CCE AWARD SUBMISSION

SUNCOR: FIREBAG BORROW PIT 6 RECLAMATION PROJECT

Golder Associates

INTRODUCTION

Suncor Energy Inc. (Suncor) retained Golder Associates Ltd. (Golder) to work collaboratively on their proposed Reclamation Plan for Borrow Pit 6, located within the Firebag In-Situ Oil Sands (Firebag). Firebag is located about 65 km northeast of Fort McMurray, Alberta and about 40 km northeast of the Suncor Oil Sands Base Plant operations (Figure 1). Borrow Pit 6 was developed to provide fill materials for the construction of the Firebag Central Processing Facility and associated access roads. Suncor initiated a plan to begin reclamation of Borrow Pit 6 during the winter of 2013.

Civil engineering principles and techniques were used in the reclamation design complemented by an innovative, integrated, multidisciplinary approach that included hydrologists, soil scientists and biophysical reclamation specialists. Together, the team worked to address the challenges of reclaiming Borrow Pits among peatlands.

Previously known Borrow Pit reclamation consisted of simply replacing salvaged soils on pit slopes above the expected water line. Borrow Pit 6 is one of the first Oil Sands Region's borrow pits to be fully reclaimed and integrated into a neighbouring peatland with a shallow water table, actively flowing into the pit.

Reclamation Goals

General reclamation objectives for Borrow Pit 6 included:

- Ecosystems re-established on disturbed lands will be self-sustaining and capable of maturing naturally, to present suitable opportunities for the needs of resident and migratory wildlife species.
- Reclaimed lands will be maintenance-free, thereby qualifying for reclamation certification. Various end uses will be possible for the reclaimed landscape, with end-use decisions made based on input from both regional communities and recommendations from multi-stakeholder committees.

PRE-RECLAMATION SITE CONDITIONS

The Athabasca Oil Sands Region is made up of about 40 to 60% wetlands terrain; specifically, peat forming wetlands (peatlands) with thick, saturated, organic layers. To construct facilities in this type of terrain requires large amounts of fill material extracted from borrow pits scattered throughout each Project area.

Borrow Pit 6 is located adjacent to a road and pipeline right-of-way. The area that was used for borrow was water-filled with an average depth of 2 to 3 m. Before the reclamation process, the perimeter of the water body had begun to naturally revegetate with wetlands species in the riparian areas and jack pine, willows, grasses and forbs in the upland areas. At the northern end of the pit, shallow water had ponded and sedge species had ingressed. The eastern edge was adjacent to an upland area that had been cleared of vegetation and was regenerating naturally with blueberry and jack pine. Some of these blueberry plants had begun to spread into the exposed overburden areas.

There is a cleared observation well pad located immediately east of the borrow pit. That pad was not effectively draining, resulting in ponded water on the pad surface. The south end of the pit was cut into the edge of a treed bog (BTNN). A nearly vertical cut showing mineral subsoil and the peat layer was apparent above the water level (Photo 1). Surface water was seen to be draining from this bog into the pit. Topsoil and subsoil stockpiles were located along the western and northwestern edges of the cleared area.

