

Translating the closure plan into an operational reclamation programme at Canadian Natural's Horizon Oil Sands Mine

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Abstract

The conceptual Horizon Reclamation and Closure Plan was filed in 2002 in support of the Environmental Impact Assessment (EIA) as a green field project application with an updated Closure and Reclamation Plan submitted in 2006. The Horizon Project reclamation goal is to achieve self-sustaining ecosystems with a capability equivalent to pre-development conditions using locally common boreal forest communities as the template for revegetation activities. Self-sustaining ecosystems will evolve on reclaimed areas, from these new plantings to mature vegetation communities typical of the region.

Within any organisation, the implementation of new processes can test the systems that have been used as well as understanding the pressures and incentives to taking on new activities, such as reclamation. As a green field operation, Horizon Oil Sands has reclaimed the area for the compensation lake in 2008, but had not completed reclamation of any structures associated with the development of the mine until 2010 as the mining activities and processing of the oil sands started in early 2009. As a result of development of this new mine, Waste Area 1 was the first available mine structure upon which reclamation could be conducted.

There have been a number of learning elements from the implementation of reclamation for Horizon Oil Sands Waste Area 1 that will be useful in helping reduce the challenges of future on site reclamation activities. The systems and methods for turning the conceptual closure plan into an operational reclamation program are the focus of this paper.

1 Introduction

Horizon Oil Sands is a wholly owned oil sands production operation of Canadian Natural Resources Limited (Canadian Natural), headquartered in Calgary, Alberta and is located within the Regional Municipality of Wood Buffalo, approximately 70 km north of the community of Fort McMurray, Alberta (Figure 1).

The Horizon Oil Sands operation consists of a surface mine, a bitumen processing facility with associated tailings ponds, and a heavy oil upgrading facility which produces Synthetic Crude Oil (SCO). Major site development for the project began in 2004 and initial production of SCO began February 2009. Current design capacity for the existing plant is for 110,000 barrels per day of synthetic crude oil. When the approved expansions are fully implemented the mine is scheduled to produce 270,000 barrels per day (bbl/d) of bitumen and the heavy oil upgrader is scheduled to produce 232,000 bbl/d of SCO. Mining at Horizon is expected to end in 2050 and surface reclamation is planned to be completed by 2060.

The largest surface disturbances on the project site are a result of mine surface soil and overburden removal operations and the construction of the tailings pond dyke for the bitumen processing facility.

The Horizon Closure and Reclamation (C&R) Plan for the Horizon Oil Sands project describes Canadian Natural's vision, philosophy and commitment to reclamation of the Horizon Project development area. The first closure plan for the Horizon Project was prepared and submitted as part of the application in 2002 (Canadian Natural Resources Limited, 2002). This plan was revised in 2006 (Canadian Natural Resources Limited, 2006) with a new revision scheduled to be submitted to Alberta Environment (AENV) by December 31, 2011. Development of the Horizon Project will be implemented using a phased approach, allowing for successive reclamation practices to be employed.

