General Design Guidelines

for a

Constructed 'Habitat' Wetland – Parkland Natural Region of Alberta

Updated March 2014

Alberta Government

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More information regarding the "General Design Guidelines for a Constructed Habitat Wetland – Parkland Natural Region" may be obtained by contacting:

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Acknowledgements

This document has been prepared for Alberta Transportation by Green Plan Ltd. Environmental Consultants.

1.0 INTRODUCTION

Wetlands have a very significant value on both a site and landscape context, and play an important role in providing habitat for an enormous range of plant and animal life, while serving to retain and moderate flows of surface and ground water. In addition to their ecological and hydrological functions, wetlands have important social/cultural, aesthetic, recreational and educational functions. The emphasis of particular functions will depend on the location, drainage, geology, and configuration of the site.

1.1 Purpose

This document provides general design parameters for reclaiming planned borrow and aggregate excavations into constructed habitat wetlands for the **Parkland Natural Region** of Alberta (Figure 1.0), that may be suitable for the Alberta Transportation's Wetland Habitat Bank Initiative. These sites may be used by the Department to mitigate for wetland disturbance when avoidance and minimization is not an option.

Figure 1.0 Parkland Natural Region of Alberta

Source: Natural Regions and Subregions of Alberta, 2006

These Guidelines are subject to change pending site-specific conditions (i.e., location and subregion) and end land use requirements. As such, a Regional Environmental Coordinator with Alberta Transportation (AT) and Alberta Environment and Sustainable Resource Development (ESRD) should be consulted prior to finalizing related design plans.

The reader is advised that these Guidelines do not necessarily apply to stormwater management systems, treatment wetlands for water quality improvement or end land uses other than habitat for aquatic plants and wildlife (e.g., recreation and agriculture). These Guidelines do not discuss reclamation techniques for organic wetlands, otherwise known as peatlands (i.e., bogs and fens).

A glossary of terms used in this Guideline is provided in Appendix 3.

1.2 About the Parkland Natural Region

Information contained within this section was obtained from Natural Regions and Subregions of Alberta, 2006.

The Parkland Natural Region can be characterized by aspen and willow shrublands mixed with native grasslands. Although the most densely populated Natural Region in Alberta, productive agricultural lands are a common feature of the region. Wetlands are also a notable and extensive feature in the region.

The Parkland Natural Region includes the following sub-regions; Refer to Appendix 1- Figure 3.0 for a Natural Sub-Regions map of Alberta:

- Foothills Parkland;
- Central Parkland; and
- Peace River Parkland

The Parkland Natural Region contains highly productive croplands. Characteristic native vegetation is a mixture of aspen-grassland and willow-grassland. Grasslands are the dominant vegetation in the southern part of the Region with isolated patches of willow-shrublands found on northerly, moist aspects. To the north, aspen and balsam popular stands occupy a wide range of habitats.

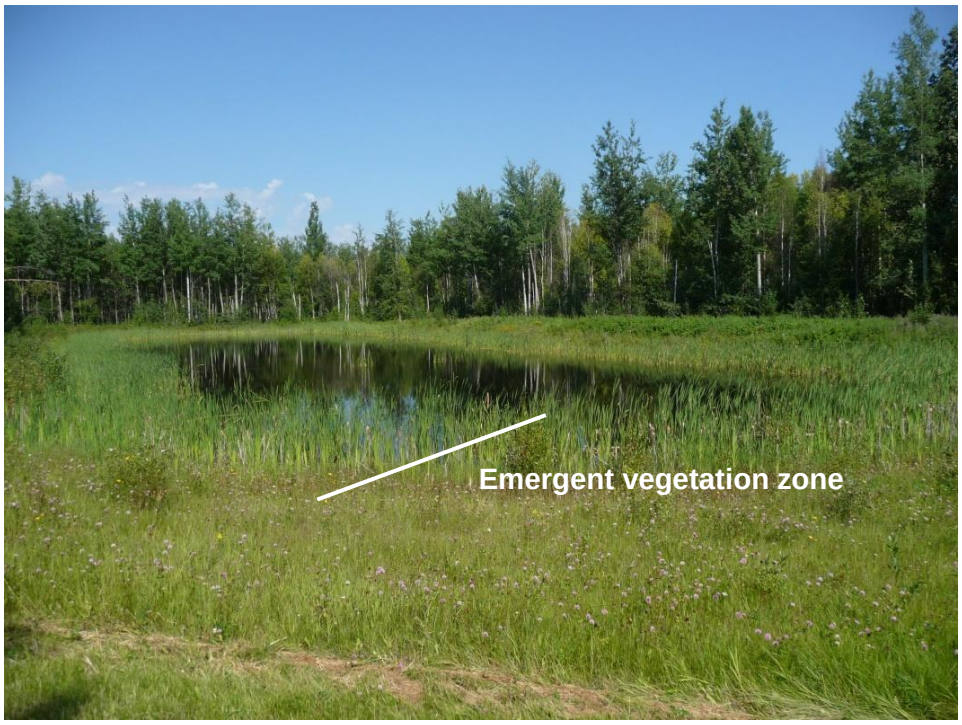
Parkland vegetation also includes wet, low-lying areas unsuitable for agriculture. These are most common in the northern Central Parkland and upland Peace River Parkland Natural Subregions, and support cattail marshes, willow-sedge shrublands or treed fens.

1.3 What is a Constructed Habitat Wetland?

A constructed wetland is defined as a manmade surface water feature that has been developed to mimic a natural occurring wetland. There are seven types of naturally-occurring wetlands ranging from ephemeral ponds (Class I), which contain water for only a short period of time, to permanent ponds and lakes (Class V) that contain open water all year long (Stewart and Kantrud, 1971). Classes VI and VII deal with alkali ponds/lakes and fens and are not of relevance to these Guidelines.

A constructed wetland habitat (which is the subject of this Guideline) is typically created for its value as habitat for plants and wildlife and is comprised of significant littoral zones (shallower areas) for the establishment of emergent and submergent macrophytes (Alberta Environment, 2007). A case study of a constructed habitat wetland is provided in Appendix 4.

Figure 2.0 Example of a Constructed Habitat Wetland



1.3.1 Wetland Types

While many exhausted borrow areas lend themselves to becoming a permanent pond type of wetland due to their configuration and depth, managers should bear in mind other types of wetlands can be produced from a borrow area, including shallow marsh and wet meadow forms. In some cases, it may be practical to plan for a composite of wetland types on a single site (e.g. a permanent pond in deeply excavated parts of the site, with shallow marsh or wet meadow zones in shallower depressions of the site). Such a plan would enhance biodiversity because of the diversity of habitats.

1.4 Terms of Reference and Design Criteria

Design parameters outlined in this Guideline are based on information retained in Alberta Transportation's *Development of Technical Criteria for Wetland Establishment at Borrow Pit Sites in Alberta, 2012.* Information outlined in this report has been derived from studying a series of abandoned borrow pits in south-central Alberta to determine pertinent parameters required for pits to evolve into hydrologically and ecologically functioning wetlands.

Constructed wetland design parameters are also based on recognized standards, namely; the *Guideline for Wetland Establishment on Reclaimed Oil Sand Leases, Oil Sands Wetlands Working Group, 2007*, *Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northeastern Slopes, 2009*, and *Alberta Transportation's General Design Parameters for a Constructed 'Habitat' Wetland, 2011.*These documents are available under separate cover.

Accordingly, habitat wetlands should meet the following design criteria:

- The wetland should be self-sustaining and evolve as an ecologically functioning diverse aquatic ecosystem.

- The wetland should be designed and constructed so that long-term maintenance and management is either minimal or not required.

- The wetland should be designed so that it can be maintained by the available stream flow or groundwater recharge in the area and can be constructed in an area of sufficient natural recharge (groundwater or surface runoff).

1.5 How to Use These Guidelines

These guidelines have been developed for the purpose of outlining a general approach for constructing habitat wetlands in the Parkland Natural Region of Alberta. These Guidelines have been developed for use by consultants and contractors involved with constructed habitat wetlands for Alberta Transportation projects. Wetland construction should be done with the assistance of a hydrologist and *qualified wetland professional* as defined by Alberta Transportation. It is recommended that the planting prescription is discussed with a *Professional Agrologist*. Engineered drawings and/or as built drawings of the constructed habitat wetland should be submitted to the responsible regulatory authority through the Department.

The user of these Guidelines should use them in the context of the environment at the subject site. The Guidelines should be used as a reference source in consultation with Alberta Environment and Sustainable Resource Development and/or a Regional Environmental Coordinator with Alberta Transportation for site-specific-requirements.

1.6 Where to Get More Information?

This document has been written in accordance with recognized standards and information retained through research conducted by Green Plan. Further information may be obtained from:

- Alberta Transportation's *Development of Technical Criteria for Wetland Establishment at Borrow Pit Sites in Alberta, 2012*;

- Guideline for Wetland Establishment on Reclaimed Oil Sand Leases, 2007;

- Guidelines for Lake Development at Coal Mine Operations in Mountain Foothills of the Northeastern Slopes, 2009; and

- Alberta Transportation's General Design Parameters for a Constructed Habitat Wetland, 2011.

2.0 WETLAND DESIGN PARAMETERS

The general design requirements to meet the criteria are summarized in Table 1.0 and illustrated in the appended schematic drawing. The design parameters assume suitable water conditions exist in the proposed project area to support wetland development and that the wetland is not being used for stormwater management or treatment for water quality improvements.

