TECHNICAL MEMORANDUM

Blackmud/Whitemud Creek Surface Water Management Group

Blackmud/Whitemud Creek Natural Areas and Aquatic Ecosystem Assessment

October 2016

Executive Summary

Associated Engineering (AE) was retained by the Blackmud/Whitemud Surface Water Management Group to complete the Blackmud/Whitemud Creek Natural Areas and Aquatic Ecosystem Assessment.

This report is one component of a larger study. This report documents the environmentally sensitive areas and biodiversity features within the Blackmud and Whitemud Creek basins (the study area) (**Figure 1-1**) and addresses key aspects of watershed health in greater detail. Desktop data collection focused on stream channel morphology, riparian health, wetland extent and functional capacity on the basis that these components of the watershed play an important role in flood abatement, erosion, and water quality improvement. A field reconnaissance level survey provides additional information on the morphology in both Blackmud and Whitemud Creeks and on erosion issues.

The purpose of this technical memorandum is to characterize the study area and provide recommendations for additional data collection and analyses to guide sound land use decision making processes.

Approach and Assessment Methods

The Blackmud/Whitemud Creek Natural Areas and Aquatic Ecosystem Assessment focused on four areas of interest:

- Morphological Assessment
- Riparian Analysis
- Wetland Functional Analysis
- Water Quality Analysis.

The following resources were used to compile the desktop analyses and prepare for the field reconnaissance survey:

- Fish and Wildlife Management Information System (FWMIS) (Government of Alberta 2014b)
- Alberta Conservation Information Management System (ACIMS) (Government of Alberta 2014a)
- Agricultural Region of Alberta Soil Inventory Database (AGRASID) (Government of Alberta 2015)
- *Historical Resources Act* (RSA 2000, c. H-9) listings
- Alberta Flood Hazard Map application
- Public aerial imagery collections
- City of Edmonton Land Use Planning Map
- Leduc County 2015 ESA Final Land Cover Classification (Fiera 2015)
- Strathcona County Prioritized Land Ecology Assessment Land Cover
- Alberta Merged Wetland Inventory (Government of Alberta 2016)
- Natural Resources Canada Natural Hydro Network (NHN)
- ESRI Basemap imagery
- Various community reports previously completed for development and planning purposes within the Blackmud and Whitemud watersheds

- Water quality monitoring database searches from local stewardship/monitoring organizations (The RiverWatch Institute of Alberta 2016) and provincial websites (e.g., Inventory of Sampling Locations and Water Quality Data, Lake Water Quality Data, River Network Station Water Quality, Trophic State of Alberta Lakes, Authorization Viewer)
- Leduc and Strathcona County websites (Leduc County 2016, Strathcona County 2016).

Overview of Study Area

The Whitemud Creek basin covers a total area of 1,081 km^2 and the Blackmud Creek, a sub-basin of Whitemud Creek, covers an area of 671 km^2. The study area is located predominantly within the Central Parkland Natural Subregion of the Parkland Region, and a small area in the northeast of the Blackmud Creek sub-basin (29.8 km^2) is located within the Dry Mixedwood Subregion of the Boreal Forest Region. There are various vegetation communities occurring within grasslands, shrublands, forests, and wetlands (Government of Alberta 2006). Although the study area has significant urban centres including the City of Leduc, Town of Beaumont, and City of Edmonton, agriculture represents about 66% of the land use in the watershed. Other major land uses in the watershed include oil and gas, and industrial facilities (North Saskatchewan Watershed Alliance 2012).

Whitemud Creek north of Township Road 512 (41 Avenue SW) is coded as a Class B waterbody under the Code of Practice for Watercourse Crossings established pursuant to the *Water Act* (R.S.A., 2000, c. W-3). Class B waterbodies contain important habitat necessary for various life processes of certain fish species, and Whitemud Creek contains important spawning habitat for walleye (*Stizostedion vitreum*). Blackmud Creek and the portion of Whitemud Creek south of Township Road 512 (41 Avenue SW) are coded as Class C waterbodies. The lower reaches of both Blackmud and Whitemud Creeks within the City of Edmonton as well as lands surrounding Ord Lake and Saunders Lake have Historical Resource Value designation of 5 and 4, indicating that they may have high potential or have previously recorded archaeological and palaeontological resources respectively. Two heritage sites are located west of Telford Lake in the City of Leduc. These are the Alberta Wheat Pool Grain Elevator Site Complex and Dr. Wood's House.

Morphological Assessment

AE visited representative sites during the reconnaissance level review of stream channel morphology. Both creeks have similar morphology with maximum depths ranging from approximately 0.5 metres (m) near the headwaters, to 2 m for Whitemud Creek near the confluence with the North Saskatchewan River. Stream widths average between 1-2 m in first (Strahler) order headwater stream reaches, and increase to 10-12 m in the downstream fifth (Strahler) order segment and confluence with the North Saskatchewan River. There is evidence that channel re-alignments have occurred on both creeks. Whitemud Creek was re-aligned to accommodate the construction of 23rd Avenue NW in Edmonton and where the creek crosses 41st Avenue SW. Minor straightening of Whitemud Creek was observed in an agricultural area in the upper reach of the creek. Blackmud Creek has also had significant channel re-alignment due to human development. It was straightened along the west side of Highway 2 and for over 6.5 km adjacent to an industrial area north of the City of Leduc to accommodate increased development and improve flood management. Sites along both creek channels with visible erosion issues were identified. Of these, a representative subset of sites was selected for field assessment to further document the condition of the sites.

Riparian Analysis

Land cover categories were based on the land cover classification categories provided in the Leduc County Environmentally Significant Areas Study (Fiera 2015). These categories were simplified into six land cover types:

- **Open Water** –all areas of standing water including lakes, rivers, and wetlands with open water
- **Wetlands** –areas classified as wetlands and ephemeral waterbodies, not captured by the Open Water category
- **Forested** – areas covered by trees
- **Open Natural** –areas covered by low-growing natural vegetation such as grass, forbs, or shrubs
- **Semi - Natural** –cultivated and pasture agricultural lands and vegetated areas along roads
- **Developed** –built up urban areas and roads, areas of disturbed ground due to development, and areas containing low-growing vegetation that contains human footprints, such as well sites or farm yards.

The land cover analysis indicated that a significant portion of the riparian area in the upper reaches of the study area was modified by removing woody vegetation and native plant species. There is also significant straightening of Blackmud Creek channel in its upper reaches to accommodate industrial land use. The increased velocity of water moving downstream results in decreased resiliency against erosion and flooding.

Further riparian health studies should examine both reference and at risk sites within the upper, middle, and lower reaches of these creek systems to make informed restoration decisions. Urban and agricultural communities should collaborate to protect existing natural and wooded riparian areas on private land, and restore areas along the creek channels by implementing buffers and planting native woody vegetation. Riparian health should be assessed at regular intervals to determine if restoration goals are being met.

Wetland Functional Analysis

Wetland inventory data were acquired from the City of Edmonton, City of Leduc, Leduc County, and Strathcona County. New wetland inventory data were created by AE using photo interpretation of satellite imagery for the Town of Beaumont and the southern-most portion of the study area in Wetaskiwin County. Wetlands associated with each dataset were combined and then classified. All wetlands included in the wetland inventory were assigned a class (i.e., marsh, swamp, and shallow open water) following the Alberta Wetland Classification System (GoA 2015). All wetlands were also assigned one of three Hydrogeomorphic (HGM) classes (i.e., depressional, riverine, and lake fringe) based on the Hydrogeomorphic Classification System by Brinson (1993).

Following wetland mapping and classification, a functional analysis of wetlands took place using existing GIS data. The analysis evaluated potential for wetlands to function based on landscape position. This study incorporated the HGM approach to assessing wetland functions, which is designed to address the fact that wetlands in different HGM classes have different processes that govern the way they function. Therefore, function assessment cannot be approached in the same manner for the different HGM classes.

This analysis focused on two key areas related to surface water management: water quality functions and hydrologic functions. Water quality improvement functions relate to a wetland's filtering capabilities while hydrologic functions include flood storage and erosion protection.

Based on the wetland class, there were 54 depressional (21.8 ha), 105 riverine (306 ha) and 12 (406.6 ha) lake fringe wetlands assessed with a high rating to provide potential water quality improvement functions. There were 353 (243.8 ha) depressional wetlands, 26 (17.6 ha) riverine, and 3 (48.3 ha) lake fringe wetlands assessed as having a high potential to provide hydrologic functions.

Understanding wetland area as well as functions and values they provide is important to ensure sound land-use planning as it pertains to watershed health. This is particularly important so that the decision-making process captures opportunities to retain wetlands on the landscape and considers their functional capacity. It is recommended that evaluating the loss of wetland area and function be incorporated in activities associated with land use planning as well as municipal policy development.

Water Quality Analysis

The objectives of the water quality analysis were to review existing surface water quality data for significant watercourses (i.e., creeks, tributaries) and waterbodies (i.e., lakes, wetlands), establish baseline conditions, and assess potential impacts on water quality as a result of continued development. Baseline surface water quality was summarized and described for three distinct time periods: pre-1985; 1985 to 2010; and 2011 to 2015.

Surface water quality data for general water quality parameters are readily available for the lower reaches of Whitemud and Blackmud Creeks. Data for the upper reaches of the Blackmud/Whitemud watersheds (i.e., southern and eastern areas), key tributaries of the Blackmud and Whitemud Creeks, and larger waterbodies (e.g., Telford Lake, Cawes Lake, Ord Lak, Saunders Lake, Looking Back Lake, Levering Lake, and Schultz Lake) are lacking, making it difficult to assess source-specific impacts and contaminant loads. Based on observed concentrations of total suspended solids and biochemical oxygen demand, surface water quality near urban developments (e.g., residential, commercial, and industrial developments) may contribute to localized impacts on surface water quality when compared to the upper reaches associated with mostly agricultural activity.

Further surface water quality assessment is recommended to gain a good understanding of baseline water quality for all areas of the watershed. This assessment would support the development of a watershed protection plan, which could include detailed source protection policy and management.

Table of Contents

List of Tables

PAGE NO.

List of Figures

1 Introduction

Associated Engineering (AE) was retained by the Blackmud/Whitemud Creek Surface Water Management Group to complete the Blackmud/Whitemud Creek Natural Areas and Aquatic Ecosystem Assessment. This assessment involved hydrologic, hydraulic, and environmental analyses of the Blackmud and Whitemud Creek basins.

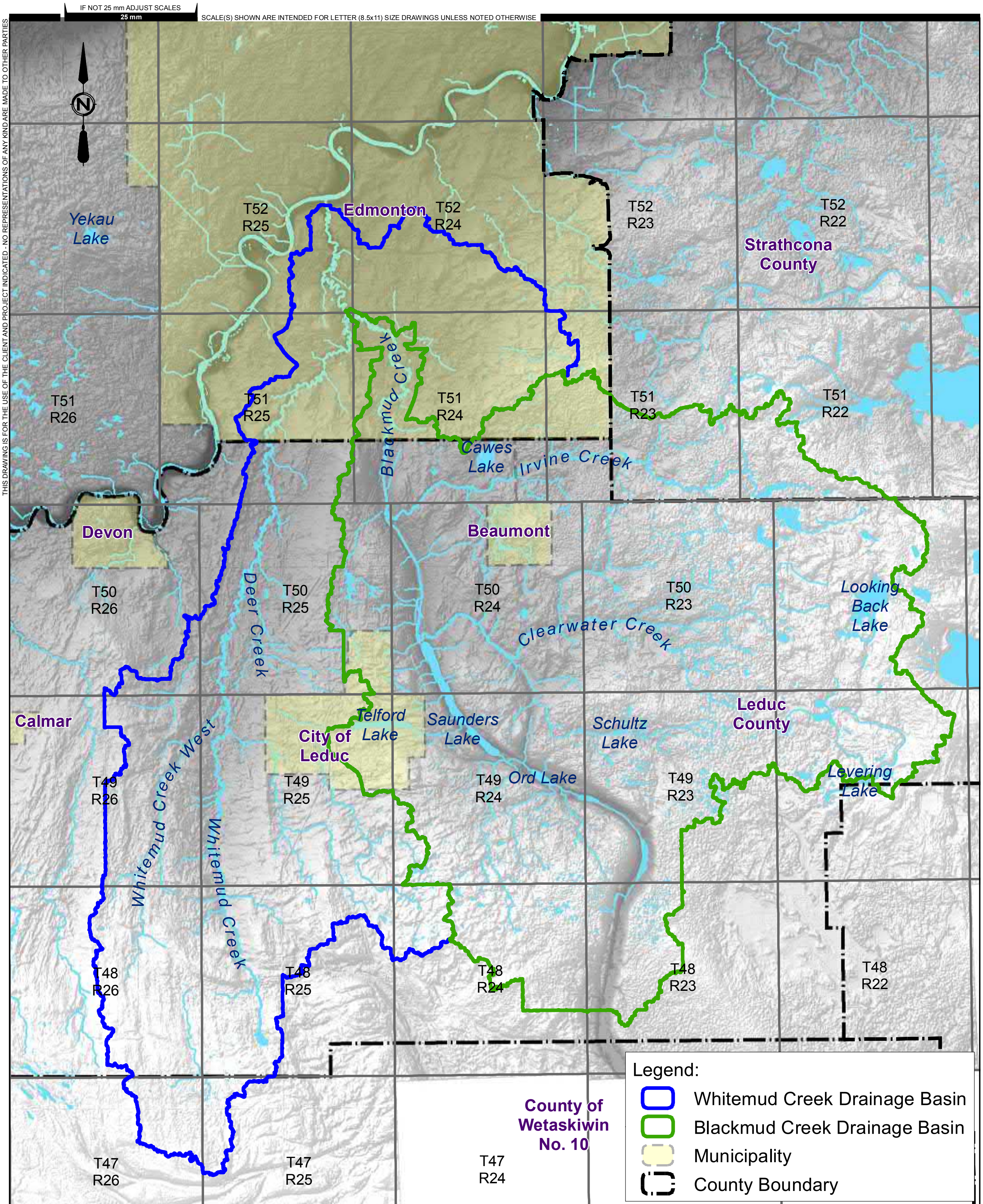
Large portions of the Blackmud /Whitemud Creek basins are expected to be intensively developed in the foreseeable future as their urban areas continue to grow. This development will place additional stresses on the creeks, creating an increasing need for surface water management strategies to mitigate impacts on water quality, erosion, and flooding. Key aspects of developing land use planning tools and policy include understanding watershed conditions and filling in data gaps to ensure that sufficient information is available for decision making.