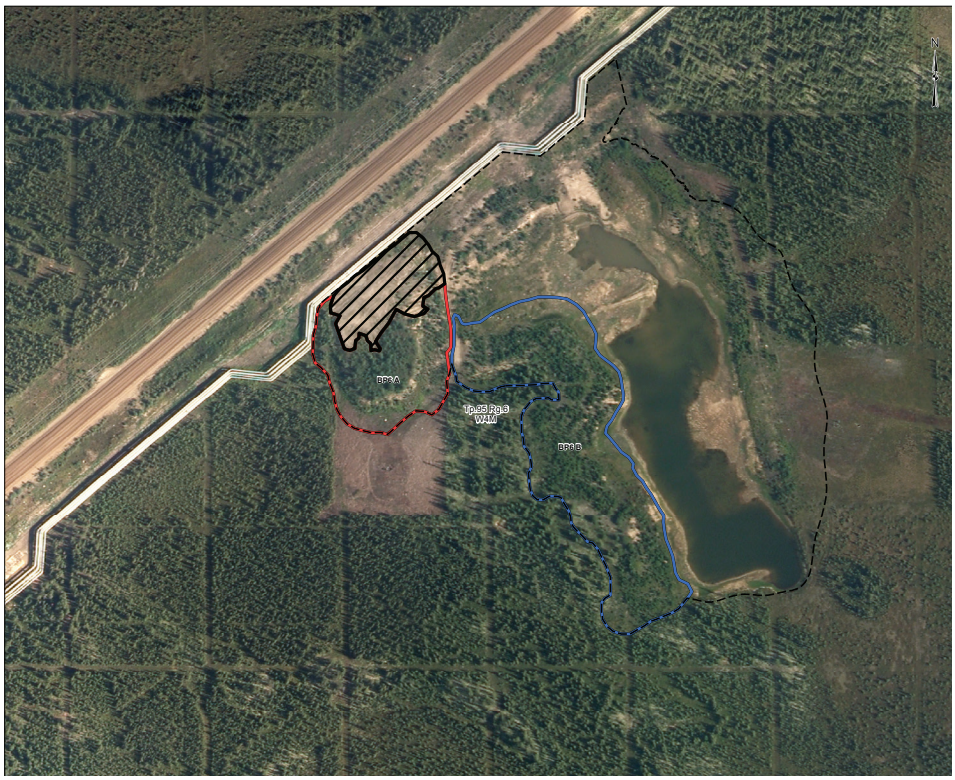

Figure 1: Borrow Pit 6 Reclamation Area and the location of the Central Processing Facility

Photo 1: Peatland at the edge of Borrow Pit 6 before reclamation

RECLAMATION DESIGN

Golder's proposed final design to Suncor for the reclaimed waterbody and surrounding area is shown in Figure 2. The goal was to create a natural appearing landform that blends into the landscape and provides habitat for diverse vegetation establishment and wildlife habitat. Golder's objective was to design a waterbody to reflect natural analogues in the oil sands region.

Slope Design and Contouring

Construction material that was identified as unsuitable for reclamation within the Project area was used in creating final slopes. Areas where material was available for excavation are shown in Figure 3 as the cut areas (blue). Areas receiving material were identified by the green, orange, red and yellow polygons.

The primary source of fill material was two small peninsulas found in the waterbody. Exact construction material sources (cut) and placement (fill) locations were determined at the time of construction, based on site conditions.

The reclaimed waterbody was expected to be approximately 2 m deep at its deepest point, with seasonal water level fluctuations. The north end of the waterbody was designed to become gradually shallower to allow for the

