{P}{9C_u D}$$

C_u = Undrained shear strength (use C_u = 120 kPa)

The above expression is valid for cohesive soils and is considered suitable for the extremely weak bedrock. The maximum positive moment acting on the free-head pile may be determined by:

M_{max} = $P(e+ 1.5D + 0.5f)$

Where:

e = height of load application above the top of clayshale or sandstone (m)

5.2.2.3 Recommendations on Pile Installation

Other than restricted access, the key challenge with drilled pile installation at this site is associated with groundwater seepage and potential soil collapse during the pile shaft excavation. Temporary casing should be assumed to be required during construction. Ideally, temporary casing penetrating into the clay shale is recommended to form a temporary seal to control caving and seepage during pile installation. Casing may not be required if the caving condition or water seepage is relatively minor. In this case, a portable submersible pump may be used to remove the water from the bottom of the drilled hole prior to concrete placement, which will likely require tremie methods.

To reduce the degree of softening and disturbance to the pile wall, the concrete should be placed within two hours after the completion of the drilled hole. Concrete should be placed without segregation and carefully vibrated to a minimum depth of 3 m. The slump of the concrete should be between 100 mm and 150 mm.

Where casing has been used for a specific pile, the excavation (drilling) for adjacent piles within 9 shaft diameters should be deferred until the concrete in the constructed pile has set. The level of fresh concrete in the casing must be maintained above the caving or seepage zone as the casing is withdrawn, and should be sufficiently high to counteract groundwater pressures.

A qualified and experienced inspector should be on site during the entire period of pile installation. The inspector should keep complete and accurate records of the pile installations.

5.2.3 Micropiles

Consideration may be given to the use of micropiles for the support of the boardwalk structure. Micropiles typically have a diameter less than 300 mm and are typically designed to resist axial loading conditions. Battered micropiles would likely be required to resist lateral loads. The installation method would likely require air circulation with a temporary casing to remove the drill cuttings (auger methods may not achieve sufficient penetration depth due to practical auger refusal, which was observed during for the geotechnical investigation auger drilling equipment). A micropile typically comprises a central steel reinforcing bar along the full length of the pile with a permanent outer steel casing that extends some distance below the ground surface (but usually not to the pile tip). Grout is injected during casing withdrawal. There are numerous variations the above design and installation method; the geotechnical recommendations herein are preliminary and require verification once the preferred micropile design and installation method are selected.

For design, the ultimate (unfactored) axial geotechnical resistance of a micropile, Q_u, may be determined by the following:

$$Q_u = \sum \alpha_{bond,i} \pi D_b L_{b,i}$$

Where $\alpha_{bond,i}$ is the grout to ground ultimate bond strength along the i^{th} pile segment (kPa)

D_b is the diameter of the drill hole (m)

$L_{b,i}$ is the bond length along the i^{th} pile segment (m)

To determine the factored resistance, a geotechnical resistance factor (ϕ) of 0.4 should be applied to the ultimate resistance (Q_u). End bearing resistance is typically neglected for micropiles.

Based on the soil conditions encountered at the Site, a "Type A" or "Type B" micropile (FHWA/NHI 2005 section 2.3) are considered to be feasible. A "Type A" micropile consists of a gravity grouted micropile with the bond zone within the clayshale and bedrock at the crest of the slope and within the sandstone at the base of the slope. A "Type B" micropile consists of a pressure-grouted micropile, typically grouted through the drilling casing as it is withdrawn.

Based on the subsurface conditions encountered at the site, and the bond zone assumptions made above, the following ultimate grout-to-ground bond strength (α_{bond}) values are recommended for preliminary design:

Table 7: Recommended Ultimate Grout-to-Ground Bond Strengths for Micropile Design

Location	Major Soil Type	Ultimate Grout-to-Ground Bond Strength (α_{bond}) (kPa)	
		Type A Micropile	Type B Micropile
Crest of Slope	Silty Clay and Sand	40	60
	Clayshale Bedrock	100	120
	Sandstone Bedrock	150	200
Base of Slope	Silty Clay and Sand	15	20
	Clayey Sand	15	20
	Sandstone Bedrock	150	200

It should be noted that the grout-to-ground bond values should be confirmed by carrying out a pre-production verification load test prior to the start of production piling. If a sufficient number of verification load tests are performed, the geotechnical resistance factor may be increased up to 0.6 (pending the results confirming design assumptions).

The drill hole diameter and length of the micropile are dependent on the design loads. For both options, it is recommended that casing be installed to at least below the existing silty clay and sand and clayey sand deposits and into the top of the bedrock.

The center to center spacing should be the greater of a minimum of 760 mm or 3 micropile diameters, whichever is greater. The structural resistance of the micropile will also need to be checked by a structural engineer to ensure that the modified foundation system is capable of supporting the design loads.

The ease of equipment access, size of working area and headroom available at the micropile locations should be considered when selecting the most appropriate size and type of micropile to be installed. Where a small drill rig will be required due to tight access and a small working area, micropiles may be more cost effective than shallow foundations or reinforced concrete drilled shafts.

5.3 Slope Stability Recommendations

The natural slope at the north end of the boardwalk is about 4.7 m high and has an existing slope angle that varies between about 26 and 38 degrees below the horizontal (2H:1V to 1.3H:1V), with the upper section being steeper due to surficial slumping. Based on the available subsurface data, the natural slope is expected to be comprised of predominantly stiff to very stiff silty clay and sand underlain by clayshale and sandstone. Near the toe of the slope the material transitions into very soft to soft silty clay and sand, underlain by very loose clayey sand, further underlain by sandstone.

Static slope stability analysis was conducted to assess the factor of safety of the slope. The failure cases assessed included:

- Circular failure surfaces under undrained conditions;
- Circular failure surfaces under drained conditions; and,

- Circular failure surfaces under high water conditions in the floodplain.

The modeled layers and their inferred geotechnical design parameters are summarized in Table 8.

Table 8: Material Properties

Material	Bulk Unit Weight (kN/m^3)	Undrained condition		Drained Condition	
		Cohesion (kPa)	Angle of Friction (degrees)	Cohesion (kPa)	Angle of Friction (degrees)
Topsoil	18	2	28	2	28
Silty Clay and Sand (upper slope)	18	60	--	1	26
Silty Clay and Sand (lower slope)	18	10	--	0	24
Clayey Sand	16	15	--	0	26
Clayshale	20	10	26	10	26
Sandstone	20	Infinite Strength		Infinite Strength	

A minimum recommended factor of safety of 1.5 is normally used for the evaluation of slope stability adjacent to public infrastructure. The results of the stability analysis are shown on Figures 2 to 4 following the text of this report. The failure surfaces that are shown on Figures 2 to 4 are those surfaces with a calculated factor of safety of less than 1.5.

The slope stability analyses of the three failure cases resulted in the factors of safety shown in Table 9 below.

Table 9: Factors of Safety

Case	Factor of Safety
Circular failure under undrained conditions	>1.5
Circular failure under drained conditions	1.0
Circular failure under flood conditions	1.0

Based on the calculated factors of safety and the observed conditions at the Site, the circular failure with a drained condition is the most applicable model. Based on the circular failure with drained condition model and site observations, it is likely that the instability being observed at the Site is a result of surficial movements rather than a deeper seated slope failure.

The slope is considered marginally stable; however, ongoing slumping and surficial movements are expected. For the new boardwalk and trail development, it is understood that the existing slope will be cut by approximately 1 m at the trail location. For long term stability considerations, it is recommended to develop side slopes not steeper than 2.5H:1V along the trail and under the boardwalk.

In addition, consideration should be taken to the set the set-back distance of the new trail and boardwalk to the edge of the slope. A basic set-back analysis was conducted for the slope for the drained condition at the Site. The results of the set-back analysis are summarized in Table 10 below.

Table 10: Set-Back Distances for Drained Conditions

Factor of Safety	Required Set-Back (m)
1.0	1.6
1.1	2.6
1.2	3.1
1.3	3.4
1.5	4.1

Additional slope stability analysis is recommended once the final design of the boardwalk structure and location of the proposed foundations are known. The proposed cuts into the slope have not been modelled at this time.

5.4 Erosion Control

Potential erosion processes at the toe of the North Slope include those related to ice formation, and scour and bank erosion during filling of the oxbow lake during flooding events.

Thus, erosion protection measures for the toe of the North Slope should be designed in consideration of potential ice formation, scour and bank erosion, and aesthetics, given its location in the City of Edmonton river valley.

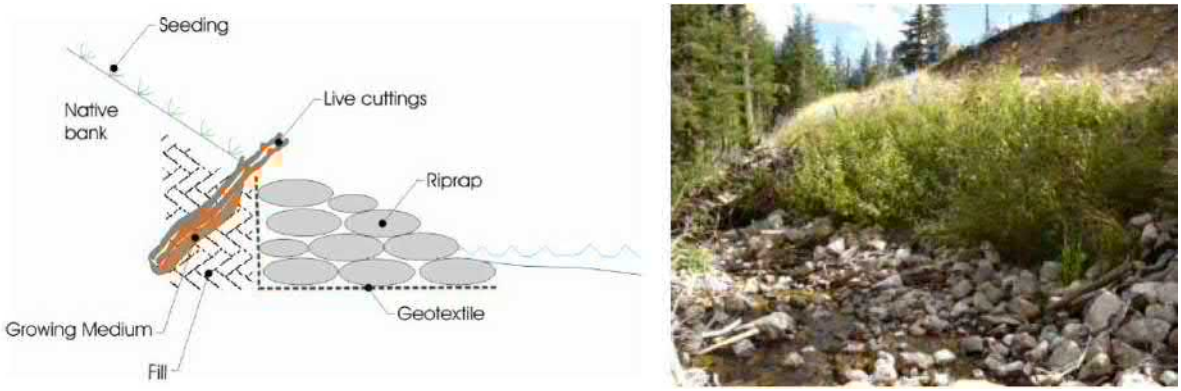
Based on discussions with the City of Edmonton and Associated Engineering, a riprap alternative is preferred. Thus, the recommended alternative is a vegetated riprap, a combination of the widely-accepted, traditional riprap revetment with vegetative techniques that enhance geotechnical stability and improve aesthetics. Vegetated riprap provides immediate and long-term erosion protection to the engineered slope with limited maintenance requirements, and has been recommended for previous City of Edmonton projects, some of which include outfalls along the banks of the North Saskatchewan River, and the Wolf Willow bank trail rehabilitation.

Advantages and disadvantages are summarized in Table 11. This alternative is illustrated in Graphic 1, adapted from design guidelines for erosion and sediment controls along streambanks and riparian areas (AMEC 2012).

Additional hydraulic studies are required to determine design parameters of this recommended alternative, which were not included in this scope of work and are not discussed herein. Water management measures (e.g., vegetated channel) should also be considered to convey runoff draining from the realigned trail. Water management measures were not included in this scope of work and are not discussed further.

Table 11: Summary of Advantages and Disadvantages for Recommended Alternative

Alternative	Advantages	Disadvantages
Vegetated riprap	■ Provides a more natural appearance than traditional riprap ■ Effective for high velocities and potential ice impact ■ Limited maintenance requirements	■ Limited biological advantages ■ Vegetated riprap does not provide a fully natural appearance ■ Labour intensive to install



Graphic 1: Toe Applications of Vegetated Riprap (AMEC 2012)

5.5 Excavation and Groundwater Control

Excavations will typically extend through the slope on the north of the site within the existing stiff to very stiff silty clay and sand deposit. All temporary and permanent excavations, including trenches should be carried out in accordance with the guidelines outlined in the Alberta Occupational Health and Safety Regulation (OH&S), specifically Part 32, which deals with excavation and tunnelling (2009). Based on the OH&S, the clay and till are classified as “likely to crack or crumble”.

It is recommended that temporary excavations (i.e. those that are open for a relatively short time period) be developed with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V) within the silty clay and sand layer. Flatter side slopes will be required if seepage is encountered. Excavations should be monitored frequently by qualified geotechnical personnel; if signs of suspected instability are observed, shallower slope angles may be required.

The stockpiling or storage of excavation spoils, construction materials or heavy equipment should not be permitted within 3 m of the crest of excavation slopes to prevent overloading of the crest and reduce the potential for slope movements.

During drilling operations no seepage was observed within the silty clay and sand deposit in BH16-01; however there is still the possibility that water can be encountered within the slope during construction. Water was

encountered in boreholes BH15-02 to BH15-04 at the completion of drilling, typically between 1.8 m and 3.5 m below ground surface.

Due to the high water levels, it is anticipated that if excavations on the south side of the site will likely be below the groundwater table. Dewatering of the excavations may be required depending on the depth of the proposed excavations. At this time, it is expected that the water could be adequately controlled by pumping from properly filtered sumps within the excavations.

Should seepage or wet zones be encountered during excavation, flatter temporary and permanent slopes may be required. If the seepage or wet zones are encountered below the toe of the slope, the groundwater may be managed using ditches and properly filtered sump and pump systems. Water removed from excavations should be directed toward a suitable discharge location.

Control of surface water should be maintained at all times and surface water should be directed away from all excavations and exposed subgrade soils.

5.6 Water Soluble Sulphate Content and Cement Type

One water soluble sulphate content test was completed on a selected sample retrieved from the drilling investigation. The test result is contained in Appendix B and indicated that water soluble sulphate concentrations were less than 0.05%, indicating a negligible presence of water soluble sulphates. However, past experience in the surrounding area indicates that the sulphate content within the observed materials can vary significantly with depth. As a result, greater sulphate contents than measured in the laboratory are considered possible. A summary of the results of the water soluble sulphate testing is provided in Table 12 and contained in Appendix B.

Table 12: Analytical Test Results

Borehole / Sample No.	Depth (m)	pH	Soluble Sulphates (%)	Chloride Concentration (mg/L)	Electrical Resistivity (Ohm-cm)
BH16-04	1.8 – 2.1	8.41	<0.05	12.2	2170

Based on past experience and soil testing in this area, it is recommended that the Site be classified as an S-3 exposure class. For design purposes, type MS or MSb cement is recommended for all concrete in contact with soil. To enhance durability, an appropriate quantity of entrained air, as per CSA A23.1-09, Clause 4.1.1.3, is recommended for all concrete exposed to freezing and thawing. Based on an S-3 exposure class, the maximum water-to-cementing material ratio 0.5 is recommended, with a minimum specified compressive strength of 30 MPa at 56 days. If used, imported soils should be tested for compatibility with the recommended cement type.

5.7 Seismic Site Classification

The seismic response of the Site was classified according to the National Building Code of Canada 2005 (NBCC), which categorizes the soil conditions into 6 types – Class 'A' to 'F'. This classification is based on the average shear wave velocity, SPT "N" values, or undrained shear strength over the top 100 ft (30 m) of the soil profile.

No boreholes were drilled to depths over 30 m at the proposed Site. However, it is expected that consideration in selecting the seismic site classification will be dominated by the silty clay and sand and clayey sand deposits in the upper 3.0 m; however a weighted average was used to calculate the class type. Based on the SPT profile in the advanced boreholes, the Site is characterized as a Class 'D' according to NBCC 2015.

6.0 CLOSURE

The recommendations presented in this report are made based on our present understanding of the project. Should any conditions at the site be encountered which differ from those addressed, we require that we be notified immediately in order to permit re-assessment of our recommendations.

We trust that the information presented in this report meets your present requirements. If you have any questions, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.

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ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soils

ASTM D1587 Standard Penetration for Thin-Walled Tube Sampling

ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

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Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface

conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

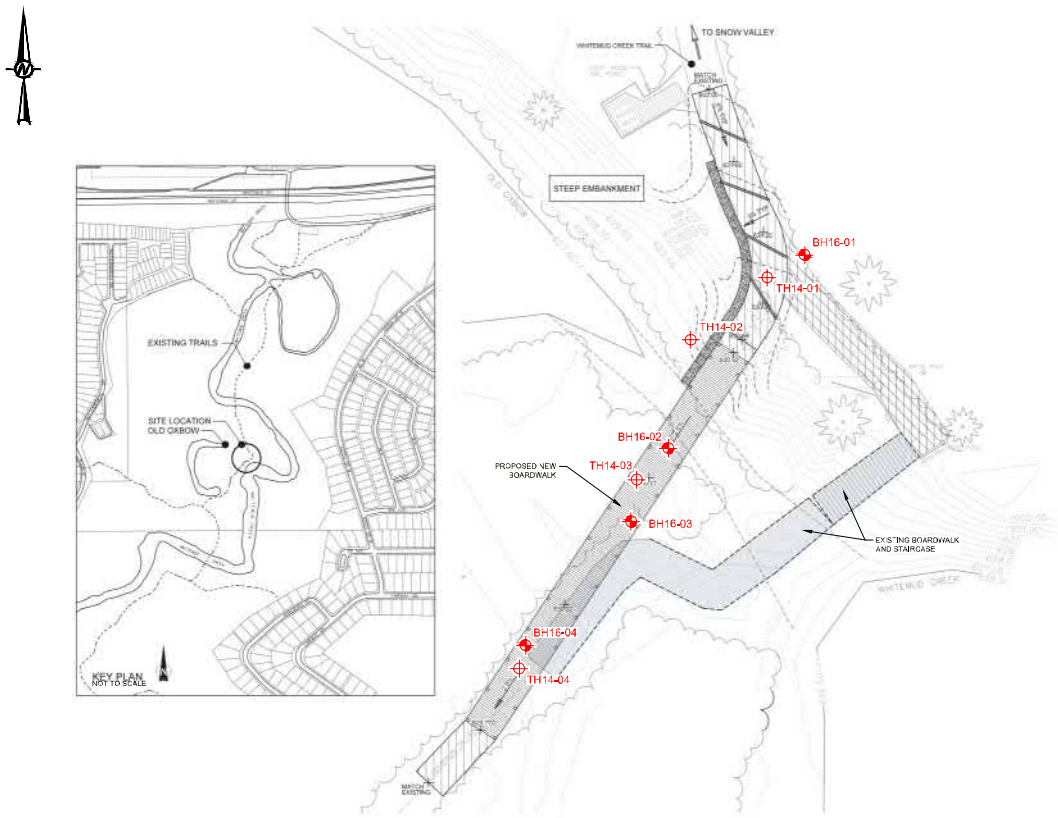
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



LEGEND

- 2014 TEST HOLE LOCATION
- 2016 BOREHOLE LOCATION

REFERENCE
ORIGINAL DRAWING PROVIDED BY THE CITY OF EDMONTON
DATED DECEMBER 2012; ORIGINAL SCALE 1:100; REF. FILE CONSTRUCT.TBL

DRAFT

0 5 10
1:250 (APPROX.) METRES

CLIENT
ASSOCIATED ENGINEERING ALBERTA LTD.