The study area consists in the Whitemud Creek basin, which covers a total area of 1,081 km^2 and Blackmud Creek, a sub-basin of Whitemud Creek, which covers an area of 671 km^2 (**Figure 1-1**). This report provides an overview of the natural areas within the Blackmud and Whitemud creek basins. It documents the environmentally sensitive areas and biodiversity features within the study area and addresses key aspects of watershed health in detail. Data collection focused on stream channel morphology, riparian health, wetland extent and functional capacity on the basis that these components of the watershed play an important role in flood abatement, erosion, and water quality improvement. The purpose of this report is to characterize the study area and describe recommendations for additional data collection and analyses to guide sound land use decision making processes.

The assessment included a review of the background data, followed by documentation of known environmentally sensitive areas and biodiversity features within the study area. This part of the investigation involved the compilation and review of available physical, biophysical, and environmental information to provide an assessment of ecological condition and habitat values of the natural areas and aquatic ecosystems. Additional field data were collected during a reconnaissance-level survey of riparian condition and stream channel erosion on the Blackmud and Whitemud creeks.

Key components considered in the assessment included: overall aquatic and ecological health and stressors; high/low ecological value areas; and restoration, management, and protection priorities. Recommendations to protect and conserve significant natural and sensitive resources (including retention and mitigation measures, and best management practices), including any requirements for future environmental considerations and investigations (e.g., additional species-specific investigations), are provided in the report.

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



P:\20163785\00_Blackmud_Whitemud\Working_Dwgs\010_GIS\ArcMap\01_Environmental\Map_Study_Area_8x11.mxd
DATE: 6/27/2017,

Associated Engineering

AE PROJECT No. 2016-3785
SCALE 1:270,000
APPROVED
DATE 2017 JUNE
REV
DESCRIPTION ISSUED FOR REPORT

FIGURE No. 1-1

BLACKMUD/WHITEMUD CREEK WATERSHED MANAGEMENT STUDY

STUDY AREA

2 Approach and Assessment Methods

The Blackmud/Whitemud Creek Natural Areas and Aquatic Ecosystem Assessment focused on four areas of interest as described below.

Overview of Study Area
Section 3 provides a description of topography; land use; ecoregions and vegetation; wildlife and wildlife habitat; fisheries and aquatic resources; provincially and federally listed species (vegetation and wildlife); and heritage resources.

The following resources were consulted to obtain relevant information:

- Fish and Wildlife Management Information System (FWMIS) (Government of Alberta 2014b)
- Alberta Conservation Information Management System (ACIMS) (Government of Alberta 2015)
- Agricultural Region of Alberta Soil Inventory Database (AGRASID) (Government of Alberta 2015a)
- *Historical Resources Act* listings (RSA 2000, c. H-9)
- Alberta Flood Hazard Map application
- Public aerial imagery collections.

Morphological Assessment
Section 4 provides an overview of stream channel morphology in both Blackmud and Whitemud Creeks and erosion issues based on a reconnaissance level survey within the study area. Historic and current aerial photography were reviewed to evaluate changes in channel location. This information can be further evaluated to identify a correlation with hydrologic and hydraulic analyses that will be completed subsequent to this report.

To understand changes that have occurred over time in the Blackmud and Whitemud Creek channels, current and historical channel locations were digitized using recent aerial satellite imagery and t historical air photos available for the study area. A combination of ESRI basemap imagery from 2009 to 2012 and recent imagery provided by the City of Edmonton were used to digitize current channel alignments. Historical air photos from AEP's Aerial Photographic Record System dated 1949 – 1950 with resolutions of 1:30,000 to 1:40,000 were selected to digitize the historical channel alignments.

Riparian Analysis
Section 5 provides a description of riparian factors and characteristics (e.g., cover, width, grade, habitat, and overall ecological value) contributing to health or pollution of the aquatic environment. Riparian areas were categorized and recommendations for conservation, restoration, or modification were developed to support the overall plan.

The following resources were used to categorize land cover:

- City of Edmonton Land Use Planning Map (City of Edmonton 2010)
- Leduc County 2015 ESA Final Land Cover Classification (Fiera 2015)
- Strathcona County Prioritized Land Ecology Assessment Land Cover

- Alberta Merged Wetland Inventory (Government of Alberta 2016)
- Natural Resources Canada Natural Hydro Network (NHN)
- 1 m Contour Data
- ESRI Basemap imagery
- Recent air photos provided by each municipality

Wetland Functional Analysis

Section 6 is based on an inventory of wetlands using aerial photographs and available GIS data. Wetland data were combined and supplemented and then analyzed for capacity to function based on landscape position. Results of the wetland functional analysis allowed us to rate wetlands and assign categories based on their potential to provide flood, erosion, and water quality related functions to guide future management decisions. Wetland management strategies include prioritizing wetlands for retention on the landscape as natural systems or integrated into stormwater management facilities and identifying wetlands where unavoidable impacts should require on-site replacement to maintain ecosystem benefits.

Methods used to complete this work include:

- Generate GIS data for wetland polygons in the study area;
- Apply common classification schemes to all wetlands;
- Use GIS analysis including available remotely sensed data such as land use to identify potential for wetland functions to be performed based on landscape position; and
- Rate functional capacity of each wetland as high, medium, or low for both hydrologic functions and water quality functions.

Water Quality Analysis

Section 7 provides a summary of the existing water quality data for significant waterbodies (e.g., tributaries, creeks, wetlands) that establish baseline conditions, contribute to the understanding of hydrologic and hydrogeological characteristics, and assess potential impacts on surface water quality.

The surface water quality assessment included a desktop compilation and review of the following resources:

- Various community reports previously completed for development and planning purposes within the Blackmud and Whitemud watersheds;
- Aerial imagery (e.g., Google Earth);
- Water quality monitoring database searches from local stewardship/monitoring organizations (The RiverWatch Institute of Alberta, 2016), and provincial websites (e.g., Inventory of Sampling Locations and Water Quality Data, Lake Water Quality Data, River Network Station Water Quality, Trophic State of Alberta Lakes, Authorization Viewer); and
- Leduc and Strathcona County websites (Leduc County 2016, Strathcona County 2016).

The desktop review is not intended to be exhaustive, but at a minimum provides a general understanding of surface water quality data based on readily available information. To accurately assess potential impacts on surface water quality as a result of current and future development, a thorough understanding of baseline water quality is needed, which would involve a more exhaustive records review and likely additional surface water quality sampling, which are outside the scope of this assessment. Baseline surface water quality was summarized and described for three distinct time periods: pre-1985; 1985 to 2010; and 2011 to 2015. Where data were present for multiple years or over multiple months within a given year, mean values were calculated and presented. No seasonality was investigated, as water quality data were typically associated with samples collected in spring and summer.

3 Overview of Study Area

This section provides an overview of the ecoregions and vegetation, topography, land use, wildlife and wildlife habitat, provincially and federally listed species, fisheries and aquatic resources (i.e., species and habitat), and heritage resources within the study area (**Figure 1-1**).

Due to the large study area (i.e., 1,081 km^2), this overview provides only a high-level description of the biophysical characteristics of the study area. This section does not document location-specific features.

3.1 ECOREGIONS

The study area includes the Blackmud and Whitemud Creek basins, which are located predominantly within the Central Parkland Natural Subregion of the Parkland Region. A small area in the northeast portion of the Blackmud Creek sub-basin (29.8 km^2) is located within the Dry Mixedwood Subregion of the Boreal Forest Region.

The Central Parkland Natural Subregion encompasses approximately 50,000 km^2 in central Alberta with agriculture as the primary land use (Government of Alberta 2006). The Dry Mixedwood Subregion encompasses approximately 85,321 km^2. The southern unit of the Dry Mixedwood Subregion occupies a crescent-shaped area in central Alberta between the Central Parkland and the Central Mixedwood Natural Subregions (Government of Alberta 2006). **Table 3-1** provides information on both subregions.

The National Ecological Framework (Government of Canada 1999) provides a land classification system that has been integrated with the provincial scheme (Government of Alberta 2006). The Framework consists of several levels from the national to local scales to characterize ecosystems. Ecodistricts are subdivisions of ecoregions, and are characterized by a distinctive assemblage of relief, landforms, geology, soil, vegetation, waterbodies, and fauna. The study area is located within two Ecodistricts: Leduc Plain Ecodistrict and Cooking Lake Upland Ecodistrict.

Table 3-1
Subregion characteristics

Subregion Characteristics	Parkland (deciduous-grassland mosaic) - Central Parkland Subregion	Deciduous–leading mixedwood - Dry Mixedwood Subregion
Mean annual temperature (°C)	+1.5 to +3.0	+0.2 to +1.1
Mean annual precipitation (mm)	440–450	450–500
Growing degree days >5°C	1,100–1,400	1,000-1,300
Frost-free period (days)	>100	95–100
Summer moisture index	3.0–4.5	3-4
Average elevation (metres above sea level)	750 (500–1250)	600 (225–1225)
Major soils	Mainly Black Chernozems; some Dark Gray Chernozems. Significant Solonetzic soils. Wetlands are Gleysols.	Orthic and Dark Gray Luvisols. Brunisols on sands. Wetlands are Mesisols and Gleysols.

3.2 TOPOGRAPHY AND LAND USE

Topography

The dominant landform of the Central Parkland Natural Subregion of the Parkland Region is undulating glacial till plains, with about 30 percent as hummocky, rolling and undulating uplands. Surficial materials are dominantly medium to moderately fine textured, moderately calcareous glacial till that may be a thin (less than 2 m) blanket over bedrock in some of the low-relief plains (Government of Alberta 2006).

Bedrock formations underlying the central Alberta unit of the Dry Mixedwood Subregion include Upper Cretaceous shale, sandstone, and siltstone formations (Government of Alberta 2006). There is a significant component (10%) of glaciofluvial sands and organic deposits but only minor inclusions of glaciolacustrine materials (Government of Alberta 2006). Soils are typically medium to fine textured Gray and Dark Gray Luvisols (Government of Alberta 2006).

Within the Central Parkland Natural Subregion, the Leduc Plain Ecodistrict is characterised as an undulating lacustrine and morainal plain (Geowest 1999). The Cooking Lake Upland Ecodistrict, in the Dry Mixedwood Subregion, has moderate drainage in a convoluted system of sloughs, bogs, and small lakes linked by small watercourses (Geowest 1997).

Land Use

The study area has significant urban centres including the City of Leduc, Town of Beaumont and City of Edmonton. Other major land uses in the watershed include agriculture, coal extraction, and oil and gas facilities (North Saskatchewan Watershed Alliance 2012). Agriculture represents about 64% of the land use in the study area **(Figure 3-1)**.

Several locations along Blackmud and Whitemud Creeks are considered Environmentally Significant Areas (Leduc County 2015) and assessed as having *High Development Risk.* These locations have the potential to experience high growth pressure over the short term (within 3-years). The County of Leduc considers the North Saskatchewan River and significant streams and shoreland ravines to be open space corridors (Leduc County 2014). There are measures in place to protect these corridors from encroachment by incompatible development by allowing the integration of uses that are considered compatible with the landscape and sensitivities of the valley and encouraging the retention and conservation of river and ravine natural features.

In addition, the City of Edmonton (1993) identified a number of sensitive and significant areas within the Blackmud and Whitemud basin. The Municipal Development Plan, The Way We Grow (City of Edmonton 2010), identifies the Blackmud and Whitemud Creeks as Biodiversity Core Areas. Within the City of Edmonton, the creeks are included in the North Saskatchewan River Valley Area Plan, Bylaw 7188. Adopted in 1985, the North Saskatchewan River Valley Area Plan (Bylaw 7188) identifies a boundary for the river valley and ravine system and a set of policies and development approval procedures for lands within this boundary. The purpose of Bylaw 7188 is to protect the North Saskatchewan River Valley and Ravine System as part of Edmonton's valuable open space heritage and to establish the principles for future implementation plans and programs for parks development (City of Edmonton 2014).

