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Reclamation of the Gregg River Mine, Canada

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Abstract

Construction of the Gregg River Mine began in 1981. Coal production occurred continuously from 1983 through to October of 2000. With the closure of the mining operation, site activities switched entirely to completing reclamation of the 1,362 hectares of land that had been disturbed over the life of the mine. The Gregg River Mine was the first large scale open pit mine in Alberta closed under the current closure and reclamation legislation.

The mining and reclamation activities were influenced by a number of climatic, topographic and geographic factors. The mine is located in west central Alberta on the east slopes of the Rocky Mountains, elevations range from 1,400 to 2,000 m and soils are generally thin and rocky. The climate is severely influenced by the mountains and the elevation; snow is common in all months of the year. Strong Chinook winds blow in the winter, melting and moving snow and creating a very difficult growing environment for plants and young seedlings.

The initial five years of the reclamation programme concentrated on completing the recontouring of the disturbed surface, replacement of the previously salvaged surface soil and revegetation of the mining areas. This work included the removal of haul road river crossings, the relocation and reconstruction of surface water streams and the decommissioning of waste water treatment facilities. The second phase of the project was the demolition of the coal processing, equipment maintenance, load out and rail facilities. Soil remediation and land reclamation of these areas followed.

The reclamation objective for the Gregg River Mine is equivalent land capability with designated reclaimed land use objectives of wildlife habitat and watershed protection. A measure of the achievement of equivalent capability and reclamation success may be the abundant wildlife and clear flowing streams throughout the site. Large bighorn sheep, deer, elk, coyote, wolf and grizzly bear populations may be seen on many areas of the site. Recent carnivore activity is one indication of the eventual return of a healthy, balanced and sustainable ecosystem to the reclaimed Gregg River mine site.

1 Introduction

In Alberta under the *Environmental Protection and Enhancement Act* (EPEA) (Government of Alberta, 1992), and the associated *Conservation and Reclamation Regulation* (CRR) (Government of Alberta, 1993) the objective of conservation and reclamation of specified land is to return the disturbed specified land to an equivalent land capability upon the completion of the approved activity. Within the operating approvals that are issued under this legislation, standards, criteria and guidelines are set for the conservation of reclamation materials at the time of disturbance and the utilisation of these materials during the reclamation phase of the activity. The final step in the reclamation process is the granting of a reclamation certificate. The application for a reclamation certificate provides documentation showing that all of the approval conditions have been met and, that through satisfaction of the approval conditions, the previously disturbed land has achieved an equivalent, although not necessarily identical, capability.

The Environmental Impact Assessment conducted prior to the disturbance of the Gregg River Mine area identified the major existing land uses as wildlife habitat and a very small area of commercial forest. The proposed end land use plan suggested that successful reclamation could provide watershed protection, wildlife habitat and some opportunities for small areas of commercial forest. This use definition recognised that prior to mining there was not a forest of significant commercial value present and that the primary use of the land had been recreational hunting and fishing with some commercial trapping. Mining had been present

intermittently on the landscape at a relatively small scale since the early 1900s and there were several remnants of that activity present in the mine area.

2 Mining and reclamation process

At the Gregg River Mine the highly folded and faulted geology, in combination with variable coal prices and demand fluctuations associated with the export metallurgical coal marketplace, resulted in a complex mining plan and schedule. From the start of mining in 1983 until closure in 2000, the need to keep a constant supply of coal to the preparation plant and to effectively utilise the available equipment created simultaneous mining at pits of varying haul distances and strip ratios and pits at different stages of completion. This greatly reduced the opportunity for reclamation to occur concurrently with mining as large non-contiguous blocks of disturbed land were always required for current and future mining and waste rock dumps. The waste rock removed to expose the coal was placed both in external rock dumps and within completed pits. The decision to close the mine was made in 2000 during a time when the remaining coal quality was declining, cost of recovery was increasing, and world coal markets were depressed. There was no opportunity for a staged process of gradually declining exploration, development and production activities to allow the Mine to refocus their efforts on reclamation and to prepare for the closure. The sudden closure of the mine resulted in 5 pits being only partially backfilled and about 900 hectares of land requiring reclamation.