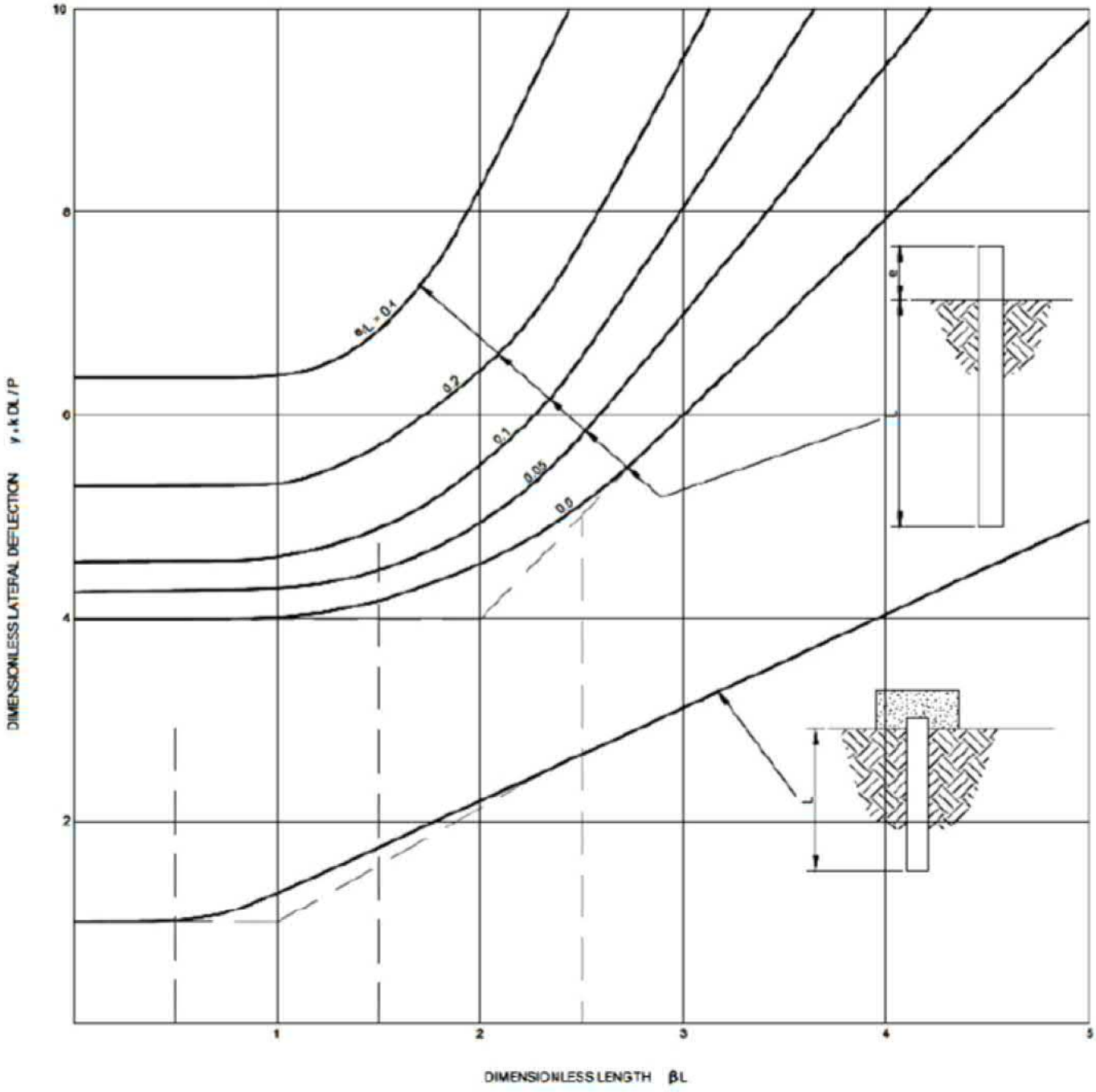
PROJECT
OXBOW BOARDWALK
WHITEMUD CREEK WALKING TRAIL
EDMONTON, ALBERTA

TITLE
SITE AND BOREHOLE LOCATION PLAN

CONSULTANT

YYYY-MM-DD	2016-05-06
PREPARED	AM
DESIGN	JB
REVIEW	
APPROVED	

PROJECT No.	CONTROL	Rev.	FIGURE
1404541	2000-BG-0001	A	1



CLIENT

Associated Engineering Ltd.

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-06
PREPARED	KW
DESIGN	-
REVIEW	NK
APPROVED	PT

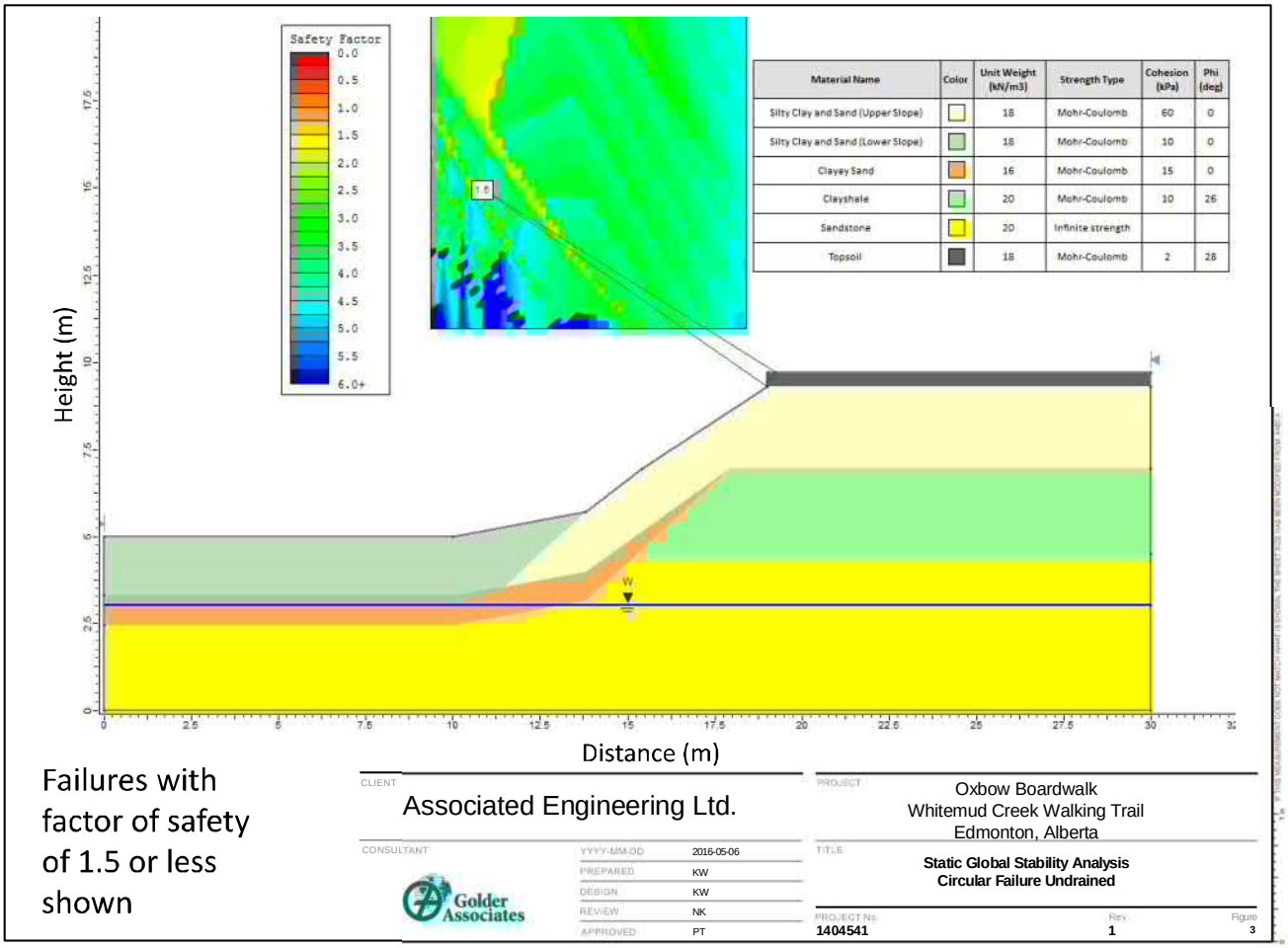
PROJECT

Oxbow Boardwalk
Whitemud Creek Walking Trail
Edmonton, Alberta

TITLE

Design Chart For Lateral Loaded Pile in Cohesive Soil

PROJECT No.	Rev.	Figure
1404541	**1**	**2**



Failures with factor of safety of 1.5 or less shown

CLIENT
Associated Engineering Ltd.

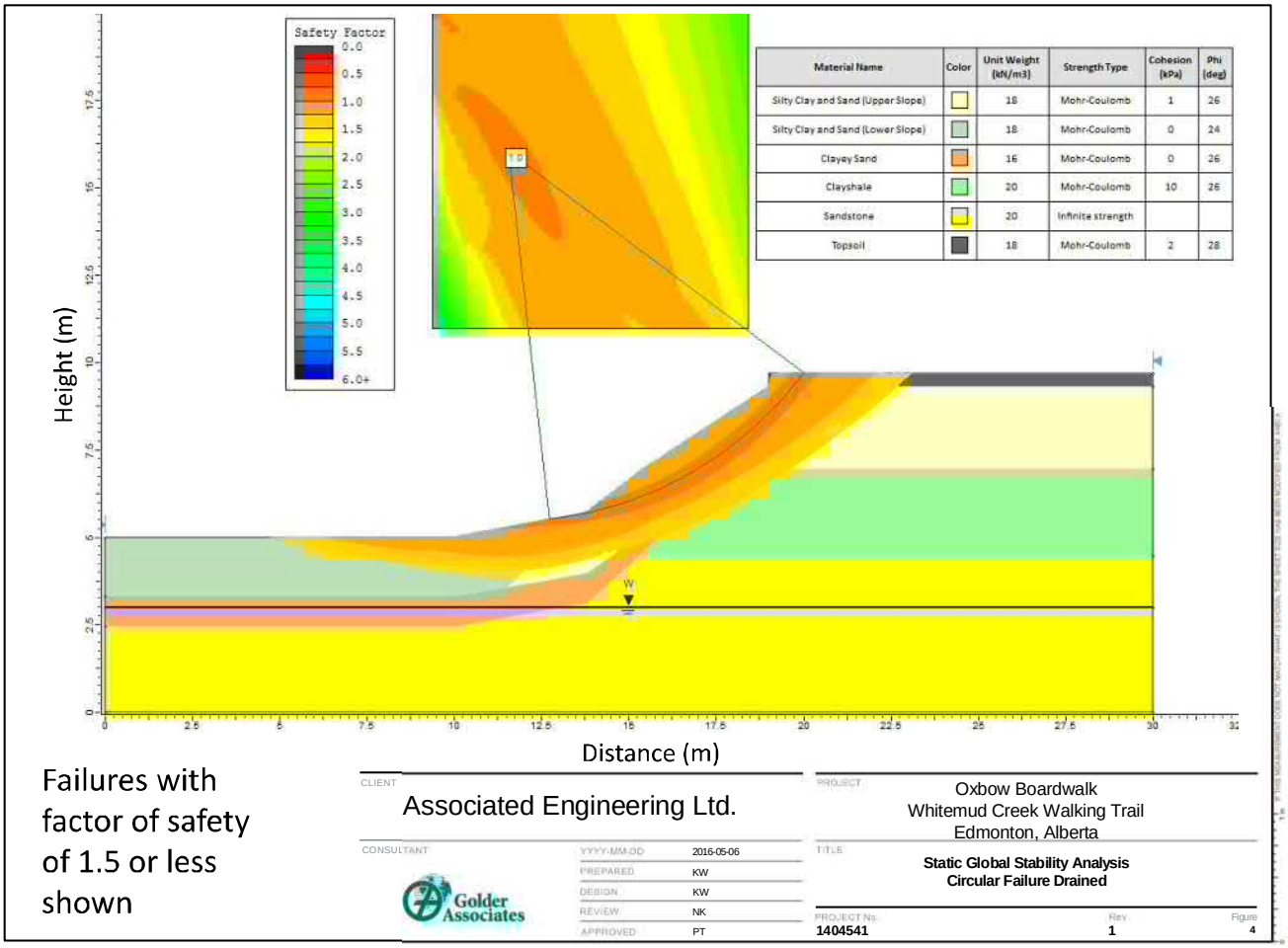
PROJECT
Oxbow Boardwalk
Whitemud Creek Walking Trail
Edmonton, Alberta

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-06
PREPARED	KW
DESIGN	KW
REVIEW	NK
APPROVED	PT

TITLE
Static Global Stability Analysis
Circular Failure Undrained

PROJECT No.	Rev.	Figure
1404541	**1**	**3**



Failures with factor of safety of 1.5 or less shown

CLIENT
Associated Engineering Ltd.

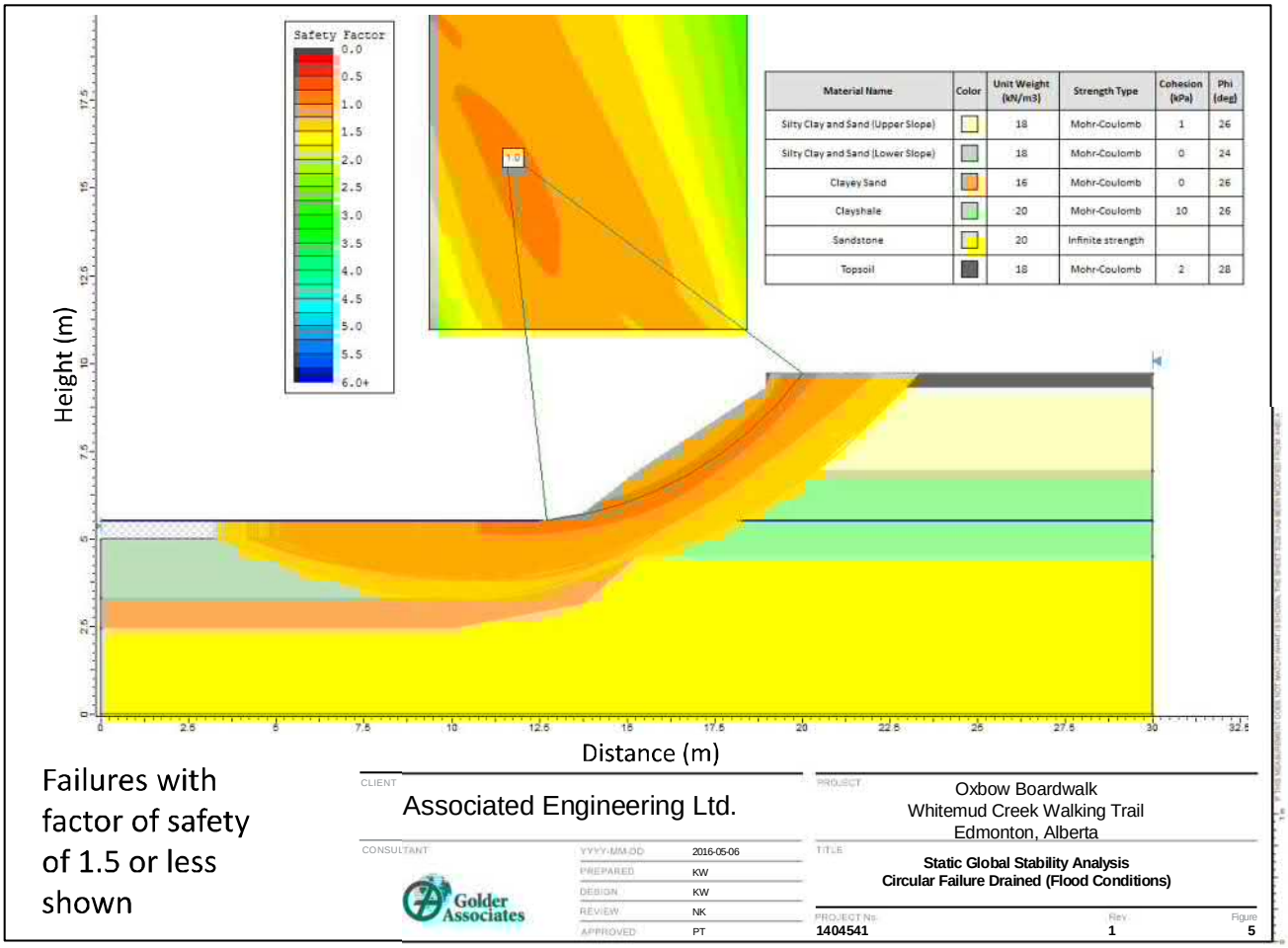
PROJECT
Oxbow Boardwalk
Whitemud Creek Walking Trail
Edmonton, Alberta

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-06
PREPARED	KW
DESIGN	KW
REVIEW	NK
APPROVED	PT

TITLE
Static Global Stability Analysis
Circular Failure Drained

PROJECT No.	Rev.	Figure
1404541	**1**	**4**



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Silty Clay and Sand (Upper Slope)		18	Mohr-Coulomb	1	26
Silty Clay and Sand (Lower Slope)		18	Mohr-Coulomb	0	24
Clayey Sand		16	Mohr-Coulomb	0	26
Clayshale		20	Mohr-Coulomb	10	26
Sandstone		20	Infinite strength		
Topsoil		18	Mohr-Coulomb	2	28

Failures with factor of safety of 1.5 or less shown

CLIENT
Associated Engineering Ltd.