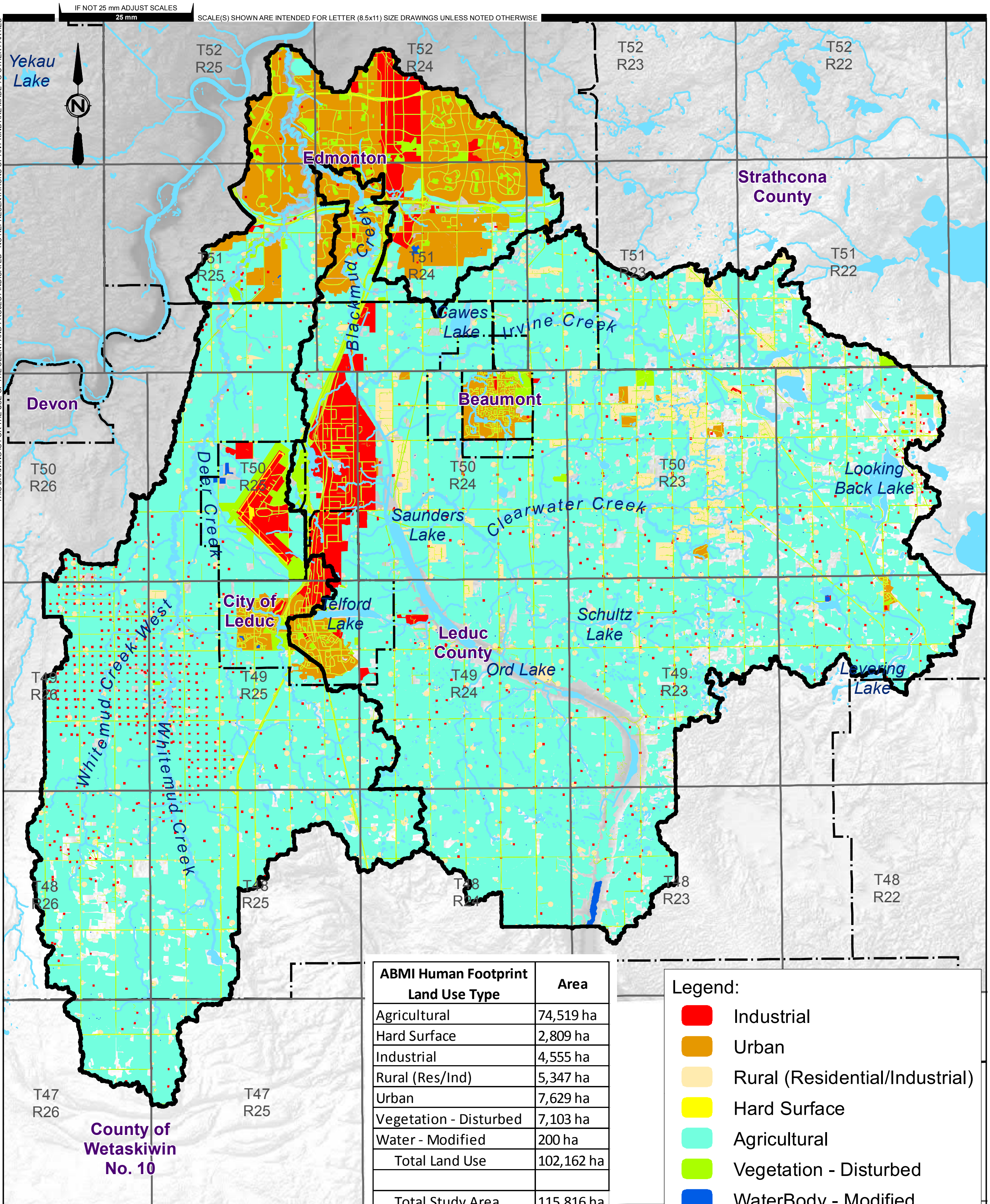
3.3 VEGETATION

Natural vegetation communities within the Central Parkland Natural Subregion include various community types that occur within grasslands, shrublands, forests, and wetlands (Government of Alberta 2006). Grassland communities typically include western porcupine grass (*Stipa spartea*), june grass (*Koeleria macrantha*), needle-and-thread grass (*Stipa comata*), blue grama grass (*Bouteloua gracilis*), dryland sedges, and pasture sagewort (*Artemisia frigida*) (Government of Alberta 2006). Plains rough fescue (*Festuca scabrella*), slender wheat grass (*Agropyron trachycaulum*), and smooth brome (*Bromus inermis*) can occur in areas with increased soil moisture (Government of Alberta 2006). Shrublands can support buckbrush (*Ceanothus cuneatus*), silverberry (*Elaeagnus* spp.), prickly rose (*Rosa acicularis*), chokecherry (*Prunus virginiana*), and Saskatoon (*Amelanchier alnifolia*) (Government of Alberta 2006). Forested areas can vary greatly depending on soil moisture conditions; dominant tree species include trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and white spruce (*Picea glauca*) while the understorey can consist of Saskatoon, prickly rose, beaked hazelnut (*Corylus cornuta*) and various forbs and grasses (Government of Alberta 2006). Wetland species typically include common cattail (*Typha latifolia*), sedges (*Carex* spp.), bulrush (*Schoenoplectus* sp.), willows (*Salix* spp.), black spruce (*Picea mariana*), white spruce, Labrador tea (*Rhododendron groenlandicum*), and feather mosses (Government of Alberta 2006).

IF NOT 25 mm ADJUST SCALES

25 mm

SCALE(S) SHOWN ARE INTENDED FOR LETTER (8.5x11) SIZE DRAWINGS UNLESS NOTED OTHERWISE



ABMI Human Footprint Land Use Type	Area
Agricultural	74,519 ha
Hard Surface	2,809 ha
Industrial	4,555 ha
Rural (Res/Ind)	5,347 ha
Urban	7,629 ha
Vegetation - Disturbed	7,103 ha
Water - Modified	200 ha
Total Land Use	102,162 ha
Total Study Area	115,816 ha

\\s-edm-fs-01\projects\20163785\00_Blackmud_Whitemud\Working_Dwgs\010_GIS\ArcMap\01_Environmental\Map_Landuse_8x11.mxd
DATE: 6/30/2017,

Associated Engineering

AE PROJECT No. 2016-3785
SCALE 1:250,000
APPROVED
DATE 2017 JUNE
REV
DESCRIPTION ISSUED FOR REPORT

FIGURE No. 3-1

BLACKMUD/WHITEMUD CREEK WATERSHED MANAGEMENT STUDY

LAND USE

In this geologically distinct area of the Dry Mixedwood Subregion, vegetation communities include aspen stands with scattered white spruce interspersed with fens, and cultivated areas on suitable soils throughout (Government of Alberta 2006).

A search of available rare plant information for the study area was conducted using the Alberta Conservation Information Management System (ACIMS) rare plant database (Government of Alberta 2015). The ACIMS database contains information on locations of rare plants and rare plant communities that were previously recorded. However, it does not provide detailed information on the likelihood of occurrences in an area. Further details on rare plants that may occur within the study area are provided in **Section 3-7**.

3.4 WILDLIFE AND WILDLIFE HABITAT

Typical wildlife species within the grassland regions of the Central Parkland Subregion include upland sandpiper (*Bartramia longicauda*), Sprague's pipit (*Anthus spragueii*), Baird's sparrow (*Ammodramus bairdii*), broad-winged hawk (*Buteo platypterus*), rose-breasted grosbeak (*Pheucticus ludovicianus*), and woodchuck (*Marmota monax*) (Government of Alberta 2006). Within the shrubland and forested community types, typical wildlife species include red-tailed hawk (*Buteo jamaicensis*), least flycatcher (*Empidonax minimus*), Baltimore oriole (*Icterus galbula*), red-eyed vireo (*Vireo olivaceus*), yellow warbler (*Setophaga petechial*), white-tailed deer (*Odocoileus virginianus*), snowshoe hare (*Lepus americanus*), northern pocket gopher (*Thomomys talpoides*), and American porcupine (*Erethizon dorsatum*) (Government of Alberta 2006).

Wildlife diversity is highest in the south-central and eastern portions of the Dry Mixedwood Subregion. Typical wildlife species within the deciduous-dominated forests of the Subregion are least flycatcher, house wren (*Troglodytes aedon*), ovenbird (*Seiurus aurocapilla*), red-eyed vireo, warbling vireo (*Vireo gilvus*), Tennessee warbler (*Vermivora peregrine*), Baltimore oriole, and rose-breasted grosbeak. The most species-rich habitats are mixedwoods and tall shrub communities associated with swamps, beaver ponds, streams, and lakes (Government of Alberta 2006). Some species, such as the yellow warbler, black-and-white warbler (*Mniotilta varia*), American redstart (*Setophaga ruticilla*), song sparrow (*Melospiza melodia*), northern waterthrush (*Seiurus noveboracensis*), fox sparrow (*Passerella iliaca*), and philadelphia vireo (*Vireo philadelphicus*) are mostly restricted to these sites. Some of the most productive pond, meadow, and swamp habitats are the result of activities by the American beaver (*Castor Canadensis*), an important inhabitant of the subregion. Widespread mammals of forested areas include red squirrel (*Tamiasciurus hudsonicus*), southern red-backed vole (*Myodes gapperi*), least chipmunk (*Neotamias amoenus*), and deer mouse (*Peromyscus maniculatus*) (Government of Alberta 2006).

The study area falls within Bird Conservation Region "B4," with a migratory bird nesting period from **April 9 to August 31** (Government of Canada 2014b). In addition, the nesting period for owls ranges from February 15 to late April.

Figure 3-2 provides detailed breeding periods for migratory birds recorded within the ecodistricts for Leduc and Cooking Lake.

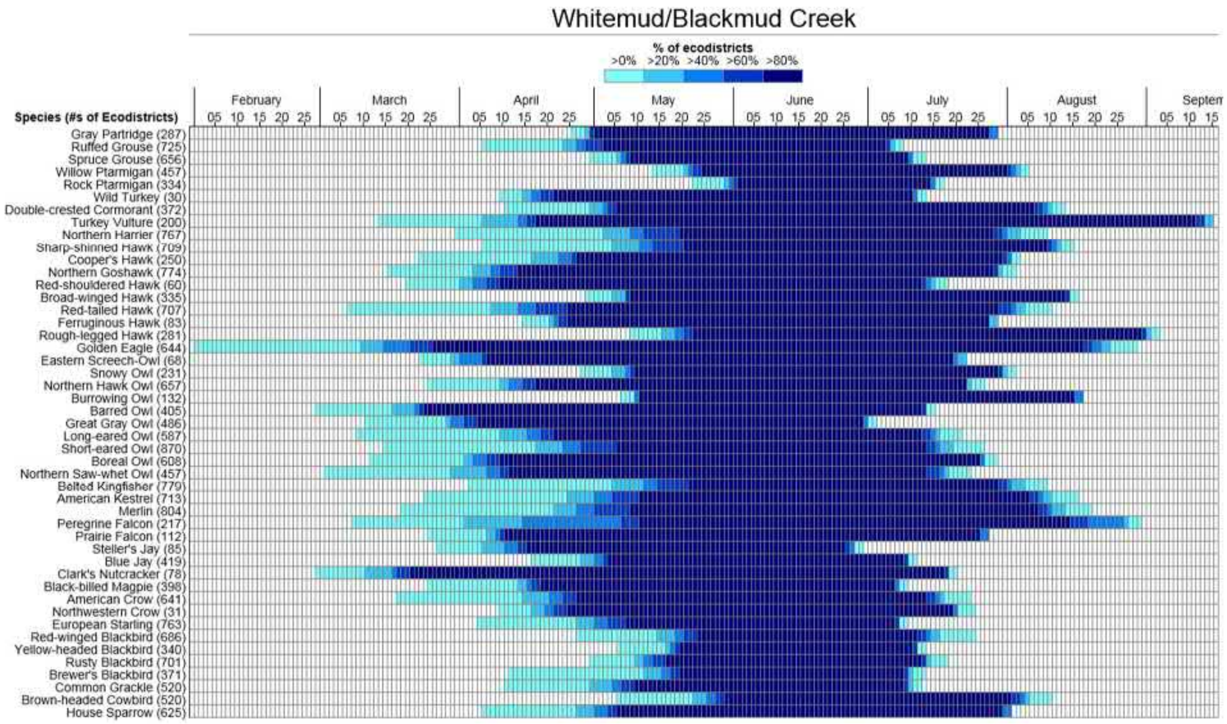


Figure 3-2
Migratory Bird Breeding Period

The search of the FWMIS database (Government of Alberta 2014b) indicated that the study area lies within the following sensitive wildlife zones:

- Sharp-tailed Grouse (*Tympanuchus phasianellus*) Survey Area, and
- Sensitive Raptor Range – bald eagle (*Haliaeetus leucocephalus*) (Government of Alberta 2014b).

There are no guidelines or timeline restrictions provided by the Alberta Government in association with the Sharp-tailed Grouse Survey Area. The noted Sensitive Raptor Range specifically relates to bald eagle. Bald eagles have a provincial status of "sensitive" (Government of Alberta 2010), but a federal status of "not at risk" (Government of Alberta 2015, COSEWIC 2015).

The lower reaches of Whitemud Creek as it flows into the North Saskatchewan River are within a Key Wildlife and Biodiversity Zone. These zones typically occur along river valleys and provide appropriate conditions to sustain increased levels of biodiversity (Government of Alberta 2015). These areas also provide opportunities to maintain landscape connectivity and act as locally and regionally significant wildlife movement corridors.

3.5 FISHERIES AND AQUATIC RESOURCES

Blackmud Creek and the portion of Whitemud Creek south of Township Road 512 (41 Avenue SW) are coded as Class C waterbodies under the Code of Practice for Watercourse Crossings established pursuant to the *Water Act* (R.S.A., 2000, c. W-3). Habitat contained in Class C waterbodies is considered common and not unique in Alberta. The entire length of Whitemud Creek north of Township Road 512 (41 Avenue SW), is coded as a Class B waterbody under the same Code of Practice. Class B waterbodies contain important habitat necessary for various life processes of certain fish species. The Class B portion of Whitemud Creek contains important spawning habitat for walleye (*Stizostedion vitreum*). Both classes of waterbody carry the same Restricted Activity Period in the Blackmud and Whitemud Creeks, from April 16 to June 30 for scheduled activities.

The substrate matrix throughout is dominated by fines; however, gravels also comprise a considerable component of the substrate, and cobbles are present in some areas, although in small quantities. Substantial instream cover is provided by aquatic dense beds of macrophytes, large woody debris, beaver pond impoundments, and undercut banks. Overhead cover is substantial, especially in downstream reaches, and is provided by overhanging vegetation including grasses, shrubs, and trees.

Both creeks contain a well distributed series of riffles, runs, and pools. Riffles are present in most upstream reaches, with runs forming along the midstream reaches in the network. Pools are present immediately upstream of beaver dams and provide valuable overwintering habitat that is likely limited only to these areas in the mid and upstream reaches of these creeks. Runs are present throughout the midstream reaches, and are deep/dominant features in downstream reaches of the creeks.

Aside from the walleye spawning habitat contained in Whitemud Creek, both waterbodies contain a diverse assortment of cyprinid such as fathead minnow (*Pimephales promelas*), lake chub (*Couesius plumbeus*), longnose dace (*Rhinichthys cataractae*), pearl dace (*Margariscus margarita*), and trout-perch (*Percopsis omiscomaycus*), as well as stickleback species. Other species that likely use habitat in these creeks include northern pike (*Esox lucius*), white sucker (*Catostomus commersoni*), and longnose sucker (*Catostomus catostomus*). Species using the habitat in the North Saskatchewan River may also be present in the downstream reaches of Blackmud and Whitemud Creeks. Non-native goldfish have also been documented in Whitemud Creek and can be attributed to the release of domestic pet fish.

3.6 PROVINCIALLY AND FEDERALLY LISTED SPECIES

The data obtained through the search of the FWMIS database only provides records for areas where surveys were conducted. The information provided in **Table 3-2** does not contain an exhaustive list of all species at risk that might occur in the study area.

Table 3-2
Species at risk in Study Area

Common Name	Scientific Name	Provincial Status		Federal Status	
		General Status of Alberta Wild Species[a]	*Wildlife Regulation*, Schedule 6[b]	COSEWIC	*Species at Risk Act*, Schedule 1[c]
bald eagle	*Haliaeetus leucocephalus*	Sensitive	Not scheduled	Not at Risk	Not scheduled
barn swallow	*Hirundo rustica*	Sensitive	Not scheduled	Threatened	Not scheduled
barred owl	*Strix varia*	Sensitive	Not scheduled	Not assessed	Not scheduled
black-throated green warbler	*Dendroica virens*	Sensitive	Not scheduled	Not assessed	Not scheduled
brown creeper	*Certhia americana*	Sensitive	Not scheduled	Not assessed	Not scheduled
common nighthawk	*Chordeiles minor*	Sensitive	Not scheduled	Threatened	Threatened
common yellowthroat	*Geothlypis trichas*	Sensitive	Not scheduled	Not assessed	Not scheduled
fisher	*Martes pennanti*	Sensitive	Not scheduled	Not assessed	Not scheduled
great blue heron	*Ardea herodias*	Sensitive	Not scheduled	Not assessed	Not scheduled
least flycatcher	*Empidonax minimus*	Sensitive	Not scheduled	Not assessed	Not scheduled
lesser scaup	*Aythya affinis*	Sensitive	Not scheduled	Not assessed	Not scheduled
northern goshawk	*Accipiter gentilis*	Sensitive	Not scheduled	Not at Risk	Not scheduled
northern harrier	*Circus cyaneus*	Sensitive	Not scheduled	Not at Risk	Not scheduled
northern leopard frog	*Lithobates pipiens*	At Risk	Endangered	Special Concern	Special Concern
northern pygmy-owl	*Glaucidium gnoma*	Sensitive	Not scheduled	Not at Risk	Not scheduled

Common Name	Scientific Name	Provincial Status		Federal Status	
		General Status of Alberta Wild Species[a]	*Wildlife Regulation*, Schedule 6[b]	COSEWIC	*Species at Risk Act*, Schedule 1[c]
purple martin	*Progne subis*	Sensitive	Not scheduled	Not assessed	Not scheduled
sandhill crane	*Grus canadensis*	Sensitive	Not scheduled	Not assessed	Not scheduled
sora	*Porzana carolina*	Sensitive	Not scheduled	Not assessed	Not scheduled
Swainson's hawk	*Buteo swainsoni*	Sensitive	Not scheduled	Not assessed	Not scheduled

A list of rare plant species encounters and their provincial rank (S#), locations, and dates observed are listed in **Table 3-3**. There were 13 rare plant occurrences reported to ACIMS (Government of Alberta 2014a) in the study area: five vascular species, four bryophyte species (with two occurrences of one species), and three lichen species. The majority of species occurrences were found in the northern portion of the study area along Whitemud Creek with two occurrences to the south along Blackmud Creek and one occurrence near the east boundary of the study area. ACIMS assigns a conservation rank to each plant species on a global, national, and subnational scale of 1 to 5. The rank is based on rarity of a species or community and risk of extirpation. Those species that current data suggest may be rare are placed on a tracking or watch list (i.e., usually species ranked S3 or lower). Species identified in the ACIMS query in the study area have provincial ranks that range from S1 to S3.