The key design criteria are highlighted below:

- Soil, overburden and reject material should be salvaged to construct the required landscape features and rebuild soil profiles along the wetland bottom;

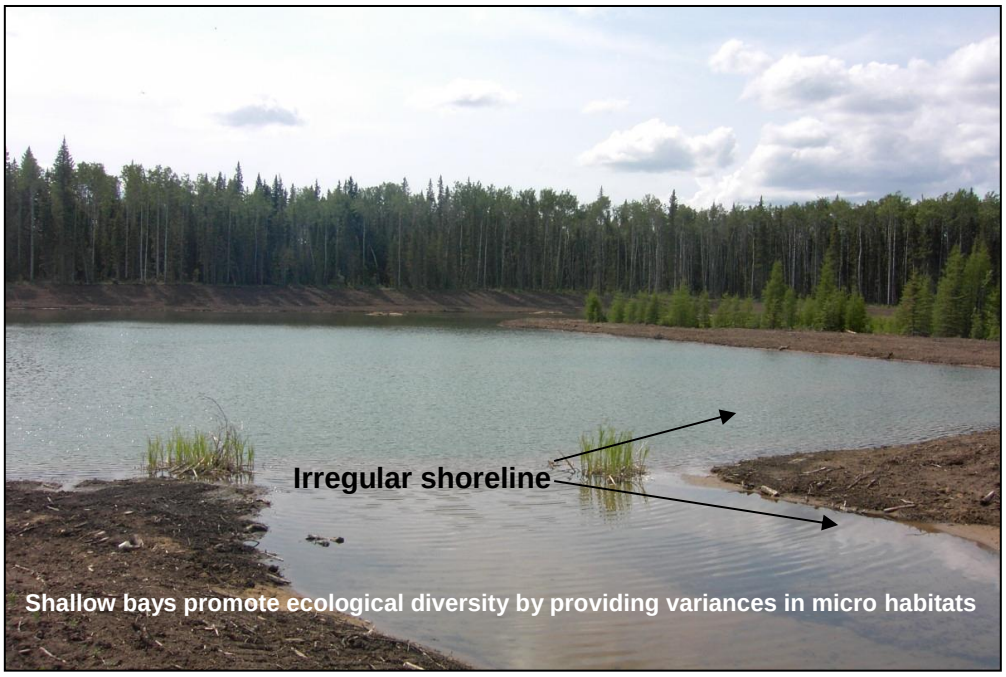
- Site drainage features (channels) should be constructed during reclamation site grading, to direct surface runoff to the wetland. If possible, the wetland should be constructed with an inlet and outlet to control water recharge;

- Buffer zones should be established around the wetland to protect the littoral zone habitat. In most studies, authors recommend buffer zones of 100 m to protect most bird species, or colonies of either nesting or foraging birds;

- Littoral zones and semi-submerged islands should be constructed to promote growth of aquatic macrophytes which are large rooted plants that inhabit the littoral zone (shallow zone) of most lakes or ponds. Most guidelines suggest that these areas have a maximum depth of 2 metres and comprise 20% of the wetland;

- Islands, irregular shorelines and areas of emergent vegetation (e.g., cattails and bulrushes) should be incorporated in the wetland design. This will provide nesting and hiding cover for water fowl, and add to the species diversity in the area;

Figure 3.0 Example of a Shallow Bay and Irregular Shoreline



- The constructed wetland should be designed to incorporate a variety of shoreline habitats and increased habitat edge for wildlife. Irregular shoreline islands and mounds all enhance physical habitat and biodiversity;

- Shoreline transition zones, also known as riparian areas, should be constructed between the upland areas to facilitate semi-aquatic wildlife and vegetation habitat;

- Deep sections of the wetland should be constructed to promote turnover and water temperature control. These areas should have bathymetric diversity;

- The littoral zone should be vegetated with aquatic plants for habitat, food and water quality. Riparian and upland areas should be vegetated with appropriate plants species to control erosion and the influx of sediment; and

- If possible, measures should be put in place to stabilize water levels to preclude drawdown effects on the littoral zone; although, a certain amount of drawdown is beneficial for a broad emergent vegetation zone.

Table 1.0 Summary of Constructed Wetland Design Parameters

Information contained in this Table is derived from both *Oil Sand's Wetlands Working Group and* Alberta Transportation's *Development of Technical Criteria for Wetland Establishment at Borrow Pit Sites In Alberta*

Component	**Selected Design Recommendations**
1. Extent	• Littoral zone should be at least 20% of the wetland (i.e., <3m); that is, similar to other wetlands in the area.
2. Depths	• Establishment of aquatic macrophytes is related to depth: emergent aquatic macrophytes-depths of <1 m (0.1 to 0.5 m); submergent macrophytes – maximum depths of 2-3 m. For fish, depths of 2-3 m for overwintering pools, as well as shallower areas for feeding and spawning. *Note: for any wetland end plan, measurements of groundwater table levels and runoff should be done in advance of pit closure, preferably for several years.*
3.0 Bottom Contours	• Bottom contours should provide: irregular, narrow, to wide shoreline shelves; gradual slopes (9:1 – 5:1); average depths of 0.5-1.5 m. • Steeper slopes (3:1 – 2:1) along some parts of the shoreline should be used to provide access to deep water and limit plant growth. • Incorporate irregular bottom contours using natural or surplus material.
4.0 Shoreline Configuration	• Littoral zones should provide a variety of shoreline characteristics (i.e., emergent vegetation, waterfowl cover nesting sites). • Irregular shorelines with shallow bays have the potential to develop into marsh habitats; • Mudflats/gravel bars provide habitat (i.e., shorebird foraging, nesting sites). • Shore slopes of ponds should generally be 6H:1V or less; steeper slopes along some parts of the shoreline may be incorporated to provide fish habitat.
5.0 Special Waterfowl	• Islands along the foreshore provide valuable habitat for wetland bird species: design criteria for the creation of nesting islands for raptors and colonial birds are found in Multi-Species Habitat Techniques. • Elevated nesting platforms can provide secure nesting areas.
6.0 Substrate Composition	• A sediment/mineral soils mix (ratio 1.5:1; Leskiw 1998) should be applied in a layer of about 20 cm on areas with projected water depth < 45 cm. • Gravel, cobble, and boulders may be added to provide special habitats and habitat diversity but must conform to desired wetland function. • For deeper portions of the pond, substrate can be composed of inorganic material such as rock, gravel, cobble, boulders or sand. • Native plants could be encouraged through the addition of sediment material from nearby natural wetlands or donor wetlands.
7.0 Revegetation	• Refer to Section 3.5 and Table 2.0.
8.0 Habitat Diversity	Habitat diversity can be promoted in a variety of ways: • diversity of upland habitat (i.e., grasslands, forests); • irregular shorelines with the development of shallow bays; • mudflats, sandbars and islands; • irregular bottom sediment/substrate (i.e., rocks, gravel, sand, overburden); • underwater structures such as reefs utilizing natural or surplus material (i.e., waste rock, and logs/stumps.); • a diversity of quiet water and wave susceptible areas.

An example of a wetland functions analysis is provided in Appendix 4 – Table 1.0.

3.0 RECLAMATION PRACTICES

The following reclamation practices are recommended to meet the design parameters discussed in Section 2.0.

3.1 Grading and Contouring

Grading and contouring is used to develop successive transition zones namely upland habitat; riparian; and shallow and deep wetland margins.

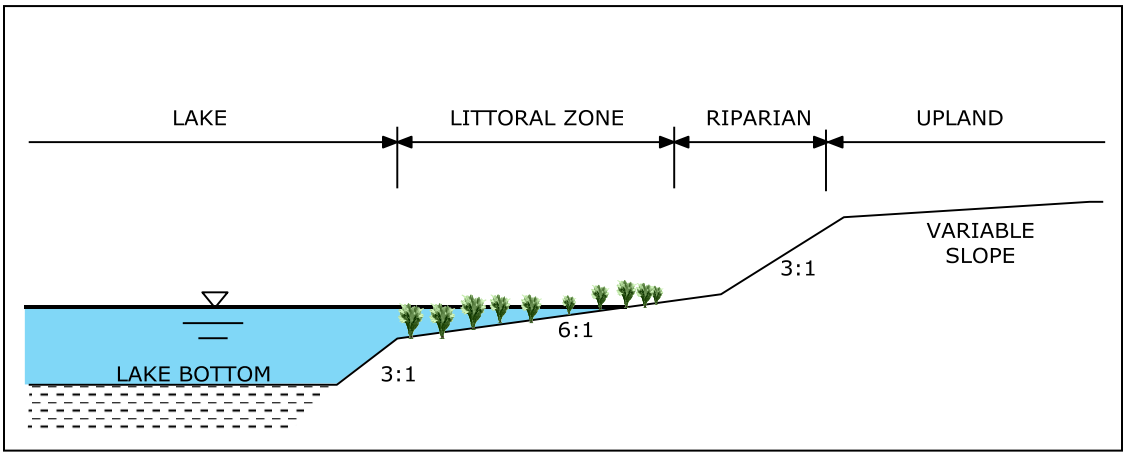
The reclaimed side slopes (upland area) will be a maximum of 2H:1V towards the riparian areas near the wetland slope and the adjoining riparian areas will be formed with a maximum 3H:1V slopes using mostly native material. The uplands should be graded to transition smoothly into the riparian areas and in a manner that directs runoff to the wetland. Irregular shorelines should be constructed to provide micro sites for vegetation and wildlife and to give the wetland a more natural look.

Littoral areas (or the shallow wetland area with fluctuating waterline) will be provided along the shorelines of the wetland down gradient of the riparian areas. The littoral slopes will be a maximum of 6H:1V or more gradual and will occupy 20 to 30 percent of the total surface area of the wetland. They can consist of narrow bands along the shoreline or larger plateaus.

The slope connecting the littoral zone with the wetland bottom will be a maximum of 3H:1V and the wetland bottom will be 20H:1V (note: dependent on the type of wetland constructed and site specific characteristics, as noted in Table 1.0, this may vary) and sloped towards the outlet. Shallow and deep water areas will be constructed by enhancing the natural pit bottom contours to improve aquatic habitat diversity.

Note: Steeper slopes along the wetland are acceptable provided other sections of the wetland are graded to provide gentler slopes using the specified ratios.

Figure 4.0 Typical Profile for a Constructed Habitat Wetland



3.1.1 Shoreline Configuration

In terms of habitat for aquatic vegetation, a generous and vigorous zone of emergent (e.g., cattails), submergent (e.g., pond weed species) and floating (e.g., water lilies or duck weed) aquatic plants is critical to the future functioning of the constructed wetland. Features that encourage this growth, and that will be incorporated into the construction design, include:

- A broad littoral zone, alternatively known as the shallow wetland area with fluctuating waterline, will be developed along the shorelines of the wetland down gradient of the wet meadow area. The littoral zone should be between 0.0 to 0.3 meters in depth and vary in width.

- A steeper shelf of 2 to 3 meters in width may be constructed to encourage the growth of submergent aquatic vegetation.

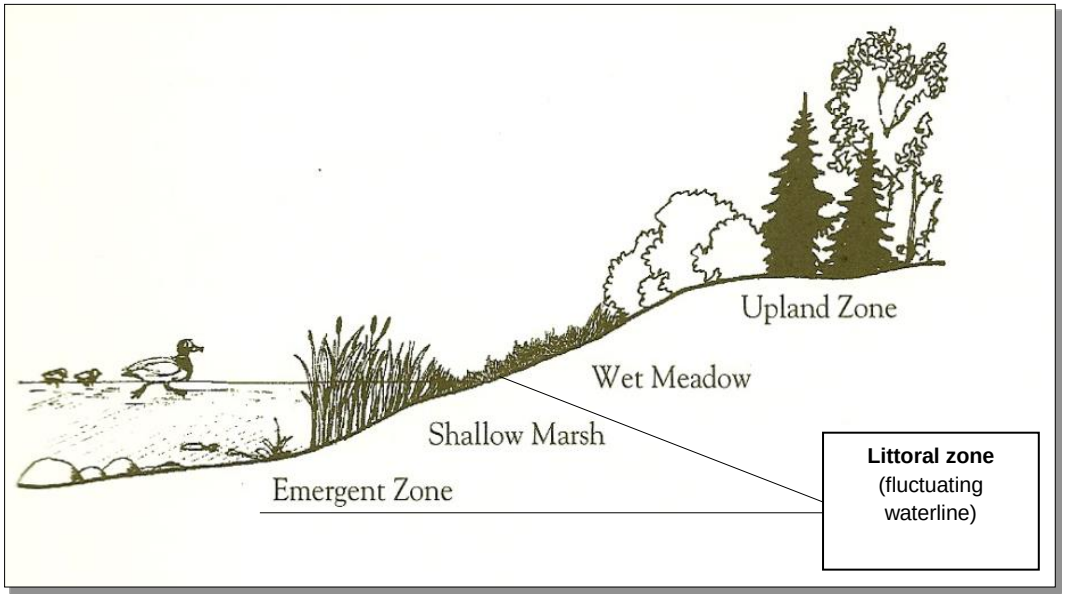
- Irregular pond bottom sediment/substrate may be constructed using rocks, overburden or reject material.