PROJECT
Oxbow Boardwalk
Whitemud Creek Walking Trail
Edmonton, Alberta

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-06
PREPARED	KW
DESIGN	KW
REVIEW	NK
APPROVED	PT

TITLE
Static Global Stability Analysis
Circular Failure Drained (Flood Conditions)

PROJECT No.	Rev.	Figure
1404541	**1**	**5**

APPENDIX A

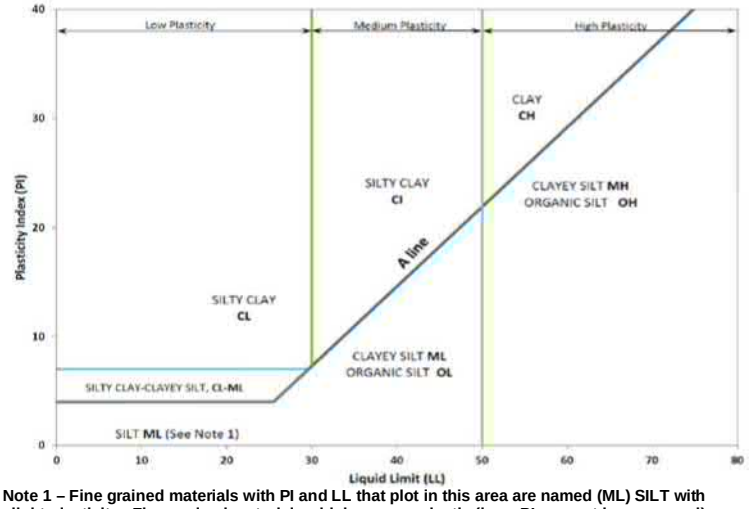
Record of Borehole Sheets from Current Investigation

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil		Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
					Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)		Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
					Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
					Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
				Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
					None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)		Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
				Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
				Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures								30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat								75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to ~~or~~ indicate~~s~~ a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1] (blows/0.3m)
Very Soft	<12	0 to 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	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

PROJECT: 1404541

RECORD OF BOREHOLE: BH16-01

SHEET 1 OF 1

LOCATION: N: 5,928,311; E: 330,415

BORING DATE: March 11, 2016

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕, rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		633.00							stick-up
	M2.5T Track Mounted Drill Rig - 150 mm Solid Stem Augers Mobile Augers and Research Ltd.	(GP) GRAVEL, trace organics		0.00 0.05							
		(CI) SILTY CLAY and SAND, trace organics and root fibres; brown, containing oxidation stains, mild organic odour to 0.75 m; cohesive, w<PL, stiff to very stiff.			1	AS					Cuttings
1					2	SS	12				
		... increased sand content and trace sand pockets below 1.5 m			3	AS				MH	Bentonite Seal
2		... some gravel, inferred cobbles due to grinding of augers below 2.25 m			4	SS	27				Filter Sand
				630.26							
		Highly to completely weathered, massive, grey, non porous, extremely weak, CLAYSHALE (Horseshoe Canyon Formation).		2.74	5	AS					
3					6	SS	43				Screen and Filter Sand
					7	AS					
4											
5				627.82							
		Highly to completely weathered, laminated, grey, faintly porous, extremely weak, SANDSTONE (Horseshoe Canyon Formation).		5.18	8	SS	50/ 0.08 m				
				627.21	9	AS					Slough
6		AUGER REFUSAL END OF BOREHOLE		5.79							
7		Notes: 1. Borehole open to a depth of 5.5 m on completion of drilling. 2. Open borehole dry on completion of drilling. 3. Water levels in standpipe piezometer measured as follows: Date / Depth (m) / Elev (m) Mar 11/16 / Dry / - April 8/16 / Dry / - April 22/16 / Dry / - 4. Borehole coordinates were surveyed with a handheld GPS. Borehole elevation was approximated using Google Earth. Borehole coordinates and elevation should be considered approximate.									
8											
9											

DEPTH SCALE

1 : 45

LOGGED: JB

CHECKED: NK

GTA-BHS 001 1404541 OXBOW BOREHOLE RECORDS.GPJ GAL-MIS.GDT 04/27/16

PROJECT: 1404541

RECORD OF BOREHOLE: BH16-02

SHEET 1 OF 1

LOCATION: N: 5,928,297; E: 330,413

BORING DATE: April 8, 2016

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕, rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		631.00							
	M4T Track Mounted Drill Rig - 150 mm Solid Stem Augers Mobile Augers and Research Ltd.	TOPSOIL		0.00 630.82							
		(CI) SILTY CLAY and SAND, trace plant fibres and organics to 1.5 m; brown, containing oxidation stains; cohesive, w>PL, very soft to soft.		0.18	1	AS					
1					2	SS	2				
				629.48							
		(ML) Sandy CLAYEY SILT; grey; cohesive, w>PL, soft.		1.52 629.17	3	AS					
2		(SC) CLAYEY SAND, fine to medium; grey; non-cohesive, wet, very loose.		1.83	4	AS					
				628.33	5	SS	41				
3		Completely weathered, massive, grey, containing oxidation stains, faintly porous, extremely weak, SANDSTONE (Horseshoe Canyon Formation).		2.67	6	AS					
4					7	SS	50/ 0.15 m				
				626.43							
		AUGER REFUSAL END OF BOREHOLE		4.57							
5		Notes: 1. Borehole open to a depth of 2.1 m on completion of drilling. 2. Water level in open borehole at a depth of 1.8 m (Elev 629.2 m) on completion of drilling. 3. Borehole backfilled with soil cuttings and sealed with bentonite near surface. 4. Borehole coordinates were surveyed with a handheld GPS. Borehole elevation was approximated using Google Earth. Borehole coordinates and elevation should be considered approximate.									
6											
7											
8											
9											

DEPTH SCALE
1 : 45

LOGGED: JB
CHECKED: NK

GTA-BHS 001 1404541 OXBOW BOREHOLE RECORDS.GPJ GAL-MIS.GDT 04/27/16

PROJECT: 1404541

RECORD OF BOREHOLE: BH16-03

SHEET 1 OF 1

LOCATION: N: 5,928,294; E: 330,409

BORING DATE: April 8, 2016

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕; rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		631.00									Stick-up
	M4T Track Mounted Drill Rig - 150 mm Solid Stem Augers; Mobile Augers and Research Ltd.	TOPSOIL		0.00 630.80									Bentonite
		(CI) SILTY CLAY and SAND, trace plant fibres and organic pockets; brown, containing oxidation stains; cohesive, w>PL, very soft.		0.20	1	AS							
1					2	SS	1						Cuttings
		(SC) CLAYEY SAND, fine to medium, trace organic pockets; grey; non-cohesive, wet, very loose.		629.48 1.52	3	AS						MH	Bentonite
2				628.56									Apr 22/16
		Completely weathered, massive, grey, containing oxidation stains, faintly porous, extremely weak, SANDSTONE (Horseshoe Canyon Formation).		2.44	4	SS	19						Slough
3					5	AS							
4					6	SS	50/ 0.15 m						
					7	AS							
				626.12									
5		AUGER REFUSAL END OF BOREHOLE		4.88									
6		Notes: 1. Borehole open to a depth of 1.8 m on completion of drilling. 2. Water level in open borehole at a depth of 1.8 m (Elev 629.2 m) on completion of drilling. 3. Water levels in standpipe piezometer measured as follows: Date / Depth (m) / Elev (m) Apr 8/16 / 3.5 / 627.5 Apr 22/16 / 2.0 / 629.0 4. Borehole coordinates were surveyed with a handheld GPS. Borehole elevation was approximated using Google Earth. Borehole coordinates and elevation should be considered approximate.											
7													
8													
9													

DEPTH SCALE

1 : 45

LOGGED: JB

CHECKED: NK

GTA-BHS 001 1404541 OXBOW BOREHOLE RECORDS.GPJ GAL-MIS.GDT 04/27/16

PROJECT: 1404541

RECORD OF BOREHOLE: BH16-04

SHEET 1 OF 1

LOCATION: N: 5,928,284; E: 330,401

BORING DATE: April 8, 2016

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕, rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		632.00							
0	M4T Track Mounted Drill Rig - 150 mm Solid Stem Augers Mobile Augers and Research Ltd.	TOPSOIL		0.00 631.82							
		(CI) SILTY CLAY and SAND, trace plant fibres to 1.8 m; brown; cohesive, w<PL, very soft to soft.		0.18	1	AS					
1					2	SS	2				
2		... w>PL below 1.8 m.			3	AS				MH CHEM	
		... decreased sand content below 2.1 m.			4	AS					
				629.56							
		(SC) CLAYEY SAND, fine to medium; brown, containing oxidation stains; non-cohesive, wet, very loose.		2.44	5	SS	3			MH	
3				628.95							
		Completely weathered, massive, grey, faintly porous, extremely weak, SANDSTONE (Horseshoe Canyon Formation).		3.05	6	AS					
4					7	SS	50/ 0.15 m				
				627.12							
5		AUGER REFUSAL END OF BOREHOLE		4.88							
6		Notes: 1. Borehole open to a depth of 2.0 m on completion of drilling. 2. Water level in open borehole at a depth of 1.9 m (Elev 630.1 m) on completion of drilling. 3. Borehole backfilled with cuttings and sealed with bentonite near surface. 4. Borehole coordinates were surveyed with a handheld GPS. Borehole elevation was approximated using Google Earth. Borehole coordinates and elevation should be considered approximate.									
7											
8											
9											

DEPTH SCALE

1 : 45

LOGGED: JB

CHECKED: NK

Golder Associates

GTA-BHS 001 1404541 OXBOW BOREHOLE RECORDS.GPJ GAL-MIS.GDT 04/27/16

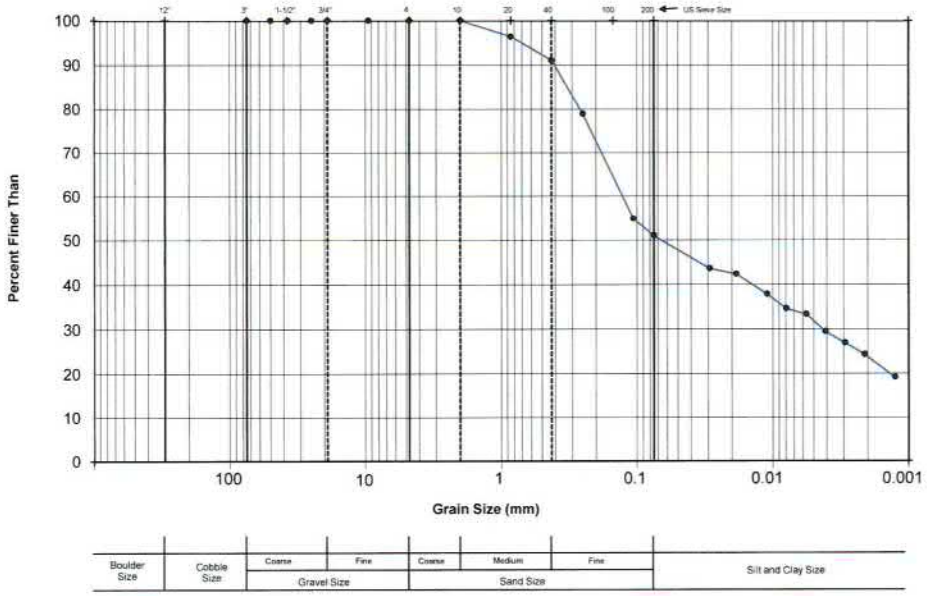
APPENDIX B

Laboratory Test Results

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	14-04541	Lab No.:	E150-03
Project Title:	AE/Whitemud Oxbow		
Borehole:	BH16-01	Sample No.:	AS3
Depth:	5-6 m		
Date Tested:	15-Mar-16	By:	KT



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	100.0
4.75	100.0
2.0	100.0
0.850	96.4
0.425	91.0
0.250	78.9
0.106	54.8
0.075	51.0
0.029	43.7
0.019	42.4
0.011	37.8
0.008	34.6
0.006	33.3
0.004	29.5
0.003	26.9
0.002	24.3
0.001	19.1

Comments:

Reviewed:

Atterberg Limits (ASTM D 4318)

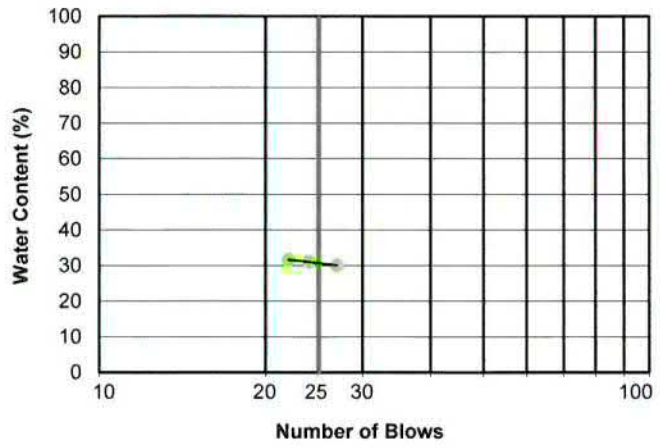
Project No.: 14-04541
Short Title: AE/Whitemud Oxbow
Tested By: KT

Phase: -
Lab No.: E150-03
Date: 16-Mar-16

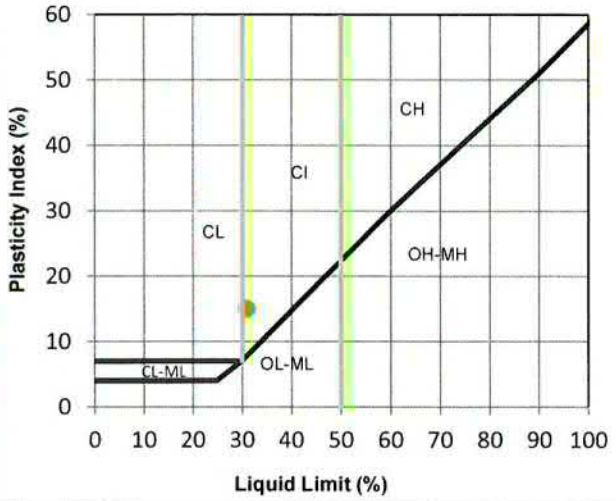
Borehole: BH16-01 Sample No.: AS3 Depth: 5-6 m

Liquid Limit Determination:				Natural Water Content:		
Trial No.	1	2	3	As Received Water Content (%)		11.4%
No. of Blows	22	24	27	Plastic Limit Determination:		
Mass of wet sample + tare (g)	31.12	28.63	30.79	Mass of wet sample + tare (g)	27.36	27.29
Mass of dry sample + tare (g)	27.48	25.49	27.32	Mass of dry sample + tare (g)	25.74	25.70
Mass of tare (g)	15.96	15.37	15.78	Mass of tare (g)	15.46	16.00
Weight of Water (g)	3.64	3.14	3.47	Weight of Water (g)	1.62	1.59
Weight of dry soil (g)	11.52	10.12	11.54	Weight of dry soil (g)	10.28	9.70
Water Content (%)	31.6	31.0	30.1	Water Content (%)	15.76	16.39
				Average Water Content (%)		16.08

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit = 31 %
Plastic Limit = 16 %
Plasticity Index = 15

Comments: _____

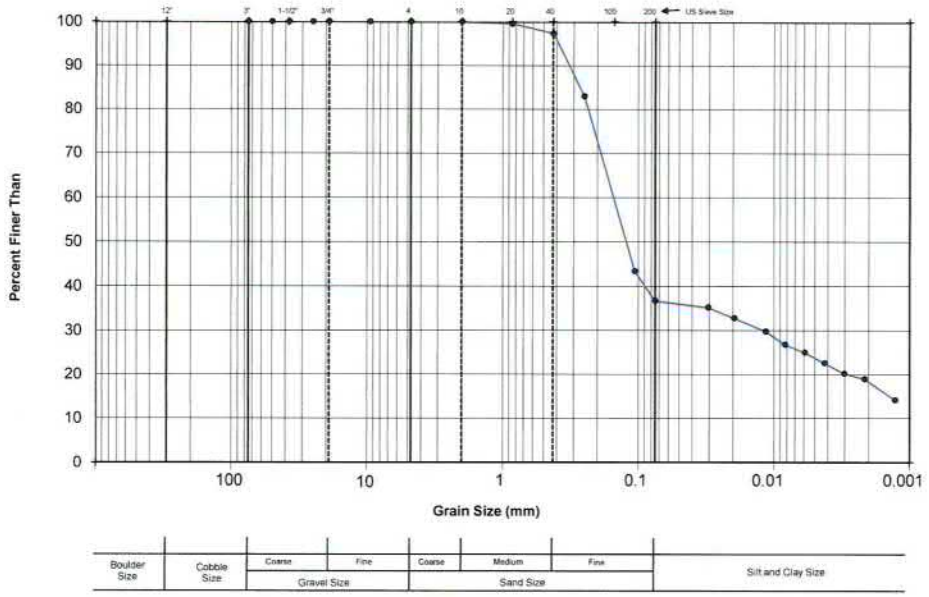
V2.2

Reviewed: _____ DN: cn=Derek Hudson, o=Golder Associates Ltd., ou, email=dhudson@golder.com, c=CA Date: 2016.04.12 13:59:30 -06'00'

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	14-04541	Lab No.:	E157-10
Project Title:	AE/Whitemud Oxbow		
Borehole:	BH16-03	Sample No.:	AS3
Depth:	5-6		
Date Tested:	13-Apr-16	By:	KT



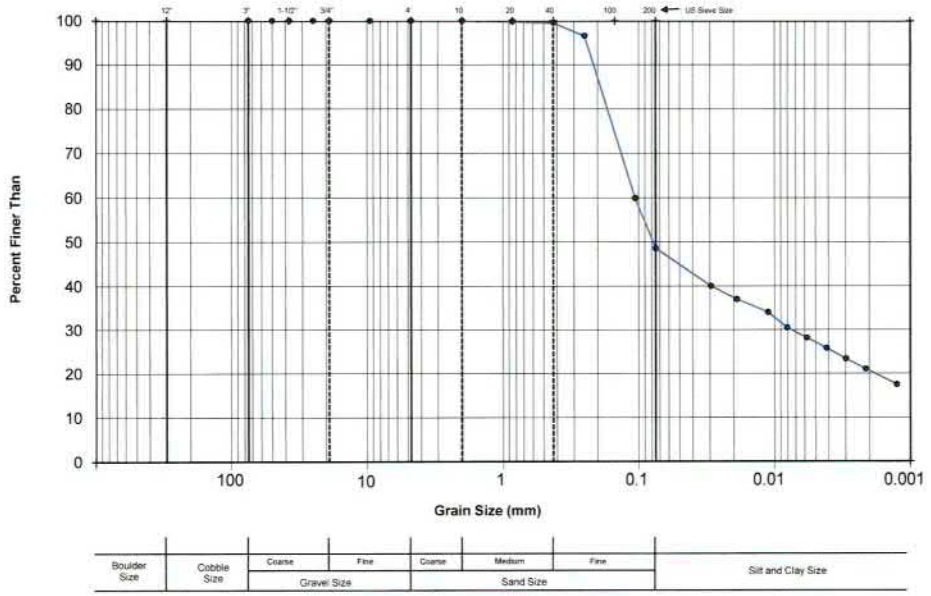
Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	100.0
4.75	100.0
2.0	100.0
0.850	99.5
0.425	97.3
0.250	83.0
0.106	43.4
0.075	36.7
0.030	35.2
0.020	32.8
0.011	29.8
0.008	26.8
0.006	25.0
0.004	22.6
0.003	20.1
0.002	18.9
0.001	14.1

Comments:

Reviewed:

Project No.:	14-04541	Lab No.:	E157-17
Project Title:	AE/Whitemud Oxbow		
Borehole:	BH16-04	Sample No.:	AS3
Depth:	6-7		
Date Tested:	13-Apr-16	By:	KT

Particle Size Analysis of Soil
(ASTM D422)



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	100.0
4.75	100.0
2.0	100.0
0.850	99.9
0.425	99.5
0.250	96.6
0.106	59.9
0.075	48.5
0.029	40.0
0.019	37.0
0.011	34.0
0.008	30.5
0.006	28.1
0.004	25.7
0.003	23.4
0.002	21.0
0.001	17.4

Comments:

Reviewed:

Atterberg Limits (ASTM D 4318)

Project No.: 14-04541
Short Title: AE/Whitemud Oxbow
Tested By: KT

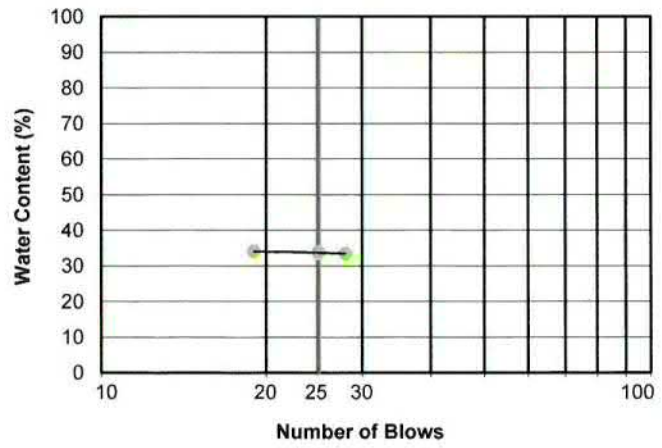
Phase: -
Lab No.: E157-17
Date: 19-Apr-16