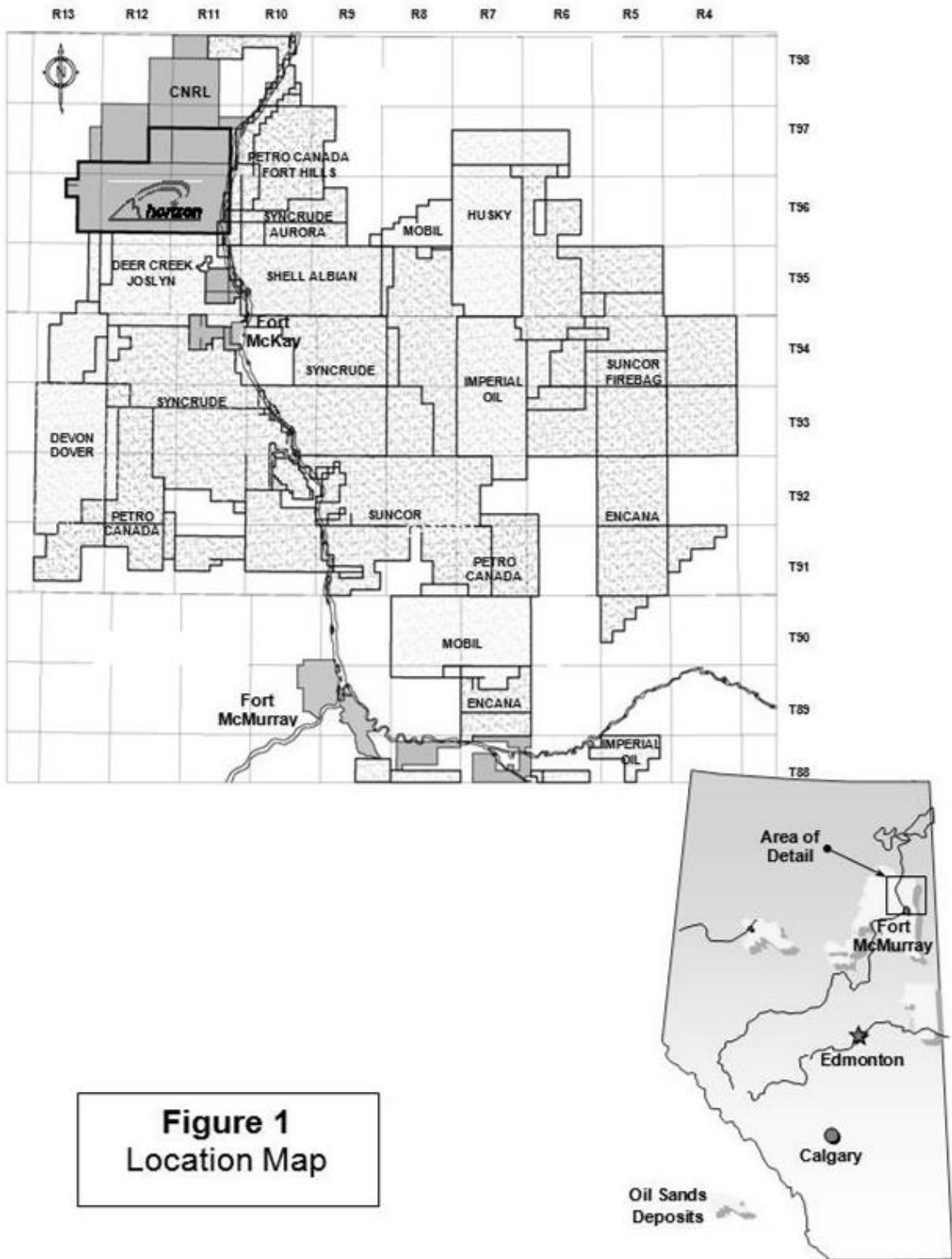


Figure 1 Location map for the Horizon Oil Sands operation

2 Project components

The Horizon Oil Sands facility includes the central plant site with an upgrader, mine pits, roads, utility connections, storage facilities and watercourse diversion structures with the disturbance footprints is illustrated in Figure 2 and detailed in Table 1.