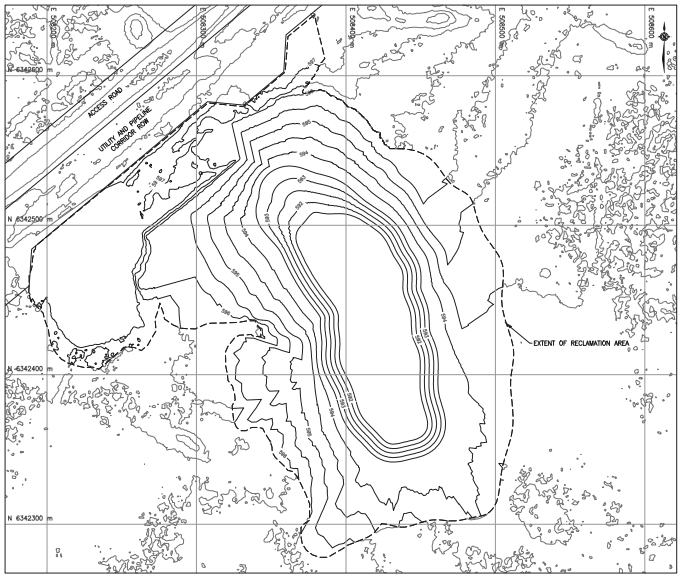

Figure 2: Proposed Final Contours for the Borrow Pit 6 Reclamation Area

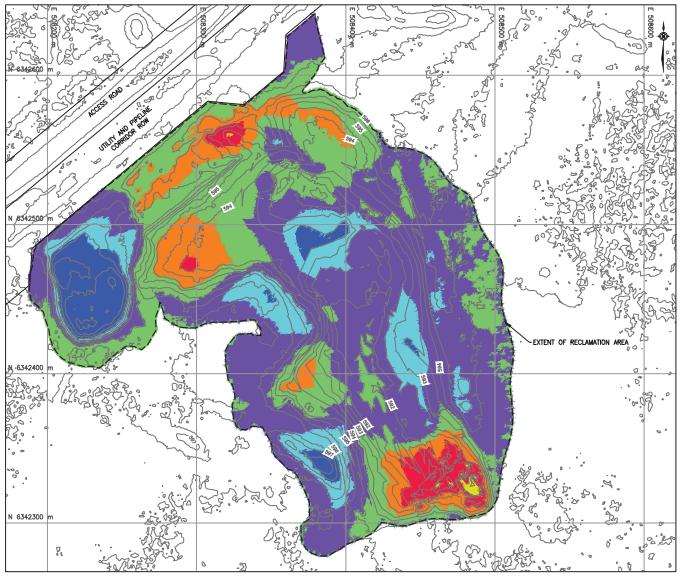

Figure 3: Estimated Cut and Fill Depths for the Borrow Pit 6 Reclamation Area

development of a littoral zone containing emergent aquatic vegetation. The final open water area (when water is at 2 m depth; elevation 593.5 m) is expected to be 1.4 ha. Final contours were subtle and gently ran toward the pit waterbody with 0.5% to 1% slopes (Figure 2). The surface was left rough to allow for microsite development and irregular water edges.

Prior to reclamation material placement, the following site preparation was conducted:

- Surfaces were re-contoured to create undulating surfaces and slopes that blend with the surrounding environment and to support local drainage patterns.
- Contours were representative of natural waterbodies located elsewhere within the Firebag lease.
- Drainage direction was consistent with the predevelopment conditions.

TABLE 1: DESIGN CRITERIA FOR RECLAIMED WETLANDS DEVELOPMENT

Development Area Feature	Criteria	Comments
Water Depth	Maximum of 2 to 3 m	Maximum design depth is 2 m
Upland Areas	Maximum slope of 2H:1V	Sloped toward riparian areas
Riparian Areas	Maximum slope of 3H:1V	Sloped toward open water wetlands
Littoral Areas	Maximum slope of 6H:1V	Can be narrow band or larger plateaus occupying 20 to 30% of wetland; irregular edges
Littoral to Waterbody Bottom	Maximum slope of 3H:1V	
Waterbody Bottom	Slope of 20H:1V	Irregular pit bottom contours

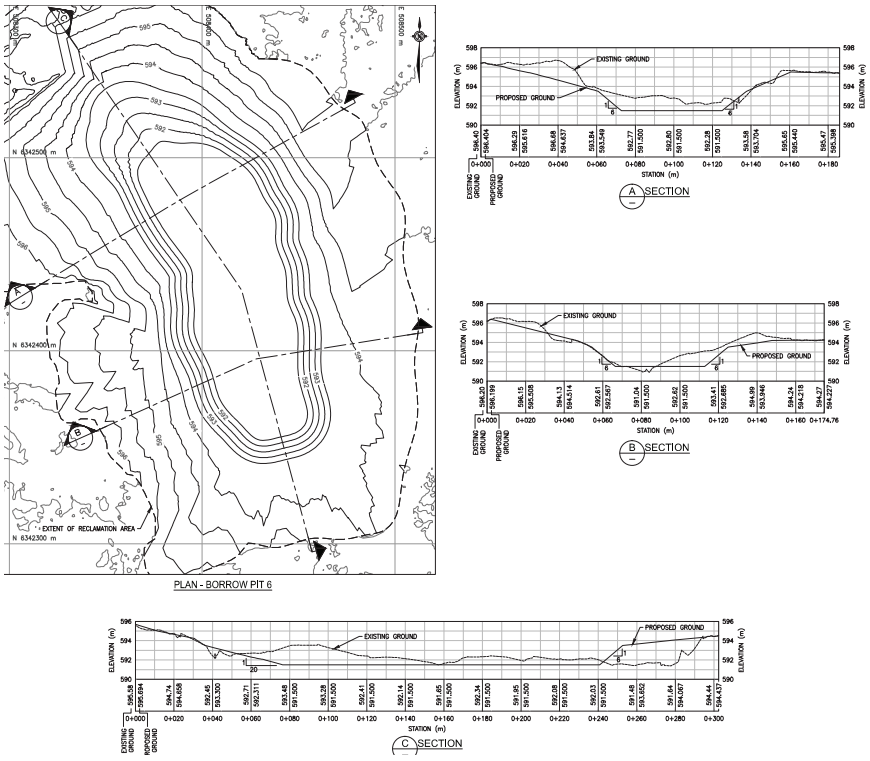

Figure 4: Cross-Sections of the Proposed Borrow Pit 6 Reclamation Area

Photo 2: Integration of the peatland at the south end of the water body

- Upland areas were deep ripped to alleviate compaction. Where soils were excessively wet, ripping operations were postponed until conditions were dry enough to ensure that the soils would fracture when ripped.