Borehole: BH16-04 Sample No.: AS3 Depth: 6 - 7

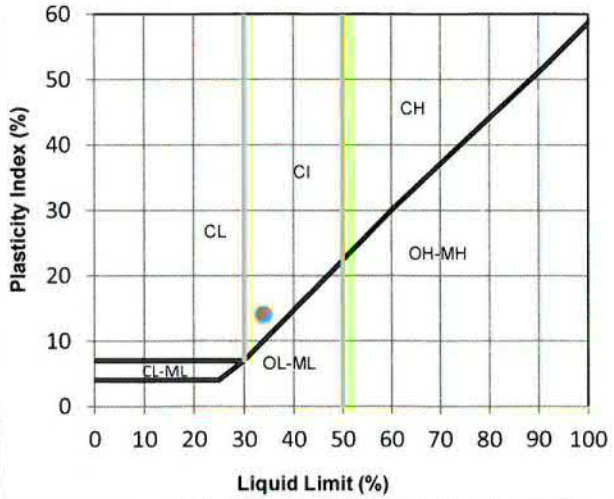
Liquid Limit Determination:			
Trial No.	**1**	**2**	**3**
No. of Blows	28	25	19
Mass of wet sample + tare (g)	31.32	28.84	29.57
Mass of dry sample + tare (g)	27.35	25.36	26
Mass of tare (g)	15.46	15.06	15.52
Weight of Water (g)	3.97	3.48	3.57
Weight of dry soil (g)	11.89	10.3	10.48
Water Content (%)	33.4	33.8	34.1

Natural Water Content:		
As Received Water Content (%)		37.7%
Plastic Limit Determination:		
Mass of wet sample + tare (g)	25.61	25.32
Mass of dry sample + tare (g)	23.90	23.62
Mass of tare (g)	15.42	15.14
Weight of Water (g)	1.71	1.70
Weight of dry soil (g)	8.48	8.48
Water Content (%)	20.17	20.05
Average Water Content (%)		20.11

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit = 34 %
Plastic Limit = 20 %
Plasticity Index = 14

Comments: _____

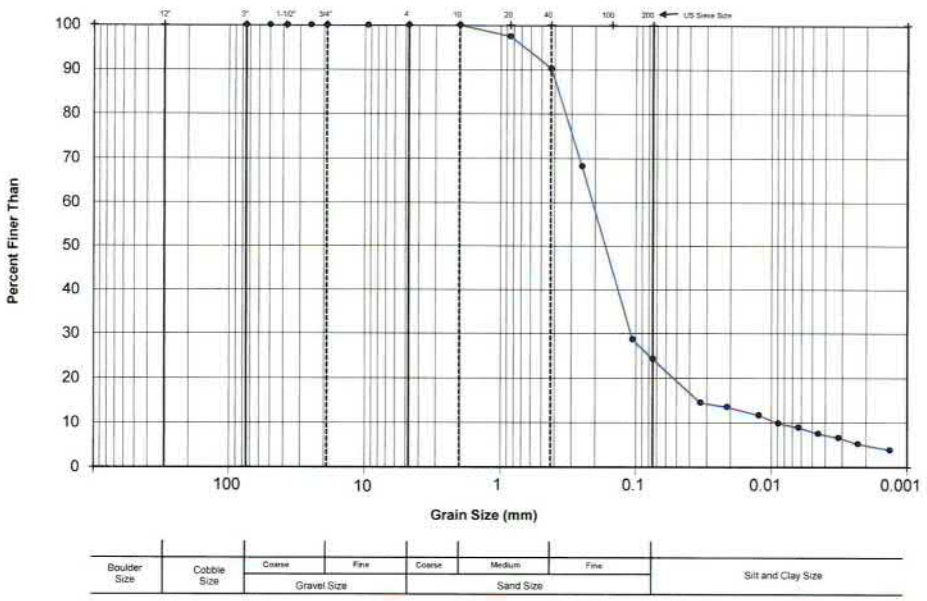
V2.2

Reviewed: _____ DN: cn=Derek Hudson, o=Golder Associates Ltd., ou, email=dhudson@golder.com, c=CA Date: 2016.04.21 14:22:33 -06'00'

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	14-04541	Lab No.:	E157-19
Project Title:	AE/Whitemud Oxbow		
Borehole:	BH16-04	Sample No.:	AS5
Depth:	8-9.5		
Date Tested:	14-Apr-16	By:	KT



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	100.0
4.75	100.0
2.0	100.0
0.850	97.5
0.425	90.3
0.250	68.2
0.106	28.7
0.075	24.2
0.033	14.5
0.021	13.6
0.012	11.7
0.009	9.9
0.006	9.0
0.005	7.6
0.003	6.6
0.002	5.3
0.001	3.9

Comments:

Reviewed:

GOLDER ASSOCIATES LTD
ATTN: Nikol Kochmanova
16820 107 Ave NW
EDMONTON AB T5P 4C3

Date Received: 14- APR- 16
Report Date: 20- APR- 16 13:04 (MT)
Version: FINAL

Client Phone: 780- 483- 3499

Certificate of Analysis

Lab Work Order #: L1755926

Project P.O. #:	NOT SUBMITTED
Job Reference:	1404541
C of C Numbers:	10- 326067
Legal Site Desc:	

Jessica Spira, Env. Tech. DIPL
Senior Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1755926-1 AS3 BH16-04 6-7 FEET DEPTH							
Sampled By: CLIENT on 14-APR-16 @ 11:30							
Matrix: BAG							
Miscellaneous Parameters							
Chloride (Cl)	12.2		5.0	mg/kg	18-APR-16	19-APR-16	R3441417
Resistivity	2170		1.0	ohm cm		20-APR-16	R3441490
Total Sulphate Ion Content	<0.050		0.050	%	18-APR-16	18-APR-16	R3441095
pH (1:2 soil:water)	8.41		0.10	pH		18-APR-16	R3440057

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

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-1:5-DI-COL-ED	Soil	Chloride (Cl)	APHA 4500 Cl E-Colorimetry
PH-1:2-ED	Soil	pH 1:2 H2O Extract	CSSS 16.2 - PH OF 1:2 WATER EXTRACT
RESISTIVITY-PASTE-CL	Soil	PASTE RESISTIVITY	ASTM G57-95A

This analysis is carried out using procedures adapted from ASTM G57-95a (2001) "Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method". In summary, 200 to 500 grams of sample is mixed with deionized water as required to create a saturated paste. The sample is then placed directly into a four electrode resistivity soil box and measured for resistivity using a resistivity meter.

SO4-T-CSA-A23-ED	Soil	Total Sulphate Ion Content	CSA INTERNATIONAL A23.2

Total sulphate content is determined by mixing soil with water then hydrochloric acid, and digesting just below boiling point, for 15 minutes. Analysis by ion chromatography follows.
NOTE: the CSA-A23 method states that for a total sulphate ion content greater than 0.2%, sulphate ion content shall be determined on the basis of a water extraction. This water extraction requires the total sulphate ion content result to calculate the correct ratio for the water extraction.

** 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

Chain of Custody Numbers:

10-326067

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.

Quality Control Report

Workorder: L1755926 Report Date: 20-APR-16

Client: GOLDER ASSOCIATES LTD
16820 107 Ave NW
EDMONTON AB T5P 4C3
Contact: Nikol Kochmanova

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-1:5-DI-COL-ED	Soil							
Batch R3441417								
WG2292697-3 DUP		**L1755926-1**						
Chloride (Cl)		12.2	12.4		mg/kg	1.9	30	19-APR-16
WG2292697-2 IRM		**SALINITY SOIL5**						
Chloride (Cl)			111.7		%		70-130	19-APR-16
WG2292697-4 IRM		**SALINITY SOIL5**						
Chloride (Cl)			105.6		%		70-130	19-APR-16
WG2292697-1 MB								
Chloride (Cl)			<5.0		mg/kg		5	19-APR-16
PH-1:2-ED	Soil							
Batch R3440057								
WG2292710-1 IRM		**SALINITY SOIL5**						
pH (1:2 soil:water)			7.34		pH		7.11-7.71	18-APR-16
WG2292710-3 LCS		**PH-4**						
pH (1:2 soil:water)			4.0		%		3.8-4.2	18-APR-16
WG2292710-4 LCS		**PH-7**						
pH (1:2 soil:water)			6.98		pH		6.8-7.2	18-APR-16
WG2292710-5 LCS		**PH-10**						
pH (1:2 soil:water)			9.9		%		9.8-10.2	18-APR-16
RESISTIVITY-PASTE-CL	Soil							
Batch R3441490								
WG2293728-1 IRM		**SAL-STD8**						
Resistivity			99.3		%		80-120	20-APR-16
SO4-T-CSA-A23-ED	Soil							
Batch R3441095								
WG2292717-2 CRM		**1880A CEMENT**						
Total Sulphate Ion Content			90.0		%		60-140	18-APR-16
WG2292717-1 MB								
Total Sulphate Ion Content			<0.050		%		0.05	18-APR-16

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

10- 326067

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ___ of ___

Report To	Nikol Kachmarova	**Report Format / Distribution**	**Service Request:** (Rush subject to availability - Contact ALS to confirm TAT)
Company:	Golder Associates Ltd	Standard: ✓ Other (specify):	X Regular (Standard Turnaround Times - Business Days)
Contact:		Select: PDF ✓ Excel ✓ Digital Fax	Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	16820 107 AVE	Email 1: nikol_kachmarova@golder.com	Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Edm AB T5P 4C3	Email 2: khews@golder.com	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	7804833499 Fax: 7804831574		**Analysis Request**
Invoice To	Same as Report ? (circle) Yes or No (If No, provide details)	**Client / Project Information**	(Indicate Filtered or Preserved, F/P)
	Copy of Invoice with Report? (circle) Yes or No	Job #: 1404541	
Company:		PO / AFE:	
Contact:		LSD:	
Address:			
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only):	L1755926	**ALS Contact:**	**Sampler:**

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH	Resistivity	Chlorides	Water Extract Soluble Sulphate (SO4)	Number of Containers
AS3	BH16-04 6-7 feet depth	14 Apr 16	11:30	Bag					

L1755926-COFC

Special Instructions / Regulation with water or land use (CCME-Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

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.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)			SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
	Apr 14/16			14/04/16	2:40pm	N/A °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

GENF 18.01 Front

APPENDIX C

Record of Test Hole Sheets from Previous Investigation

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-01

SHEET 1 OF 1

LOCATION: N: 5928304 E: 330418

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕; rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		632.00									
0	50 mm Hand Auger	TOPSOIL		0.00									
				631.80									
		(SP) SAND, medium grained, uniformly graded, trace to some fines; brown; non-cohesive, dry, loose to compact.		0.20	1	AS							
1					2	AS							
					3	AS							
					4	AS							
2					5	AS							
					6	AS							
				629.20									
		END OF TEST HOLE		2.80									
3		NOTES: 1) No sloughing observed in open borehole upon completion of drilling. 2) No water observed in open borehole upon completion of drilling. 3) Hand auger refusal at 2.8 mbgs due to possible bedrock.											
4													

DEPTH SCALE

1 : 20

LOGGED: JJB/IK

CHECKED:

Golder Associates

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-02

SHEET 1 OF 1

LOCATION: N: 5928305 E: 0330411

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa — nat V. + Q - ⊕ rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT Wp — W — Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		628.80									
0	50 mm Hand Auger	TOPSOIL		0.00 / 628.70									
		(SP) SAND, medium grained, poorly graded, some fines, trace organics; brown, signs of oxidation; non-cohesive, dry, loose to compact.		0.10	1	AS							
				628.15									
		CLAYSHALE, medium to high plastic, sandy; mottled brown and grey, completely weathered; cohesive,w~PL, stiff to very stiff.		0.65	2	AS							
1					3	AS							
				627.70									
		CLAYSHALE, medium to high plastic; tan, weathered, blocky; cohesive, w<PL, very stiff to hard.		1.10	4	AS					73	I_p=49	
				627.40									
		CLAYSHALE, medium to high plastic, some sand; light grey, weathered, blocky; cohesive, w<PL, hard.		1.40 / 627.30	5	AS							
2		END OF TEST HOLE		1.50									
		NOTES: 1) No sloughing observed in open borehole upon completion of drilling. 2) No water observed in open borehole upon completion of drilling. 3) Hand auger refusal at 1.5 mbgs due to hard clayshale.											
3													
4													

DEPTH SCALE

1 : 20

Golder Associates

LOGGED: JJB/IK

CHECKED:

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-03

SHEET 1 OF 1

LOCATION: N: 5928292 E: 0330410

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕, rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		628.00							
0	50 mm Hand Auger	TOPSOIL		0.00 627.90							
		(SP) SAND, medium grained, poorly graded, trace to some fines, trace organic fibres; brown; dry to moist, non-cohesive, loose to compact.		0.10	1	AS					
				627.60							
		(CI) SILTY CLAY, medium to high plastic, some sand; brown, signs of oxidation; w>PL, cohesive, soft to firm.		0.40	2	AS					
1		... Localized seepage at 1.4 m.									
		... Wet grey sand nodules at 1.5 m.									
2					3	AS					
3				624.70							
		CLAYSHALE, some sand; light grey; w~PL, cohesive, hard.		3.30 624.60	4	AS					
		END OF TEST HOLE		3.40							
4		NOTES: 1) No sloughing observed in open borehole on completion of drilling. 2) Localized seepage observed at ~1.4 mbgs. 3) Auger refusal due to hard ground at 3.4 mbgs.									

DEPTH SCALE

1 : 20

LOGGED: JJB/IK

CHECKED:

Golder Associates

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-04

SHEET 1 OF 1

LOCATION: N: 5928280 E: 0330402

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕, rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl, 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		628.60							
0		TOPSOIL		0.00 628.50							
		(SP) SAND, medium grained, poorly graded, trace to some fines, trace organic fibres; brown; non-cohesive, dry.		0.10	1	AS					
				628.10							
		(CI) SILTY CLAY, medium plastic, some sand, coal flecks; brown; cohesive, w>PL, soft to firm.		0.50	2	AS					
1	50 mm Hand Auger									19 mm FV	
					3	AS				33 mm FV	
2		... Localized seepage at 2.0 m.			4	AS					
				625.60							
3		SANDSTONE, medium grained; light grey, highly weathered; non-cohesive, moist, dense.		3.00	5	AS					
				625.20							
		END OF TEST HOLE		3.40							
4		NOTES: 1) No sloughing observed in open borehole on completion of drilling. 2) Localized seepage observed at ~2.0 mbgs.									

DEPTH SCALE

1 : 20

LOGGED: JJB/IK

CHECKED:

Golder Associates

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

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Golder Associates

REPORT

October 2014

GEOTECHNICAL INVESTIGATION REPORT

Oxbow Boardwalk
Whitemud Creek Walking Trail
Edmonton, Alberta

Submitted to:
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Associated Engineering
1000, 10909 Jasper Avenue
Edmonton, AB T5J 5B9

Report **Number:** 14-04541

Distribution:

2 Copies Associated Engineering

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Associated Engineering (AE) to provide geotechnical engineering services for the proposed construction of a boardwalk along the walking trail located in the Whitemud ravine adjacent to Whitemud Creek about 0.8 km south of Rainbow Valley Campground in Edmonton, Alberta.

The professional services for this report address only the geotechnical (physical) aspects of the subsurface conditions at this Site. The geo-environmental (chemical) aspects for the projects are outside the terms of reference for this geotechnical study and have not been investigated or addressed herein. It is noted that geotechnical engineering comments and recommendations presented in this report are based on a limited number of boreholes with significant spacing, and additional borehole drilling will be required during detailed design.

The purpose of this investigation was to obtain some information on the subsurface soil and groundwater conditions at the site, and based on our interpretation of this information, provide geotechnical engineering recommendations pertaining to foundations and slope stability issues for the design and construction of proposed boardwalk. The scope of work for this project was outlined in Golder's proposal submitted to AE dated June 6, 2014.

The factual data, interpretations and recommendations provided in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within 12 months of the date of the report, Golder should be given an opportunity to confirm that the recommendations are still valid.

Use of this report is subject to the conditions outlined in the *Important Information and Limitations of this Report* that follows the main text and forms an integral part of this document. The readers' attention is specifically drawn to this information, as it is essential for the proper use and interpretation of the report.

2.0 SITE LOCATION AND DESCRIPTION

It is understood that the City of Edmonton is planning to replace an existing staircase and boardwalk along the walking trail within the Whitemud Creek ravine, approximately 700 m south of Whitemud Drive (see location map on Figure 1). The trail will be shifted approximately 10 m to the west in order to cross an old oxbow of the creek, and a new raised boardwalk will be constructed.

The existing boardwalk traverses a narrow stretch of land between the oxbow and the creek which is prone to flooding during high water events. Based on the concept plan (Whitemud Creek Oxbow Site Stair and Boardwalk Replacement Concept Plan, dated Dec. 2012) provided to Golder by AE, the north section of the realigned trail will traverse a steep slope requiring a small amount of cut and fill along the 4.5 m high north slope, tying into the existing trail at the top of the slope. This portion of the trail will be graded at 8 percent with a 3 percent cross fall. The boardwalk is to have a grade of 2.5 percent and will tie in with the existing trail to the south. Screw piles with a 2.4 m centre-to-centre spacing were noted on the concept plan as the preferred foundation support for the boardwalk.

3.0 FIELD INVESTIGATION

Prior to commencing field work, Alberta One-Call was contacted to provide clearances of underground utilities in the project area. In addition a private utility locating company was contracted to perform a sweep of the area per Golder's health and safety policy.

The field geotechnical investigation for the boardwalk was carried out on September 2, 2014. Four (4) test holes were advanced at the site at the locations shown on Figure 1. The test holes were advanced using a 50 mm hand auger operated by two Golder employees. The test holes were advanced to auger refusal at depths ranging between about 1.5 and 3.4 m below the existing ground surface. Soil samples were obtained from the hand auger at selected intervals. In-situ field shear vane testing was performed in the softer cohesive soils.

The groundwater conditions were observed in the open test holes during and immediately following completion of each test hole. The test holes were then backfilled with soil cuttings.

The test holes were logged by a geotechnical field engineer from Golder. Soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Edmonton for further examination and laboratory testing. Index and classification tests consisting of water content determinations and Atterberg limits testing were carried out on selected soil samples.

The test hole locations were measured in the field relative to existing infrastructure, where possible, and using a hand-held GPS unit which is generally accurate to +/- 5 m. The elevations were approximated in the field using a hand-held clinometer.

4.0 SUBSURFACE CONDITIONS

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the current investigation and the results of in situ and laboratory testing are provided on the Record of Test Hole sheets contained in Appendix A.

The soil descriptions provided in this report are based on accepted standard methods of classification and description routinely used in current geotechnical practice. The stratigraphic boundaries shown on the Record of Test Hole sheets are inferred from observations made during drilling and from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsurface conditions will vary between and beyond the test hole locations.