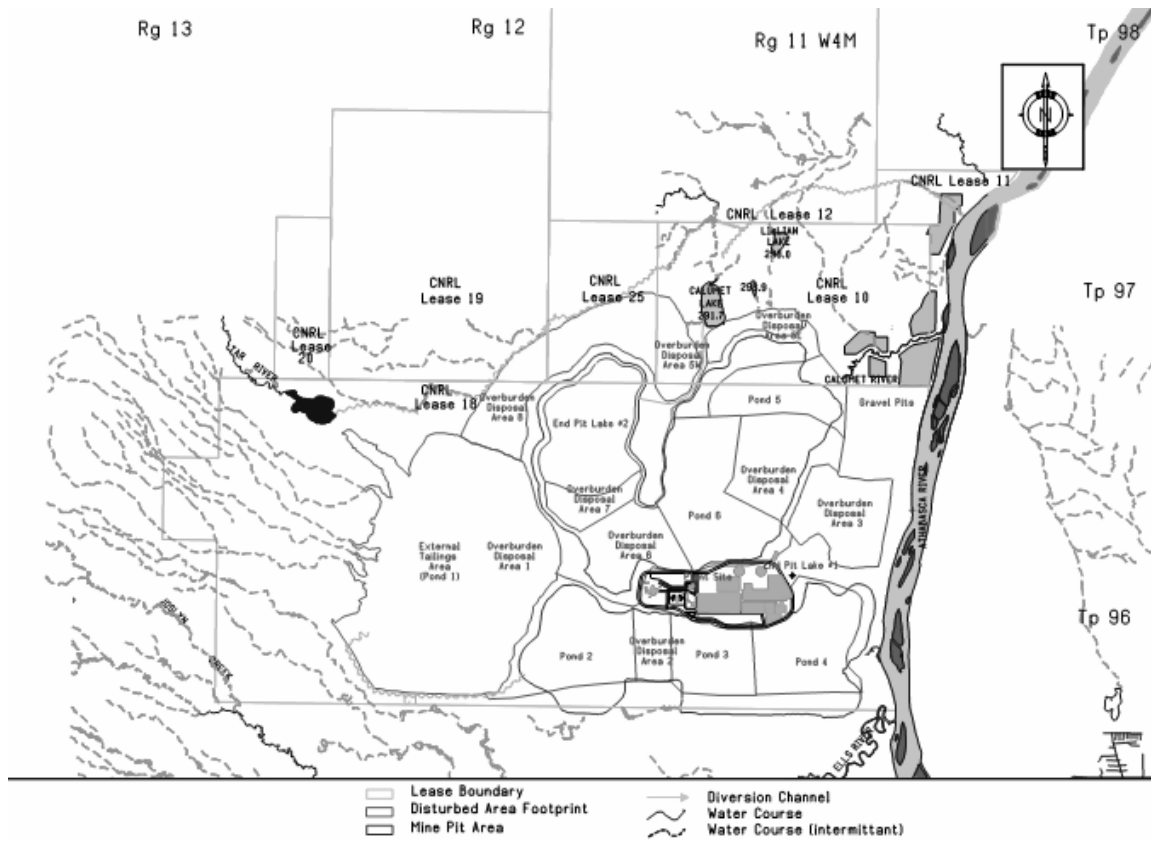


Figure 2 Horizon Oil Sands facility development components

Table 1 Horizon project disturbances

Project Component	Land Disturbed (ha)
Mine pits	8,890
Plant site	552
Waste areas (overburden)	3,290
Sulphur storage	49
Reclamation material stockpiles	148
Roads and utility corridors	2,831
Water control structures	999
Ponds and waterbodies	434
Total	17,193

The development components covered in the Horizon Closure and C&R Plan includes:

- Central plant site.
- Mine pits.
- Waste areas.
- External and internal tailings disposal areas.
- Coke and sulphur storage areas.
- Reclamation material stockpiles.

- Main access and utility corridors connecting the plant site with external services (e.g. roads, natural gas, power and the product pipeline(s)).
- Miscellaneous facilities including end-pit lakes and water control structures.

3 Reclamation and closure plan assumptions

The Horizon Project C&R Plan was developed using several assumptions regarding closure planning, detailed reclamation planning, end land uses, final certification and release of land back to the Crown.

The assumptions used for the closure planning process include:

- The process is driven by the mine plans and the landforms that are created as a result of the mine advance. Changes to the mine plans will necessitate changes to the closure plans.
- The goals of the closure plan will moderate and influence the design of mine related structures.
- The probability of changes to both the mine and closure plans increases over time. For example, changes over a 5 year period are expected to be less than over a 20 year period.
- Several uncertainties exist in the closure planning process including long-term performance of landforms, feasibility of developing trafficable tailings landforms, long-term performance of vegetation species and ability to return landscape biodiversity.
- Uncertainties in landscape performance and technology are to be dealt with using the principles of adaptive management and knowledge gaps are to be examined through research programs jointly undertaken by the oil sands industry.
- Forest productivity following reclamation will be equivalent to the baseline conditions to ensure that the effect on annual allowable cut is minimised.

The following assumptions were used for the detailed reclamation planning process:

- Reclamation practices of the existing oil sand operators (Synchrude and Suncor) are used as the basis for soil reconstruction and revegetation.
- The goal of equivalent capability is to be met using land capability for forest ecosystems in the oil sands region (Alberta Environment, 2006).
- Reconstructed soil performance over time will mimic natural soils.
- Revegetation practices follow the recommendations and practices of the Oil Sands Vegetation Reclamation Committee (Alberta Environment, 2010).
- Target ecosites identified in the closure plan are conceptual in nature and it is recognised that it is not currently possible to predict ecosystem succession over time.