**Table 3-3
ACIMS rare plant occurrences**

Growth Form	Scientific Name	Common Name	Provincial Rank
Vascular	*Carex vulpinoidea*	fox sedge	S3
	Doellingeria umbellata var. pubens	flat-topped white aster	S3
	Houstonia longifolia	long-leaved bluets	S3
	Osmorhiza longistylis	smooth sweet cicely	S3
	Piptatherum canadense	Canadian rice grass	S2
Bryophyte	*Bryum uliginosum*	moss	S1S2
	Didymodon tophaceus	blunt-leaved hair moss	S2S3
	Entodon schleicheri	Schleicher's silk moss	S2S3
	Rhodobryum ontariense	Ontario Rhodobryum moss	S1S2
	Rhodobryum ontariense	Ontario Rhodobryum moss	S1S2
Lichen	*Micarea melaena*	dot lichen	S1
	Peltigera horizontalis	flat fruited pelt lichen	S2S4
	Pseudevernia consocians	lichen	S2

3.7 HERITAGE RESOURCES

Throughout Alberta, sites designated under the provisions of the *Historical Resources Act* (R.S.A. 2000, c. H-9) are listed on the Alberta Register of Historic Places. Land parcels are assigned a Historic Resource Value (HRV) ranging from 1 to 5 where the highest level of protection (HRV 1) is assigned to lands designated as Provincial Historic Resources (Government of Alberta 2016a). An HRV of 1 is also used to identify World Heritage Sites and lands owned by government for historic resource protection and promotion purposes. Other designations include:

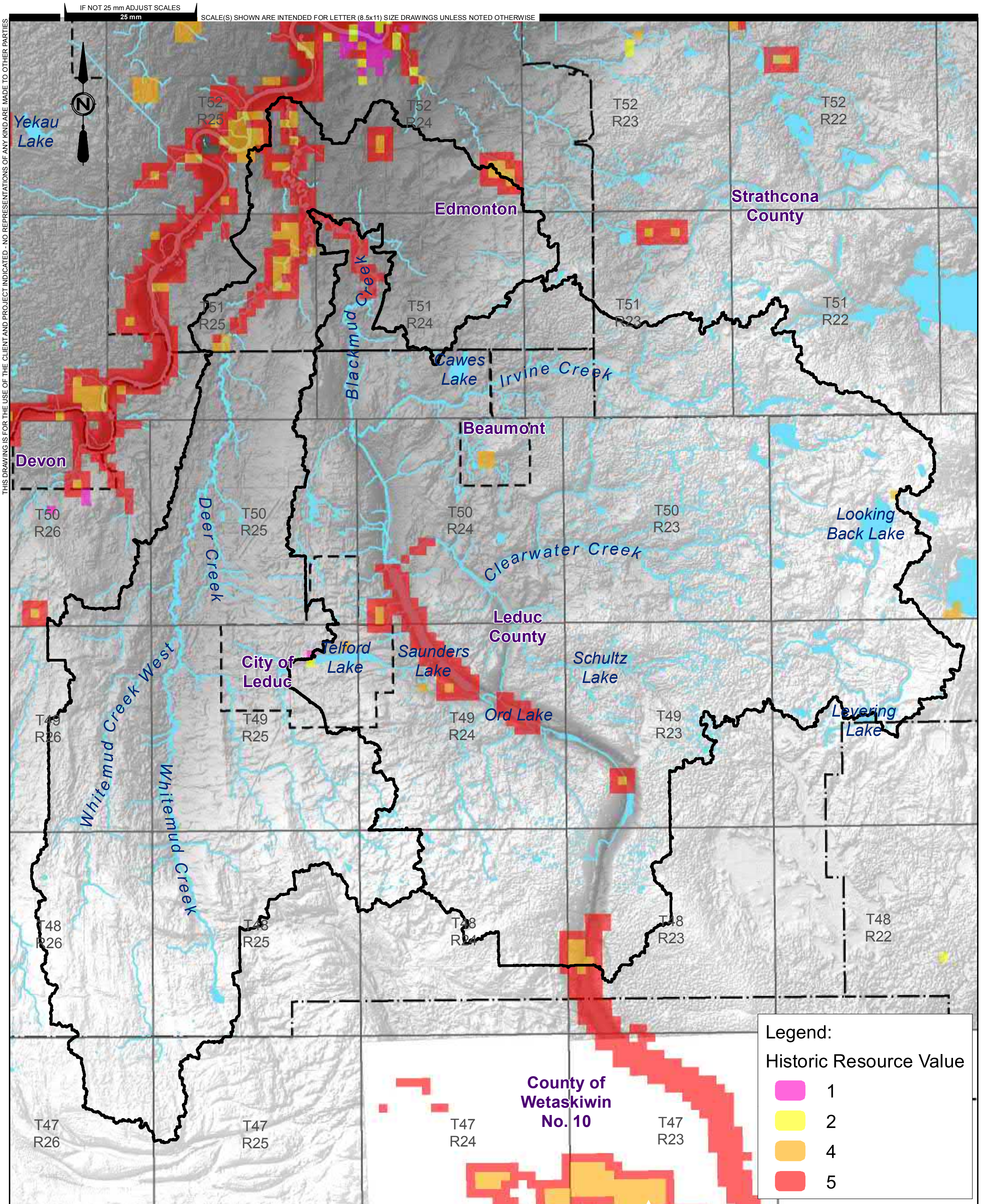
- HRV 2: a Municipal or Registered Historic Resource
- HRV 3: contains a significant historic resource that will likely require avoidance
- HRV 4: contains a historic resource that may require avoidance
- HRV 5: believed to contain a historic resource

There are several land parcels within the study area that have an HRV designation.

In the upper reaches of Blackmud Creek, lands surrounding Ord Lake are designated HRV5 for their high potential for archaeological resources. Lands surrounding Saunders Lake also have a designation of HRV5 for their high potential for both archaeological and palaeontological resources. West of Telford Lake, within the boundaries of the City of Leduc, there is an historic site owned by the Government of Alberta, which is designated as HRV1 site (LSD 2, 25-49-25W4M). It is identified as the Alberta Wheat Pool Grain Elevator Site Complex. Located south, there is a registered historic resource with a designation of HRV2, Dr. Wood's House (LSD 15, 26-49-25W4M). There is also a parcel of land (SE35-49-25W4M) that has a designation of HRV4 and has previously recorded palaeontological resources.

The lower reaches of both Blackmud and Whitemud Creeks within the City of Edmonton have land designation of HRV5 and HRV4 and are believed to have high potential or have previously recorded archaeological and palaeontological resources.

The map in **Figure 3-3** shows the location of the lands with HRV designations in the study area.



Associated Engineering

AE PROJECT No. 2016-3785
SCALE 1:250,000
APPROVED
DATE 2017 JUNE
REV
DESCRIPTION ISSUED FOR REPORT

FIGURE No. 3-3

BLACKMUD/WHITEMUD CREEK
WATERSHED MANAGEMENT STUDY

PROVINCE OF ALBERTA
HISTORICAL RESOURCES

3.8 FLOOD HAZARD MAPPING

The potential for flooding exists along all rivers and streams in Alberta. Flood events can cause significant damage to private property, cause hardship, and in extreme events, loss of life.

Alberta Environment and Parks has identified flood hazard areas across the province as part of the Flood Hazard Identification Program that was initiated in the 1970's. Flood hazard studies include a hydrological assessment, topographic data collection, hydraulic modelling, and mapping. The flood hazard mapping delineates areas that would be inundated during a one percent or 100-year flood event. One percent floods are used as the current design standard in Alberta and are defined as a flood whose magnitude has a one percent chance of being equaled or exceeded in any year.

The flood hazard mapping divides flood hazard areas into floodway and flood fringe areas. The Flood Hazard Identification Program defines the floodway as the portion of the flood hazard area where flows are deepest, fastest, and most destructive. The floodway usually includes the main stream channel of the stream and a portion of the adjacent overbank area. New development is discouraged in the floodway. The flood fringe is estimated to have shallower and slower flowing water during a one percent flood event. New development in the flood fringe may be permitted in some communities and should be flood-proofed.

Flood hazard mapping has not been complete for all communities in Alberta. The Nisku – Blackmud Creek Flood Study was completed March 2014. The study area included 12 km of the Blackmud Creek from where Clearwater Creek meets the Blackmud Creek, downstream to the outer limits of the City of Edmonton municipal boundary. The report summary states that flooding in the Nisku area typically occurs during the open water season, with peak flows commonly occurring in March and April due to snowmelt. The largest floods occur as a result of rainfall on snowmelt.

No other flood hazard mapping studies were available for the other major creek systems in the Whitemud and Blackmud basins. Future flood hazard mapping studies would be beneficial to the communities within the Whitemud and Blackmud basins. These studies could be used to designate environmental reserve areas, prevent future loss or damage to property, and maintain riparian integrity, while supporting sustainable community development.

4 Morphological Assessment

4.1 STREAM CHANNEL MORPHOLOGY

Stream channel morphology is dynamic and dependent upon specific environmental factors and processes. Morphology is determined by stream channel width, depth and slope, roughness, volumes, velocity, and the nature of sediment (Leopold et al. 1964). Erosion and sedimentation are key processes that influence a stream's form. Channel morphology can also be influenced by human activities.

AE visited representative sites to provide a reconnaissance level review of stream channel morphology. Morphology in both creeks is similar with maximum depths ranging from approximately 0.5 m near the headwaters of the creeks, to 2 m near the confluence with the North Saskatchewan River. Stream widths average between 1-2 m in first (Strahler) order headwater stream reaches, and increases to 10-12 m in the downstream fifth (Strahler) order segment and confluence with the North Saskatchewan River.

The substrate matrix throughout is dominated by fines; however, gravels also comprise a considerable component of the substrate, and cobbles are present in some areas, although in small quantities. Substantial instream cover is provided by aquatic dense beds of macrophytes, large woody debris, beaver pond impoundments, and undercut banks. Overhead cover is substantial, especially in downstream reaches, and is provided by overhanging vegetation including grasses, shrubs, and trees.

4.2 HISTORIC AND CURRENT CHANNEL ALIGNMENT

Comparing land cover between historical air photos and recent imagery, the most significant change appears to have occurred in the lower reach of the Blackmud and Whitemud Creek buffers, where agricultural lands have been developed into urban residential neighborhoods. Natural changes in the Blackmud and Whitemud Creek channels are visible in locations where current oxbow features exist. The majority of these natural re-alignments were observed in the mid-lower reaches of Blackmud and Whitemud Creeks.

Channel re-alignments have also occurred as a result of human development. A flooded area along Whitemud Creek was re-aligned to accommodate the construction of 23rd Avenue NW in Edmonton. Another channel re-alignment was observed where Whitemud Creek crosses 41st Avenue SW. Minor straightening of Whitemud Creek is also observed in an agricultural area in the upper reach of the creek. Blackmud Creek has also had significant channel re-alignment due to human development. The Blackmud Creek channel was straightened along the west side of Highway 2 after crossing under the highway. Blackmud Creek was also straightened for over 6.5 km adjacent to an industrial area north of the City of Leduc to accommodate increased development and improve flood management.

Appendix A includes maps that show the current Blackmud and Whitemud Creek channels and highlight locations were erosion processes and human development have altered the creek channels since 1950.

4.3 EROSION ASSESSMENT

The desktop and reconnaissance level field assessment identified eroding sites within the Blackmud and Whitemud Creeks channels, and can be further evaluated to identify a correlation with hydrologic and hydraulic analyses that will be completed subsequent to this report.

Sites along both creek channels with visible erosion issues were identified using the most recent Google satellite imagery. Historical satellite imagery was used to determine if significant changes have taken place over the past 12 years and to estimate the dominant erosion processes. In addition, sites identified in a previous Erosional Sites Characterization Study (AMEC 2011) prepared for the City of Edmonton Drainage Services, were added to the data set.

In total, 114 sites were identified along the Blackmud and Whitemud Creek channels with visible erosion concerns. Erosion sites were distributed throughout both creek channels; however the majority of the sites were identified in the lower reaches of both creeks. Of the 114 sites, 63 sites (53%) were identified along Whitemud Creek. Of these 63 sites, 81% were identified within the lower reach of Whitemud Creek. There were 51 sites (45%) identified along Blackmud Creek, all of which were located within the lower reaches.

A representative subset of sites, based on dominant erosion processes and accessibility, were selected for field assessment. In total, 59 sites were selected to provide details on erosion indicators, dominant erosion or destabilization processes, surrounding land use, structures at risk, and riparian health indicators. Of the 59 sites, 17 sites were along Whitemud Creek and 42 sites were along Blackmud Creek. The Blackmud Creek sites included 33 sites that had previously been assessed in the AMEC study (2011) and were re-visited to characterize them based on this study's criteria. Six of the 33 sites overlapped sites identified during the desktop component of this assessment.

Few field assessments were conducted in the middle reach of Whitemud Creek, and no assessments were conducted in the upper reaches of the creeks. This was primarily due to two factors, a lower number of obvious erosion sites visible in satellite imagery, and limited access to sites identified in these areas. A significant portion of the riparian area located in the mid to upper reaches of these creeks is privately owned and cultivated. Maps in **Appendix B** show all erosion sites identified during the desktop assessment and distinguishes which sites were visited during the field assessment. **Table B-1** in **Appendix B** documents the results of the field assessment.