4.1 Subsurface Soil Conditions

In general, the subsurface conditions on the embankment at the north end of the site consist of uniformly graded sand containing some fines overlaying highly weathered clayshale bedrock. Below the embankment in the floodplain between the oxbow and Whitemud Creek the subsurface conditions generally consist of silty clay overlaying highly weathered bedrock of either clayshale or sandstone. Topsoil was encountered in all of the test holes from the existing ground surface to depths ranging between about 0.1 and 0.2 metres below the existing ground surface (mbgs).

More detailed descriptions of the subsurface conditions encountered in the test holes are provided in the following sections.

4.1.1 Sand

In test holes TH14-01 and TH14-02, sand was encountered underlying the topsoil to depths of 2.8 and 0.65 mbgs respectively. The sand deposit was uniformly graded, dry at the time of the investigation, contained trace to some fines and in a loose to compact state. Laboratory testing indicates measured water contents on the selected samples from the sand deposit encountered in TH14-01 range between about 9 and 13 percent.

Sand deposits were also encountered underlying the topsoil in test holes TH14-03 and TH13-04 to depths of 0.4 and 0.5 mbgs, respectively.

4.1.2 Silty Clay

Approximately 2.5 to 3.0 m thick layer of silty clay was encountered underlying the sand deposit in test holes TH14-03 and TH14-04. The silty clay deposit contained trace to some sand, signs of oxidation, coal flecks and was wet of the plastic limit. Laboratory testing indicates measured water contents on selected samples from the silty clay deposit encountered in TH14-03 and TH14-04 range between about 30 and 38 percent.

In-situ field vane (FV) tests performed in the silty clay deposit in test hole TH14-04 (as shown on Record of Test Holes in Appendix A) showed undrained shear strength values of 20 and 21 kPa indicating a soft consistency.

4.1.3 Clayshale/Sandstone

Highly weathered clayshale/sandstone bedrock was encountered underlying the silty clay deposit in test holes TH14-03 and TH14-04 and under the sand deposit in TH14-02. In test hole TH14-01 auger refusal was encountered at 2.8 m depth, possibly due to encountering bedrock.

An Atterberg limit test was carried out on one of the clayshale samples which indicated a plastic limit of 24 percent, a liquid limit of 73 percent which indicates that the clayshale is of high plasticity.

The laboratory water content measured on selected clayshale samples ranged between about 19 percent and 28 percent. Compared to the Atterberg Limit results for the clayshale, this material likely has a very stiff to hard state consistency.

4.2 Groundwater Conditions

On higher ground, no seepage was observed in test holes TH14-01 or TH14-02. Localized seepage was observed in test holes TH14-03 and TH14-04 at depths of 1.4 and 2.0 mbgs, respectively.

The water level at the site is expected to fluctuate seasonally in response to changes in the creek level and precipitation.

5.0 GEOTECHNICAL COMMENTS AND RECOMMENDATIONS

This section of the report provides geotechnical engineering comments and recommendations for consideration during design and construction of the boardwalk. The recommendations are based on our interpretation of factual information obtained from the test holes put down as part of the current subsurface investigation at the site and available project information.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information

provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

5.1 Pile Foundations

5.1.1 General

Drilled cast-in-place straight-shaft concrete piles are considered as a suitable pile type for the proposed boardwalk. This type of pile was also been used for the two existing pedestrian bridges to the north. Screw piles are not recommended as they may encounter shallow refusal in the clayshale or sandstone, especially near the location of Test Hole TH14-02.

5.1.2 Design for Compressive and Uplift Loads

It is expected that the finished grade will be close to the existing grade with no significant cut or fill required. Drilled cast-in-place straight shaft concrete piles subjected to compressive loads should be designed based on the unfactored skin friction values given in Table 1.

Table 1 - Unfactored Skin Friction For Drilled Cast-In-Place Straight Shaft Concrete Piles

Depth Below Existing Grade	Major Soil Type	Unfactored Skin Friction (kPa)
0 to 3 m	Clay	0
Below 3 m	Clay Shale / Sandstone	60

No end bearing component should be included in the design of conventional drilled cast-in-place straight shaft concrete piles since water, soil debris, and disturbed soils are likely to be present at the bottom of the drilled shaft.

To determine the Ultimate Limit States (ULS) factored compressive resistance of a pile, a resistance factor (Φ) of 0.4 should be applied to the unfactored resistance determined using the above recommended unfactored skin friction values.

The minimum diameter of conventional drilled cast-in-place piles should be 400 mm. The minimum center-to-center spacing between piles should be not less than 2.5 times the pile diameter. The piles should be embedded and reinforced a minimum of 6 m below the finished grade to resist tensile stresses that may result from frost jacking.

5.1.3 Lateral Load Resistance of Piles

The resistance of piles against lateral loads and moments may be calculated using the Method of Broms[1]. Due to the soft nature of the upper clay, it is expected that majority of the lateral resistance will be provided by the underlying clayshale and sandstone. For design purpose, it can be conservatively assumed that the pile is cantilevered above the clayshale or sandstone with no lateral resistance from the upper clay.

[1] Broms, B., (1964). The Lateral Resistance of Piles in Cohesive Soils. Journal of the Soil Mechanics and Foundations Division, American Society of Civil Engineering, Vol. 90, SM 2, March, pp. 27-63

The recommended values for the Modulus of Subgrade Reaction, k for such soils, are given in Table 2.

Table 2 - Modulus of Subgrade Reaction for Laterally Loaded Piles

Loading Condition	Modulus of Subgrade Reaction, k (MN/m^3)
For sustained lateral loads	10/D*
For repetitive lateral loads	8/D*
For transient lateral loads	12/D*

1. *D= Pile Diameter (m)

The lateral capacity of piles should be limited by a deflection criterion of 6 mm or less. To determine the lateral load, the chart developed by Broms, as illustrated on the attached Figure 2 should be used. The use of the chart requires the calculation of a dimensionless length βL, where:

$$\beta = \sqrt[4]{\frac{kD}{4E_{pile}I_{pile}}}$$

k = Modulus of Subgrade Reaction (MN/m^3, see Table 2)

D = Pile Diameter (m)

E_{pile} = Elastic Modulus of the pile (MPa)

I_{pile} = Moment of Inertia of the pile section (m^4)

L = Pile Length (m)

The y axis of the chart is given in terms of a dimensionless lateral deflection value y_okDL/P, where:

y_o = Lateral Deflection (mm)

P = Lateral Load (kN)

In the calculation for the maximum positive moment for a free-head pile, the point of fixity (f) below surface may be determined by the following, where:

$$f = \frac{P}{9C_u D}$$

C_u = Undrained shear strength (use C_u = 120 kPa)

The above expression is valid for cohesive soils only. The maximum positive moment acting on the free-head pile may be determined by:

M_{max} = $P(e + 1.5D + 0.5f)$

Where:

e = height of load application above the top of clayshale or sandstone (m)

5.2 Recommendations on Pile Installation

Other than restricted access, the key challenge with drilled pile installation at this site is associated with groundwater seepage and potential soil collapse during the pile hole formation. Ideally, temporary casing penetrating into the clay shale is recommended to form a temporary seal to control caving and seepage during pile installation. Casing may not be required if the caving condition or water seepage is relatively minor. In this case, a portable submersible pump may be used to remove the water from the bottom of the drilled hole prior to concrete placement.

To minimize the degree of softening and disturbance to the pile wall, the concrete should be placed within two hours after the completion of the drilled hole. Concrete should be placed without segregation and carefully vibrated to a minimum depth of 3 m. The slump of the concrete should be between 100 and 150 mm.

Where casing has been used for a specific pile, the excavation (drilling) for adjacent piles within 9 shaft diameters should be deferred until the concrete in the constructed pile has set. The level of fresh concrete in the casing must be maintained above the caving or seepage zone as the casing is withdrawn, and should be sufficiently high to counteract groundwater pressures.

A qualified and experienced inspector should be on site during the entire period of pile installation. The inspector should keep complete and accurate records of the pile installations.

5.3 Slope Stability Recommendations

The natural slope at the north end of the boardwalk is about 4 m in height and has an existing slope geometry of about 2H:1V with the upper section being steeper due to surficial slumping. Based on the test hole data, the natural slope is expected to be comprised of predominantly loose to compact uniform sand. The slope is considered marginally stable with an inclination of 2H:1V. For the new boardwalk and trail development, it is understood that the existing slope will be cut by approximately 1 m at the trail location. For long term stability

considerations, it is recommended to develop side slopes not steeper than 2.5H:1V along the trail and under the boardwalk. In addition the toe of the slope should be protected against erosion along the north bank.

6.0 CLOSURE

The recommendations presented in this report are made based on our present understanding of the project. Should any conditions at the site be encountered which differ from those addressed, we require that we be notified immediately in order to permit re-assessment of our recommendations.

We trust that the information presented in this report meets your present requirements. If you have any questions, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.

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Brian L.J. Myllevile, Ph.D., P.Eng.
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\\golder.gds\gal\edmonton\active\2014\1376 geotechnical 2014\4-projects\14-04541 - associated engineering-ox bow boardwalk-edmonton\3. analysis and reporting\report\14-04541 rpt 02oct2014 whitemud walking trail - oxbow boardwalk.docx

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface

conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

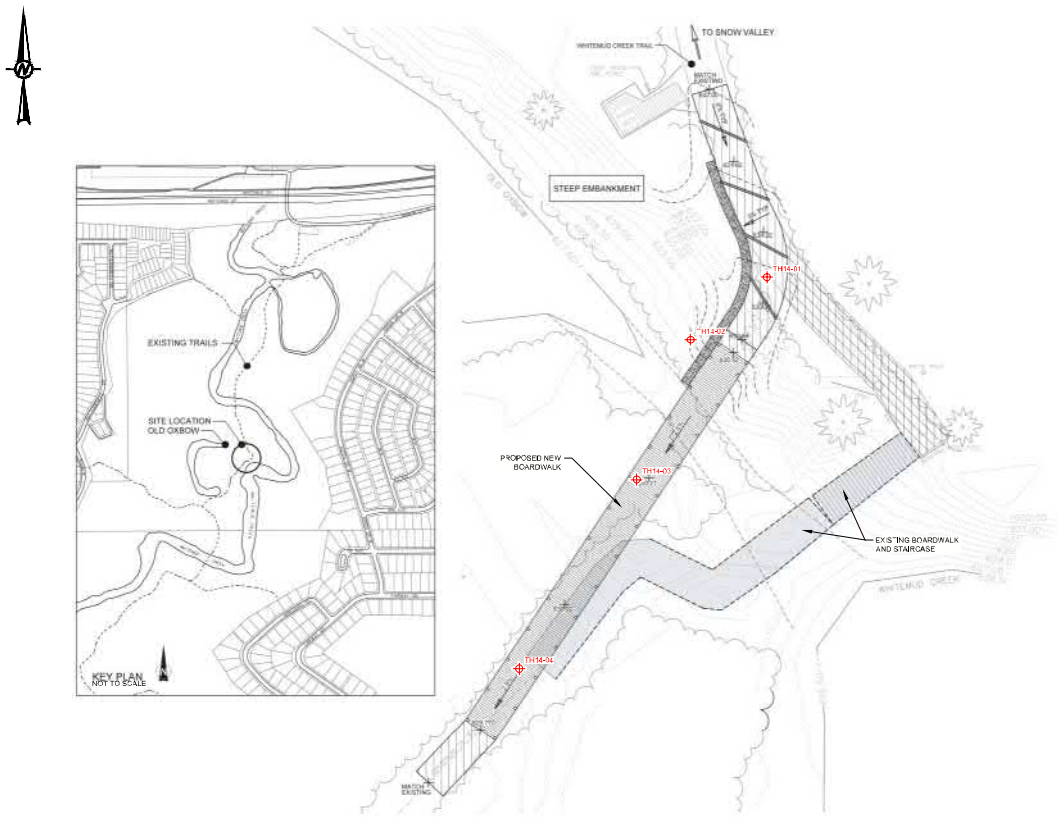
Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

FIGURES

Figure 1: Borehole Location Plan

Figure 2: Design Chart for Lateral Loaded Piles in Cohesive Soils



LEGEND

⊕ TEST HOLE LOCATION

REFERENCE

ORIGINAL DRAWING PROVIDED BY THE CITY OF EDMONTON
DATED DECEMBER 2012; ORIGINAL SCALE 1:100; REF. FILE CONSTRUCT.TBL

DRAFT

0 5 10
1:250 (APPROX.) METRES

CLIENT
ASSOCIATED ENGINEERING ALBERTA LTD.

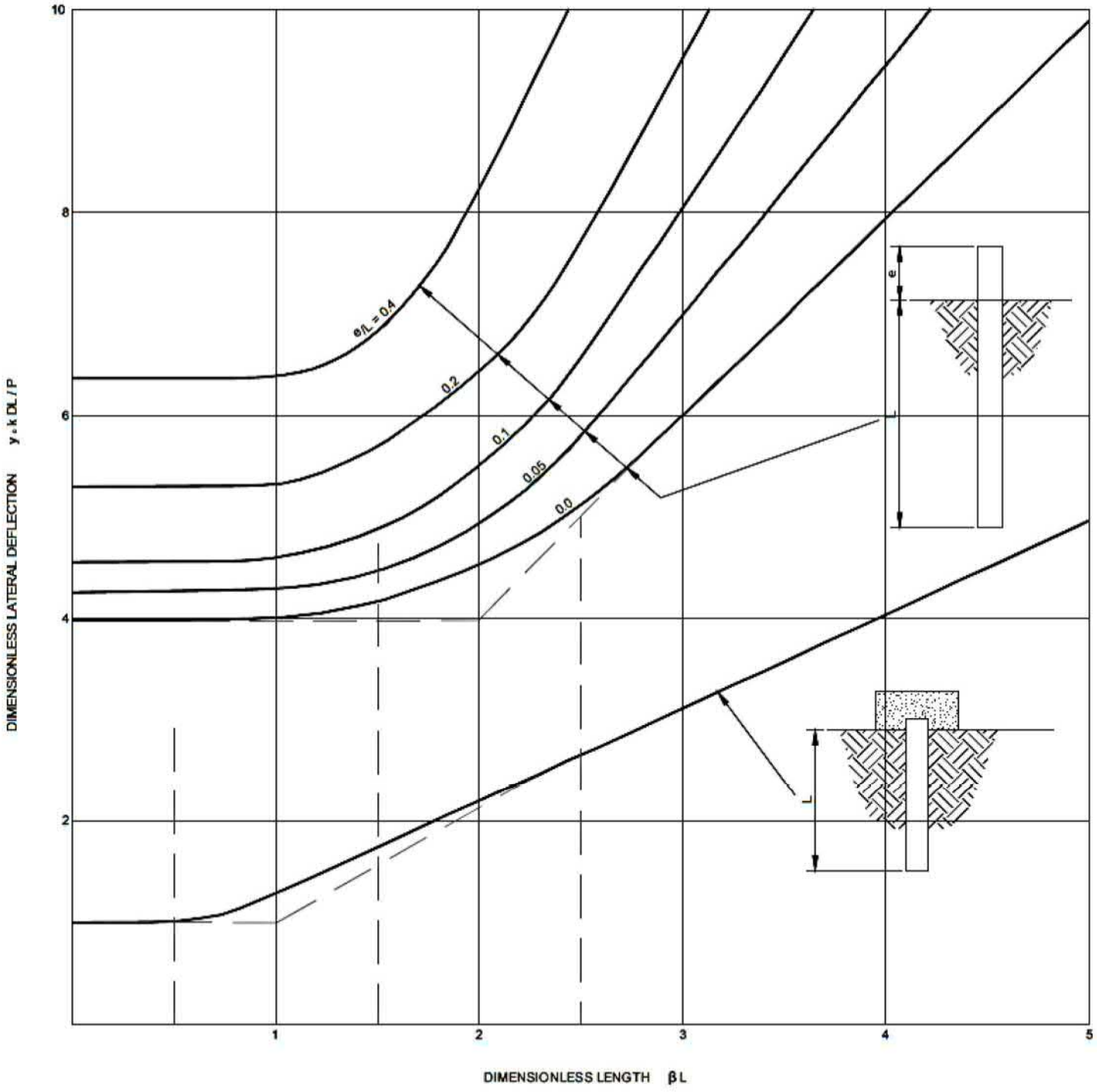
PROJECT
WHITEMUD CREEK
OXBOW SITE STAIR AND BOARDWALK REPLACEMENT
EDMONTON, ALBERTA

TITLE
TEST HOLE LOCATION PLAN

CONSULTANT

YYYY-MM-DD	2014-09-11
PREPARED	S. CHARLTON
DESIGN	J. BELOIN
REVIEW	X. LUI / S. MYLLEVILLE
APPROVED	

PROJECT No.	CONTROL	Rev.	FIGURE
1404541	1000-BG-0001	A	1



PROJECT

WHITEMUD CREEK OXBOW BOARDWALK, EDMONTON, ALBERTA

TITLE

DESIGN CHART FOR LATERAL LOADED PILE IN COHESIVE SOILS

Golder Associates

PROJECT NO: 14-04541			FILE NO. ----	
DESIGN	SD	12 MAR 14	SCALE: AS SHOWN	REV:
CAD	--			
CHECK	XL	12 MAR 14		
REVIEW	BLJM	12 MAR 14		

FIGURE 2

APPENDIX A

Record of Borehole sheets from the Current Investigations

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-01

SHEET 1 OF 1

LOCATION: N: 5928304 E: 330418

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕; rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		632.00									
0	50 mm Hand Auger	TOPSOIL		0.00									
				631.80									
		(SP) SAND, medium grained, uniformly graded, trace to some fines; brown; non-cohesive, dry, loose to compact.		0.20	1	AS							
1					2	AS							
					3	AS							
					4	AS							
2					5	AS							
					6	AS							
				629.20									
		END OF TEST HOLE		2.80									
3		NOTES: 1) No sloughing observed in open borehole upon completion of drilling. 2) No water observed in open borehole upon completion of drilling. 3) Hand auger refusal at 2.8 mbgs due to possible bedrock.											
4													

DEPTH SCALE

1 : 20

LOGGED: JJB/IK

CHECKED:

Golder Associates

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-02

SHEET 1 OF 1

LOCATION: N: 5928305 E: 0330411

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa — nat V. + Q - ⊕ rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT Wp — W — Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		628.80									
0	50 mm Hand Auger	TOPSOIL		0.00 / 628.70									
		(SP) SAND, medium grained, poorly graded, some fines, trace organics; brown, signs of oxidation; non-cohesive, dry, loose to compact.		0.10	1	AS							
				628.15									
		CLAYSHALE, medium to high plastic, sandy; mottled brown and grey, completely weathered; cohesive,w~PL, stiff to very stiff.		0.65	2	AS							
1					3	AS							
				627.70									
		CLAYSHALE, medium to high plastic; tan, weathered, blocky; cohesive, w<PL, very stiff to hard.		1.10	4	AS					73	I_p=49	
				627.40									
		CLAYSHALE, medium to high plastic, some sand; light grey, weathered, blocky; cohesive, w<PL, hard.		1.40 / 627.30	5	AS							
2		END OF TEST HOLE		1.50									
		NOTES: 1) No sloughing observed in open borehole upon completion of drilling. 2) No water observed in open borehole upon completion of drilling. 3) Hand auger refusal at 1.5 mbgs due to hard clayshale.											
3													
4													

DEPTH SCALE

1 : 20

Golder Associates

LOGGED: JJB/IK

CHECKED:

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-03

SHEET 1 OF 1

LOCATION: N: 5928292 E: 0330410

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕, rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		628.00							
0	50 mm Hand Auger	TOPSOIL		0.00 627.90							
		(SP) SAND, medium grained, poorly graded, trace to some fines, trace organic fibres; brown; dry to moist, non-cohesive, loose to compact.		0.10	1	AS					
				627.60							
		(CI) SILTY CLAY, medium to high plastic, some sand; brown, signs of oxidation; w>PL, cohesive, soft to firm.		0.40	2	AS					
1		... Localized seepage at 1.4 m.									
		... Wet grey sand nodules at 1.5 m.									
2					3	AS					
3				624.70							
		CLAYSHALE, some sand; light grey; w~PL, cohesive, hard.		3.30 624.60	4	AS					
		END OF TEST HOLE		3.40							
4		NOTES: 1) No sloughing observed in open borehole on completion of drilling. 2) Localized seepage observed at ~1.4 mbgs. 3) Auger refusal due to hard ground at 3.4 mbgs.									