For end land uses and final certification the following was assumed:

- The reclamation target ecosystems will allow multiple uses. Areas designated for commercial forest use will also provide wildlife, recreation and traditional land uses.
- End land use options available will be constrained by the type of landforms to be constructed (e.g. end-pit lakes are not available for dry land uses).
- Final end land use decisions will depend on government and stakeholder community input (Oil Sands Mining End Land Use Committee, 1998).
- Reclamation certification by the government will use the approval requirements in place at the date of land reclamation.

4 Reclamation goals and principles

The reclamation goal is to achieve maintenance-free, self-sustaining ecosystems with a capability equivalent to pre-development conditions. This does not imply an unchanging state, as landforms will experience normal successional processes leading to ongoing landscape evolution. Self-sustaining ecosystems will evolve on reclaimed areas, from new plantings to mature vegetation communities typical of the region. Following initial ecosystem re-establishment, minimal to no management input is expected. These original and closure land uses will not be the same, but will be designed to be acceptable changes based on stakeholder consultation.

Goals and principles for the reclamation and closure of the Horizon Project include:

- Progressive reclamation is integrated with the mine planning process.
- Landforms will be geotechnically stable and will be integrated with the surrounding landforms.
- Drainage systems will be designed to minimise erosion and substance loadings.
- End-pit lakes will be ecologically sustainable.
- Forest capability, including commercial forestry potential, will be equal to pre-development conditions.
- Reclaimed areas will be developed into self-sustaining ecosystems with an acceptable degree of biodiversity.
- On-site public health and safety will be protected during the life of the operation.
- Reclamation certification will be achieved to transfer the land back to the Crown.
- Direct placement of reclamation materials will be undertaken whenever practical to optimise viability of native seed banks and propagules.
- Natural invasion of native vegetation will be encouraged in ecologically receptive areas.
- Local native seed sources will be used wherever practical to maintain genetic integrity of re-established plant communities.

Corporate policies relevant to the ongoing closure process include:

- End land use objectives will be developed in consultation with stakeholders.
- There will be an ongoing consultation process with adjacent oil sands developers to ensure continuity of landforms and drainage systems across lease boundaries.
- Adaptive management of the closure plan will be pursued through the incorporation of results of regional research by Canadian Oil Sands Network for Research and Development (CONRAD) and regional management systems developed by the Cumulative Environmental Management Association (CEMA).

Basic end land use goals for the Horizon Project include:

- Reclaim the landscape to an equivalent capability, optimising the value of watershed, timber, wildlife habitat, fish habitat, recreation or other resources and taking into account stakeholder preference.
- Return equivalent pre-development levels of forest productivity.
- Protect the aesthetic qualities of the landscape.
- Provide for traditional land uses (e.g. hunting and trapping) as preferred by key stakeholders.
- Leave open the opportunity for other end uses (e.g. recreation, agriculture).

5 From conceptual plan to operational practice

The priority at Horizon from 2004 to 2009 was to bring the plant into production. The plant produced first oil in February of 2009, bringing to a successful conclusion the project phase of Horizon and changing to a fully operational oil sands facility.

On the closure and mine reclamation perspective for a green field development, the translation of the conceptual closure plan into an integrated operational component of the mine was the challenge. In the case of Canadian Natural Resources, Horizon Mine, the active and demonstrated support of management is the key to the effort to put into effect an operational reclamation programme. The components needed to implement an effective reclamation programme have been successfully initiated.

5.1 Mining activities

With the integrated oil sands facility operational, the mining activities were scaled up to pace the demands of the operating plant. The mine focus was changed from the early stages of overburden removal to actively provide feedstock to the breakers for the production of bitumen. This increase in all mine related work resulted in additional movement of waste overburden materials. Waste overburden and interburden is selectively used for construction of tailings pond dykes as well as placed in long term storage structures that will be left as part of the post mining landscape. Once structures are completed and no longer needed as part of the mining requirements they are considered to be candidates for reclamation. The completion of one of the mine overburden structures, Waste Area 1 (WA1) provided Horizon with a reclamation opportunity.

The mining operation creates a variety of land forms that must be reclaimed, including:

- Tailings dyke structures.
- Overburden waste dumps.
- End pit (wall and floor).
- Tailings disposal areas.
- Roads, pipelines, and electrical corridors.
- Ancillary areas such as coke and sulphur storage pads, ponds, and roads.