- Emergent structures such as reefs may be constructed using natural or surplus material (e.g., waste rock, logs/stumps).

Irregular shelves (i.e. narrow to wide) in the littoral zone may be designed to create diverse habitats, encouraging biodiversity. Otherwise, slopes in the littoral zone should be 6H:1V or more gradual, and as broad as feasible (2-5 m depending on the size of the pond). Littoral zone

or reef depths of 0.1 - 0.5 m will accommodate growth of aquatic emergent plants. A deeper 'shelf' of 0.5 - 1.5 m and 2 - 3m wide will provide habitat for submergent aquatic vegetation.

Figure 5.0 Littoral Zone



Source: A User Guide to Pit and Quarry Reclamation in Alberta, 1992.

3.1.2 Bottom Contours

For ponds, generally a bowl shaped bathymetry is desirable, to promote a succession of emergent, submergent and shoreline aquatic plant communities as water levels fluctuate. To promote a diversity of habitat for aquatic organisms and vegetation, incorporate irregular bottom contours and underwater structures using natural or surplus material. Refer to Figure 6.0.

3.2 Wetland Substrate and Lining

Lining the wetland floor with an appropriate substrate is dependent on hydrologic conditions. In areas where hydrologic connectivity is low it may be suitable to line the floor with a substrate that has low permeability (i.e., clay) to maximize water retention. If the wetland is influenced by ground water recharge and/or subsurface seepage, it may be beneficial to line the wetland bottom with a permeable material such as sand and/or gravel.

3.2.1 Water Fluctuations

For ponds, there should be some seasonal fluctuation in water level, approximately similar in timing to natural fluctuations for similar sized water bodies. There should be about a 0.3 m vertical fluctuation for a large pond, and a flood zone of about 1 - 2 m wide to encourage emergent vegetation in the littoral area. Clearly this will depend on local groundwater tables, annual precipitation and resulting runoff, as well as evapotranspiration rates. Shallow marsh and wet meadow forms of wetland should have soil saturated for at least the spring and early summer parts of the year.

3.2.2 Water Levels

Water levels may range in accordance with the following:

- Aquatic emergent plants; 0.1 – 0.5 m.

- Submergent aquatic plants; 2 - 3 m (average depth, 0.5 – 1.5 m)

- For fish, depths of 2 - 3 m for overwintering pools, as well as shallower areas for feeding and spawning. Minimum spring depth of 60 cm, and overall range of 0.5 – 3 m depth.

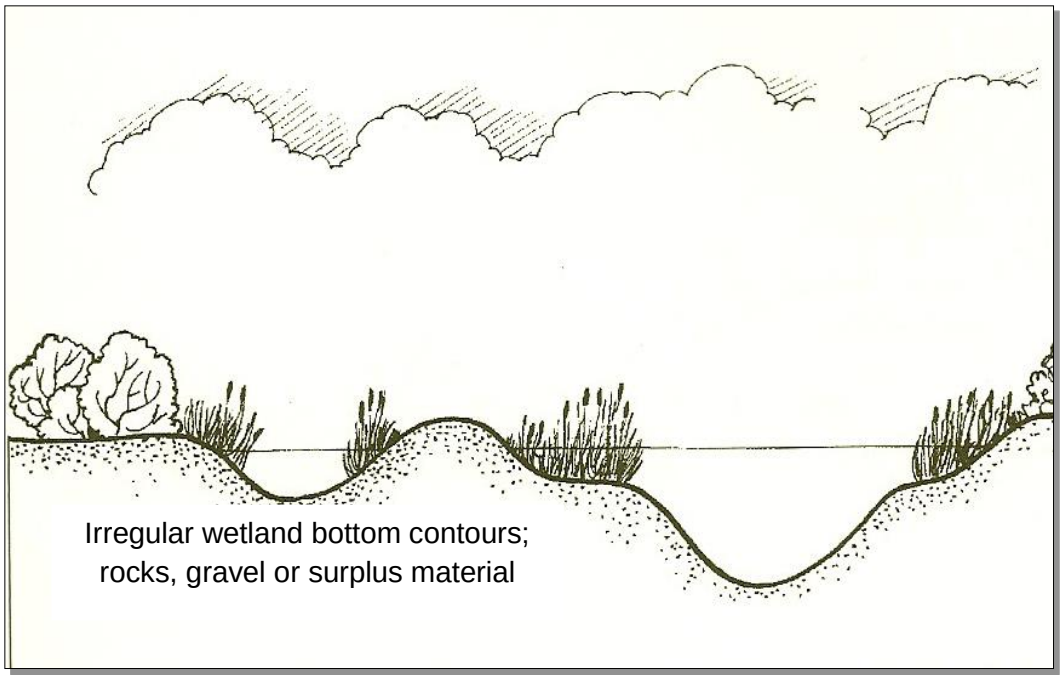
The mix of these depth ranges is to conform to the agreed end pit plan (the plan for end pit closure and post-operational management, as agreed with AT) and desired wetland functions. Shallow marsh and wet meadow forms of wetland should have soil saturated for at least the spring and early summer parts of the year. For any wetland end plan, measurements of groundwater table levels and runoff should be done in advance of pit closure, preferably for several years.

3.3 Topsoil, Overburden and Reject Material Management

Topsoil and overburden should be salvaged to conserve the soil resources and build new soil landscapes and soil profiles on the reclaimed areas. Overburden may be used to backfill pits; fill and contour pit edges, and create landscape features for the constructed wetland. Reject material may be utilized to construct irregular wetland bottom contours to diversify habitat. Topsoil should be applied as a growth medium.

Topsoil should be distributed evenly in all of the wetland zones except for the deep zone where plant growth will be limited. The technique of direct placement of salvaged topsoil and vegetation will be used where possible to transplant live vegetation and the ‘topsoil seed bank’ along with soil material. A minimum 10 cm depth of topsoil is recommended but should be equivalent to the existing soil depth.

Figure 6.0 Irregular Wetland Bottom Contours



Source. *A User Guide to Pit and Quarry Reclamation in Alberta*, 1992.

3.4 Erosion Control

Slope erosion, especially along water feature is a natural process and will likely occur in certain areas. Every reasonable effort will be made to address erosion using erosion resistant overburden to backfill critical areas such as the wetland outlet, inlet, and designated shorelines. Erosion rates will be minimized first and foremost by revegetating disturbances as they become available. In addition, erosion control will be incorporated in drainage channels, including armoring with rip rap, wood debris and other erosion resistant material.

Although, a greater diversity and abundance of wetland vegetation can be expected in substrates that hold more dark, fine organic matter, as opposed to coarse, sandy substrates. Leaving topsoil around the edges of the pond will to some extent contribute, through erosion, to the buildup of a pond bed that is rich in fine-grained material. This will present a good rooting layer for aquatic plants, as well as organic matter and nutrients, which will boost primary productivity in the littoral zone.

3.5 Planting Prescription

The wetland vegetation should add to the biodiversity of the area by providing a mix of aquatic and wetland habitat with the terrestrial landscape.

The preferred method of vegetation establishment is natural recolonization with local plant species. Wetland vegetation may be salvaged from other similar areas and planted in the

reclaimed area. Most importantly littoral areas should be inoculated with ‘pond muck’ or salvaged wetland soils that contain seeds, rootstock and aquatic invertebrates to kick start the aquatic ecosystem. Planting willows, saskatoon, alder and red osier dog wood in riparian areas will provide browse for terrestrial wildlife (where applicable). The treatments may be enhanced with native nursery stock of native wetland plants.

Disturbed upland areas including the riparian zone can be seeded with an appropriate upland seed mix supplemented with native nursery stock and/or local cuttings. It should be noted that seed mixes may speed up the process of vegetation at the expense of reduced biodiversity.

Materials should also be collected to enhance habitat features for landscaping. Rocks, logs and branches will be retained and submerged and/or anchored in the water and along the shoreline to provide erosion protection and refuge for aquatic species, nesting sites, bird perches, etc. Small brush piles, boulders, logs and stumps will be placed in the reclaimed landscape to provide habitat for small mammals.

Wetland vegetation suitable for constructed wetlands in the Parkland Natural Region is provided in Table 2.0. It should be noted that the planting prescription will vary according to soil type, exposure and geographic location (among other factors). Accordingly, the local ESRD government authority should be consulted before finalizing a planting prescription.

Table 2.0 Wetland Vegetation Suitable for Constructed Wetlands in the Parkland Natural Region

Species Name	Common Name	Type of Microhabitat	Reclamation Techniques
Alnus crispa	Green Alder	Well drained, course textured soils	Nursery stock, seeds, tillers
Salix exigua	Sandbar willow	Sandy or gravelly flood plain, shores	Nursery stock or natural colonization
Salx spp.	Willows-other	Various soils, moisture regimes	Nursery stock or natural colonization
Populus balsamifera	Balsam popular	Moist depressions and banks	Seeds. If tree has been cut or destroyed by fire, it will resprout from the stringers or roots. Branch segments also have the ability to take root
Populus trenuloides	Trembling aspen	Well-drained moist soils	Seed and root suckers
Alnus rugosa	River alder	Pond banks and shores	Nursery stock
Betula papyrifera	White birch	Well-drained but moist soils	Nursery stock or natural colonization
Hippuris vulgaris	Mare's tail	Ponds, lakeshores, streambeds, muddy flats	
Scippus lacustris	Bulrush	Edges of ponds, lakes, marshes, shallow water	Obligate (donor) wetland
Potamogeton sp.	Pondweed	Floating, submergent	
Typha latifolia	Cattail	Deep marsh and shallow marsh zones	Seeds, plugs or rhizomes containing live bud

Table 2.0 Wetland Vegetation Suitable for Constructed Wetlands in the Parkland Natural Region

Sagittaria cuneata	Arum-leaved arrowhead	Marshes, shallow water, muddy shores, wet meadows	
Equisetum fluviatile	swamp horsetail	Lake margins, river meadows, marshes	
Solidago canadensi	Goldenrod	Marshes and wet meadows; saline places	Rhizomes/seeds; donor wetland. Aggressive
Aster puniceus	Purple stemmed aster	Moist ground	
Rumex maritimus	Golden dock	Marshes and wet meadows	Seeds
Rumex occidentalis	Western dock	Mashes and wet meadows	Seeds
Sium suave	Water parsnip	Banks, shorelines, deep marshes, wet meadows	Seed or rootstock; donor wetlands.
Glyceria striata	Fowl manna grass	Shallow marsh and shores	Seeds or plugs; intolerant of saline conditions.
Glyceria grandis	Tall manna grass	Shallow water around edges, shallow marshes, wet meadows	Obligate (donor) wetland perennial; seeds or plugs
Phalaris arundinacea	Reed canary grass	Lake margins, upper marsh zone, wet meadows	Facultative
Phleum pratense	Timothy	Upland banks, moist meadows	Seed. Natural reseeding ability considered moderate.
Equisetum pratense	Meadow horsetail	Moist thickets and meadows	
Scripus validus	Common great rush	Moist ground, marshes and shores	Rhizomes or seeds; donor wetland
Scirpus microcarpus	Small-fruited bulrush	Pond emergent zone, shallow marshes	Seeds or roots; donor wetland

4.0 TECHNICAL SUPPORT AND MONITORING

Engineered drawings and/or as built drawings should be submitted to the responsible regulatory authority through the Department.