DEPTH SCALE

1 : 20

LOGGED: JJB/IK

CHECKED:

Golder Associates

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

PROJECT: Whitemud Creek Oxbow Boardwalk

RECORD OF TEST HOLE: TH14-04

SHEET 1 OF 1

LOCATION: N: 5928280 E: 0330402

BORING DATE: 02 September, 2014

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ⊕, rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl, 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		628.60							
0		TOPSOIL		0.00 628.50							
		(SP) SAND, medium grained, poorly graded, trace to some fines, trace organic fibres; brown; non-cohesive, dry.		0.10	1	AS					
				628.10							
		(CI) SILTY CLAY, medium plastic, some sand, coal flecks; brown; cohesive, w>PL, soft to firm.		0.50	2	AS					
1	50 mm Hand Auger									19 mm FV	
					3	AS				33 mm FV	
2		... Localized seepage at 2.0 m.			4	AS					
				625.60							
3		SANDSTONE, medium grained; light grey, highly weathered; non-cohesive, moist, dense.		3.00	5	AS					
				625.20							
		END OF TEST HOLE		3.40							
4		NOTES: 1) No sloughing observed in open borehole on completion of drilling. 2) Localized seepage observed at ~2.0 mbgs.									

DEPTH SCALE

1 : 20

LOGGED: JJB/IK

CHECKED:

Golder Associates

GTA-BHS 001 14-04541 GINT LOGS 03SEP2014.GPJ GAL-MIS.GDT 09/25/14

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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Golder Associates

Appendix C – Historical Resources Impact Assessment

THE PALAEONTOLOGICAL HISTORICAL RESOURCE IMPACT ASSESSMENT OF THE CITY OF EDMONTON RIVER SOUTH WHITEMUD BOARDWALK REPAIR

NPI Report No. 1458
HRMB # 4725-14-0018-001
Permit # 14-070

October 1, 2014

Samuel M. Wilson, MSc, P. Geol, Prof. Palaeontologist (AB)
Nautilus Paleontology, Inc.
47 Cortina Villas SW, Calgary, AB T3H 0W8

Miriam Reichel-Bodner, MSc, PhD

Table of Contents

THE PALAEONTOLOGICAL HISTORICAL RESOURCE IMPACT ASSESSMENT OF THE CITY OF EDMONTON RIVER SOUTH WHITEMUD BOARDWALK REPAIR 1

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Field Assessment 4

Methodology 4

Observations 5

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APPENDIX A:

The City of Edmonton is proposing the South Whitemud Creek Boardwalk Repair Trail (the "Project") **(Fig 1)** which will consist of:

- The removal of portions of the existing gravel trail,
- The removal of portions of the existing stairs and existing boardwalk and posts
- The construction of 30 meters of new boardwalk and with rails on screwpiles
- The construction of new gravel trails and the addition of rip rap along steep grade
- Other minor remedial measures

The total Project footprint is approximately .008 ha. A study of the Project Design Plan (Appendix A) indicates that there will be minimal excavation during construction. Screwpiles will be utilized in boardwalk installation. Gravel trail construction will involve or no removal of surface deposits or vegetation.

In support of the Project, this palaeontological Historical Resource Impact Assessment ("pHRIA") has been prepared at the request of the Proponent through Summit Environmental Consultants to ensure compliance with Alberta's Historical Resources Act requirements as per Schedule B, HRA Requirements Project File 4725-14-0018-001. That requirement focuses the assessment on Quaternary palaeontological resources. The pHRIA will combine baseline geology and palaeontology with field assessment to determine if further mitigative action be required to protect significant fossil resources that may be present and at risk during Project construction.

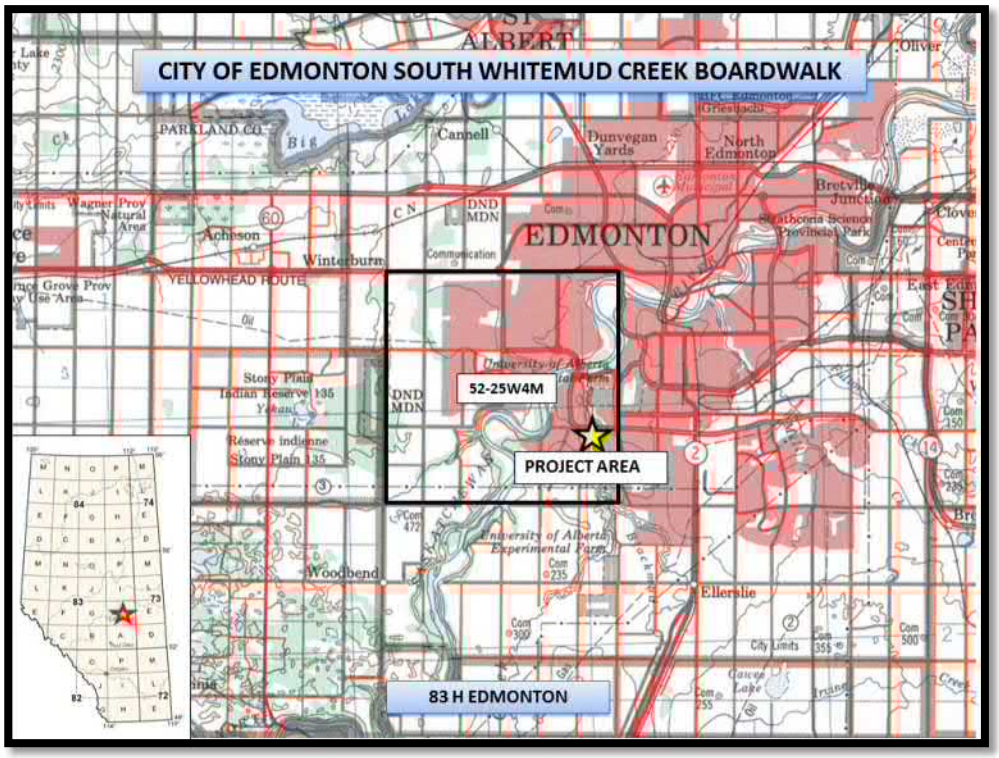

Figure 1. Project location shown on 83 H Edmonton 1:250,000 NTS map.

Baseline Geology and Palaeontology

The bedrock underlying the Project area consists of, in descending order, the early Postglacial North Saskatchewan River alluvium, the Empress Formation (including the Saskatchewan Gravels and Sands), and the Late Cretaceous Horseshoe Canyon Formation. This configuration is seen throughout the North Saskatchewan River system, including its tributaries, in the Edmonton region **(Fig 2**.

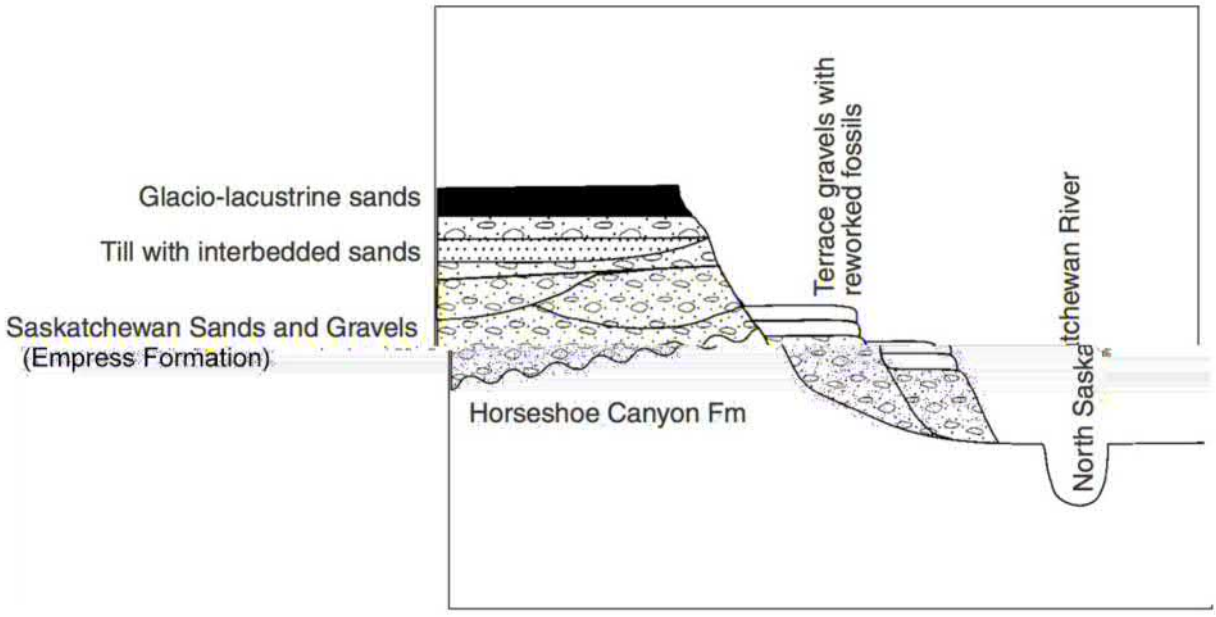

Figure 2. Schematic cross-section of the North Saskatchewan River system. Modified from Hills and Wilson (2003).

In the Beverly reach of the River Valley (Eastern Edmonton), the postglacial gravel fills are inset into and superimposed upon preglacial deposits (Hills and Wilson 2003). The early Postglacial North Saskatchewan River alluvium is poorly sorted, with abundant Shield-derived clasts reworked from till. Vertebrate fossils are known from this deposit, but are many times reworked from lower deposits (Hills and Wilson 2003).

The Empress Formation deposits, on the other hand, are dominated by clasts of quartzite, or quartzose sandstone, and black chert, with lesser amounts of arkosic sandstone, jasper, and locally derived coal fragments, wood, and clay ironstone. Their relatively high compositional maturity likely reflects multiple cycling of resistant materials from the Rocky Mountains through Tertiary upland conglomerates to the Quaternary fills (Hills and Wilson 2003). A diverse Pleistocene fauna was reported from pits in the Beverley (East Edmonton) area (Fuller and Bayrock 1965), as well as numerous gravel quarries between Edmonton and Fort Saskatchewan (Burns and Young, 1994). There are more than sixteen taxa represented in these localities, and these include large

herbivores, such as mammoths (*Mammuthus sp.*), bison, camel (*Camelops hesternus*), ground sloths (*Megalonyx jeffersoni*), as well as carnivores such as wolves (*Canis lupus*), the American Pleistocene Lion (*Panthera leo atrox*), and the giant short-faced bear (*Arctodus simus*).

The Horseshoe Canyon Formation in South Edmonton consists of sandstone with minor amounts of interbedded siltstone, ironst 0.013 Tc 0.013 T5nA T5n4 Tc 4 Tc d [(s)-2(ilt)-4(5(me)-7(ri)-1(

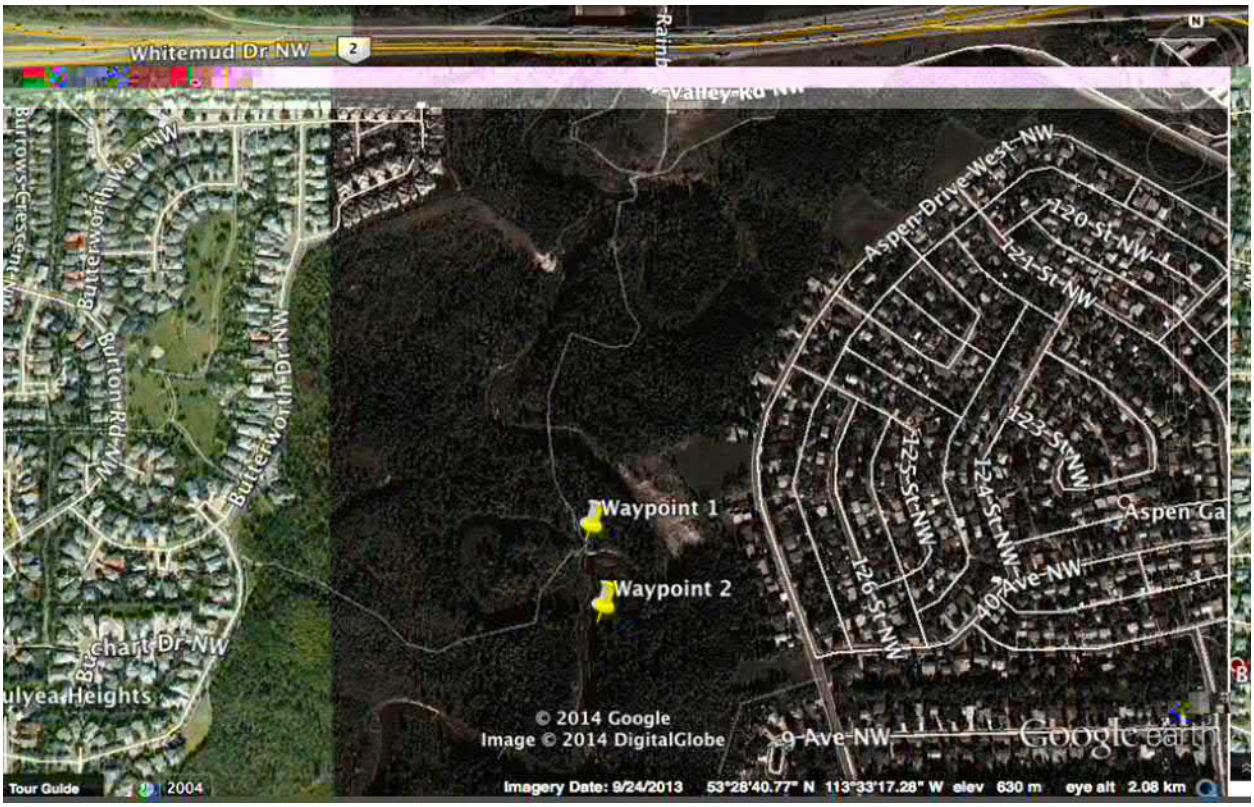

Figure 3. Location of waypoints (yellow tacks) plotted Google earth air photo.

Observations

The area surrounding Waypoint 1 **(Fig. 4)** is the area of the proposed project. Figure 4 illustrates the general condition of the area and the original trail still being used. The exposed banks surrounding the area were surveyed, however no fossils were recovered in these small areas. The scant exposed banks represent rocks of Holocene and Quaternary ages. It is evident from the pictures in Figure 3 that most of the area relevant to the project is covered in thick vegetation and it is, at the moment, not possible to properly assess its fossiliferous potential

In the interest of further assessing the fossiliferous potential of the area in question, a quick surveillance was also done upstream of the Project area (Fig. 3, Waypoint 2). This area **(Fig. 5)** has a glacial deposit with alternating beds of the Empress Formation conglomerate, siltstone and sandstone, as well as the early Postglacial North Saskatchewan River alluvium. Only a small fragment of petrified wood was found in this area.

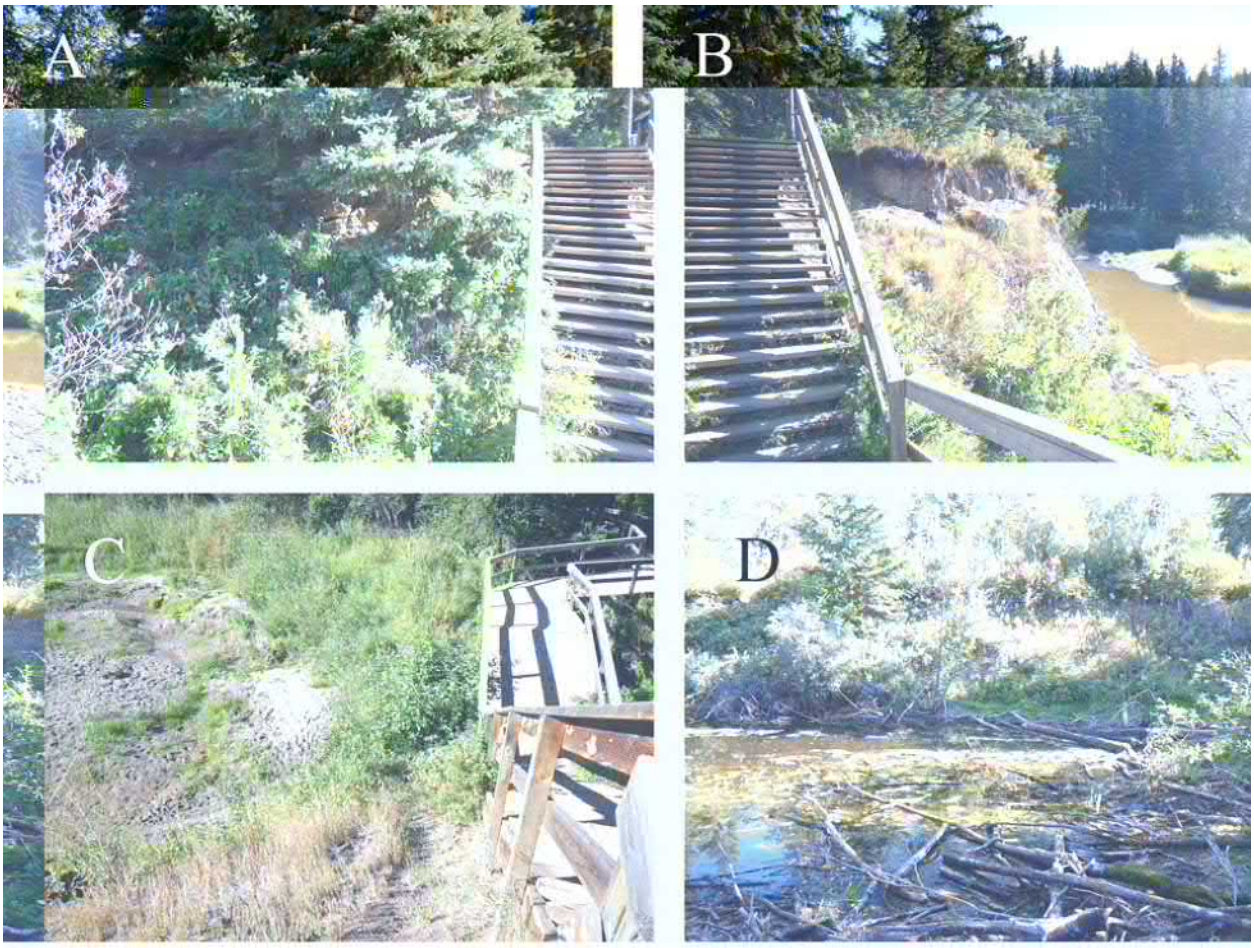

Figure 4 Areas surrounding the original trail system (*A* to *C*) and the area for the proposed Project (*D*) (Waypoint 1).