Erosion and instability processes included in-stream erosion only, in-stream erosion dominant, slope instability only, and slope instability dominant. Evaluation of erosion processes included a reconnaissance level assessment that was qualitative only. Additional information is necessary to validate observations.

Of the 114 sites assessed, 73% were classified as in-stream or in-stream erosion dominant, and 34% were classified as dominated by slope instability. During the field assessment, three (3) sites were identified as not having active erosion processes occurring. These sites had been impacted by natural and human influences, such as beaver activity, drainages, and decommissioned roads that appeared to be erosional sites from satellite imagery.

Creek position appeared to influence the frequency of different erosion and instability processes occurring at each site. Along Whitemud Creek, 49% of sites in the lower reach of the channel were dominated by slope instability, while no sites in the mid to upper reach were dominated by slope instability. This is likely attributed to the increase in relief found in the lower reach, closer to the North Saskatchewan River, and replacement of native woody vegetation with invasive grasses along slopes. Woody vegetation has a significant influence on hillslope hydrology and can remove excess soil moisture. This trend is similar along Blackmud Creek, where a greater proportion of sites are dominated by slope instability closer to the North Saskatchewan River. Sites along the lower reaches of the creeks also have increased flows due the larger catchment area. The increased prevalence of in-stream erosional issues towards the mid to upper reaches of the creeks may also be correlated to decreases in native woody vegetation in the riparian buffers that would normally provide root zone diversity to bind soils together along the banks and increase roughness thereby reducing flow velocities.

Riparian health indicators were assessed and the field component included assessment of woody and non-woody native vegetation cover, percent cover of bare ground, presence of invasive species, instances and intensity of deadwood, percentage of streambank bound by deep-rooted vegetation, incisement of the bank, and identification of human alterations to creek bank and surrounding lands. Land cover classification was assessed at the landscape level for lands within 100 m of named creeks in the study area. The land cover provides information on woody or native vegetation and surrounding land uses.

While the riparian health field data collected at the erosion sites along the both creeks channels do not accurately reflect the overall health of the riparian areas along these creeks, this information can be used in the future to correlate erosion issues and hydrologic conditions within these creeks. Assessment of reference sites from the upper and middle reaches of the creek channels, and sites without obvious erosion concerns, should be included in future studies to gain a more holistic approach to riparian health.

5 Riparian Analysis

5.1 RIPARIAN LAND COVER CLASSIFICATION

The study area overlaps a number of political boundaries that include the City of Edmonton, City of Leduc, Strathcona County, Leduc County, and Town of Beaumont. To provide a representative assessment of riparian land cover and riparian health, a buffer of 100 m along all named creeks in the study area was evaluated. Named creeks within the study area included Whitemud, Blackmud, Clearwater, and Irvine Creeks. Spatial data from a variety of sources were compiled, clipped to the buffered area, and normalized to categorize land cover within the 100 m buffer.

Land cover categories were based on the land cover classification categories provided in the Leduc County Environmentally Significant Areas Study (Fiera 2015). These categories were simplified into six land cover types:

- **Open Water** –all areas of standing water including lakes, rivers, and wetlands with open water
- **Wetlands** –areas classified as wetlands and ephemeral waterbodies, not captured by the Open Water category
- **Forested** – areas covered by trees
- **Open Natural** –areas covered by low-growing natural vegetation such as grass, forbs, or shrubs
- **Semi - Natural** –cultivated and pasture agricultural lands and vegetated areas along roads
- **Developed** –built up urban areas and roads, areas of disturbed ground due to development, and areas containing low-growing vegetation that contains human footprints, such as well sites or farm yards.

In locations where suitable data were not available or too coarse for this analysis, land cover was manually digitized using the most recent aerial imagery available. The Alberta Merged Wetland Inventory (Government of Alberta 2016) was used within the County of Strathcona for identifying wetland cover; however, it’s accuracy within the City of Edmonton was not sufficient and land cover was primarily assessed by vegetation.

Maps in **Appendix D** depict land cover within the 100 m buffers of Whitemud, Blackmud, Clearwater, and Irvine Creeks. **Table 5-1** provides the areas of each land cover type and as a percentage of the total buffer area.

Table 5-1
Riparian land cover in the Blackmud and Whitemud Creek Basins

Land Cover Type	Area	
	Square Metres (m^2)	Percentage (%)
Open Water	1,825,161	6%
Wetland	1,585,102	5%
Forested	6,311,592	22%
Open Natural	4,041,234	14%
Semi-Natural	13,023,632	44%
Developed	2,554,165	9%
Total Area	29,340,886	100%

Tables 5-2, 5-3, 5-4, and 5-5 provide land cover information by creek position for each of the named creeks within the study area. This information provides a spatial representation of how intact riparian buffers are for each creek.

Table 5-2
Whitemud Creek riparian land cover by creek position

Land Cover Type	Creek Position					
	Upper		Middle		Lower	
	Area (m^2)	Percent	Area (m^2)	Percent	Area (m^2)	Percent
Open Water	356,863	7%	361,475	8%	310,858	6%
Wetland	311,927	7%	362,476	8%	98,199	2%
Forested	374,814	8%	458,368	10%	2,968,452	61%
Open Natural	1,107,798	23%	1,189,722	27%	651,347	13%
Semi-Natural	2,481,101	52%	1,855,487	42%	358,069	7%
Developed	154,569	3%	234,334	5%	464,541	10%
Total Area	4,787,072	100%	4,461,862	100%	4,851,466	100%

Table 5-3
Blackmud Creek riparian land cover by creek position

Land Cover Type	Creek Position			
	Upper		Lower	
	Area (m^2)	Percent	Area (m^2)	Percent
Open Water	3,841	0%	245,778	6%
Wetland	22,126	2%	10,315	0%
Forested	34,276	3%	1,306,230	29%
Open Natural	56,582	4%	538,291	12%
Semi-Natural	1,162,786	90%	1,097,720	25%
Developed	12,400	1%	1,261,179	28%
Total Area	1,292,011	100%	4,459,513	100%

Table 5-4
Clearwater Creek riparian land cover by creek position

Land Cover Type	Creek Position			
	Upper		Lower	
	Area (m^2)	Percent	Area (m^2)	Percent
Open Water	67,483	6%	181,889	6%
Wetland	68,898	6%	94,914	3%
Forested	104,024	9%	534,931	19%
Open Natural	17,789	1%	358,893	13%
Semi-Natural	925,919	77%	1,475,439	52%
Developed	20,846	2%	185,243	7%
Total Area	1,204,959	100%	2,831,309	100%

Table 5-5
Irvine Creek riparian land cover by creek position

Land Cover Type	Creek Position			
	Upper		Lower	
	Area (m^2)	Percent	Area (m^2)	Percent
Open Water	72,367	3%	203,013	7%
Wetland	547,444	24%	68,803	2%
Forested	269,658	12%	233,823	8%
Open Natural	27,142	1%	93,670	3%
Semi-Natural	1,250,459	55%	2,412,448	78%
Developed	125,974	5%	71,855	2%
Total Area	2,293,044	100%	3,083,612	100%

The land cover analysis indicated that over half of the total lands within creek buffers have been altered by human development. Lands designated in the upper reach of the Whitemud, Blackmud, Clearwater, and Irvine Creek buffers were dominated by semi-natural land cover used primarily for agricultural activities. In many locations in the upper portions of these creeks, there were no naturally vegetated buffers between agricultural lands and creek channels. In some locations, the ephemeral headwaters of Whitemud Creek, were being farmed. However, the upper reach had a greater percentage of wetland cover than what was observed in the lower creek portions.

Developed areas, with minimal or highly manicured vegetation, typically increase in prevalence in the lower reach of the creek buffers where urban residential land use dominates the surrounding landscape. This is not the case with lands within the Irvine Creek buffer, where surrounding land use is predominantly rural. However, forested land cover appeared to increase in the lower reaches of Whitemud, Blackmud, and, to a lesser extent, Clearwater Creek buffers, potentially corresponding to increases in topological relief.

Limitations of the data include different land cover classification methods over the various datasets, lack of (or coarse nature of) land classification/wetland data in some areas, different quality of satellite imagery for rural areas in the study area, and availability of recent data.

5.2 RIPARIAN CHARACTERISTICS AND HEALTH

Riparian areas provide valuable ecological functions within their basins. These functions include trapping and storing sediments, stabilizing banks and shorelines, slowing flood water, recharging aquifers, reducing the amount of contaminants and nutrients entering waterbodies, reducing water velocity, and maintaining biodiversity across the landscape. Past and future human development puts pressure on the riparian and aquatic ecosystems in the Blackmud and Whitemud Creek basins.

The land cover analysis indicated that a significant portion of the riparian area in the upper reaches of the study area has been modified for agricultural purposes. The removal of woody vegetation and native plant species, along with the introduction of invasive species, has decreased the riparian area's resiliency against erosion and flooding. In addition to the modification of the riparian areas along Blackmud and Whitemud Creeks, alteration of the Blackmud Creek channel in its upper reaches has taken place to accommodate industrial land use. The straightening of the creek channel has increased the velocity of water moving downstream. The impact of modified riparian areas and stream channels at the headwaters of these major creeks is reflected in the intensity of sites with erosion concerns downstream.

Further studies assessing both at risk and reference sites along Blackmud and Whitemud Creek channels should be conducted to provide a more holistic representation of the overall riparian health.

5.3 RECOMMENDATIONS

The conservation and restoration of riparian areas along Whitemud, Blackmud, Clearwater, and Irvine Creeks, especially in their upper reaches should be a priority. A significant portion of the surrounding lands are being used for agricultural and rural residential uses. Pressure on the lower reaches of these creek systems is increasing as urban sprawl and industrial development continues. It is important to continue to protect and maintain the native forest and riparian communities surrounding the lower reaches of these creeks.

Further riparian health studies should be conducted that examine both reference and at risk sites within the upper, middle, and lower reaches of these creek systems in order to make informed restoration decisions. Communities within the Blackmud and Whitemud Creek basins should work with the local agricultural community to protect existing natural and wooded riparian areas on private land, and restore areas along the creek channels by implementing buffers and planting native woody vegetation. Riparian health should be assessed at regular intervals to determine if restoration goals are being met.

Erosion control measures in the mid to lower reaches of the creeks may be required to protect public and private infrastructure. This assessment has identified structures that may be at risk and could be candidates for bioengineering projects.

6 Wetland Functional Analysis

Wetland mapping that included high-level inventories were collected from various jurisdictions. Best available data were combined and a common classification system was applied to each wetland. The wetland mapping and classification data were used to perform a landscape level analysis and rating of capacity for wetland to provide both water quality and hydrologic functions using existing GIS data.

6.1 INVENTORY OF WETLANDS

Wetland inventories are conducted through remote sensing. Aerial photos and satellite imagery are evaluated and wetland extent is identified based on changes in vegetation, topography and signs of inundation or saturated soils. Wetland boundaries that are mapped using remote sensing methods should be considered approximate, and field investigations are required to confirm exact locations.

Wetland inventory data were acquired from existing sources described below. New wetland inventory data were created by AE using photo interpretation of satellite imagery where existing inventory data were not available. This included the Town of Beaumont and the southern-most portion of the study area in Wetaskiwin County. Wetlands associated with each dataset were combined and then classified. Due to the various mapping methods performed to create each dataset, accuracy and completeness vary across the study area. As described below, wetland mapping from each data source were reviewed to characterize limitations and some data were supplemented or updated to a limited degree.

City of Edmonton

Wetland mapping within the City of Edmonton comprises data from the Urban Primary Land and Vegetation Inventory (UPLVI) (Greenlink Forestry Inc. 2016). This includes wetlands that are 0.5 ha and larger. No wetland polygons were removed or modified, but a small number of additional wetlands were mapped and classified. Alberta Wetland Classes (marsh and swamp) were determined by the Site Type database codes that were provided for each wetland polygon in this dataset.

City of Leduc

GIS data that included mapped wetlands and riparian areas were provided by the City of Leduc. Each wetland polygon provided in the City of Leduc dataset was assigned a wetland class (Section 6.2). The majority of wetland polygons were not altered except where polygons were split to separate wetland classes, and where some small forested polygons were removed that were determined to likely be non-wetland.

Leduc County

The Leduc County Environmentally Significant Areas GIS data (Fiera, 2015) were incorporated, and comprises the majority of wetland mapping used for this study. Given the large area of the county, remote sensing methods used for wetland mapping resulted in limitations such that a large number of temporary or seasonal marshes that are very small in size were not mapped. Where some wetland polygons were reviewed and determined to likely be non-wetland, the polygon was removed. In the case of some riparian wetlands, some of these wetland polygons encompassed area beyond the wetland and some riparian wetlands were not mapped. Minimal modifications were made to these riparian wetland polygons, which could provide an overestimate of area covered by riverine wetlands. An exhaustive review of the existing wetland data was not conducted.

For the Leduc county wetland inventory data, AE applied the Alberta Wetland Classification System, but all wetlands were not evaluated due to quantity and time limitations. A small number of swamp and open water wetlands were classified, while the majority of wetlands were classified as marshes based on likelihood given landscape characteristics.

Strathcona County

The Alberta Merged Wetland Inventory (AMWI) dataset was used to map wetland coverage in the area of Strathcona County that lies northeast of the Blackmud Creek sub-watershed. The Canadian Wetland Classification System provided in this dataset was used to determine Alberta wetland class. A small subset of wetlands classified as fen were checked and were changed to swamp or marsh based on likelihood due to landscape position. Minimal modifications to wetland polygons were made other than splitting polygons to separate wetland classes or deleting a few small polygons that were determined to likely be non-wetland.

6.2 CLASSIFICATION OF WETLANDS

All wetlands included in the wetland inventory were assigned a class (i.e., marsh, swamp, and shallow open water) following the Alberta Wetland Classification System (GoA 2015). This was conducted using different approaches based on the available data (Section 6.1). Form and type described in the classification system were not assigned for purposes of this study.

All wetlands were also assigned a Hydrogeomorphic (HGM) class (i.e., depressional, riverine, and lake fringe) based on the Hydrogeomorphic Classification System by Brinson (1993). HGM classification is based on the geomorphic setting, water source, and hydrodynamics as described below. The three HGM classes used in this assessment include:

Depressional

- Wetlands that occur in topographic depressions.
- Sources of water are precipitation, groundwater discharge, and runoff.
- The direction of water movement is normally from the surrounding uplands toward the center of the depression.

Lake Fringe

- Wetlands that are located adjacent to lakes where water elevation of the lake maintains the water table in the wetland.
- The direction of water movement is bidirectional and horizontal between the lake and the wetland.