5.2 Reclamation vision

Horizon's vision for reclamation includes the construction of stable landforms and re-establishment of productive, self-sustaining ecosystems which will provide land use capabilities equivalent to those of the pre-mining environment. The following general operational and reclamation criteria form the basis for reclamation program design:

- Structures are assessed prior to reclamation to ensure they are geotechnically stable.
- Total suspended solids in the water discharged through surface erosion processes will be controlled to rates which are acceptable to the environment.
- Discharge of surface and seepage waters will be managed to ensure an acceptable level of impact on the receiving water courses or wetland systems.
- The ecosystems re-established on disturbed lands will be fully self-sustaining and will mature naturally without presenting significant risk to resident or migratory wildlife, or plant species.
- Fully reclaimed lands will be stable and require minimal maintenance, thereby justifying reclamation certification.

Development of methodologies to achieve the Horizon reclamation objectives required an understanding of the principal processes that influence ecosystem development. The types of vegetation and soil that will develop on the Horizon lease are dependent on climate, topography, parent material, drainage and time. However, of these environmental factors only parent materials and topography can be modified to any extent

by the mining operation. The other factors are essentially fixed by virtue of the oil sands mining and extraction methodologies or by natural conditions.

The Horizon reclamation approach is to reconstruct a “soil” from parent material combined with muskeg soil (peat and mineral fines) or through the application of topsoil and LFH. This creates a mixture that is capable of sustaining an initial plant cover to resist wind and water erosion. The reconstructed soil is also designed to be capable of supporting the growth of tree and shrub species which were found in the pre-mined forest communities and exist in areas adjacent to the lease. The use of topsoil and LFH in combination is also expected to result in the earlier return of ecosystem components as both seed and viable propagules are brought in with the soil (MacKenzie, 2006).

5.3 Soil reconstruction

The restoration of soil capabilities to a state equal to or greater than pre-disturbed conditions required design specifications ensure that the reconstructed soil provides:

- Adequate moisture supply.
- Adequate nutrient supply.
- Acceptable erosion control.

Natural soil types have been selected as references to represent comparable pre-mining capabilities for the post-mining landforms. Physical and chemical parameters of these reference soils are used to assess the effectiveness of reconstructed soils in meeting the above specifications and in meeting Horizon’s long term reclamation goals. These practices were designed to be consistent with industry accepted methods for use in oil sands reclamation (Macyk and Drozdowski, 2008).

5.4 Regulatory context

The following major Regulatory Approvals administered by AENV and Alberta Sustainable Resource Development (ASRD) are currently held by Canadian Natural for the Horizon Project:

- Public Lands Act Mineral Surface Lease MSL No. 033406 Letter of Authority (as amended).
- Alberta *Environmental Protection and Enhancement Act* (EPEA) Approval No. 149968-00-01 (as amended) issued in 2004 and expires in 2014.
- *Water Act* Approval 00201931-00-00 (as amended).

Included in oil sands operator approvals issued following 2007, Alberta Sustainable Resource Development (ASRD) and AENV have incorporated a requirement to selectively salvage and preferentially use topsoil instead of peat mineral soil for land reclamation. As Horizon’s environmental approval was issued to cover the years 2004 to 2014, this detail was not included. While this specific component was not a requirement in the Horizon site environmental approval, the decision was made by mine management to implement the selective salvage and use of topsoil into our operational reclamation practice. In order to better manage this resource and plan for the use of topsoil for upcoming reclamation, a soil survey was conducted to understand the topsoil quality and quantity in the mine advance footprint. This survey was completed prior to the commencement of the 2009/2010 winter soil stripping activities.

6 Operational challenges

Within any organisation, the implementation of new processes can test the systems that have been used as well as understanding the pressures and incentives to taking on new activities. Such was the case with the land reclamation at Horizon. As a start-up operation, Horizon Oil Sands had not completed reclamation of any structures associated with the development of the mine as none were available until late 2009. The mining activities and processing of the oil sands needed to advance sufficiently so long term structures were completed and available for reclamation. As a result of the mine advance, Waste Area 1 (WA1) was the first available structure upon which reclamation could be conducted.