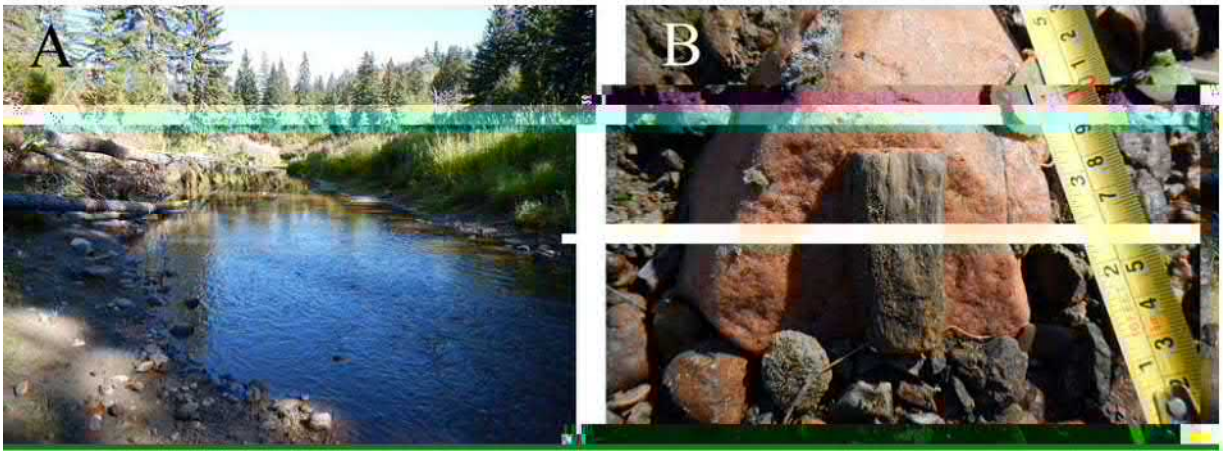

Figure 5. Area upstream of the proposed Project (Waypoint 2). The Empress Formation conglomerate is visible in *A*. A petrified wood fragment recovered from the area is illustrated in *B*.

Conclusions and Recommendations

The only fossil observed during field assessment was a fragment of petrified wood found upstream of the proposed Project area. This fossil is likely from the Empress Formation of Quaternary age. The fossil material alone that was recovered during this surveillance is not significant, however the area of the project itself could not be properly assessed due to inaccessibility to the rocks that yield fossil resources. Although this area is part of the Edmonton River Valley system and has a high potential for Quaternary and Cretaceous fossil resources, there is minimal risk to fossil resources during Project construction as there will be minor disturbance to surficial deposits and any possible bedrock exposures that may be present within the Project footprint. Therefore, Section 31 HRA clearance is recommended for the Project. . However, if during the conduct of developments, fossiliferous material is encountered, the Proponent and/or their agents should immediately contact Dan Spivak, Head, Resource Management, Royal Tyrrell Museum of Palaeontology at 403-820-6210 (toll free 310-0000) or e-mail dan.spivak@gov.ab.ca.

Report Authorization

This report has been written by:

Samuel M. Wilson

Miriam Reichel-Bodner

October 1, 2014

***Disclaimer required by Alberta Culture:**
"Any recommendations made in this report are not necessarily consistent with the requirements of the *Historical Resources Act*

REFERENCES

Bell, P.R. 2011. Chapter 7: Taphonomy of an *Edmontosaurus* (Hadrosauridae) bonebed from the Horseshoe Canyon Formation, Alberta. *In* Systematics and palaeobiology of the crested hadrosaurine, *Saurolophus*, from Canada and Mongolia. Ph. D. Thesis, University of Alberta, Department of Biological Sciences. 308 pp.

Burns, J.A.; and Young, R.R. 1994. Pleistocene mammals of the Edmonton area, Alberta. Part 1: The Carnivores. Canadian Journal of Earth Sciences, 31: 393 - 400.

Catto, N.R. 1984. Glacigenic deposits at the Edmonton Convention Centre, Edmonton, Alberta. Canadian Journal of Earth Sciences, 21: 1473 - 1482.

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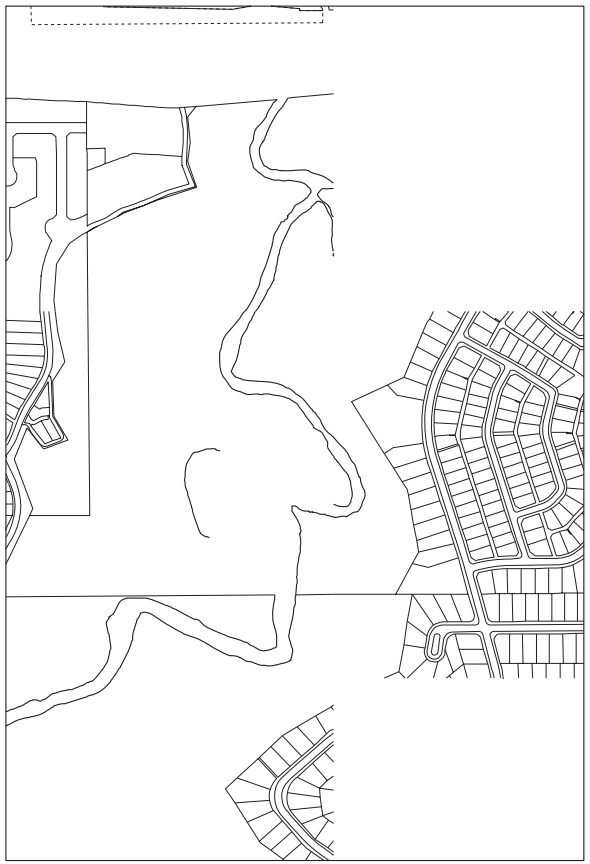
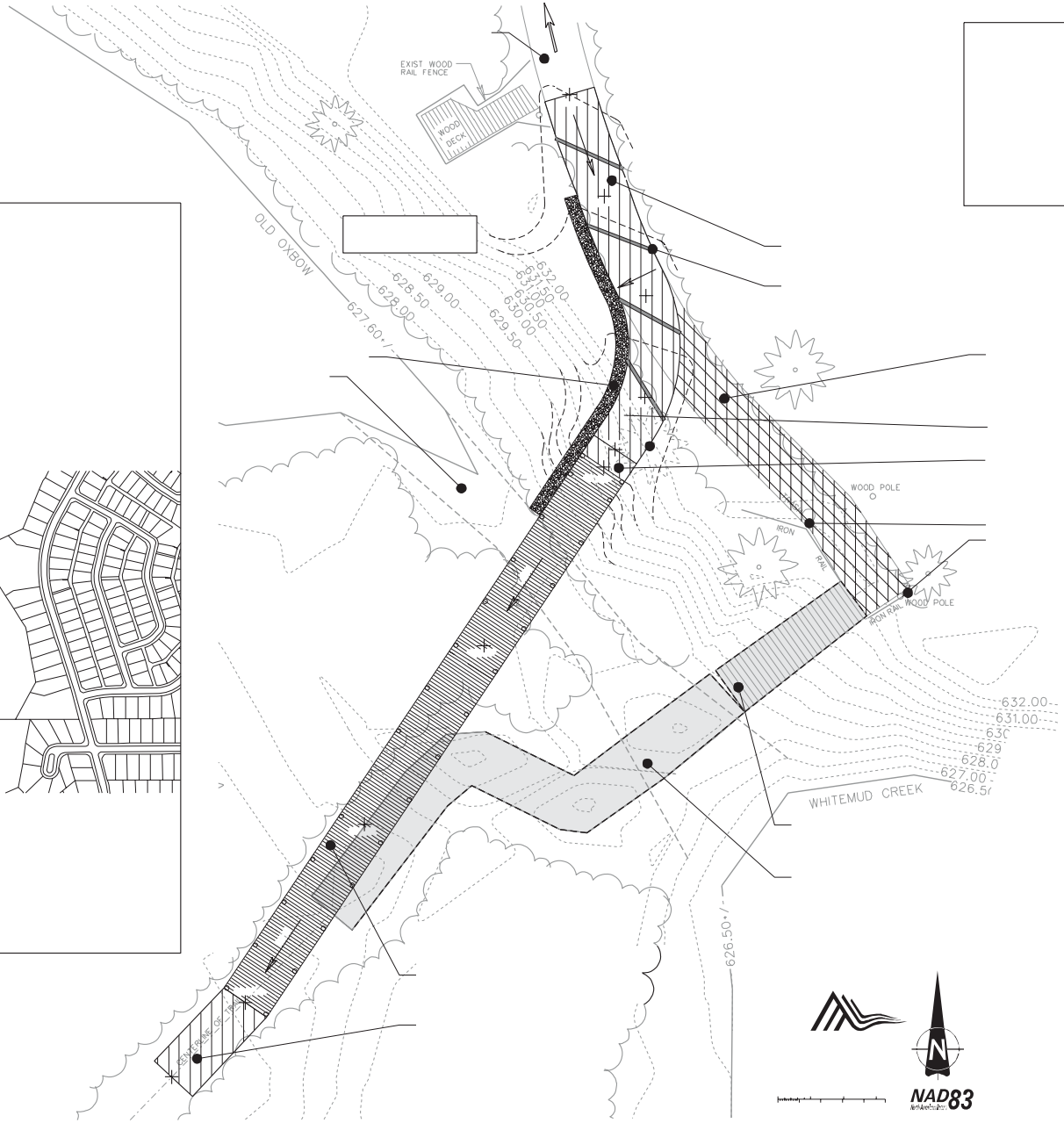
Fuller, W.A.; and Bayrock, L.A. 1965. Late Pleistocene mammals from central Alberta, Canada. *In* R.E. Folinsbee and D.M. Ross, eds., Vertebrate Paleontology in Alberta. Report of a Conference (Department of Geology, University of Alberta, Aug. 29-Sept. 3, 1963), Bulletin 2, 76 p. pp 53-63.

Hills, L.V.;and Wilson, M.C.2003. Helmeted muskox (*Bootherium bombifrons*) from near Fort Saskatchewan, Alberta: dating evidence for redeposition in Late Pleistocene alluvium. Géographie physique et Quaternaire, 57(2-3): 237 - 240.

APPENDIX A: PROJECT DESIGN PLAN, SCHEDULE B, AND APPROVED PERMIT




EXIST WOOD RAIL FENCE
WOOD DECK
OLD OXBOW
628.50
629.00
628.00
627.60+/-
632.00
631.50
631.00
630.50
630.00
629.50
WOOD POLE
IRON RAIL
IRON RAIL
WOOD POLE
632.00
631.00
630
629
628.0
627.00
626.5+/-
WHITEMUD CREEK
626.50+/-
NAD83

Alberta Culture

OPaC: 005786259

HISTORICAL RESOURCES ACT APPROVAL

CITY OF EDMONTON
CITY OF EDMONTON - SOUTH WHITEMUD CREEK BOARDWALK REPAIR TRAIL

HRA REQUIREMENTS PROJECT FILE: 4725-14-0018-001

For the purposes of this Schedule City of Edmonton shall be referred to as the "Proponent" and City of Edmonton - South Whitemud Creek Boardwalk repair shall be referred to as the "Project".

A Historic Resources Impact Assessment is required for portions of the Project as outlined below. Part I provides the Proponent with *Historical Resources Act* approval for components of the Project while Part II outlines the conditions attached to this approval.

I. *HISTORICAL RESOURCES ACT* APPROVAL

Historical Resources Act approval is granted to the Proponent for the Project as illustrated on the attached plan.

II. CONDITIONS ATTACHED TO APPROVAL

The Proponent is granted *Historical Resources Act* approval to proceed with the Project on the understanding that a targeted Historical Resources Impact Assessment (HRIA) for Quaternary (Ice Age) palaeontological resources will be conducted in the area where the new trail is planned, particularly that portion of the project that impacts steep sedimentary exposures, as outlined in the project plans.

1.0 QUATERNARY (ICE AGE) PALAEONTOLOGICAL RESOURCES

The potential for this Project to affect Quaternary palaeontological resources is high.

1.1 Historic Resources Impact Assessment

Pursuant to Section 37(2) of the *Historical Resources Act* (*HRA*, or Act) a Historic Resources Impact Assessment (HRIA) for palaeontological resources and any work resulting from this assessment is to be conducted on behalf of the Proponent by a palaeontologist qualified to hold a "Permit to Excavate Palaeontological Resources

(Mitigative)" within the Province of Alberta. In order to conduct the HRIA, the palaeontological consultant must submit "An Application for Permit to Excavate Palaeontological Resources (Mitigative)" to the Royal Tyrrell Museum of Palaeontology. Please allow ten working days for the permit to be processed. An approved permit must be issued prior to the initiation of any palaeontological field investigations.

1.1.1 Alberta Regulation 254/2002

Palaeontological investigations conducted under permit in Alberta are subject to the conditions stated within Alberta Regulation 254/2002, *Archaeological and Palaeontological Research Permit Regulation*, conditions set forth in the approved permit, and any other conditions that the Minister imposes under Section 30 of the Act.

1.1.2 Contacting the Royal Tyrrell Museum of Palaeontology

For further information regarding the acquisition of a "Permit to Excavate Palaeontological Resources", the conduct of the required palaeontological resource HRIA and/or palaeontological consultants obligations under Alberta Regulation 254/2002, please contact Dan Spivak, Head, Resource Management, Royal Tyrrell Museum of Palaeontology at 403-823-7707 (toll-free 310-0000), e-mail dan.spivak@gov.ab.ca

1.1.3 Coverage

The HRIA is required only for areas where new trail is planned, particularly the area of steep sedimentary exposure outlined in the project plans

1.1.4 Timing

The HRIA is to be carried out prior to the initiation of any land surface disturbance activities under snow free, unfrozen ground conditions.

1.2 Reporting the results of the palaeontological resources HRIA

1.2.1 Submission of specimen data sheets

The Proponent's palaeontological consultant is required to submit "Palaeontological Specimen Data Sheets" for each fossil collected during mitigative studies.

1.2.2 Submission of HRIA final report for palaeontological resources

A digital copy of the HRIA final report must be submitted within 180 days after the expiration of the permit, or at least six weeks prior to the anticipated conduct of land surface disturbance activities, whichever comes first. The final report and interim reports are to be submitted to the Historic Resources Management Branch, Heritage Division, Alberta Culture using the Online Permitting and Clearance (OPaC) system.

1.2.3 Submission of interim report(s) for palaeontological resources

Should the Proponent find it necessary to obtain *Historical Resources Act* clearance for portions or all of the lands affected by the Project prior to the submission of the final report, Alberta Culture will consider accepting the submission of an interim report, or reports.

2.0 STANDARD CONDITIONS UNDER THE *HISTORICAL RESOURCES ACT*

During the conduct of historic resources studies a consultant may encounter historic resources that are not the subject of their field of expertise. Under this circumstance, the consultant must follow instructions included in Attachment 1, *Standard Requirements under the Historical Resources Act, Reporting the Discovery of Historic Resources.*

The Proponent must also comply with standard conditions under the *Historical Resources Act*, which are applicable to all land surface disturbance activities in the Province. Standard conditions require applicants to report the discovery of historic resources. These requirements are stated in Attachment 1- *Standard Requirements under the Historical Resources Act, Reporting the Discovery of Historic Resources*.

3.0 FURTHER SALVAGE, PRESERVATIVE OR PROTECTIVE MEASURES

Based upon the results of the HRIA(s) reporting the discovery of archaeological resources, palaeontological resources, historic period sites and/or Aboriginal Traditional Use Site(s), the Proponent may be ordered to undertake further salvage, preservative or protective measures or take any other actions that the Minister responsible for the *Historical Resources Act* considers necessary.

4.0 REQUESTS FOR *HISTORICAL RESOURCES ACT* CLEARANCE

Based upon the results of the HRIA studies, Alberta Culture may consider granting *Historical Resources Act* clearance to all or portions of the Project area. In the final report, and any interim report(s) the Proponent's consultant(s) must clearly identify and illustrate those portions of the Project area for which *Historical Resources Act* clearance is requested.

5.0 PRE-EMINENCE OF CONDITIONS OF HRA REQUIREMENTS

Should the contents of conditions included within this Schedule be at variance with any instructions associated with the *Listing of Historic Resources* and/or the permit application, the conditions of the Schedule take precedence. Following instructions as outlined in this Schedule should result in the granting of *Historical Resources Act* clearance and/or the issuance of requirements regarding further historic resources studies in a timely manner.

6.0 COMPLIANCE IS MANDATORY

These conditions shall be considered directions of the Minister of Alberta Culture under the *Act*. The Proponent and agents acting on behalf of the Proponent are required to become knowledgeable of the conditions. Failure to abide by the conditions will result in *Historical Resources Act* approval not being granted, or delayed.

Alberta Culture

Royal Tyrrell Museum of Palaeontology
P.O. Box 7500
Drumheller, Alberta T0J 0Y0
Telephone 403/823-7707 Fax 403/823-7131

PERMIT TO EXCAVATE PALAEONTOLOGICAL RESOURCES 14-070

NAME: Wilson, Sam

ADDRESS: 47 Cortina Villas SW, Calgary, AB T3H 0W8

AFFILIATION: Nautilus Paleontology Inc.

Is hereby authorized to conduct the palaeontological investigations described on the applicant's Application dated Sep 02, 2014 subject to the conditions of the *Historical Resources Act* and the Regulations passed pursuant to that Act, the *Occupational Health and Safety Act* and Regulations passed pursuant to that Act and any other relevant Provincial legislation. It is the permit holder's responsibility to ensure that all necessary permits and permissions are in place prior to the commencement of fieldwork.

PERMIT SUMMARY AND SCHEDULE

1. Purpose of investigations: Mitigative, Historical Resources Impact Assessment
2. Location of investigations: City of Edmonton
   City of Edmonton South Whitemud Creek Borardwalk Repair Trail
   Edmonton
   Edmonton
   W4 R25 T52 S12 L11
3. Types of palaeontological resources sought: Fossil vertebrates, invertebrates and plants
4. Geological Ages: Cretaceous, Quaternary
5. Formations: Horseshoe Canyon, Empress, Undifferentiated Quaternary
6. Date two paper copies of final report and digital data are due: May 04, 2015
7. Institution in which palaeontological specimens and records are to be deposited: Royal Tyrrell Museum of Palaeontology - P.O. Box 7500, Drumheller, Alberta, T0J 0Y0
8. Date palaeontological specimens and records are to be deposited: Nov 05, 2015
9. Permit is valid from date of issue to: Nov 05, 2014

APPROVED

Andrew Neuman
Executive Director, RTMP

Sep 02, 2014
Date

Appendix D – Biophysical Report

Associated Engineering | GLOBAL PERSPECTIVE. LOCAL FOCUS.