Riverine

- Wetlands that occur in floodplains and riparian corridors associated with stream channels.

- The direction of water movement is predominantly unidirectional and horizontal following the same direction of stream flow.

To evaluate for riverine wetlands, each data source was queried for wetlands within a 20 m buffer of named creeks. These wetlands were then evaluated to determine if they met riverine or depression wetland criteria.

To evaluate for lake fringe wetlands, GIS data for waterbodies were queried for waterbodies greater than 8 ha then checked using satellite imagery to confirm open water extent meet the 8 ha criterion. While the depth of the waterbody is used for identifying lake fringe wetlands, this was not modelled on GIS and the extent of open water was the only parameter taken into account. Remaining wetlands not classified as riverine or lake fringe were classified as depression wetlands. Other HGM classes (e.g., slope, organic flat, etc.) are not likely to occur in the study area and were assumed to be absent.

6.3 LIMITATIONS OF WETLAND INVENTORY AND CLASSIFICATION DATA

Limitations of the wetland inventory generated for this assessment include:

- Wetland classification for fen and swamp classes were not always accurate.
- A large number of depressional mashes were not mapped across the study area, except for Strathcona County.
- Riverine wetlands were only identified along major watercourses or named creeks (mainly Whitemud, Blackmud and Clearwater Creeks). If riverine wetlands were noticed along tributaries of named creeks while reviewing datasets, then they were added to the riverine dataset. However, gaps in riverine wetland data along larger tributaries is likely.

Future and more detailed studies can improve the wetland inventory in the study area by conducting additional image analysis to delineate and capture small area depressional wetlands, increase accuracy of wetland boundaries, and update classifications.

6.4 ANALYSIS OF WETLAND FUNCTION

Wetland functions result in values to society. For example, wetlands are capable of intercepting nonpoint sources of nitrate from agriculture, which provides a value as it benefits the community with improved drinking water quality. Wetlands provide many functions and values. This study focuses on two key areas that relate to surface water management: water quality functions and hydrologic functions.
Water quality improvement functions relate to a wetland’s filtering capabilities. As surface runoff water passes through, the wetlands retain excess nutrients and some pollutants, and remove sediment.

Hydrologic functions include flood storage and erosion protection. Flood storage functions relate to the ability of wetlands to retain and slowly release surface water and to contain vegetation that can reduce speed of flood waters. The water storage and braking action can lower downstream flood heights and reduce erosion. Additionally, wetlands at the margins of lakes and rivers protect shorelines and stream banks against erosion as wetland plants hold the soil in place via their roots and energy of erosive forces such as waves along the shore.

This study incorporated a Hydrogeomporphic (HGM) Approach to assess the capacity of a wetland to perform functions. The concept is based on the fact that wetlands in different HGM classes have different processes that govern the way they function. Therefore, function assessment cannot be approached in the same manner for the different HGM classes.

6.5 WETLAND FUNCTION RATING AND CATEGORIES

Wetlands were evaluated using a landscape-level approach to assess wetland function within the study area. This approach allows the assessment of wetland functional capacity based on the position of each wetland in the landscape. Position in the landscape relates to the opportunity for the wetland to provide functions and values. For example, a wetland's proximity to specific land uses that generate pollution will influence the potential to provide functions associated with water quality improvement.

Understanding functions on a landscape-level is an important decision-making tool as it provides the opportunity to consider implications of losing wetland functions and values in specific locations as developed areas expand (e.g. wetlands that should be retained on the landscape to avoid costly issues associated with flooding or water quality).

Also important is the wetland's site-specific characteristics as they pertain to functional capacity. These characteristics are critical to the ability of a wetland to provide function. However, the site potential of wetland functional capacity was not included in this study due to the time required and high-level nature of this study. Site potential would require site visits and/or image analysis of each wetland in the study area, and can be considered for future studies.

For the purposes of this study, a wetland function rating system was developed. The rating system included attributes to estimate the potential for water quality and hydrologic functions of wetlands based on landscape position. Each element was based on Washington State Wetland Rating System for Eastern Washington (Hruby 2014), but was simplified to allow GIS analysis of remotely sensed data thereby eliminating the need to conduct a site visit or image analysis of each individual wetland.

This system uses an HGM approach to assessing wetland functions by establishing a different analysis for each HGM class. Therefore, attributes that were assessed vary between HGM classes as described below.

The rating system was applied to each mapped wetland (excluding modified waterbodies such as stormwater ponds). Scores were assigned based on answers to each question (Yes=1 point, or No= 0 points unless otherwise specified). The rating of each wetland's functional capacity based on it's landscape potential is as follows:

- 3 or more = High
- 1 or2 = Medium
- 0 = Low

DEPRESSIONAL WETLANDS

Water Quality Function Rating of Landscape Potential

- Does the wetland receive stormwater discharges (i.e., within 30 m of developed areas likely to generate urban runoff)?
- Is the wetland within 50 m of landuse that generates pollutants (i.e., agricultural, residential, commercial, urban)?
- Are septic systems within 75 m (i.e., in close proximity to residences outside city/town corporate limits)?
- Is there another source of pollutants coming into wetland not listed above (i.e., industrial)?

Hydrologic Function Rating of Landscape Potential

- Does the wetland receive stormwater discharges (i.e., within 30 m of developed areas likely to generate urban runoff)?
- Is the wetland within 50 m of landuse that generates runoff (i.e., agricultural, residential, commercial, urban)?
- Is more than 25% of the 50 m wetland buffer covered by intensive uses (e.g., residential, urban, commercial, agriculture)?

LAKE FRINGE WETLANDS

Water Quality Function Rating of Landscape Potential

- Is the lake used by power boats?
- Is the wetland within 50 m of land uses that generate pollutants (industrial = 2 points)?
- Average width of vegetated wetland along the shore is:
  - More than 20 m (3 points)
  - Between 10-20 m (1 point)
  - Less than 10 m (0 points)

Hydrologic Function Rating of Landscape Potential

- Is the lake used by power boats?
- Is the fetch on the lake side of the wetland at least 1.5 km in distance?
- Vegetation in wetland is:
  - At least 25% woody vegetation (3 points)
  - Not 25% woody vegetation but at least 2 m wide (1 point)
  - Less than 2 m (0 points)

RIVERINE WETLANDS

Water Quality Function Rating of Landscape Potential

- Is the wetland within corporate limits of a city or town? (yes=2 points)
- Does the contributing basin include a city/town? Yes= 1 if there's a city upstream of the wetland but the wetland is not within it's boundaries (answer no if preceding question was yes).

- Does at least 10% of the contributing basin contain of the creek include tilled fields or pastures?
- Is the wetland within 50 m of land uses that generate pollutants?
- Are there other sources of pollutants that are not listed above (i.e., industrial)?

Hydrologic Function Rating of Landscape Potential

- Does the up-gradient watershed include an area within corporate limits of a city/town?
- Is the up-gradient stream or river controlled by dams? (no=1)
- Is there at least 25% woody vegetation cover?

6.6 SUMMARY AND CONCLUSIONS

Results of the analysis are shown on maps in Appendix E for water quality functions and Appendix F for hydrologic functions. These maps show all wetlands included in the wetland inventory as well as their individual functional rating. A summary of wetland function rating is provided in Table 6-1. Appendix G includes maps showing wetland inventory data with the assigned Alberta Wetland Classification.

This analysis applies the concept that the location of wetlands in the landscape are directly related to their functional capacity as it pertains to the opportunity for a wetland to perform functions. Removing wetlands from the landscape and replacing them in different locations does not necessarily replace functions being lost. Typically, wetland replacement occurs outside the sub-basin where wetland loss took place due partly to land availability and land value. Therefore, assessing wetland functions is critical to land planning to ensure an understanding of functions being lost, cumulative impacts associated with surface water management, and the potential need for mitigation measures.

Both the Alberta Wetland Policy (2013) and Mitigation Directive (2016) require the proponent of development to utilize the Wetland Mitigation Hierarchy to inform their management approach to wetland impacts. This hierarchy involves the following steps:

- Avoidance – avoid impacts to wetlands
- Minimization – where avoidance is not possible, minimize impacts to wetlands
- Replacement – where avoidance and minimization efforts are not feasible or ineffective, wetland replacement is required.

Under the Alberta Wetland Mitigation Directive, wetland replacement can take several different forms including purchasing credits from a third party wetland bank, an in-lieu fee payment to a restoration agent, or permittee-responsible replacement. Replacement can also take the form of non-restorative options such as support for the advancement of wetland science, education, and outreach programs. Unfortunately, these options often result in a net loss of functional wetlands within a local sub-basin or catchment area.

Table 6-1
Wetland area by HGM class and functional rating

Potential Functional Rating	HGM Wetland Class					
	Depressional		Riverine		Lake Fringe	
	Numbers of Wetlands	Area of Wetlands (ha)	Numbers of Wetlands	Area of Wetlands (ha)	Numbers of Wetlands	Area of Wetlands (ha)
Water Quality Function						
Low	82	9.3	0	0	0	0
Medium	1912	546.3	93	128.1	10	293.1
High	54	21.8	105	306	12	406.6
Hydrologic Function						
Low	82	9.3	0	0	10	260.6
Medium	1613	324.3	172	416.6	9	390.8
High	353	243.8	26	17.6	3	48.3
Wetland Totals						
Total	2048	577.3	198	434.2	22	699.8

6.7 RECOMMENDATIONS

The mitigation hierarchy outlined in the Alberta Wetland Policy requires that wetland impacts are avoided and minimized to the extent practicable, and to replace wetlands that cannot be avoided. This responsibility is left up the project proponent and is done on a per-project basis. It is recommended that evaluating the loss of wetland area and function be incorporated in activities associated with land use planning as well as municipal policy development.

This can generate opportunities to address the concern that wetlands provide important functions and values related to their landscape position. Retaining wetlands on the landscape in specific locations is an important consideration for watershed health. As wetlands are removed and replaced outside the watershed, impacts to water quality and hydrologic health will result.

The current provincial regulatory process does not include incentives for wetland replacement to take place on the same property or within the same sub-basin where wetland loss took place. The availability of restoration agencies to conduct wetland replacement on behalf of the permittee can be either more affordable or require less work. This loss of wetland area and function is a growing concern for wetland municipalities as many have seen up to 90 percent of wetland loss in highly developed areas. Municipal wetland policies are encouraged by the provincial government so that wetland management objectives that are specific to a local jurisdiction can be achieved.

Opportunities associated with municipal wetland policy include:

- Establish local wetland conservation plans
- Incorporate wetlands into park systems and environmental reserves
- Develop detailed wetland inventories with site-specific function analyses and use the information as a tool for land use planning
- Include wetlands in policy development; consider identifying wetland areas where onsite replacement instead of in-lieu fee payment should take place
- Establish wetland replacement opportunities within the sub-basin (i.e., a wetland mitigation bank) to help ensure wetlands functions and values are retained on a local-level
- Develop regulatory framework to protect wetland buffers

A challenge to mitigating effects on a watershed relevant to surface water management is the many changes that can cause adverse effects. Changes to the landscape that result in a loss of wetland area and function is only one aspect. However, it is one of increasing importance and must be incorporated into land use planning. The broad assessment of wetland function in this study is an overview. Opportunity exists to increase its utility for land-use planning as more detailed mapping and analyses are completed.

7 Water Quality Analysis

The objectives of the water quality analysis were to review existing surface water quality data for significant watercourses (i.e., creeks, tributaries) and waterbodies (i.e., lakes, wetlands), establish baseline conditions, and assess potential impacts on water quality as a result of continued development.

7.1 EXISTING WATERSHED CHARACTERISTICS

The Blackmud and Whitemud watersheds (Blackmud/Whitemud watersheds) are located immediately south of the City of Edmonton, and mostly within Leduc County and the southern part of Strathcona County. The larger Whitemud watershed drains to the north via several tributaries that lead to Whitemud Creek, which then joins with Blackmud Creek before ending up in the North Saskatchewan River. Similarly, the Blackmud watershed (which is located within the Whitemud Creek drainage basin) drains to the north via several tributaries and two major creeks (Irvine Creek and Clearwater Creek) that lead to Blackmud Creek, which then flows north to its confluence with Whitemud Creek.

There are several existing communities within the Blackmud/Whitemud watersheds including the City of Edmonton, City of Leduc, Town of Beaumont, and various hamlets (e.g., Nisku, Looma, Kavanagh, Rolly View, New Sarepta). Continued development in these areas can potentially result in the deterioration of water quality in the Blackmud/Whitemud watersheds if left unmanaged over the long term (i.e., cumulative effects). Development and operations that can lead to the deterioration of water quality include both point and non-point source inputs related to agricultural activities and runoff, municipal development (e.g., stormwater and runoff inputs, on-site wastewater disposal), recreational use (e.g., golf courses, boating), and industrial and commercial developments (e.g., airport).

Current land use within the Blackmud/Whitemud watersheds includes agricultural use located throughout the drainage basins, but concentrated in the southern part of the Whitemud Creek drainage basin, and the southern and eastern parts of the Blackmud drainage basin. Industrial and commercial development is primarily located in the northern parts of the Blackmud/Whitemud watersheds near the City of Edmonton's southern limit, and along the east and west sides of Highway 2 near Nisku, Leduc, and the Edmonton International Airport. There are various residential developments and small hamlets distributed throughout the southern parts of the Blackmud/Whitmud watersheds. There are numerous recreational opportunities across the watershed including several golf courses. There are various lakes located throughout the Blackmud Creek drainage basin that are potentially used for recreation/open space including Telford Lake, Cawes Lake, Ord Lak, Saunders Lake, Looking Back Lake, Levering Lake, and Schultz Lake.