Final slope design followed the criteria discussed in Table 1.

Cross sections showing the original ground and proposed final slopes of the reclaimed Borrow Pit 6 area can be found in Figure 4.

On the eastern edge of the pit waterbody where ponding issues were identified contours were designed to facilitate drainage from the adjacent observation well to the reclaimed waterbody. Suncor will continue to monitor the southern end of the pit for use as a wetlands reclamation trial (Photo 2).

To reduce potential environmental impact of contamination to the reclaimed waterbody in the event of run off from the road or right-of-way, the site was contoured such that the high point would be a subtle ridge running parallel to the pipeline, approximately 10 m south of the right-of-way with gentle slopes (0.5% to 1%) on either side. This will ensure that if there are any unplanned release events, fluids will gather in the road ditch which flows to the east and would prevent contamination of the reclaimed waterbody.

CONSTRUCTION AND RECLAMATION ACTIVITIES

Site Preparation and Woody Debris Management

Vegetation clearing was conducted during the winter months when the ground was frozen to reduce soil compaction by tree removal equipment. Vegetation clearing only occurred where necessary within the

Photo 3: Woody debris spread on the reclaimed slopes to enhance biodiversity and revegetation success

project area. The woody debris was broken into lengths ranging between 15 cm and 50 cm, resulting in physical and biological characteristics considered to be intermediate between standard small wood chips and larger “branch and bole” material. The woody debris was spread randomly throughout the Project area after topsoil placement to aid in creating micro habitats and to encourage greater vegetation diversity as the site matures (Photo 3).

Berm Construction and Pit Dewatering

A temporary berm was built from fill material excavated from the peninsulas that exist in the current waterbody (Figure 3) to prevent water from seeping into the construction area from the adjacent bog during contouring activities. The berm was constructed to be slightly higher than the surrounding ground level. Once pit contouring was completed, the berm material was levelled out to create the desired grade (Figure 2) at the south end of the pit.

SITE RECLAMATION

Reclamation Material Windrowing and Placement

Once the pit was dewatered and the berm was in place, Suncor spread reclamation material over the landscape. Subsoil was redistributed first with a placement thickness of approximately 30 cm in upland and riparian areas. Topsoil placement thickness was approximately 15 to 20 cm. Inconsistencies in depth and surface irregularity aided in creating micro habitat areas.

In an effort to retain viable propagule and seed banks on stockpile surfaces for reclamation purposes, the top 5 to 10 cm of topsoil and subsoil material was removed and stored to be spread on the reclaimed surface during reclamation material placement. Following topsoil replacement, Suncor contoured the surface, around the perimeter of the waterbody, while still frozen to facilitate the formation of irregular micro-topographic features as the material thawed.

Once the waterbody was dewatered, saturated sediments were salvaged and temporarily stockpiled for use during final reclamation material placement. This material was high in organics and could help accelerate the biological development of the waterbody. Sediment was redistributed evenly along the bottom of the reclaimed waterbody and littoral zones after recontouring.

In the southern portion of the Project area, adjacent to the existing bog, approximately 40 cm of peat, sourced from within the Firebag Project area was placed over the re-contoured surface. Woody debris was spread around the site, specifically in areas that are prone to erosion.

Site Revegetation

Re-vegetation of the Project area started during the Fall of 2013. At the time of revegetation, the water reached a stable depth of approximately 2 m. Upland areas were planted with black spruce plugs and that the littoral zones were allowed to revegetate naturally. Plantings will be further refined based on the closure landscape and revegetation success monitoring.