Associated Engineering Alberta Ltd.
1000 Associated Engineering Plaza
10909 Jasper Avenue
Edmonton, Alberta, Canada, T5J 5B9

TEL: 780.451.7666
FAX: 780.454.7698
www.ae.ca

October 14, 2014
File: 2014-3177

Anton Goulko, BSc., LEED AP.
Project Manager
City of Edmonton
4th Floor, Westwood Muni
12404 - 107 Street NW
Edmonton AB, T5G 0M7

Re: OXBOW BOARDWALK REPLACEMENT - OVERVIEW BIOPHYSICAL ASSESSMENT

Dear Mr. Goulko:

Associated Engineering Alberta Ltd. is pleased to provide this Biophysical Assessment for the proposed replacement of the South Whitemud Creek boardwalk. This letter describes the desktop research and field verification methods and findings of the assessment, and provides environmental recommendations to consider in the design of the boardwalk. The findings of this letter will be expanded upon in the Environmental Screening Report (ESR) that we are currently preparing for the City of Edmonton, following detailed design.

1 BACKGROUND

The City of Edmonton is proposing to remove the existing stairs and boardwalk from the Whitemud Creek ravine and build a new structure to provide better public access to the area. North-south passage on the existing trail system has been compromised due to ice damage that the crossing sustained during the spring 2014 freshet.

The proposed new crossing location is approximately 700 m south of Whitemud Drive, at NW-12-52-25-4. The new boardwalk over the oxbow will be approximately 15 m west of the damaged crossing (specific location 53.476363, -113.555448; hereafter refered to as the project area.

2 METHODS

The following databases were searched to gather existing information about the project area:

- Fish and Wildlife Management Information System (FWMIS);
- Alberta Conservation Information Management System (ACIMS);
- *Historical Resources Act* Listings;
- Alberta Registries Spatial Information System (SpinII);
- Wetland mapping tools;
- Alberta Flood Hazard Map Application; and
- Public aerial imagery collections.

Two biologists from Associated Engineering's Environmental Science Division, Beckie Rozander, P.Biol., and Jöel Gervais, B.Sc., conducted a field assessment on July 29, 2014 to validate desktop results. The existing damaged boardwalk was inspected, the proposed boardwalk location was inspected, and the surrounding area was surveyed for wildlife and vegetation (see photographs at the end of the document).

3 BASELINE ENVIRONMENTAL CONDITIONS

3.1 GENERAL LANDSCAPE AND CROSSING CHARACTERISTICS

The project area occurs on land owned by the City of Edmonton (Government of Alberta 2002). The project area has a historical resources designation of 5a and 5p (Government of Alberta 2013). Whitemud Creek is a Class B waterbody under the Alberta *Water Act Code of Practice*, with a restricted activity period (RAP) from April 16 to June 30 (Government of Alberta 2012). The oxbow is only hydrologically connected to the creek during large flood events (approximately every 10 years[1]).

The steep slope on the north side of the proposed oxbow crossing poses significant erosion potential. The current design for rehabilitating the slope on which the stairs are currently situated can be improved upon. If erosion protection measures for this slope fail, sedimentation to both the oxbow and Whitemud Creek is likely, and this would violate requirements under the provincial *Water Act* and federal *Fisheries Act*. The current plans specify removal of one tree for the new boardwalk construction; however, there is a second tree at the edge of this steep slope with roots significantly exposed. Removal of this second tree should also be considered given that the exposed roots enable erosion of the slope, and the weakened slope could impact the proposed boardwalk in future.

3.2 FISH AND FISH HABITAT

Previous fish surveys in Whitemud Creek (accessed via FWMIS) identified the following species (Government of Alberta 2014a):

- Burbot (*Lota lota*);
- Fathead minnow (*Pimephales promelas*);
- Lake chub (*Couesius plumbeus*);
- Longnose dace (*Rhinichthys cataractae*);
- Longnose sucker (*Catostomus catostomus*);
- Northern crayfish (*Orconectes virilis*);
- Pearl dace (*Margariscus margarita*);
- River shiner (*Notropis blennius*);
- Spottail shiner (*Notropis hudsonius*); and

[1] Personal communication with City of Edmonton staff, 2014.

- White sucker (*Catostomus commersoni*).

Whitemud Creek is documented to contain important walleye (*Sander vitreus*) spawning habitat (Government of Alberta 2012). None of the fish species identified in FWMIS are currently classified as at-risk under either the provincial species-at-risk database or federal *Species At Risk Act* (Government of Alberta 2010, Government of Canada 2014). An aquatic habitat assessment of Whitemud Creek in 2010 specified fine material as the predominant substrate (<2 mm; 36%), followed by small gravel (2 - 16 mm; 28%), large gravel (20%), and cobble (4%).

According to local knowledge, the oxbow was last connected to Whitemud Creek 2 years ago[2]. Several small fish were visually identified in the oxbow during the field assessment. These were most likely fry, cyprinid (family Cyprinidae), stickleback (family Gasterosteidae), or northern pikeminnow (*Ptychocheilus oregonensis*). The oxbow's disconnection from the creek and the presence of fish together suggest that the oxbow does not freeze to the bottom during the winter months and that it supports fish reproduction.

Since the oxbow has been identified as containing fish, work in this waterbody (specifically, any work below the high water mark) would require appropriate mitigation (e.g. isolation) with input from a Qualified Aquatic Environment Specialist (QAES). The Fisheries and Oceans Canada guidelines for measures to avoid harm to fish/fish habitat must be followed (Government of Canada 2013) and riparian vegetation removal should be kept to a minimum to protect existing fish species and fish habitat in the oxbow. Additionally, silt fencing along the shore of the oxbow may be needed during boardwalk construction to prevent sedimentation into the oxbow.

3.3 WILDLIFE AND WILDLIFE HABITAT

3.3.1 Desktop Review Findings

The project area overlaps with two known habitat ranges for sensitive species (Government of Alberta 2014a).

1) Sensitive raptor range.
   This range broadly includes the following raptor species: Bald eagle (*Haliaeetus leucocephalus*), Ferruginous hawk (*Buteo reglis*), Golden eagle (*Aquila chrysaetos*), Peregrine falcon (*Flaco pergrinus*), and Prairie falcon (*Falco mexicanus*)
2) Sharp-tailed grouse (*Tympanuchus phasianellus*) survey area.

[2] J. Gervais personal communication with local residents, 2014.

Additionally, previous wildlife inventories have detected the following species (Government of Alberta 2014a):

1) Barred owl (*Strix varia*);
2) Peregrine falcon (*Falco peregrinus*);
3) Canadian toad (*Bufo hemiophrys*); and
4) Northern leopard frog (*Rana pipiens*).

Restricted activity periods and disturbance setbacks apply to the project area. These apply due to the combination of (a) the two wildlife sensitivity areas and (b) the project's location within the aspen parkland region of Alberta (Government of Alberta 2014a). Table 1 below summarizes the associated restricted activity periods and setback distances (Government of Alberta 2011).

Table 1. Restricted activity periods and associated setback distances by level of disturbance

Species	Location	Time of Year	Level of Disturbance		
			Low	Medium	High
Peregrine falcon, Bald eagle, Golden eagle, Prairie falcon, Ferruginous hawk (Sensitive Raptor Species)	Nesting sites	March 15th – July 15th	1000m	1000m	1000m
		July 16th – March 14th	50m	100m	1000m
Sharp-tailed grouse	Leks	March 15th – July 15th	500m	500m	500m
		July 16th – March 14th	100m	100m	500m

The definitions for levels of disturbance are as follows (Government of Alberta 2011):

- "Low impact disturbances are often infrequent, low-impact (eg. Land survey), habitat is not being modified by the activities, and the duration of the activity is relatively short (i.e., hours).
- Medium impact disturbances are usually high in frequency, may use vehicles and other equipment, and may involve small habitat modifications (e.g., seismic drilling) and the duration is relatively long (i.e., days).
- High impact activities generally involve disturbances that are high in frequency, involve vehivles and machinery, permanently modify the habitat by altering vegetation, soils and perhaps hydrology (e.g., buildings, roads) and the impact is long term (i.e., more than 10 years)."

3.3.2 Field Survey Findings

Various wildlife and/or their sign were observed on site:

- Garter snake (genus *Thamnophis*);
- Chipmunk (genus *Tamias*) - three individuals;
- Squirrel (family *Sciuridae*) - two individuals;
- Gadwall duck (*Anas strepera*) - 12 individuals;
- Mallard duck (*Anas platyrhynchos*) - three individuals;
- Songbirds (various species);
- Western screech owl (*Megascops kennicottii*) - one individual;
- Black hornet (genus *Vespa*) nest;
- Coyote (*Canis latrans*) print;
- Weasel (genus *Mustela*) print; and
- Beaver (genus *Castor*) activity.

3.3.3 Wildlife Sensitivities

Several of the wildlife species identified through desktop review and the field visit (above), have provincial and/or federal at-risk listings (Table 2; Government of Alberta 2010; Government of Canada 2014). Three species of chipmunks are known to occur in Alberta, but only one has a sensitive listing in Alberta ("Sensitive"; Red-tailed chipmunk (*Neotamias ruflcaudus*); Government of Alberta 2010), and it is not listed federally (Government of Canada 2014); the chipmunks observed on site are suspected to belong to one of the "Secure" species of chipmunks. Two species of weasels are known to occur in Alberta, but only one has a listing in Alberta ("May be at Risk"; Long-tailed weasel (*Mustela frenata*); Government of Alberta 2010) and this species is listed as "Not at Risk" federally (Government of Canada 2014); the weasel tracks observed in the project area cannot be identified down to species.

Table 2. Wildlife species and their provincial and federal statuses.

Common Name	Scientific Name	Alberta Status (2010)	Federal Status	Observed in project area	Sensitive range overlaps with project area
Bald Eagle	*Haliaeetus leucocephalus*	Sensitive	Not at risk (1984)	Not observed	Y
Barred Owl	*Strix varia*	Sensitive	Not listed	FWMIS	N
Canadian Toad	*Bufo hemiophrys; Anaxyrus hemiphyrs*	May be at Risk	Not at risk (2003)	FWMIS	N
Ferruginous Hawk	*Buteo regalis*	At risk	Threatened (2008)	Not observed	Y
Garter snake	genus *Thamnophis*	3 species within this genus, all Sensitive	Not listed	Field Survey	N
Golden Eagle	*Aquila chrysaetos*	Sensitive	Not at risk (1996)	Not observed	Y
Northern Leopard Frog	*Rana pipiens*	At Risk	Special Concern (2009)	FWMIS	N
Peregrine Falcon	*Flaco pergrinus*	At Risk	Not listed	FWMIS	Y
Prairie Falcon	*Falco mexicanus*	Sensitive	Not at risk (1996)	Not observed	Y
Western screech owl	*Megascops kennicottii*	Accidental in Alberta	Not listed	Field Survey	N

3.4 VEGETATION

3.4.1 Desktop Review Findings

A search of ACIMS revealed five non-sensitive element occurrences, no occurrences of sensitive elements, no protected areas, and no Crown reservations/notations in the legal section where the property is located (Government of Alberta 2013).

The following non-sensitive elements were returned for section 12:

- Flat fruited pelt lichen (*Peltigera horizontalis*)
- Marsh muhly (*Muhlenbergia racemosa*)
- Smooth sweet cicely (*Osmorhiza longistylis*)
- Flat-topped white aster (*Doellingeria umbellate* var. *pubens*)
- Moss (*Rhodobryum ontariense*)

3.4.2 Field Survey Findings

The following plant species were identified on site:

- White spruce (*Picea gluaca*);
- Prickly rose (*Rosa acicularis*);
- Green alder (*Alnus crispa*);
- Manitoba maple (*Acer negundo*);
- Cattail (*Typha latifolia*);
- Red-osier dogwood (*Cornus stolonifera*);
- Saskatoon (*Amelanchier alnifolia*);
- Reed canary grass (*Phalaris arundinacea*);
- Water hemlock (*Cicuta maculata*);
- Wild red raspberry (*Rubus idaeus*);
- Snowberry (*Symphoricarpos albus*);
- High bush cranberry (*Viburnum opulus*);
- Fireweed (*Epilobium angustifolium*);
- Stinging nettle (*Urtica dioica*);
- Mountain ash (*Sorbus scopulina*);
- Sandbar willow (*Salix exigua*);
- Wolf willow (*Elaeagnus commutata*);
- Bebb's willow (*Salix bebbiana*);
- Coyote willow (*Salix exigua*);
- Box elder (*Acer negundo*);
- Marsh skullcap (*Scutellaria galericulata*); and

- Lance-leaved primrose (*Lysimachia lanceolata*).

Lance-leaved primrose (*Lysimachia lanceolata*) was observed within 50 m of the project area. This plant is considered a rare species in Alberta, though it is not currently protected by species-at-risk legislation. Care should be taken to avoid disturbing areas where this species is growing, and a buffer area around the plant should be established prior to construction.

None of the plant species listed above are classified as at-risk in federal or provincial listings (Government of Alberta 2010, Government of Canada 2014).

3.5 WEEDS

Several Noxious weeds were observed at the project site:

- Field bindweed (*Convolvulus arvensis*);
- Canada thistle (*Cirsium arvense*);
- Common tansy (*Tanacetum vulgare*);
- White cockle (*Lychnis alba*);
- Perennial sow thistle (*Sonchus arvensis*);
- Dalmatian toadflax (*Linaria dalmatica*); and
- Tall buttercup (*Ranunculus acris*).

Other weed species observed on the site include:

- Sweet clover (genus *Melilotus*);
- Lambs quarters (*Chenopodium album*); and
- Flixweed (*Sisymbrium sophia*).

These plants have high potential to be transferred within the site and off site, specifically when soil in which they are growing is disturbed.

4 RELEVANT LEGISLATION

Environment-related legislation pertaining to the geotechnical investigations and construction of the proposed new boardwalk is summarized in Table 3.

Table 3. Environmental legislation relevant to the project

		Requirements		Approval No./ Application Outcome
Fisheries Act (Government of Canada)	Regulatory Item	Request for Review (Geotechnical and Boardwalk)		DFO File No. 14-HCAA-01127
	Effective Date	22 August 2014		
	Expiry Date			
Water Act (ESRD)	Regulatory Item	Water Act Approval (Geotechnical)	Code of Practice Notification (Boardwalk)	Water Act Approval No. 001-00355132
	Effective Date	14 August 2014		
	Expiry Date	21 December 2014		
Public Lands (ESRD)	Regulatory Item	Temporary Field Authorization (Geotechnical and Boardwalk)		Not required as long as the geotechnical work is not within the oxbow waterbody.
	Effective Date	N/A		
	Expiry Date	N/A		
Public Lands (ESRD)	Regulatory Item	Disposition (Boardwalk)	First Nations Consultation	FNC No. 201408240 No consultation required.
	Effective Date		N/A	
	Expiry Date		N/A	
Historical	Regulatory Item	Online	Historical	The online clearance

		Requirements		Approval No./ Application Outcome
Resources Act (Alberta Culture)		clearance	Resources Impact Assessment	process came back with the requirement for a Historical Resources Impact Assessment
	Effective Date	28 August 2014		
	Expiry Date	N/A		
North Saskatchewan River Valley Area Redevelopment Plan; Bylaw No. 7188 (City of Edmonton)	Regulatory Item	Initial Project Review (IPR)	Environmental Screening Report (ESR)	
	Effective Date			
	Expiry Date			
Tree Bylaw (City of Edmonton)	Regulatory Item	Request for tree assessment (urban forestry department)	Application for tree removal	
	Effective Date			
	Expiry Date			

5 RECOMMENDATIONS FOR ENVIRONMENTAL PROTECTION

We recommend the following protection measures to be carried forward in the Environmental Screening Report for the project area:

1. Consider the movement of wildlife during construction planning to avoid harassing or disturbing wildlife, or restrict their movement across the site, with special attention to the above noted species at risk. All waste should be removed at the end of each day to prevent attracting wildlife to the construction site.
2. The oxbow is currently known to contain fish, and will subsequently be treated as a fish-bearing waterbody. Boardwalk construction should aim to minimize works within Whitemud Creek and the oxbow.
3. Plan construction outside the Restricted Activity Period for Whitemud Creek and the oxbow (April 16 to June 30) as much as possible.
4. Include in construction planning a 30 m buffer around lance-leaved primrose (*Lysimachia lanceolata*) that is flagged as a no-work zone.
5. Consider and minimize the potential for workers and equipment entering the site to introduce or spread weeds. Consider methods to carefully remove existing noxious weed species identified on site.
6. Consider in the site's plans for erosion and sediment control and reclamation the following potential strategies: soil stabilization through planting water-tolerant native seeds, live willow staking, and use of wattle lines and native shrubs. Consider also the impact of intense weather events on re-seeding plans.
7. If any raptor nests are detected on site, specific disturbance buffers may need to be established. These buffers depend on the timing of the work:
    - from March 15th – July 15th setback distances are to be 1000m;
    - from July 16th – March 14th setback distances range from 50 – 1000m depending on the level of disturbance.
8. If any sharp-tailed grouse leks are detected on site, specific disturbance buffers may need to be established. These depend on the timing of the work:
    - from March 15th – July 15th buffers are to be 500m;
    - from July 16th – March 14th setback distances range from 100 – 500m and will depend on level of disturbance.

CLOSURE

The recommendations herein are intended to assist with detailed design of the boardwalk and determining construction methods. The information gathered in this assessment will also be used in the Environmental Screening Report that will be prepared once the detailed design of the boardwalk is finalized. We trust that

October 14, 2014
Anton Goulko, BSc., LEED AP.
City of Edmonton
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this assessment meets your needs at this time. Should you have any questions, please contact the undersigned at 780 451 7666, or sm@summit-environmental.com.

Yours truly,

Sarina Roots.
on behalf of:

Sandra Meidinger, P.Biol., R.P.Bio.
Senior Biologist/Manager, Alberta North
SM

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SITE PHOTOS

Photograph 1. The northern point of the oxbow.

Photograph 2. Low area between the oxbow and Whitemud Creek. This may form the connection between the two waterbodies during periods of high flow. The old boardwalk to be removed is visible.

Photograph 3. Slope on the north side of the oxbow with exposed roots of a tree not currently planned to be removed.

Photograph 4. Sign of beaver activity in the area.

Photograph 5. A damselfly (suborder Zygoptera) observed during the field visit.

Photograph 6. Gadwall duck (*Anas strepera*) adults and juveniles observed in the project area.

Photograph 7. A garter snake observed in the oxbow.

Photograph 8. Chipmunk observed during field visit.

Appendix E - Site Photographs

Oxbow facing west from northern point

Whitemud Creek, facing east from top of existing stairs

Existing boardwalk stairs

View under existing boardwalk

Low point, where the oxbow has the potential to join the creek in the event of a flood

Chipmunk species within project area