Wetland construction should be done with assistance from a hydrologist and qualified wetland professional. The planting prescription should be discussed with a *Professional Agrologist*.

The constructed wetland will also need to be monitored in order to determine whether the performance criteria agreed to by Alberta Environment and Sustainable Resource Development is being met. In many cases, monitoring can be conducted by a qualified wetland professional following the first season of construction. Corrective or remedial actions should be undertaken if performance criteria are not attained.

Suggested performance indicators are provided below. These are provided as a guide and should be confirmed with the respective government authority along with the proposed methodology for verifying compliance:

1) Water and Sediments: The water chemistry of the constructed wetland can be expected to change as the site evolves to a natural functioning wetland ecosystem. As wetlands evolve, they trend toward an environment of lower pH (more acidic), lower electrical conductivity (lower levels of solutes). However, pH and conductivity can also be influenced by external factors, such as, the surrounding forest ecosystem. Accordingly, it is recommended that water and sediment samples are gathered annually and analysed for electrical conductivity, pH and dissolved oxygen.

   Observe and record changes in water levels, especially during late spring and summer. This will give some indication if the predicted water conditions are being met.

2) Plant Diversity and Abundance: As the wetland weathers, the wetland should become increasingly favorable for various aquatic and upland plants. Species richness, i.e., the number of wetland species, will act as an indicator of a functioning and diverse wetland ecosystem.

   The predominant width of the emergent vegetation zone and the proportion of the pond's shoreline that possesses a significant emergent zone are criteria that may be utilized in monitoring the performance of the constructed wetland.

3) Littoral and Wet Meadow/Riparian Zone: Attainment of at least 20 percent absolute cover of native hydrophytic and riparian vegetation in year 1; 50 percent in year two; and 80 percent in year 5. Establish a minimum of five native wetland species, including those species which were planted, as well as species that may be volunteers.

4) Upland Vegetation: Attain at least 20 percent cover of native or naturalized tree cover and herbaceous species in year 1; 50 percent by year 3; and 80 by year 5.

5) Aquatic Animal Life: The collection of organisms which live in or on the water, sediments, or vegetation of the pond provides a further indicator and measure of biological diversity.

Over a longer term, the biodiversity of larger forms of wildlife may be used to evaluate the evolving wetland. For example, this may include amphibians, waterfowl, shorebirds, birds of prey as well as signs or sightings of beaver, muskrats, moose, deer, or other wildlife.

5.0 CARE & CONTROL

Measures should be employed to ensure long term stewardship and protection of the wetlands from activities that impede success of the wetland, e.g., human interference. Over the long term, wetlands within the study zone need to be protected from disturbance, e.g., by motorized vehicle use and particularly all-terrain vehicles.

Maintenance of the wetlands should be done on an as needed basis to control weeds and maintain vegetation plantings. Weeds should be identified and reported to Alberta Transportation. Herbicide should not be used within 100 meters of the constructed wetland. Changes in species composition should be tracked and the appropriate measures taken to protect or replace the affected plants.

Figure 7.0 Human Induced Impacts to a Constructed Wetland

6.0 LITERATURE CITED

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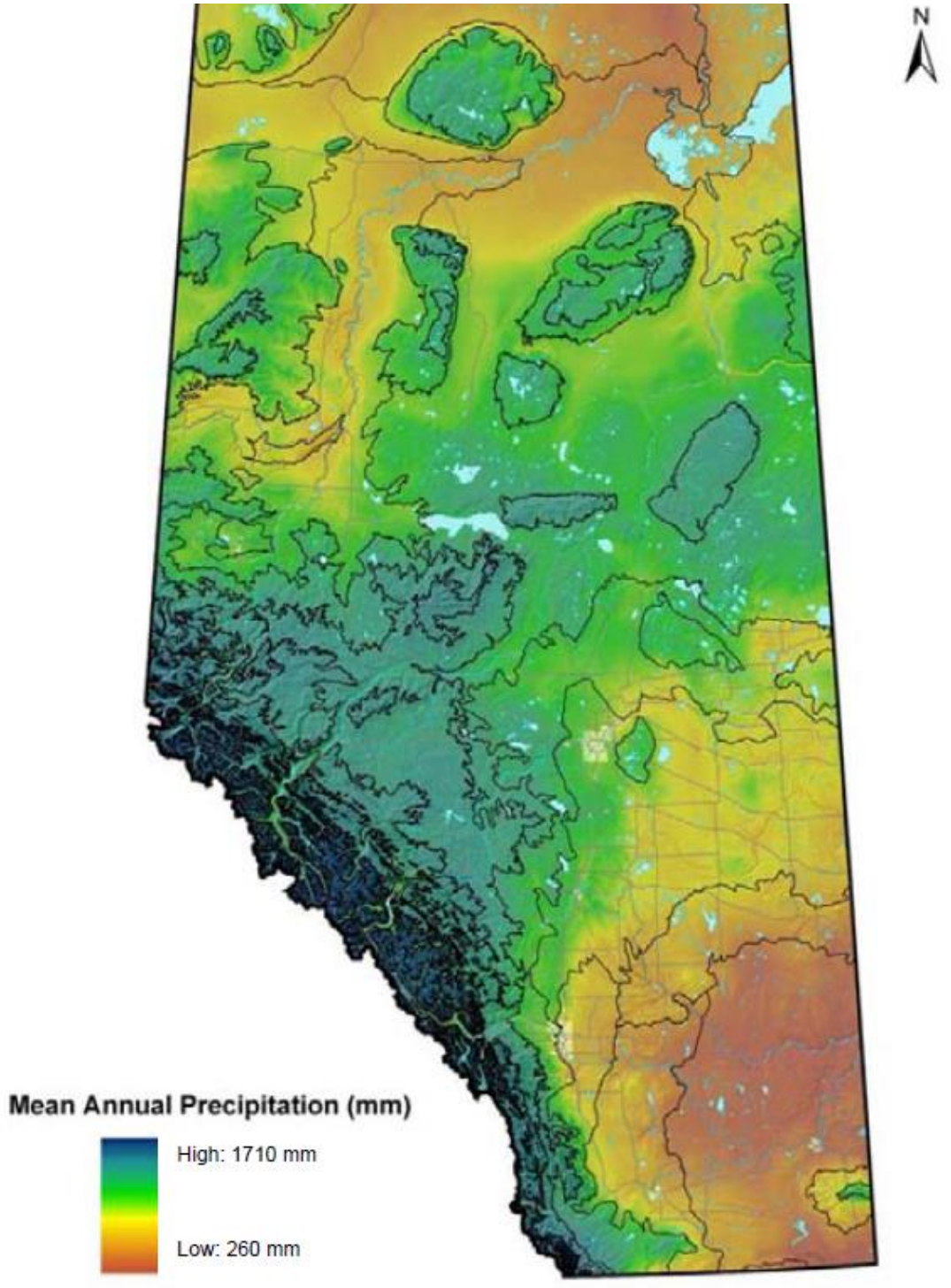
APPENDIX 1

Mean Annual Climatic Conditions across Alberta

Appendix 1 – Figure 1.0 Mean Annual Precipitation across Alberta

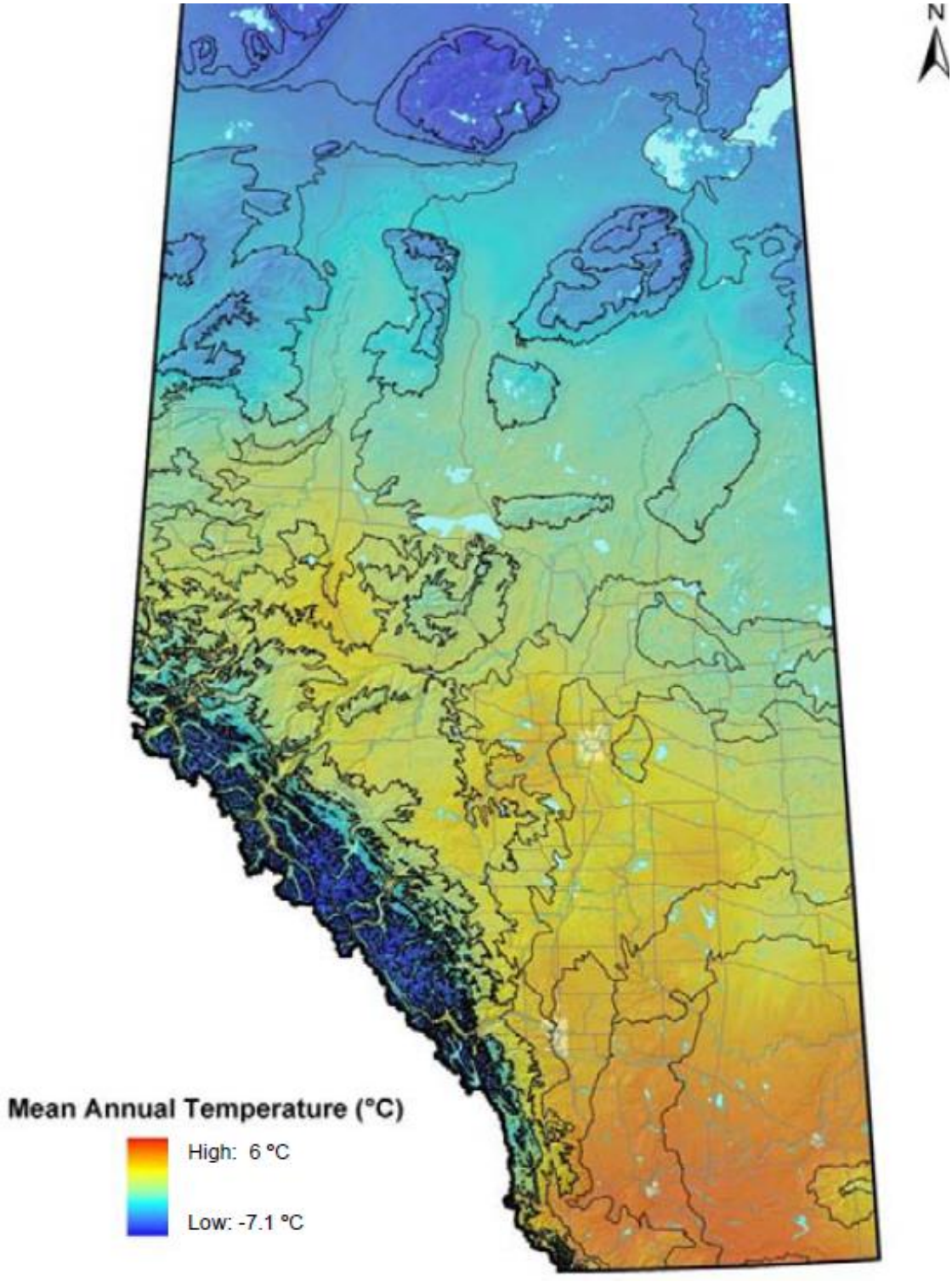
(Black lines indicate Natural Sub-Region boundaries)