Photo 4: Moose tracks found in the reclaimed area in the fall of 2013

CONCLUSION

The reclaimed pit was allowed to fill with water in the spring of 2013 and trees were planted around the perimeter of the water body. Ongoing monitoring will be used to assess vegetation growth and ingress, use of the site by wildlife and water quality and quantity. Moose tracks have already been found on the site (Photo 4). As the ecosystem matures, the biodiversity of the area will also increase. Ultimately, the site will be a natural, self-sustaining feature of the landscape. By properly reclaiming these industrial disturbances, the environmental benefits are unmistakable, including the opportunity for the continued use of these lands by First Nations to engage in and pass on traditional use activities to future generations. The lessons from this site are already being applied to the reclamation of additional Borrow Pits along the nearby highway and can be used to enhance reclamation efforts throughout the Region.

Golder's key strategy was to work within an integrated team of stakeholders and technical specialists, including the client, the construction crew, civil engineers, hydrologists, soil scientists, revegetation specialists and reclamation specialists.

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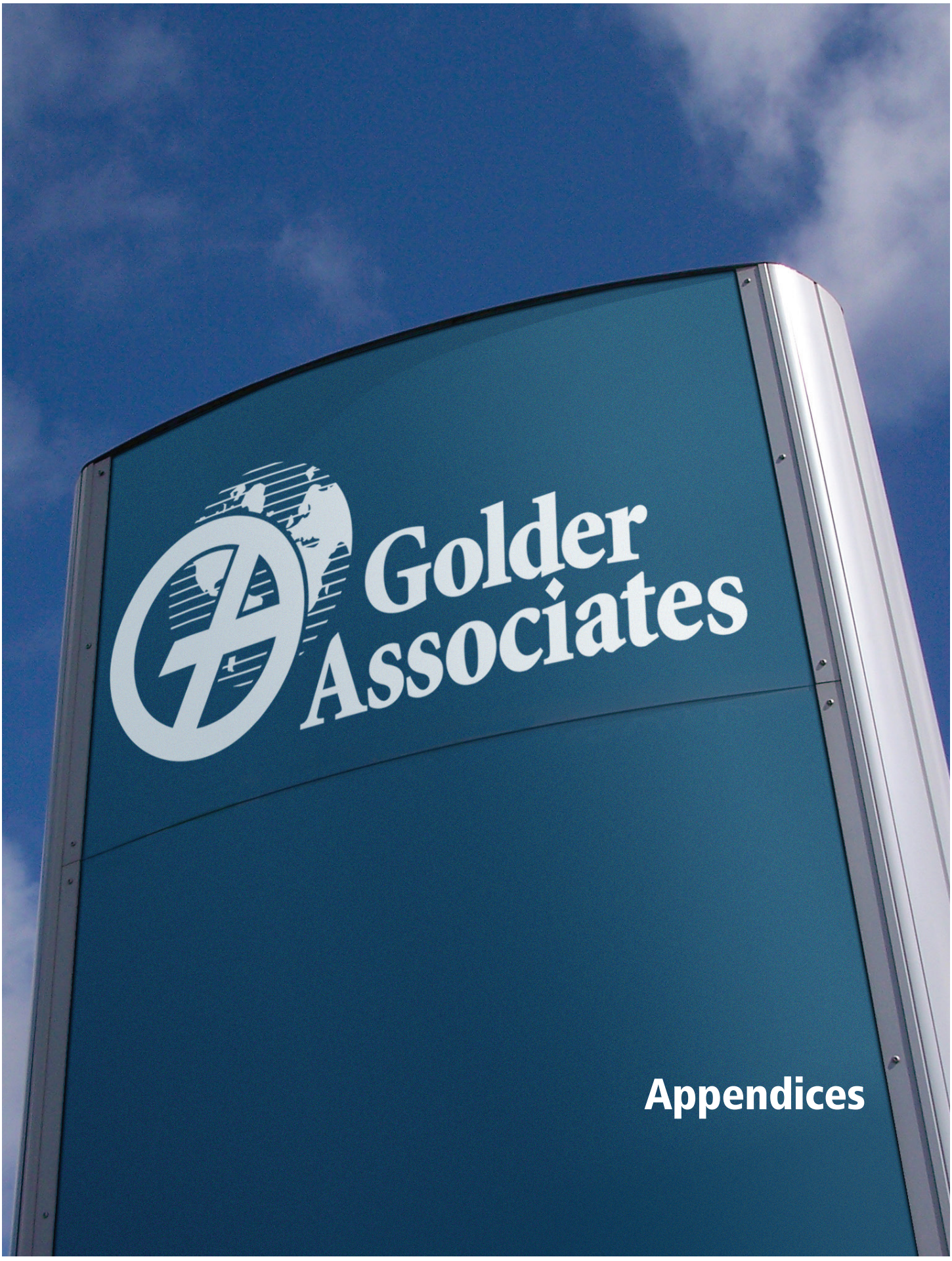
REFERENCES