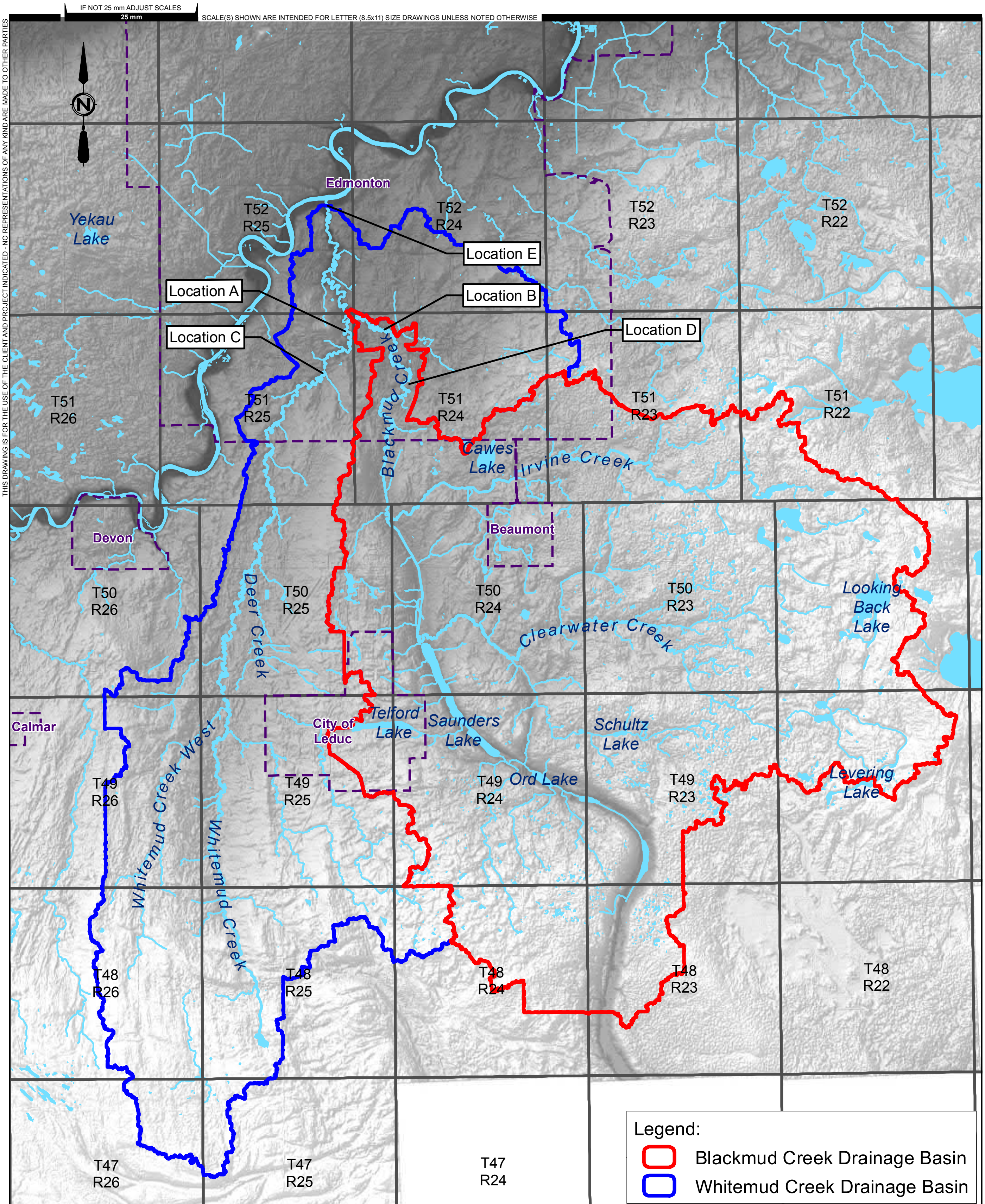
7.2 HISTORICAL AND CURRENT WATER QUALITY

Historically (i.e., pre-1985), the availability of water quality data is limited in quantity (i.e., limited to only a few reports) and temporal extent (i.e., short sampling periods) for the Blackmud/Whitemud watersheds (Hardy Associates Ltd. 1985). The locations for the six locations (i.e., Locations A to E) are shown in **Figure 7-1** and a summary of the water quality data is provided in **Table H-1** in **Appendix H**.

Water quality data were available for general water quality parameters (e.g., total dissolved solids, sulphate, chloride, biochemical oxygen demand, chemical oxygen demand, total suspended solids), select nutrients (e.g., nitrogen, phosphorus), and limited bacteriological and metal parameters. Generally, surface water quality in the area was fairly consistent. However, upper rural reaches of the Blackmud/Whitemud watersheds were typically less impacted (based on total dissolved solids and chloride concentrations) than the lower reaches. A slight deterioration of water quality in the lower reaches (i.e., northern areas of the drainage basins near the City of Edmonton) may be associated with increased urban development. Water quality data were limited to the northern part of the Blackmud/Whitemud watersheds and representative of the Blackmud and Whitemud Creeks only. There is no available information on other tributaries or waterbodies throughout the watersheds.

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

THIS DRAWING IS FOR THE USE OF THE CLIENT AND PROJECT INDICATED - NO REPRESENTATIONS OF ANY KIND ARE MADE TO OTHER PARTIES



P:\20163785\00_Blackmud_Whitemud\Working_Dwgs\010_GIS\ArcMap\01_Environmental\Figure1_Pre1985.mxd
DATE: 6/27/2017,

Associated Engineering

AE PROJECT No. 2016-3785
SCALE 1:270,000
APPROVED
DATE 2017 JUNE
REV
DESCRIPTION ISSUED FOR REPORT

FIGURE No. 7-1

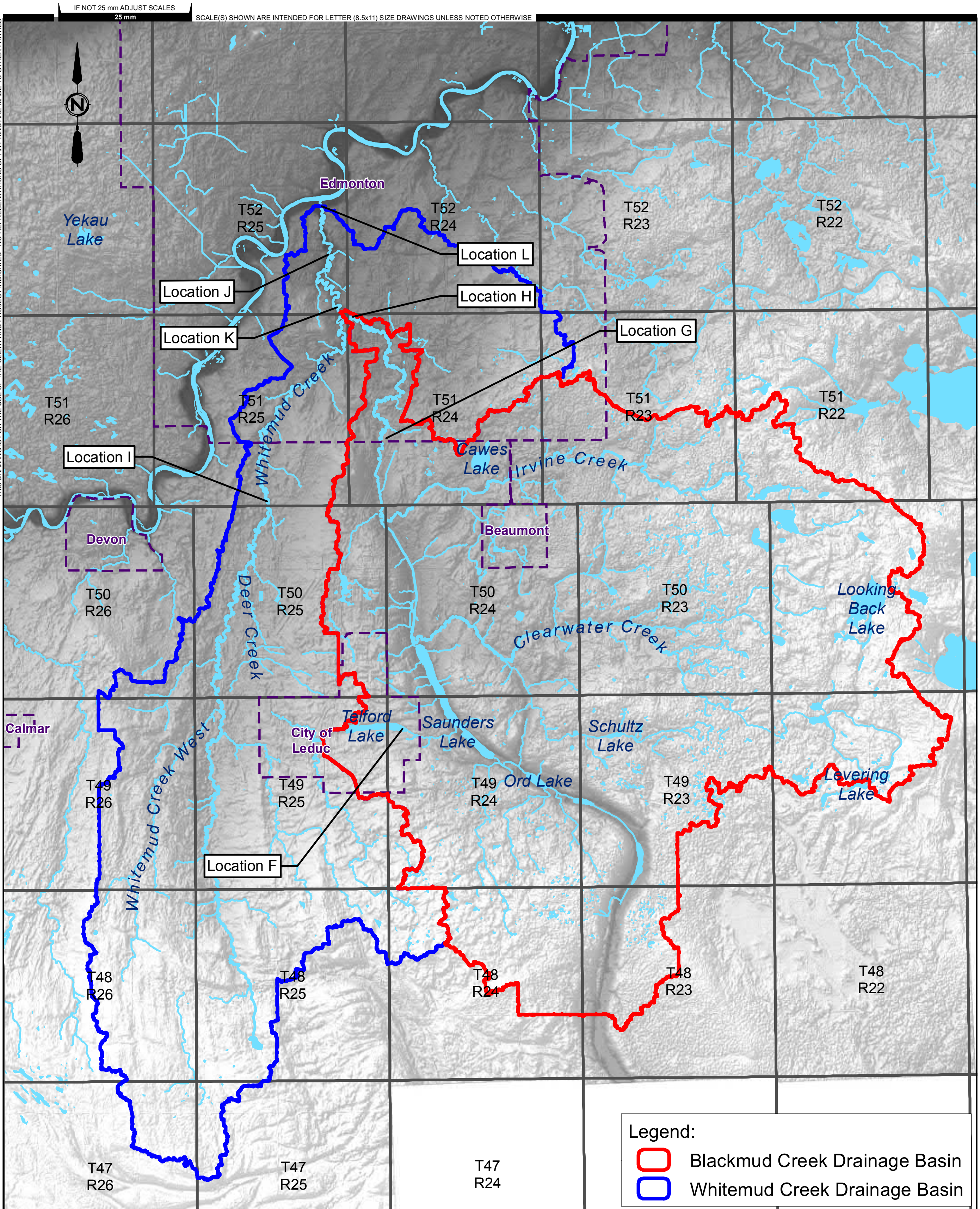
BLACKMUD/WHITEMUD CREEK WATERSHED MANAGEMENT STUDY

BLACKMUD/WHITEMUD WATERSHED WATER QUALITY PRE-1985

Similar to the summary for the pre-1985 time period, water quality data were mostly available for locations along the lower reaches of the Blackmud and Whitemud Creeks and included general water quality parameters along with selected nutrients. Detailed water quality data were available for Telford Lake located within the Blackmud Creek drainage basin, which included concentrations for total and dissolved metals, and select organics (e.g., benzene, toluene, ethylbenzene, xylene, F1 to F3 fractions). Telford Lake is associated with slightly elevated concentrations of Total Kjeldahl Nitrogen (TKN), total phosphorus, and chloride, when compared to the other sampling locations. Data for other time periods or other lakes in the area were not available, and thus it could not be determined if the difference was due to natural variability or the result of human activities. Total suspended solids (TSS) concentrations were the highest in the lower reaches of Whitemud Creek and its confluence with Blackmud Creek, which was consistent with the pre-1985 data. Elevated TSS concentrations may be related to urban development in this area.

The seven water quality data collection locations (i.e., Locations F to L) for the period between 1985 and 2010 are shown in **Figure 7-2** and are summarized **Table H-2** in **Appendix H**.

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



P:\20163785\00_Blackmud_Whitemud\Working_Dwgs\010_GIS\ArcMap\01_Environmental\Figure2_1985-2010.mxd
DATE: 6/27/2017,

Associated Engineering

AE PROJECT No.	2016-3785
SCALE	1:270,000
APPROVED	
DATE	2017 JUNE
REV	
DESCRIPTION	ISSUED FOR REPORT

FIGURE No. 7-2

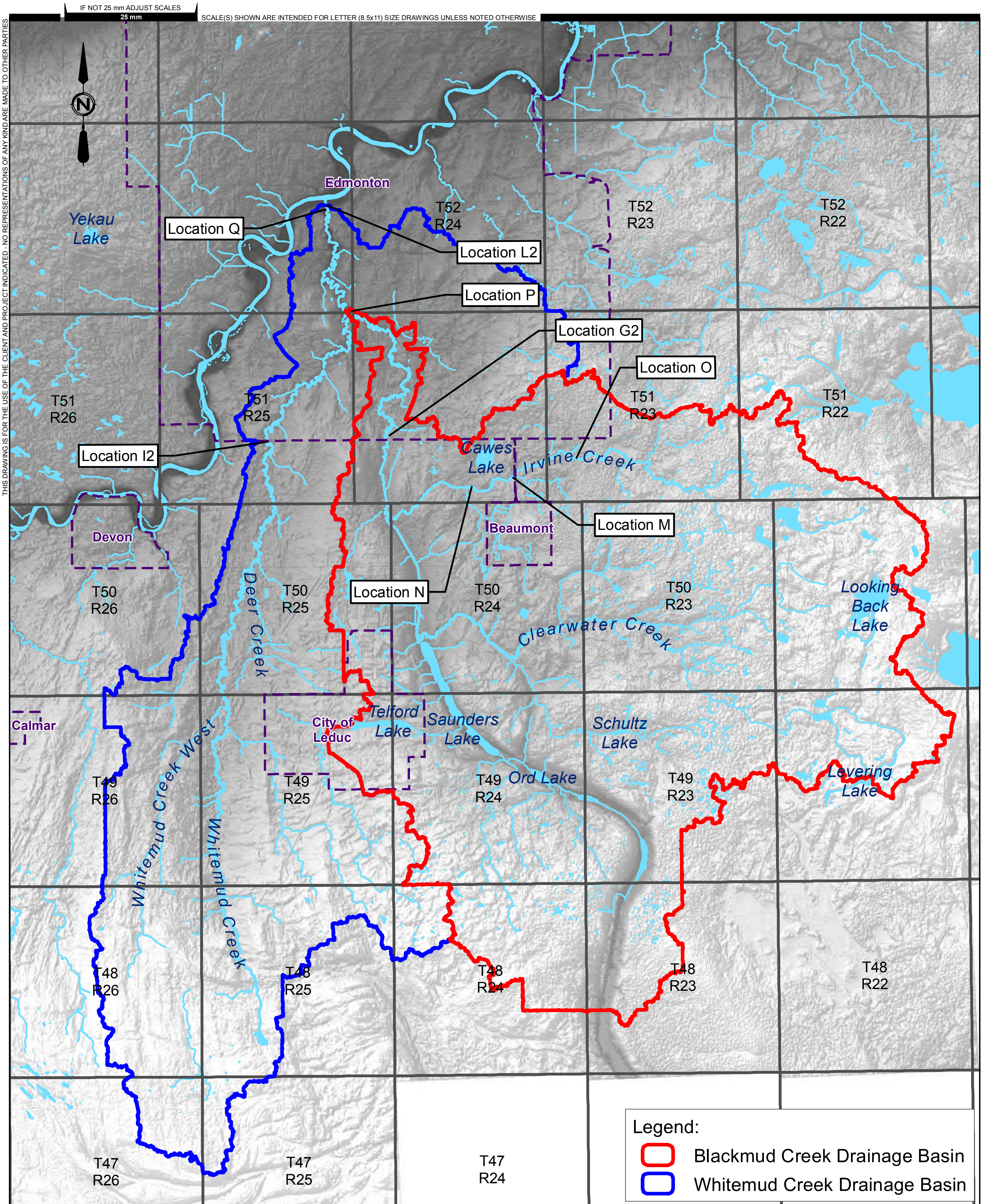
BLACKMUD/WHITEMUD CREEK WATERSHED MANAGEMENT STUDY

BLACKMUD/WHITEMUD WATERSHED WATER QUALITY 1985 - 2010

Most water quality data are associated with locations along the lower reaches of the Blackmud/Whitemud watersheds. Water quality data for Locations G2, I2, and L2 in **Table H-3** were compared to the water quality data for Locations G, I, and L in **Table H-2**, which provided an indication of potential water quality changes over time at the same locations. Total Kjeldahl Nitrogen and chloride concentrations at these locations from 1985 to 2010 were consistent with the observed concentrations from 2011 to 2015. This was consistent for most parameters except for a slight increase in total phosphorus, nitrate and nitrite (as N), total suspended solids (in the upper reach of Blackmud Creek near Location G2, and at the mouth of the Whitemud Creek where it joins the North Saskatchewan River), and biochemical oxygen demand concentrations. During this time period, general water quality data were also available for Irvine Creek (tributary of Blackmud Creek), however, data were limited to turbidity, dissolved oxygen, pH, and conductivity measurements only. Based on the turbidity measurements, TSS concentrations were lower than those observed at most other locations.