Source: Natural Regions and Subregions of Alberta, 2006

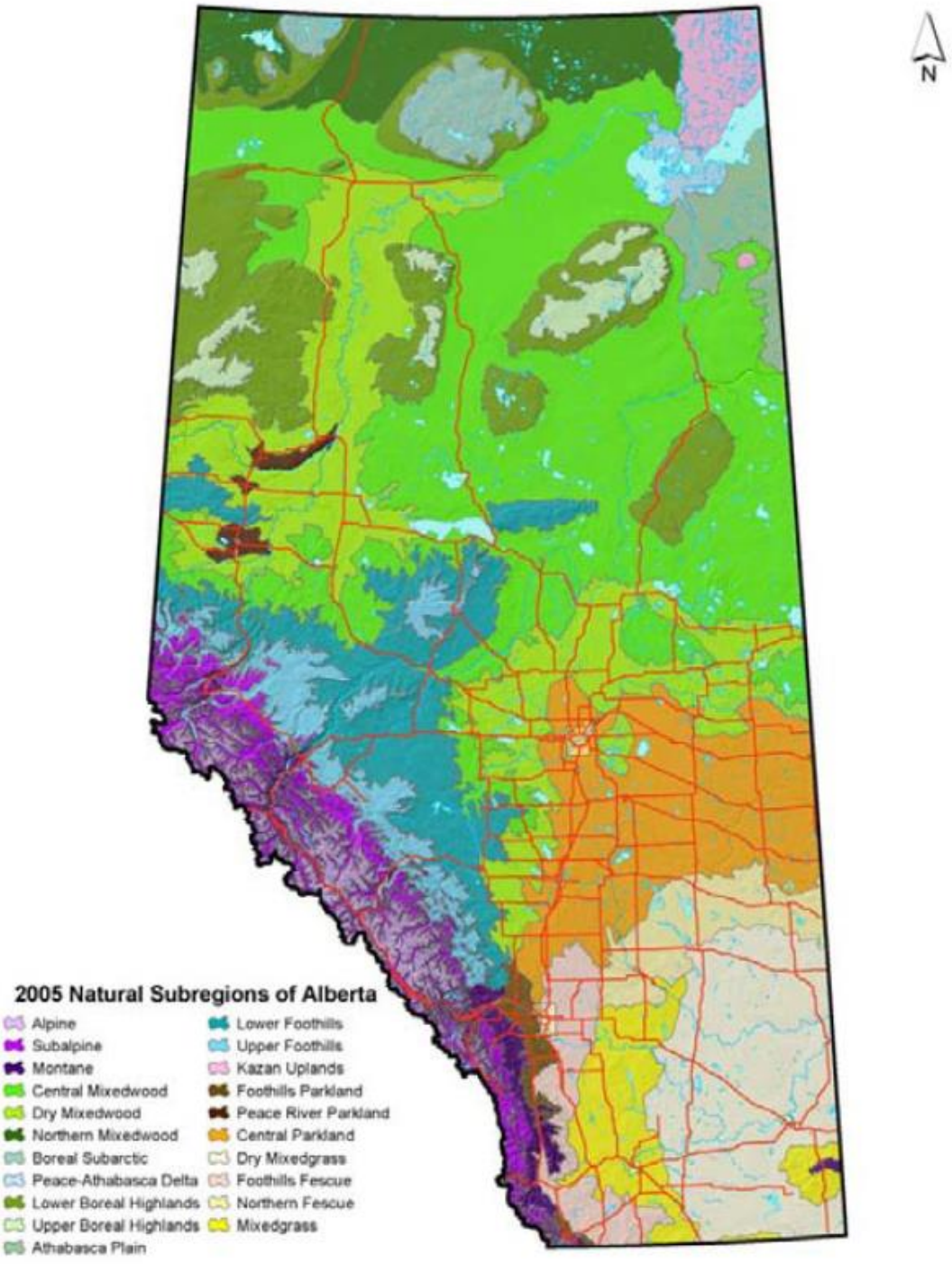
Appendix 1 – Figure 2.0 Mean Annual Temperatures across Alberta

(Black lines indicate Natural Sub-Region boundaries)



Source: Natural Regions and Subregions of Alberta, 2006

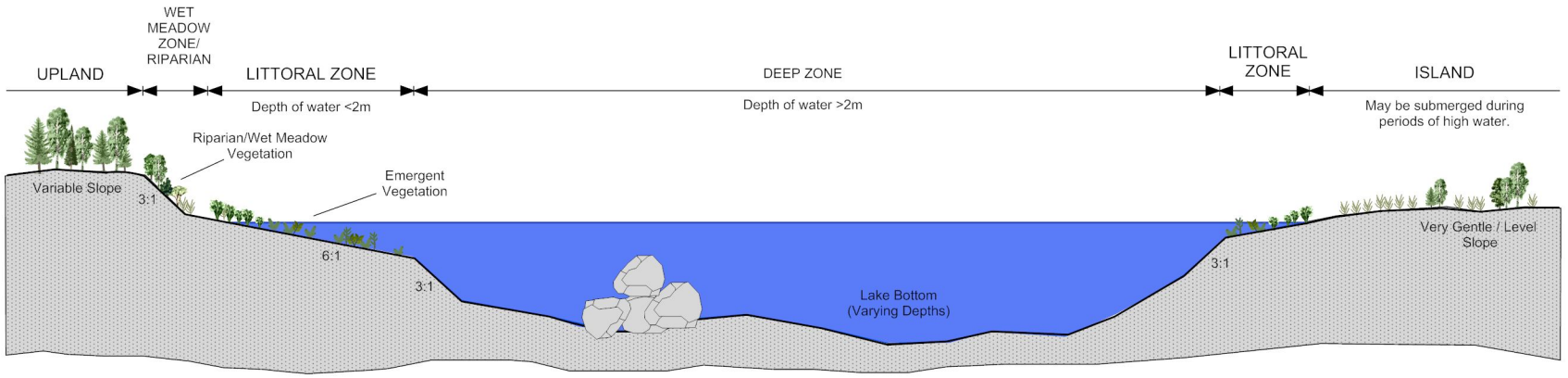
Appendix 1 – Figure 3.0 Natural Sub-Regions of Alberta

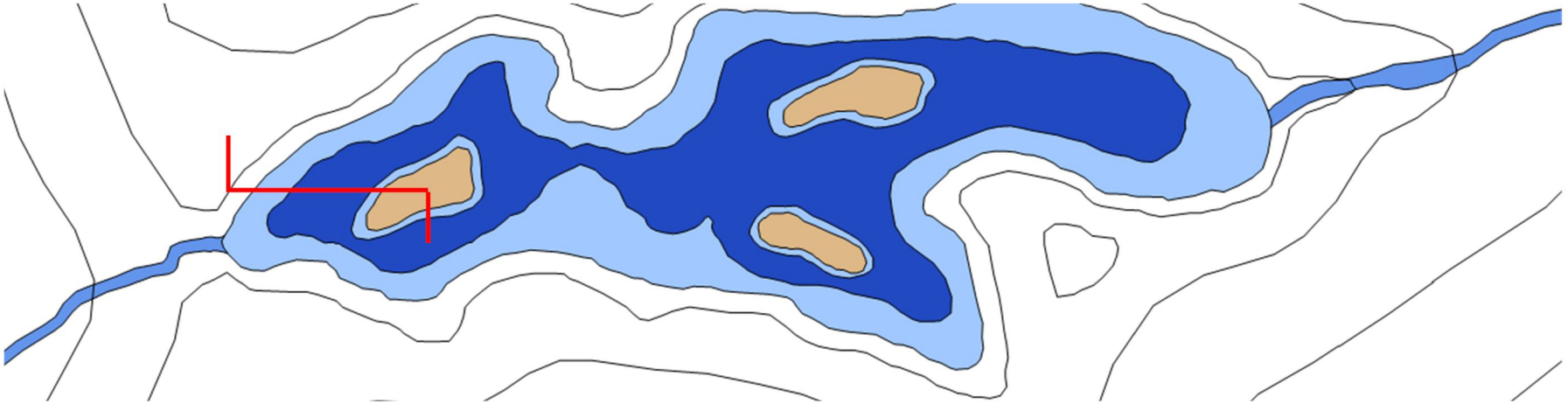


Source: Natural Regions and Subregions of Alberta, 2006

APPENDIX 2

Schematic Drawing of a Constructed Habitat Wetland





Appendix 2 - Schematic Drawing of a Typical Profile For a Constructed Wetland

Legend:

UNDER WATER STRUCTURES
CONCEPTUAL CROSS SECTION
ISLAND
DEEP ZONE
LITTORAL ZONE

Prepared for: **Alberta Transportation**
Date: July 2012

Green Plan Ltd.
ENVIRONMENTAL CONSULTANTS

APPENDIX 3

Definitions

Definitions

The following definitions are sourced from the *Alberta Environment Glossary of Reclamation and Remediation Terms* and the Guideline *for Wetland Establishment on Reclaimed Oil Sand Leases*, Oil Sands Wetlands Working Group, 2007, unless other source citation is specifically noted.

Alberta Environment and Sustainable Resource Development (AESRD) – the Ministry responsible for regulating activities such as wetland mitigation and development projects that affect water bodies under the authority of the *Water Act* (Provincial Wetland Restoration/Compensation Guide, 2007).

Aquatic - growing, living in or frequenting water; occurring or situated in or on water.

Avoid – to prevent impacts to a wetland by identifying an alternate project, activity, design, or site, or abandoning the project or activity altogether or by denial of an application by the regulator (Alberta Wetland Policy, 2013).

Benthic − living at, in or in association with the bottom substrate of aquatic environments, including wetlands.

Biodiversity − the variety of living components in an ecosystem; it is most often expressed in terms of species diversity but can be assessed on the basis of genetic diversity or landscape diversity (e.g., variety of vegetation types across the landscape); it can also incorporate structural and functional elements.

Candidate Site – wetlands that have been constructed, enhanced or restored for the purpose of wetland compensation and have the potential to meet Alberta Transportation's criteria to be transferred and reflected in the Department's wetland habitat bank. Candidate sites may also be wetlands that have naturally evolved from decommissioned borrow or aggregate operations and have the potential to meet the Department's criteria (Alberta Transportation's Wetland Banking Initiative, 2013).