Golder. 2011. Firebag 2011 Annual Conservation and Reclamation Report. Submitted to Suncor Energy Inc. Fort McMurray, AB. Submitted March 2012.



Appendices

OFFICIAL ENTRY FORM SUMMARY

Golder Associates and Suncor Energy worked together to design and implement a reclamation plan for Borrow Pit 6 at the Firebag Oil Sands Project. A multi-disciplinary team designed a closure landscape that mimics natural conditions and integrates into the surrounding ecosystem. The reclamation of Borrow Pit 6 provides wildlife habitat, traditional Aboriginal land use opportunities, economic benefits and a demonstration of Borrow Pit reclamation that can be used to enhance reclamation efforts throughout the Region.

OFFICIAL ENTRY FORM QUESTIONS

Q.1 Innovation (40%)

Suncor Firebag In-Situ Oil Sands Project (Firebag) is located about 65 km northeast of Fort McMurray, Alberta and about 40 km northeast of the Suncor Oil Sands Base Plant operations. Borrow Pit 6 was developed to provide fill materials for the construction of the Firebag Central Processing Facility and associated access roads.

Borrow Pit 6 was reclaimed in the winter of 2012/2013. General reclamation objectives for Borrow Pit 6 included:

- Ecosystems established on disturbed land will be self-sustaining and capable of maturing naturally, to present suitable opportunities for the needs of resident and migratory wildlife species.
- Reclaimed lands will be maintenance-free. Various end land uses will be possible for the reclaimed landscape, with end-use decisions made based on input from both regional communities and recommendations from multi-stakeholder committees.
- The reclaimed lands will achieve reclamation certification.

The Athabasca Oil Sands Region is made up of about 40 to 60% wetlands terrain; specifically, peat forming wetlands (peatlands) with thick, saturated, organic layers. To construct facilities in this type of terrain requires large amounts of fill material extracted from borrow pits scattered throughout each Project area. Civil engineering principals and techniques were used in the reclamation design complemented by an innovative, integrated, multidisciplinary approach that included hydrologists, soil scientists and biophysical reclamation specialists. Together, the team worked to address the following challenges of reclaiming borrow pits to integrate with the surrounding peatlands:

- There is very little experience reclaiming borrow pits in the boreal forest of the Oil Sands Region.
- The surrounding peatlands can cause unpredictable water movement into and out of the reclaimed waterbodies.
- Excessive water movement out of surrounding peatlands can lead to vegetation stress in the wetlands causing tree mortality over time.
- The reclaimed water body must have a natural-looking, irregular shape and be integrated into a surrounding, undulating terrain with proper riparian and littoral zones for habitat.

Previously known borrow pit reclamation consisted of simply replacing salvaged soils on pit slopes above the expected water line. Borrow Pit 6 is one of the first in the Oil Sands Region to be fully reclaimed and integrated into a neighbouring peatland with a shallow water table actively flowing into the pit. The natural-looking water body design allows for:

- Effective wildlife access
- Support of a healthy, local vegetation population
- The continued health and productivity of the adjacent peatland
- Natural transition from the open water into the saturated, peat-forming vegetation community of the peatland

Q.2 Complexity (20%)

There were many uncertainties prior to the design phase of the Project including lack of experience in boreal habitat, unpredictable water movements and the challenge of integrating peatlands into the design. Borrow Pit 6 was constructed early in the development of the Firebag Project so at the time of reclamation there was incomplete information around what the landform used to look like, how much topsoil and subsoil was salvaged and stockpiled, and the nature and quality of the available soil. Over time, the stockpiles naturally revegetated making them difficult to distinguish from the surrounding natural areas. Pre construction surveys were completed to delineate the stockpiles and on-site adaptive management was used so that the appropriate soil was placed and no additional disturbance was caused.