Canadian Natural has a long term agreement with North American Contracting Group (NACG) to salvage the cover soil, and remove the overburden materials from the mine. In order to facilitate the implementation of the reclamation activities for the upcoming winter season, a work scope for the reclamation of WA1 was developed, approved by mine management and planned to be implemented through 2009/2010.

6.1 2009/2010 mine reclamation plan

The 2009/2010 reclamation program involved site preparation and grading where needed on 88.6 ha of land that was available on WA1. To address the requirements of the Horizon environmental approval and prepare for a suitable rooting zone, 1 m of overburden soil was placed over the Clearwater overburden. The cover soil was placed over the suitable overburden subsoil at a minimum depth of 20 cm. The reclamation program combined with the revegetation program were designed to meet Horizon's needs of reclaiming mined lands so stakeholder commitments and environmental approval conditions.

Figure 3 illustrates the lands available for reclamation during the 2009/2010 reclamation programme and outlines the source location of the subsoil, the topsoil and peat mineral soils. The landform grading was completed prior to the placement of subsoil materials to both level the piles of waste overburden and establish a network of swales to manage the long term drainage from the structure. The donor site used for the topsoil was to be stripped by dozers with the soils pushed into windrows in preparation for transfer to WA1 in January. The subsoil material needed to provide the one metre suitable reclamation base over the Clearwater material would then be available. This soil salvage and placement work began in late 2009.

Topsoil salvage for reclamation involves the removal of the top 20 to 30 cm of soil only. Horizon planned for a total of 246,000 m³ of topsoil to be stripped with dozers from the pre-mine area to meet the reclamation topsoil placement requirements of WA1.