Clay − with reference to soils, a fine-grained textural class, made up largely of clay minerals, but commonly also having amorphous free oxides and primary minerals; with reference to particle-size, having a grain less than 0.002 mm equivalent diameter.

Coarse-grained − with reference to soil, the texture exhibited by sands, loamy sands, and sandy loams but not including very fine sandy loam; a soil containing large quantities of these textural classes.

Conservation – The management of wetland(s) to ensure they are sustained for future generations.

The planning, management, and implementation of an activity with the objective of protecting the essential physical, chemical and biological characteristic of the environment against degradation (Alberta Wetland Policy, 2013).

Credit – area of constructed, restored, or enhanced wetland stored in Alberta Transportation's wetland habitat bank available for use as a form of wetland replacement (Alberta Transportation's Wetland Banking Initiative, 2013).

Ecosystem − a complex of living organisms interacting with each other and their non-living environment, linked together by energy flows and material cycling.

Emergent vegetation − plant species that have a part extending below the normal water level; plants adapted to periodic flooding, including genera such as Carex (sedges), Scirpus (reeds), and Typha (cattails).

End land use − with reference to oil sands mining, the allowable use/s of disturbed land following reclamation; municipal zoning/approval may be required for specific land uses.

Ephemeral water body − A shallow water body that temporarily contains water after spring snowmelt or heavy rainfall and typically dries up within a matter of days to weeks (Alberta Wetland Policy, 2013)

Equivalent land capability (regulatory definition) – where the ability of the land to support various land uses after reclamation is similar to the ability that existed prior to the activity being conducted on the land, but the ability to support individual land uses will not necessarily be equal after reclamation.

Erosion − the wearing away and transportation of soils, rocks and dissolved minerals from the land surface, shorelines and river bottoms by running water, wind, ice, other geological agents, activities of man or animals, and including such processes as gravitational creep.

Evaporation − the conversion of water from liquid form in soils and aquatic environments to vapor form and release to the atmosphere.

Evapotranspiration (ET) − a collective term for the processes of evaporation of water from the soil surface and plant transpiration by which water is returned to the atmosphere from the land; see Potential evapotranspiration vs Actual evapotranspiration.

Groundwater − underground water supplies, also called aquifers; see Aquifer; water that is stored in the pores of subsurface geological deposits (strata) and flows in the direction of decreasing pressure.

Habitat − the specific area or environment in which a particular type of plant or animal lives.

Hydraulic conductivity − the measure of the ability of fluid to move through earth material; a function of both the soil medium and the fluid is sometimes used interchangeably with permeability.

Hydrology − a broad term that encompasses all hydrologic and hydraulic processes related to wetlands; the water balance and all water components.

Hydrophyte − a plant that grows in water, or in wet or saturated soils; water-loving; any plant growing in water or on a substrate.

Inorganic − not pertaining to or derived from plant or animal origins; a chemical of mineral origin which does not contain (with few exceptions) carbon or compounds of carbon.

Intermittent − with reference to aquatic environments, where the presence of water ceases for a time due to climatic conditions, including snow melt/spring runoff, seasonal storms and drought conditions.

Littoral zone − productive shallow-water zone of lakes, rivers or seas where light can penetrate to the bottom; often occupied by rooted aquatic plants; the biogeographic zone between the high- and low-water marks.

Macrophyte - an aquatic plant that grows in or near water and is either emergent, submergent, or floating. In lakes macrophytes provide cover for fish and substrate for aquatic invertebrates, produce oxygen, and act as food for some fish and wildlife.

Marsh − a class of wetland described as having the following characteristics: periodically inundated by standing or slowly moving water; surface water levels may fluctuate seasonally, with declining levels exposing drawdown zones of matted vegetation or mud flats; waters are often eutrophic; substratum usually consists dominantly of mineral material, although some marshes are associated with peat or gyttja deposits; associated soils are dominantly Gleysols with some Humisols and Mesisols; characteristically show a zonal or mosaic surface pattern of pools or channels interspersed with clumps of emergent sedges, grasses, rushes and reeds; where open water areas occur, a variety of submerged and floating aquatic plants flourish.

Mitigation – Management activities taken to avoid and minimize negative impacts on wetlands, and to replace lost wetlands, where necessary (Alberta Wetland Policy, 2013).

Node – Place on the stem from where leaves grow. Nodes are separated by internodes (Weeds of the Prairies, 2000).

Non-restorative replacement - refers to a variety of alternatives that must support the maintenance of wetland value, by advancing the state of wetland science and wetland management. Acceptable non-restorative replacement measures include (Alberta Wetland Policy, 2013):

- Specified research into wetland restoration measures
- Provincial level monitoring of wetlands
- Specified wetland inventory work and data acquisition
- Specified landscape level wetland health assessment or modeling
- Public education and outreach programs
- Wetland securement for the purpose of long term conservation

Off – site wetland compensation – off-site compensation occurs when impacts to wetland area can neither be avoided nor minimized and the developer is required to compensate for unavoidable loss (Alberta Transportation's Wetland Banking Initiative, 2013).

Off-site compensation includes:

- In-lieu fee payment, whereby Alberta Transporation may choose to pay financial restitution for a wetland loss. These finds are allocated toward specific restorative or non-restorative measures, as determined by guidance documents. Under the provisions of ESRD's current guidance document, financial restitution is paid to a Wetland Restoration Agency (WRA) for restoration works, i.e. Ducks Unlimited Canada.

- Utilizing banked wetland credits stored in Alberta Transportation's wetland habitat bank;
- Constructed, enhanced, or restored wetlands near the area of impact;
- Provide non-restorative replacement
    - Specified research into wetland restoration measures
    - Provincial level monitoring of wetlands
    - Specified wetland inventory work and data acquisition
    - Specified landscape level wetland health assessment or modeling
    - Public education and outreach programs
    - Wetland securement for the purpose of long term conservation

On-site wetland compensation – on-site compensation occurs when impacts to wetlands or wetland area can neither be avoided nor minimized and the developer is required to compensate for unavoidable wetland loss (Alberta Transportation's Wetland Banking Initiative, 2013).

On-site compensation includes:

- Improvements (enhance or restore) to existing wetlands at or near the site of wetland impact;
- Constructing a wetland at the site of wetland disturbance (within contract limits); and naturalizing it as close as possible to a natural wetland in terms of biodiversity.

Organic − with reference to soils, those having ≥ 20-30 % organic matter content by weight, depending on clay content; the majority are saturated for most of the year, unless artificially drained; contain 17% or more organic carbon, and the surface layer must extend to a depth of at least 10-60 cm, depending on the bulk density properties; includes peat.

Organic matter − the organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population.

Permeability − the capacity of some structures (e.g., a porous rock, soil, or sediment) for allowing water to be transmitted without damage to the structure; the ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass of soil or a layer of soil.

Potential wetland opportunities – potential wetland opportunities include:

- Wetlands constructed utilizing historical/decommissioned borrow or aggregate area;
- Restored naturally occurring wetland at the site of wetland disturbance; and
- Enhanced naturally occurring wetlands at the site of wetland disturbance.

A system for evaluating the hydrological and ecological importance of wetland ecosystems was put forward by Environment Canada (1998). These important functions and values could be applied to whether the wetland is being constructed, enhanced, or restored. Wetland functions and values include:

- Hydrological function;
- Biogeochemical function;
- Habitat function;
- Ecological function;
- Social/cultural/commercial values;
- Aesthetic/recreational values; and

- Education and public awareness.

Potential wetland opportunities are assessed by a Qualified Wetland Professional using Alberta Transportation's criteria to determine and evaluate wetland functionality. Constructed, enhanced or restored wetlands will be transferred into Alberta Transportation's wetland habitat bank (Alberta Transportation's Wetland Banking Initiative, 2013).

Qualified wetland professional - Alberta Transportation defines an individual qualified to conduct wetland assessments as someone whom, but is not necessarily limited to (Alberta Transportation's Wetland Banking Initiative, 2013):

(i) possesses
  (A) a post-secondary degree in biological sciences, soils and hydrology,
  (B) a technical diploma in biological sciences, soils and hydrology or
  (C) educational equivalencies, and

(ii) has a detailed knowledge of the aquatic environment, wetland soils, hydrology and wetland margin habitat and their management or assessment; and

(iii) is experienced with
  (A) wetland habitat and aquatic environment assessment methods;
  (B) the determination of ecological impacts relative to mitigation needs, and
  (C) the determination of mitigation measures required to maintain the productive capacity of the aquatic environment, including wetland and wetland margin habitats in Alberta that may be adversely affected by the carrying out of works in and adjacent to the water, bed and shore of water bodies.

A qualified professional may also be defined as someone whom possesses a:

(i) P.Bio designation recognized through the Alberta Society of Professional Biologists
(ii) R.P.Bio designation recognized through College of Applied Biology British Columbia
(iii) R.B.Tech designation recognized through the College of Applied Biology British Columbia

Reclamation (regulatory definition) − the process of reconverting disturbed land to its former or other productive uses; all practicable and reasonable methods of designing and conducting an activity to ensure: (1) stable, non-hazardous, nonerodible, favourably drained soil conditions, and (2) equivalent land capability; the removal of equipment or buildings or other structures and appurtenances, the decontamination of buildings or other structures or other appurtenances, or land or water, the stabilization, contouring.

REC: Regional Environmental Coordinator for Alberta Transporation.

Replacement – where avoidance and minimization efforts are not feasible or prove ineffective, wetland replacement is acknowledged as the last resort in the mitigation process. Wetland replacement can be divided into two overarching categories; restorative replacement and non-restorative replacement (Alberta Wetland Policy, 2013).

Replacement can be further divided into two subcategories:

- *In-lieu fee payment*, whereby the approval holder may choose to pay financial restitution for a wetlands loss.

- *Permittee – responsible replacement*, whereby the approval holder may choose to actively engage in restorative replacement, in accordance with criteria and guidance from the Government of Alberta.

Restorative replacement – refers to replacement activities that attempt to make up for the permanent loss of a wetland through restoration, enhancement, or construction of another wetland (Alberta Wetland Policy, 2013)

Rhizomes - A horizontal, underground stem with buds and roots at the nodes (Weeds of the Prairies, 2000).

Riparian margin − refers to terrain, vegetation or simply a position adjacent to or associated with a stream, flood plain, lake or wetland.

Substrate − any solid surface which forms the place of attachment or place of dwelling of an organism; may be rocks, sand, mud, or the surface of a plant; most often refers to that part of the surface of the wetland soil profile that provides biological and chemical support for the growth of hydrophytic plants; defined by function rather than by a specific soil type.

Submergent vegetation − plant species that have no part extending above the normal water level, but which are rooted in a substrate (not floating) Succession − the natural sequence or evolution of plant communities, each stage dependent on the preceding one, and on environmental and management factors; primary succession occurs on newly created surfaces, while secondary succession involves the development or replacement of one stable successional species by another on a site having a developed soil; secondary succession.