As this is a relatively new area of practice, effort was put into determining what the final water level of the water body was expected to be and how to properly integrate the water table with the surrounding peatland so that a flow regime could be established to maintain the health of the peatland. This required consideration as to where the littoral and riparian zones would be and how to create appropriate slopes to achieve functioning vegetation and hydrology.

The project required the integration of technical contributions from a variety of subject matter experts including: civil engineers and hydrologists for pit dewatering, site recontouring, and drainage establishment; soil scientists to recommend effective soil handling and placement; and biophysical and reclamation specialists for woody debris management and revegetation.

Q.3 Social and/or Economic Benefits (15%)

The boreal forest is a unique mosaic of landforms and vegetation types that were formed over thousands of years of post-glaciation, climate change and succession. These landscapes are used for forestry, mining, wildlife habitat, traditional uses and recreation. These landscapes provide direct economic benefits through timber harvest, minerals and metals extraction, recreational services and the trapping and selling of fur bearers.

The social benefits of having these landscapes available include the continued ability to conduct traditional use activities. The area is part of the traditional territories of First Nations communities who have used the land for hunting, trapping, gathering of food and medicine and for spiritual activities for generations. The restoration of these types of disturbances to locally common boreal forest ecosystems allows for the opportunity for the continued use of these lands by First Nations to engage in and pass on traditional use activities to future generations.

Implementing reclamation plans such as this will allow for continued learning in the science of boreal reclamation. The lessons from this site will act as a model for future reclamation with continual improvements. By improving the way reclamation is done in the Oil Sands Region, social and economic benefits can be realized at industrial sites throughout the region.

By aiming to re-establish a self-sustaining and naturally maturing ecosystem, the conditions are set to enable a sustainable socio-economic feature where traditional and commercial uses compatible with the boreal forest can continue.

Q.4 Environmental Benefits (15%)

The oil sands, especially in-situ oil sands, are rapidly growing in Northern Alberta. Many hectares of land will be disturbed over the life of these developments and the science of reclamation in these areas is very young. When a unique piece of reclamation is put into place, it becomes a model for the industry to learn from and to emulate as further reclamation proceeds. Reclaimed sites can be monitored for short and long term performance of vegetation, hydrology, slope stability, the establishment of aquatic species, wildlife usage of the reclaimed area, and overall reclamation success. When challenges are encountered, they become opportunities to learn what works and doesn't work and how to mitigate issues when they do arise.

By properly reclaiming these industrial disturbances, the environmental benefits are unmistakable, including:

- Decreased habitat fragmentation allowing for protection of sensitive species such as caribou.
- Increased habitat functionality for large and small mammals, waterfowl and aquatic species that will use the resulting open water bodies as resting places, watering holes, breeding grounds and wintering habitat.
- Increased biodiversity potential through the reclamation of areas that may be prone to infestation by weeds and invasive species.
- Increased overall aesthetic and function of the ecosystem as a whole.

Q.5 Meeting Client's Needs (10%)

The client's goals for this Project were:

- To re-establish a locally common boreal forest ecosystem. To achieve this, a plan was developed to provide:
    - A step by step plan for site recontouring, drainage establishment, soil handling, woody debris management and revegetation.
    - Monitoring during construction activities.
    - A trial wetlands reclamation area.

Golder's key strategy was to work in an integrated team of stakeholders and technical specialists. By creating a team including the client, construction crew, civil engineers, hydrologists, soil scientists, revegetation specialists and reclamation specialists, Golder was able to integrate technical aspects to meet the client's main Project goals.

Once the plan was in place Golder adopted an adaptive management strategy to adjust the plan to fit field conditions during construction. The plan was adapted to suit the terrain and materials available while still meeting the overall Project objectives.

The reclaimed pit was allowed to fill with water in the spring of 2013 and trees were planted around the perimeter of the water body. The initial assessment showed a stable, natural looking landscape. Ongoing monitoring will be used to assess vegetation growth and ingress, use of the site by wildlife and water quality and quantity. Moose tracks have already been found on the site. As the ecosystem matures, the biodiversity of the area will also increase. Ultimately, the site will be a natural, self-sustaining feature of the landscape. The lessons from this site are already being applied to the reclamation of additional borrow pits along the nearby highway.

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