Locations for eight more recent water quality data locations for the period between 2011 and 2015, are shown in **Figure 7-3** and are summarized in **Table H-3**, in **Appendix H**.

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



P:\20163785\00_Blackmud_Whitemud\Working_Dwgs\010_GIS\ArcMap\01_Environmental\Figure3_2011-2015.mxd
DATE: 6/27/2017,

Associated Engineering

AE PROJECT No.	2016-3785
SCALE	1:270,000
APPROVED	
DATE	2017 JUNE
REV	
DESCRIPTION	ISSUED FOR REPORT

FIGURE No. 7-3

BLACKMUD/WHITEMUD CREEK
WATERSHED MANAGEMENT STUDY

BLACKMUD/WHITEMUD WATERSHED
WATER QUALITY 2011 - 2015

7.3 SUMMARY AND CONCLUSIONS

To accurately assess potential impacts on water quality as a result of current and future development, a good understanding of baseline water quality is needed. Although limited spatially, temporally, and in detail with respect to the nature parameters, the data presented in this report provide basic information that can be used to assess impacts on surface water quality to date, and guide future management decisions (including recommendations presented in the next section) to assess and minimize impacts on surface water quality in the Blackmud/Whitemud watersheds in the future.

Associated provides the following conclusions based on this limited investigation:

- Surface water quality data for general water quality parameters are readily available for the lower reaches of Whitemud and Blackmud Creeks through various ongoing monitoring programs managed by the City of Edmonton, the RiverWatch Institute of Alberta, and the Government of Alberta, and provides a reasonable indication of cumulative effects from within the watersheds over time.
- Surface water quality data for the upper reaches of the Blackmud/Whitemud watersheds (i.e., southern and eastern areas), key tributaries of the Blackmud and Whitemud Creeks, and larger waterbodies (e.g., Telford Lake, Cawes Lake, Ord Lak, Saunders Lake, Looking Back Lake, Levering Lake, Schultz Lake) are distinctly lacking, making it difficult to assess source-specific impacts and contaminant loads that can be used to make management decisions and identify required protection measures in the short term.
- There is a significant lack of baseline surface water quality data in all areas of the watersheds related to metals and other organic parameters, which would provide better information on potential impacts as a result of continued industrial or commercial development activities in the watersheds.
- Based on observed concentrations of TSS and biochemical oxygen demand, surface water quality near urban developments (e.g., residential, commercial, and industrial developments) may contribute to localized impacts on surface water quality when compared to the upper reaches associated with mostly agricultural activity.
- Current development practices (i.e., development plans and practices, policy) appear to be sufficient in terms of maintaining surface water quality in the lower reaches of Blackmud and Whitemud Creeks. However, with projected increases in development for the area, this may not be the case, which would warrant the implementation of a more robust water quality monitoring program.
- Dilution may play an important role in the lower reaches of Blackmud and Whitemud Creeks in mitigating cumulative effects and long-term anthropogenic impacts in these watercourses, as other general water quality parameters were relatively consistent over time. However, no conclusion could be drawn for the upper reaches of the Blackmud and Whitemud Creeks and their associated tributaries (e.g., Irvine Creek, Clearwater Creek, Deer Creek) and waterbodies (e.g., lakes).
- Slightly elevated concentrations of total phosphorus, and nitrate and nitrite concentrations, in the lower reaches of Whitemud and Blackmud Creeks over time may suggest some susceptibility to nutrient enrichment. However, further monitoring would be required to accurately assess the

potential impact, which may or may not be the result of urbanization, or agricultural and recreational practices in the area.

7.4 RECOMMENDATIONS

Based on the surface water quality analysis, the following recommendations are provided to establish a better understanding of the baseline surface water quality conditions and current trends, identify potential contaminant inventories and conduct source characterization of anthropogenic inputs, and guide the development of a management framework (including governance) to track changes and minimize surface water quality impacts in the future.

Conduct a further baseline surface water quality assessment that includes the following tasks:

- Conduct exhaustive water quality database searches, to compile and summarize water quality information for other areas of the Blackmud/Whitemud watersheds (e.g., significant tributaries and waterbodies).
- Undertake contaminant inventory and source characterization for potential contaminant pathways that enter the surface waters of the watersheds. This would include: identifying point-source and non-point source municipal, industrial, commercial and agricultural inputs by examining existing licence, permits, approvals from municipal and provincial regulators; examining the locations of stormwater and wastewater infrastructure, use, and discharges; contacting personnel responsible for these operations for water quality data; and identifying and prioritizing potential contaminants of concern that may enter the watersheds.
- Conduct baseline water quality testing at additional locations in the watersheds focusing on the upper reaches to the south and east of the watersheds, and key tributaries, lakes, and wetlands. At a minimum, sample collection and analysis should be completed on a seasonal basis for a period of one year. This will help establish baseline water quality data in areas where there is no existing water quality information.
- Expand the list of parameters for analysis beyond the general water quality parameters noted in this report, developed with site-specific knowledge (e.g., recreational, fish bearing, irrigation, livestock watering) of the receiving environment, and potential industrial and commercial inputs. At a minimum, the parameters should include nutrients, total metals, and organics (e.g., petroleum hydrocarbons, oil and grease) that are included in the Government of Alberta's Environmental Quality Guidelines for Alberta Surface Waters (2014), and that are indicative of commercial and industrial development.
- Incorporate tracking/testing of emerging contaminants of concern (ESOCs) such as specific pesticides and trace organics (e.g., endocrine disrupting chemicals, pharmaceuticals and personal care products, flame retardants and fire-fighting chemicals and dispersants, and other micro-constituents). Research has shown that effluent from commercial and industrial facilities that have un-managed or inadequate treatment and disposal systems, on-site wastewater disposal, agricultural operations and runoff, and untreated stormwater flows, and urban runoff can result in the release of these compounds into surface and groundwater resources.

- With recently emerging guidelines for specific ESOCs at the federal level, monitor for select compounds that are associated with emerging guidelines and that prioritized according to risk.

Once a good understanding of baseline water quality for all areas of the watershed is obtained, a watershed protection plan should be developed and implemented, which would include detailed source protection policy and management. Considerations should include:

- The development and implementation of a long-term water quality monitoring program that encompasses the entire Blackmud/Whitemud watersheds including key tributaries, lakes, and wetlands, which can be used to monitor surface water quality conditions and assess trends based on development rates.
- The development of a framework and governance structure, that includes all stakeholders, and identifies the responsible authority for the management of this program. The development of a multi-stakeholder watershed management stewardship group has been used to successfully manage similar programs in the past, while minimizing the associated costs and resources for all stakeholders involved.

By implementing the recommendations, and moving forward with the development of a watershed management plan, stakeholders will be better able to monitor potential short- and long-term impacts on surface water quality as a result of increased development activity within the watershed. Changes in surface water quality could inevitably lead to adverse ecological (e.g., aesthetics of lakes, fish and fish habitat in lakes and creeks) and human health (e.g., recreational use of waterbodies, drinking water or other supply uses) effects. Early detection of adverse trends in surface water quality through established monitoring programs will allow decision makers to take appropriate courses of action in a timely manner (e.g., policy), while remaining compliant with current and future regulatory requirements and ensuring public safety and environmental protection.

Closure

This Technical Memo was prepared for the Blackmud/Whitemud Creek Surface Water Management Group to characterize the study area and provide recommendations for additional data collection and analyses to guide sound land use decision making processes.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,

Tonderai Chakanyuka, MBA, P.Eng, PMP, C.Eng
Project Manager

Kristen Andersen, B.Sc., PWS, CPESC
Senior Environmental Scientist

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

ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF
Signature:
Date: Oct 21, 2016

APEGA Permit to Practice P 3979

References

Abacus Datagraphics Database (Abadata2). 2016. Abadata 2. Available online at: http://abadata.ca/ Accessed October 4, 2016.

Alberta Environment and Sustainable Resource Development (ESRD). 2015. Alberta Wetland Classification System. Water Policy Branch, Policy and Planning Division, Edmonton, AB.

AMEC Environment and Infrastructure. 2011. Whitemud/Blackmud Creek Erosional Sites Characterization Study Stage 2 Final Report. Submitted to City of Edmonton Drainage Services. Edmonton, Alberta.

Brinson, M.M. 1993. A Hydrogeomorphic Classification for Wetlands. Prepared for U.S. Army Corps of Engineers. Wetland Research Program Technical Report WRP-DE-4.

Brooks, K.N., P.F. Ffolliott, and J.A. Magner. Hydrology and the Management of Watersheds (Kindle Locations 7187-7188). Wiley. Kindle Edition.

City of Edmonton. 1993. Inventory of Environmentally Sensitive and Significant Natural Areas. Consolidated Technical Report Available online at: http://www.edmonton.ca/city_government/documents/Geowest_1993_Inventory_of_ESA_and_SNAs.pdf. Accessed October 4, 2016.

City of Edmonton. 2010. The Way We Grow, Municipal Development Plan, Bylaw 15100. Available online at: https://www.edmonton.ca/city_government/documents/PDF/MDP_Bylaw_15100.pdf. Accessed October 4, 2016.

City of Edmonton. 2014. North Saskatchewan River Valley Area Re-development Plan Bylaw 7188. Adopted on February 26, 1985, Office Consolidation, September 2014. Prepared by City of Edmonton Sustainable Development, Current Planning Branch, Edmonton, AB. Available online at: http://capitalregionboard.ab.ca/-/media/7-North-Saskatchewan-River-Valley-ARP1.pdf. Accessed October 4, 2016.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2015. Database of Wildlife Species Assessed by COSEWIC. Available online at: http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm. Accessed October 4, 2016.

County of Leduc. 2014. Municipal Development Plan. Available online at: http://capitalregionboard.ab.ca/-/media/13-Leduc-County-MDP-and-Amendments.pdf . Accessed October 4, 2016.

County of Leduc. 2015. Leduc County Environmentally Significant Areas Study. Available online at: http://www.leduc-county.com/public/download/documents/12116. Accessed October 4, 2016.

Fiera Biological Consulting Ltd. (Fiera). 2015. Leduc County Environmentally Significant Area Study. Report Prepared for Leduc County. Fiera Biological Consulting Report #1358.

Geowest Environmental Consultant Ltd. (Geowest). 1997. Prioritized Landscape Ecology Assessment of Strathcona County, Alberta. Available online at: http://www.strathcona.ca/departments/planning-development-services/environment/plea/. Accessed September 22, 2016.

Geowest Environmental Consultant Ltd. (Geowest). 1999. Natural Areas in the City of Edmonton, assessment of Conservation Value and Potential. Available online at: https://www.edmonton.ca/city_government/documents/Geowest_1999_Natural_Areas_in_Edmonton_Assessment_of_Conservation_Value_and_Potential.pdf. Accessed September 22, 2016.

Government of Alberta. 2006. Natural Regions and Subregions of Alberta. Alberta. Available online at: https://www.albertaparks.ca/media/2942026/nrsrcomplete_may_06.pdf. Accessed September 15, 2016.

Government of Alberta. 2009. Environment and Parks. Sharp-tailed Grouse *(Pedioecetes phasianellus).* Available online at: http://aep.alberta.ca/fish-wildlife/wild-species/birds/grouse-related-birds/sharp-tailed-grouse.aspx. Accessed October 4, 2016.

Government of Alberta. 2011. Wild Species Status Search. Alberta Environment and Parks. Alberta. Available online at: http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. Accessed September 15, 2016.

Government of Alberta. 2014. Codes of Practice: Pipelines/Telecommunication Lines Crossing a Waterbody/Watercourse Crossing. St. Paul Management Area Map. Available online at: http://aep.alberta.ca/water/legislation-guidelines/documents/StPaul-CodePracticeCross-Map-2012.pdf. Accessed September 22, 2016.

Government of Alberta. 2014b. Fish and wildlife management information system (FWMIS). Alberta Environment and Parks. Available online at: https://maps.srd.alberta.ca/FWIMT_Pub/default.aspx?Viewer=FWIMT_Pub. Accessed October 4, 2016.

Government of Alberta. 2015. Alberta Conservation Information Management System (ACIMS). Alberta Environment and Parks. Available online at: http://www.albertaparks.ca/acims-data. Accessed September 22, 2016.

Government of Alberta. 2015a. Agricultural Regions of Alberta Soil Inventory Database (AGRASID) Available online at: http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/All/sag14652 Accessed September 22, 2016.

Government of Alberta. 2015b. Alberta Wetland Classification System. Water Policy Branch, Policy and Planning Division, Edmonton, AB.

Government of Alberta. 2015c. Recommended Land-use Guidelines: Key Wildlife and Biodiversity Zones. Available online at: http://aep.alberta.ca/fish-wildlife/wildlife-land-use-guidelines/documents/KeyWildlifeBiodiversityZones-Apr08-2015.pdf. Accessed September 22, 2016.

Government of Alberta. 2015. Flood Hazard Identification Program. Available online at: http://aep.alberta.ca/water/programs-and-services/flood-hazard-identification-program/default.aspx Accessed: Oct. 7, 2016

Government of Alberta. 2016. Alberta Merged Wetland Inventory. Available online at: https://genesis.srd.alberta.ca/genesis_tokenauth/rest/services/Alberta_Merged_Wetland_Inventory/Latest/MapServer/. Accessed September 22, 2016.

Government of Alberta. 2016a. Listing of Historic Resources: Instructions for Use. Available online at: http://culture.alberta.ca/heritage-and-museums/programs-and-services/land-use-planning/docs/listing-instructions-2016.pdf. Accessed October 4, 2016.

Government of Canada. 1999. A National Ecological Framework for Canada. Available online at: http://sis.agr.gc.ca/cansis/nsdb/ecostrat/1999report/index.html. Accessed September 22, 2016.

Greenlink Forestry Inc. 2016. Urban Primary Land and Vegetation Inventory (UPVLI). Prepared for Parks and Biodiversity, Sustainable Development. Edmonton, AB.

Hardy Associates Ltd. 1985. Watershed Plan for Whitemud and Blackmud Creeks, Geotechnical and Evironmental Evaluation.

Hruby, T. 2014. Washington State Wetland Rating System for Eastern Washington: 2014 Update. (Publication #14-06-030). Olympia, WA: Washington Department of Ecology.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial processes in geomorphology. San Francisco, CA: W.H. Freeman and Company.

North Saskatchewan Watershed Alliance. 2012. Atlas of the North Saskatchewan River Watershed in Alberta. The North Saskatchewan Watershed Alliance Society. Edmonton, Alberta. Available online at: https://www.nswa.ab.ca/sites/default/files/documents/NSWA%20Atlas.pdf. Accessed on October 4, 2016.

Blackmud/Whitemud Creek Surface Water Management Group