Stolons - A creeping, above ground, horizontal stem that roots at the nodes (Weeds of the Prairies, 2000).

Topsoil (engineering definition) − the surface soil, usually containing organic matter; the uppermost part of the soil, ordinarily moved in tillage, or its equivalent in uncultivated soils, and normally ranging in depth from 5 to 45 cm.

Water table − elevation at which the pressure in the water is zero with respect to the atmospheric pressure; the upper limit of the soil or underlying rock material that is wholly saturated with water; marks the upper boundary of an aquifer.

Wetland − Land saturated with water long enough to promote wetland or aquatic processes as indicated by the poorly drained soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to a wet environment (Alberta Wetland Policy, 2013).

Wetland replacement – Compensation for wetland value that has been permanently lost, due to human activity on the landscape. Replacement activities under the Alberta Wetland Policy include both restorative and non-restorative measures. Restorative measures may include wetland restoration, creation, or enhancement. Non-restorative measures may include those activities that indirectly advance the goal of conserving wetlands and their value such as research, securement, or education (Alberta Wetland Policy, 2013).

Wetland Restoration Agency (WRA) – an organization responsible for restoring drained wetlands to near natural conditions. Responsibilities include securing land rights, obtaining

approvals/licences under the authority of the *Water Act* and where applicable, the *Public Lands Act,* completing restoration works, operating and monitoring the restored wetlands, keeping records and reporting to Alberta Environment (Provincial Wetland Restoration/Compensation Guide, 2007)

APPENDIX 4

Case Study of a Constructed Habitat Wetland

1.0 Constructed Wetland Background

Information retained in this case study has been referenced from 'Wetland Planning Report: Design, Construction, and Monitoring Plans for a Compensation Wetland on Hwy 58 (NW 26-110-3-W6, prepared by Ecofor Consulting Ltd, 2009).

The purpose of this case study is to provide the reader with a constructed wetland scenario and to display and highlight some important construction parameters.

The constructed wetland (herein after referred to as the 'project') of interest is located in northern Alberta, along Hwy 58, 3.4 km west of the Chinchaga River crossing; NW 26-110-3-W6M. The site started out as part of a deciduous forest on the south side of the Hwy. 58 corridor. The location was initially developed as a borrow area during the original construction of Hwy 58. Since that time one of the borrow areas had regenerated into a wetland, and vegetation including small coniferous trees and grasses have grown on the surrounding developed areas. In 2008 the site was further used as a borrow area during construction work and widening of the hwy. During the 2008 construction the area was expanded into a shallow depression several hectares in size, with a fine sandy substrate. The water table at the location is generally high which has resulted in the depressions naturally filling with water.

2.0 Wetland Function

The borrow area in its flooded conditions maintain a relatively shallow depth and a complex shape, including some small islands (Figure 1.0). These conditions suited for the establishment of a naturally functioning wetland. Shallow shoreline areas around the perimeter and near the islands provide habitat for shallow emergent wetland plants; sedges and cattails (Figure 2.0). The deeper areas provide habitat for deeper wetland plants, as well as the maintenance of some open water areas.

Figure 1.0 Constructed Wetland Features - Islands

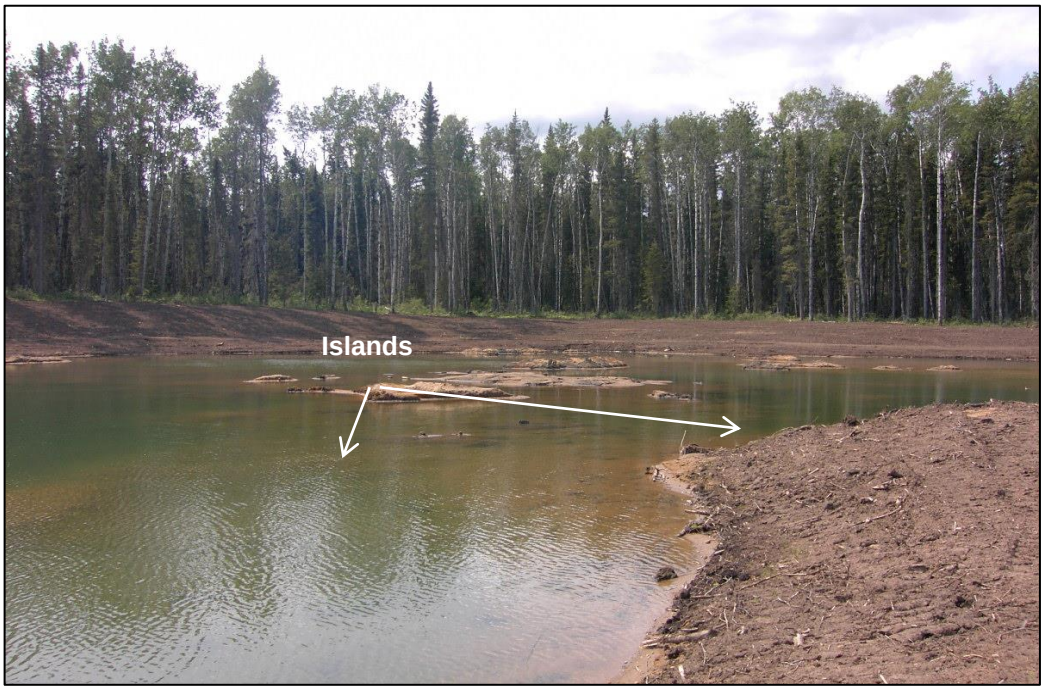
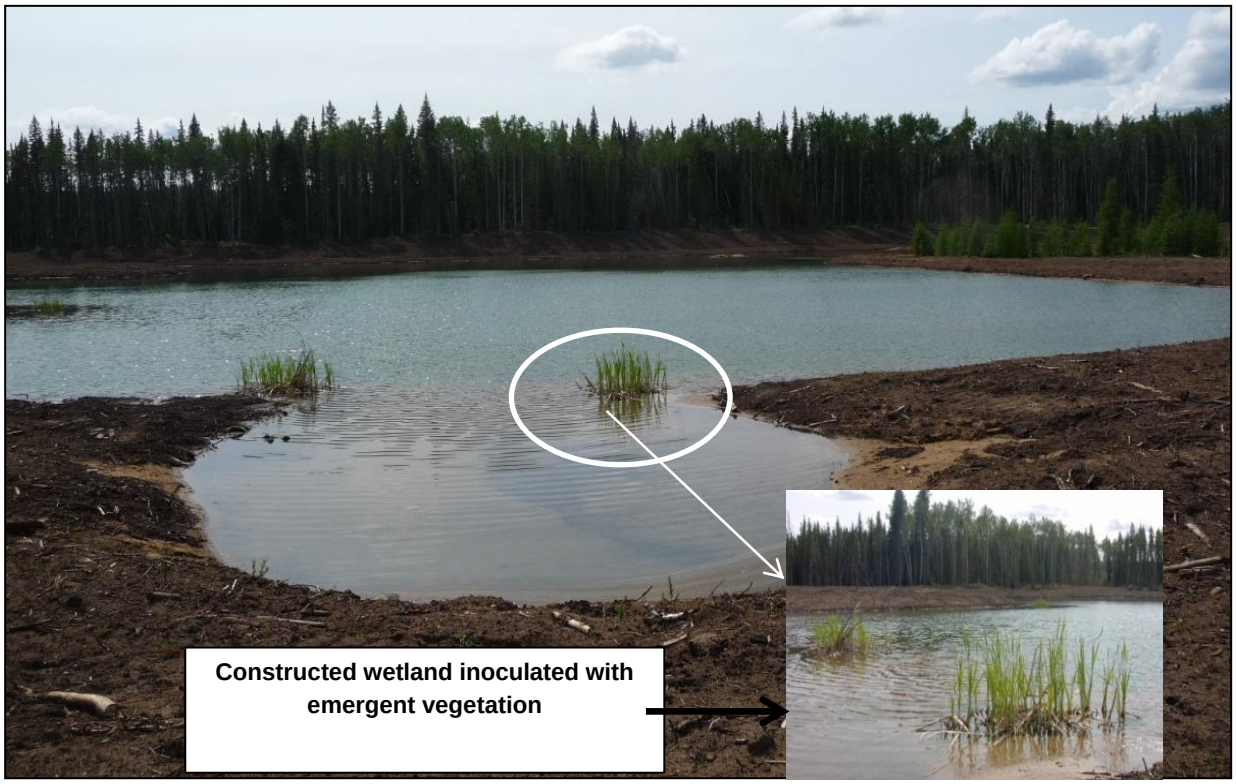


Figure 2.0 **Constructed Wetland Features**
Habitat for shallow emergent plants, cattails and sedges



3.0 Physical Dimensions and Characteristics

3.1 Water Depth Zones

The wetland is groundwater fed, and its depth is dependent on the season and ultimately the level of the water table. In the region, the water table has a high variability, rising and falling significantly.

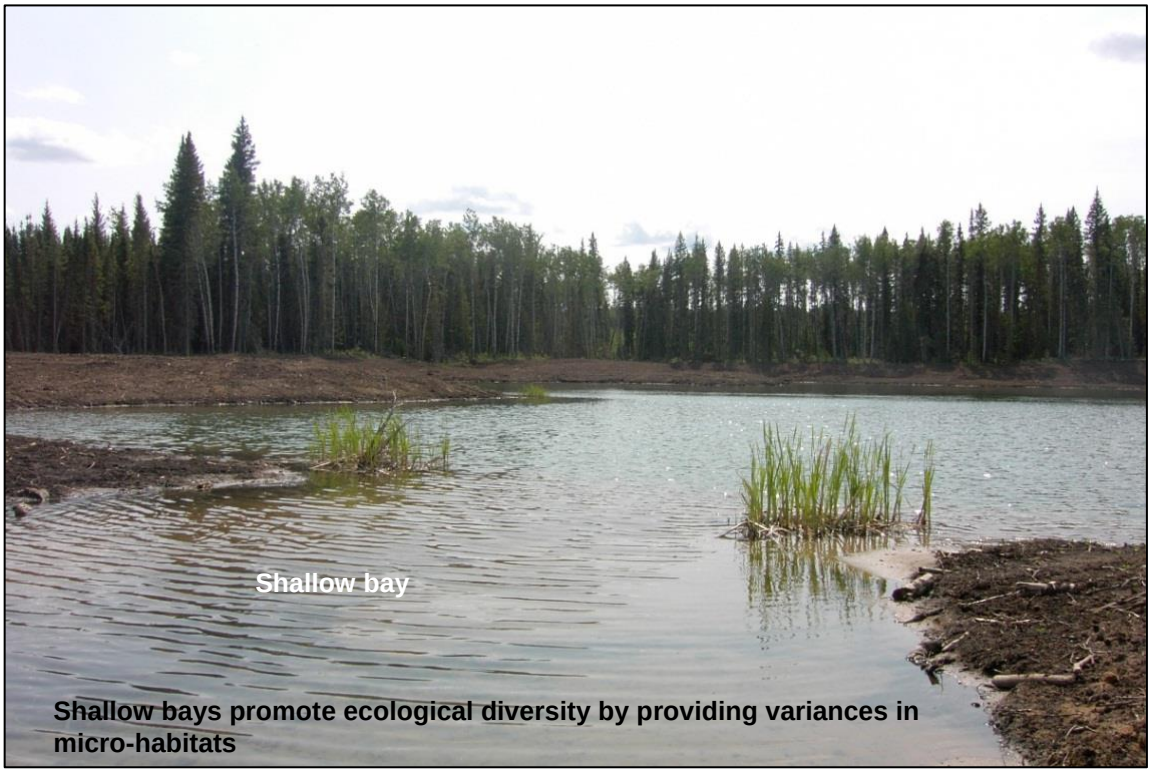
At normal high water stages, the constructed wetland is expected to have a maximum depth of 3m, and a significantly larger portion of open water. As the water table drops, the wetland is expected to shallow up and have a significant portion of vegetated area, including areas that are both above the water level, averaging 0-1m depth. The wetland was constructed to include approximately 900 linear meters of shallow water shoreline area.