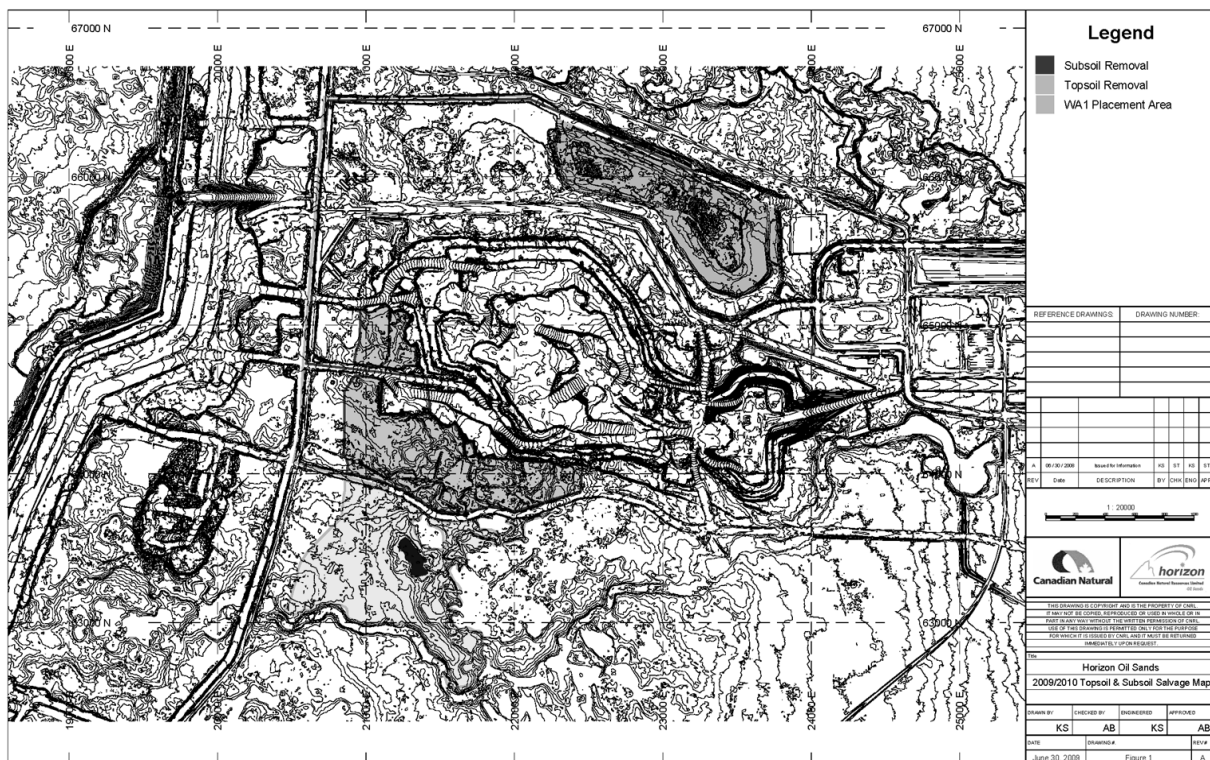


Figure 3 Reclamation soil salvage and placement plan for 2009–2010

6.2 Specific timing and weather related challenges

The mine planning process faced challenges in the fall of 2009 as the scheduled orderly advance that was designed to follow the sequential development of the mine needed to be changed. The orebody in a part of the advancing mine was too rich in fines to process properly with the high fines content adversely affecting

the operation of the plant. The decision was made to turn the mine and advance to the south east into better quality ore, instead of to the west. This change was a significant modification to the mine plan which caused a ripple effect to the operations and to the implementation of the reclamation plan.

Topsoil salvage operations as well as the salvage of the peat/mineral soils were scheduled to commence by the first of November of 2009 were delayed until January of 2010. This delay allowed for the frost to penetrate into the ground and resulted in a deeply frozen soil condition. The frozen conditions meant that the D10 dozers were not able to selectively separate the topsoil from the subsoil. This resulted in large areas having the top layer containing the Leaf Fibric Humic (LFH) scrapped off and piled with the remaining portion of the topsoil being left behind. A second pass helped take the remainder of the top soil but also resulted in a large portion of the "B" horizon being taken and piled as well. This method resulted in considerable ad-mixing of the soil. Additional equipment and man hours were also spent ripping with dozers in an attempt to open up the frozen soil profile to aid in the salvage operations. This proved to be a slow process and less effective than desired.

The pre-frozen window in November and December of 2009 that is normally the best time period for rolling up the topsoil was missed. By the end of March and the advent of spring thaw a small area of the planned soil stripping area that was to be used for the reclamation of WA1 was completed. This resulted in only a portion of the 88.6 ha scheduled to receive directly placed cover soil by March 31, 2010 was complete.

6.3 Reclamation planning and operations interface – lessons learned

One of the major hurdles identified was that reclamation planning was not fully integrated into the operational mine planning systems. While the scope of work provided to operations explained the process and the need for soil salvage and placement of the reclamation materials on WA1, it provided little to no traction as far as getting the reclamation process started. There was an opportunity for the reclamation team to attend the weekly and three month operational planning meetings to review the plans for the mine advance. These planning meetings became a venue where the reclamation components of mining were discussed as a standing agenda item. This proved to be an effective opportunity to increase the understanding of the reclamation program requirements at the supervisory and mine superintendent level of the organisation.

The placement of reclamation materials to a high standard was completed by late December 2010, with both the operations and reclamation planning providing formal sign off.

As a result of completing the first of the mine reclamation areas during 2010, a strong message was sent through the mine organisation and to our contractors about the importance of advancing the reclamation soil salvage and placement operations. The soil salvage operation for 2011 has been completed and is well advanced into salvaging the soils in the 2012 mine footprint.

7 Conclusion

As with most mines, changes to the mine direction and the development of the various landforms that are created as a result of mining, will go through modifications with time. The closure planning process is used to integrate the reclamation planning with the long term operational plans of the mine. Integrating the closure planning, the mine planning, and the reclamation planning process is necessary to ensure that we have a workable system and a functioning landscape at the end of the mine life.

Although the mining operation at Horizon is new, there have been external pressures and regulatory directives that have resulted in significant alterations to the planned development footprint. Horizon is integrating this larger footprint into the reclamation land base so the soil balance requirement is addressed and the lands identified for reclamation as soon as reasonably possible. Having the reclamation team situated within the mining organisation fosters closer communication and collaboration so the reclamation goals are being met.

The reclamation and closure plan is a key tool to help guide and foster the reclamation goals within our oil sands mining operation. As with any tool, it must be kept sharp and current. As such, a revised mine closure plan is being worked on with a planned completion date of December 31, 2011. This mine closure plan version 2011 will be submitted to AENV and become part of the Horizon regulatory commitments. This plan

as well as the plans that follow will be instrumental to the development of a usable and sustainable landform that supports commonly found boreal forest ecosystems at the end of the mine life.

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