The constructed wetland has been designed to incorporate irregular bottom contours (Figure 3.0), promoting a diversity of habitat types for aquatic organisms and vegetation.

Figure 3.0 **Constructed Wetland Features**
Deep hole located at the north end of the constructed wetland

Shallow bays (Figure 4.0) were also incorporated in the constructed wetland design.

Figure 4.0 **Constructed Wetland Features**
Inclusion of shallow bays



3.2 Wetland Substrate

Wetland substrate at the site is primarily sandy materials. Over time the decay of plant material is expected to add a component of organic material to the constructed wetland bottom.

Figure 5.0 **Constructed Wetland Features**
Placement of topsoil; growing medium

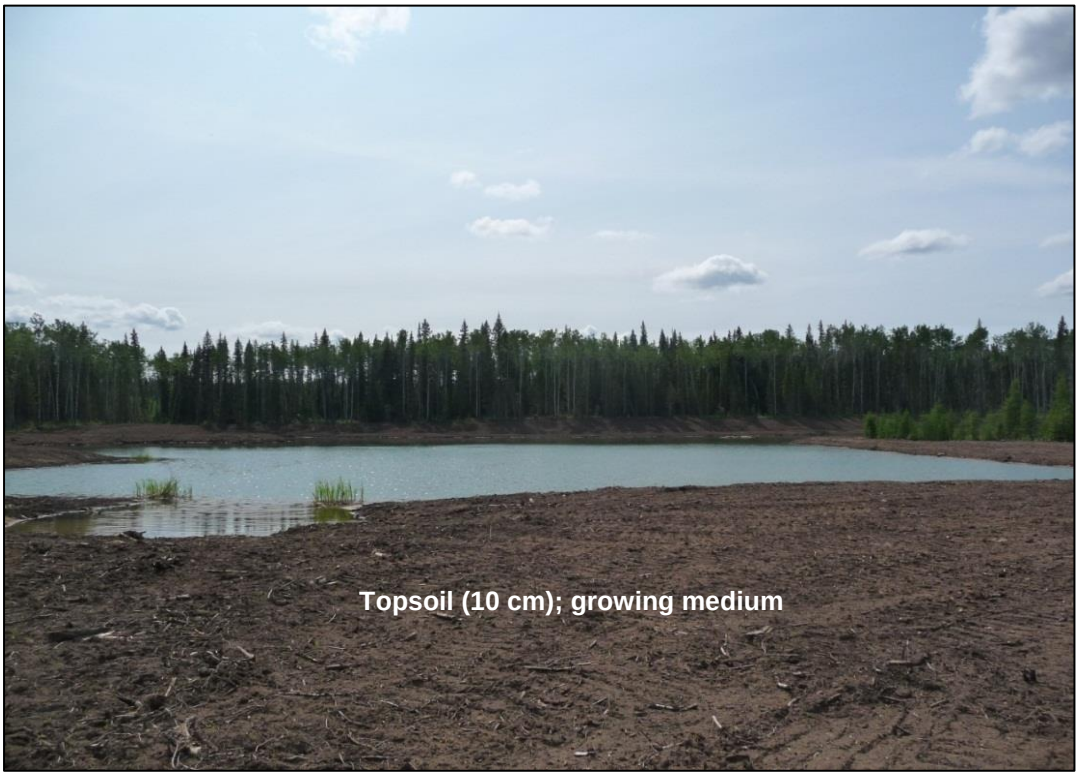
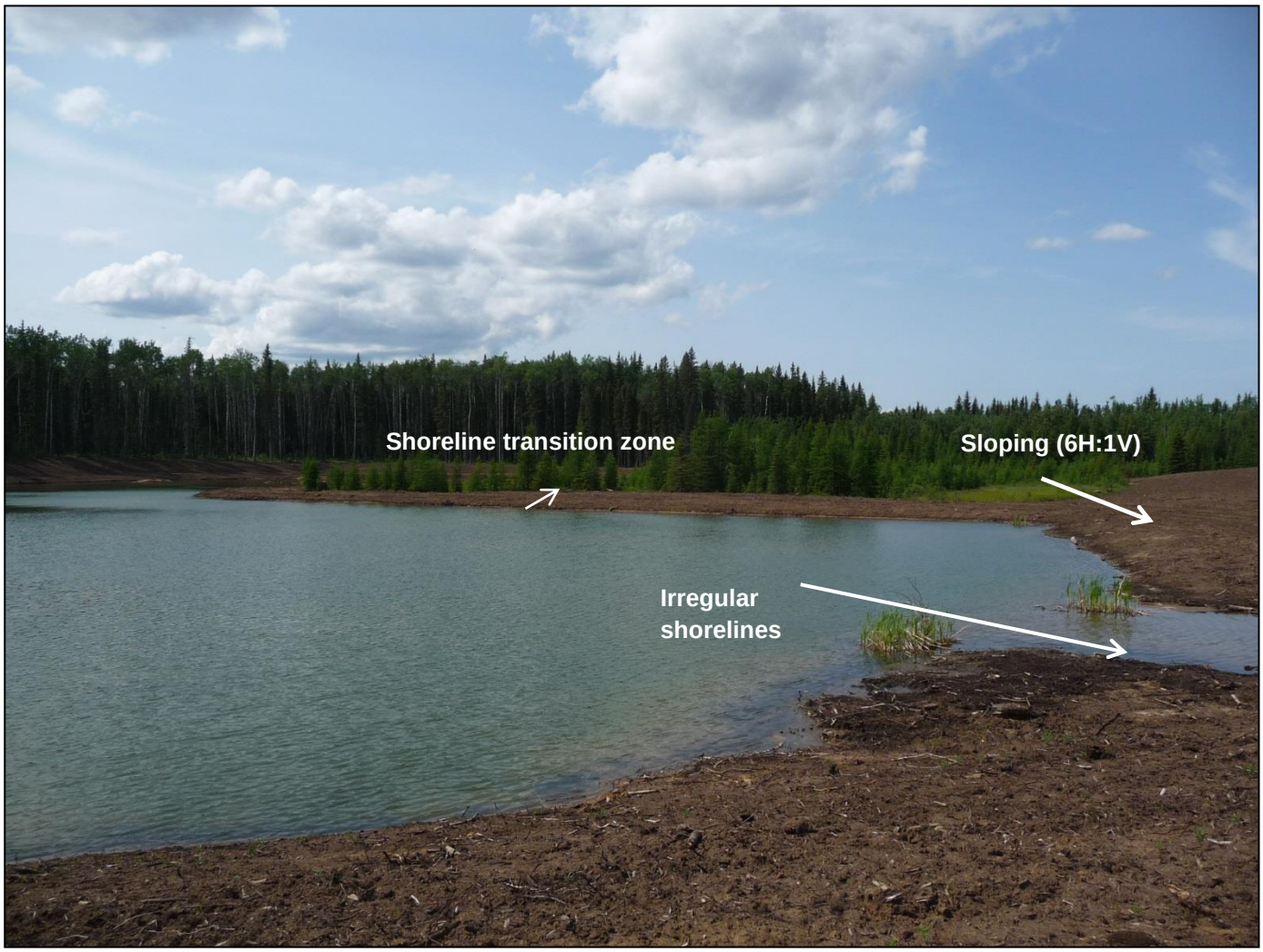


Figure 6.0 **Constructed Wetland Features**
Young cattail shoots growing naturally; post construction

Figure 7.0 Constructed Wetland Features



Appendix 4 - Table 1: *Example of Wetland Functions analysis, Dogpound Creek* Wetland Definition	
Class and Size	Creek shoreline and impounded open water, with deep marsh, shallow marsh and wet meadow zones. Overall, equivalent to Class V wetland (Stewart and Kantrud, 1971). Part of Dogpound Creek drainage. The site also includes two small wetland areas associated with a low-lying floodplain immediately west of the open water area.
Wetland Function	Role and Importance of the Wetland being Assessed
Hydrological function	Being in the headwaters of the Dogpound Creek watershed, the waterbody and associated wetland would play a significant role in the hydrology of the watercourse, moderating and maintaining flows and shoreline fluctuations, etc., especially as it is an impoundment formed by a small dam. The impounded waterbody and the associated marsh/meadow areas would tend to control erosion from the surrounding slopes, whether the land use is agricultural or industrial.
Biogeochemical function	Incrementally, the wetland would assist in metabolizing nutrients (phosphorus, nitrogen) from local/upstream agricultural runoff, turning it into biomass and preventing algal blooms and anoxic conditions resulting due to bacterial action. The wetland likely controls/stabilizes local sediment flow resulting from erosion on surrounding lands, as well as contaminants associated with particulate matter, thus enhancing water quality.
Habitat functions	Several species of waterfowl and many amphibians were observed in the wetland in the field reconnaissance: the open water, shallow marsh and deep marsh vegetation evidently provides nesting, rearing and feeding habitat. Although no fish capture was attempted, fish are known to inhabit Dogpound Creek. It is a mapped waterbody (Class D). The open water, deep marsh, shallow marsh and wet meadow habitats, overall, provide a variety of ecological niches, which enhances biodiversity.
Ecological functions	The wetland is an important link in the ecological connectivity of aquatic and riparian habitats in the upper reaches of Dogpound Creek with similar habitats downstream: loss or impairment would cut off other habitats upstream, resulting in overall fragmentation of critical wetland and riparian habitat. The wetland could be expected to have high primary and secondary biological productivity. There are fewer and fewer wetlands and open waterbodies of this type that are unaffected.
Social/cultural/commercial values	It is not known if the wetland played a significant role in Aboriginal or other (pre-)history. The waterbody and impoundment are part of a Ducks Unlimited conservation site based around wetland ecological and habitat values. The open water area is used for livestock watering.
Aesthetic/recreational	The wetland is visible from a major roadway.
Education & awareness	The wetland and impounded waterbody have the potential to be used for educational and interpretational features as part of the end use plan, depending on ownership and level of interest.