The initial reclamation strategy was to reclaim the areas of the least potential coal value first to preserve the project's mining value as long as possible. It was quickly recognised that the more efficient approach would be to reclaim in a retreat fashion, working from the extremities of the mine towards the facilities area. This allowed all of the powerlines, wastewater treatment ponds and roads to be removed sequentially so that the areas could be completely revegetated. Removal of the access roads did make environmental monitoring more difficult but this was offset by the almost complete elimination of surface water runoff from disturbed areas. Historically surface water runoff from the disturbed mining or infrastructure areas provided the greatest risk of environmental degradation for the operating mines in the area.

The reclamation process was therefore able to focus on a systematic retreat from the most remote areas of disturbance, 10 kilometres from the plant site, to those areas associated with the main processing facility adjacent to the Gregg River and Highway 40. The reclamation activities concentrated on the achievement of equivalent land capability through the provision of the approved end land uses: watershed protection, wildlife habitat and forestry.

2.1 Maintaining watershed protection

The designation of watershed protection as one of the reclamation objectives, in combination with the operating approval requirements, made preservation of surface water quality a focus of the reclamation process. Whenever possible, landscape design was intended to disperse rather than concentrate surface runoff. Waste water treatment ponds were decommissioned by capping the sediments, replacing topsoil and seeding. At the same time, a shallow depression was left in place to provide passive settling of runoff during vegetation establishment. Additional shallow depressions were incorporated into the recontoured surface when possible. In addition to removing sediment, these provided terrain diversity and wildlife values.

It was recognised that historically one of the limiting factors in successful revegetation had been the soil compaction caused by large mining equipment. To address this, any compacted recontoured waste rock was ripped prior to surface soil placement. Surface soil was placed by dozers and backhoes that minimised travel over the completed surface. This approach has improved tree survival rates and also minimised surface water runoff by maximising infiltration.

The reclamation seed mix used was selected in consultation with a number of professionals and developed with the historical knowledge of the Gregg Rive Mine operations. The three key considerations in selecting the species for the reclamation mix were: palatability for ungulates; quick rooting establishment to maximise erosion prevention functions; and, species that were known to encourage the growth of the tree seedlings that were to be planted later. Suitability for the high elevation, severe climate and poor soil conditions were also prime considerations in species selection. Finally, the reclamation seed mix was designed to provide all of the above criteria and encourage the eventual succession to the adjacent native vegetation. In areas of high relief adjacent to water courses a fast growing annual cereal crop was seeded over the reclamation seed mix

to provide additional and faster erosion protection while the slower growing reclamation mix became established.

These strategies were applied throughout the mine site and were very successful at preventing sediment from entering the adjacent water courses. A substantial amount of water quality data was gathered from surface water sources upstream, within, and downstream of the disturbed area both during mining and during the reclamation activities. Surface water quality showed marked improvements for suspended and dissolved solids upon completion of the reclamation activities and vegetation establishment in affected drainage basins.

Sedimentation was not the only identified and managed potential impact of mining at the Gregg River area. Sampling of streams flowing from the site during mining had identified higher than background, and guideline, concentrations of nitrates and selenium. The nitrates originate from residual explosive products (ammonium nitrates) in the mine waste rock. Studies predicted that these would decrease over time as the finite quantity of residual product was released; therefore no mitigation strategy was contemplated. Selenium was identified as a concern in the late 1990s, around the time of mine closure. At that time the environmental impacts and release mechanisms were poorly understood, as were the treatment options. Although some studies into affects had been done in warmer, lentic environments little work had been done in the cold fast flowing streams of the northern latitudes. The selenium content of the mine rock lithological units is known but the highly faulted sedimentary geology and complex mining sequence has resulted in an indeterminate waste rock dump composition. All of the water impacted by the waste rock shares some similar characteristics; pH is not significantly changed and selenium is the only element within the rock that has been observed to be elevated. Acid rock drainage has never been observed in the area. In consideration of these factors it was believed that land reclamation had the potential to reduce selenium concentrations by gradually reducing infiltration through increasing evapotranspiration as vegetation became established and through covering the exposed rock with surface soil.

2.2 Creating wildlife habitat

At the time of closure, the Gregg River Mine was a large surface disturbance having islands of undisturbed landscape and completed reclamation. Large areas of undisturbed forested landscape separated areas where the coal outcrop had been extracted. The characteristics of this landscape make it attractive for the deer and elk that utilise the forest edge for concealment but graze in the reclaimed grass and shrub lands (Figure 1).

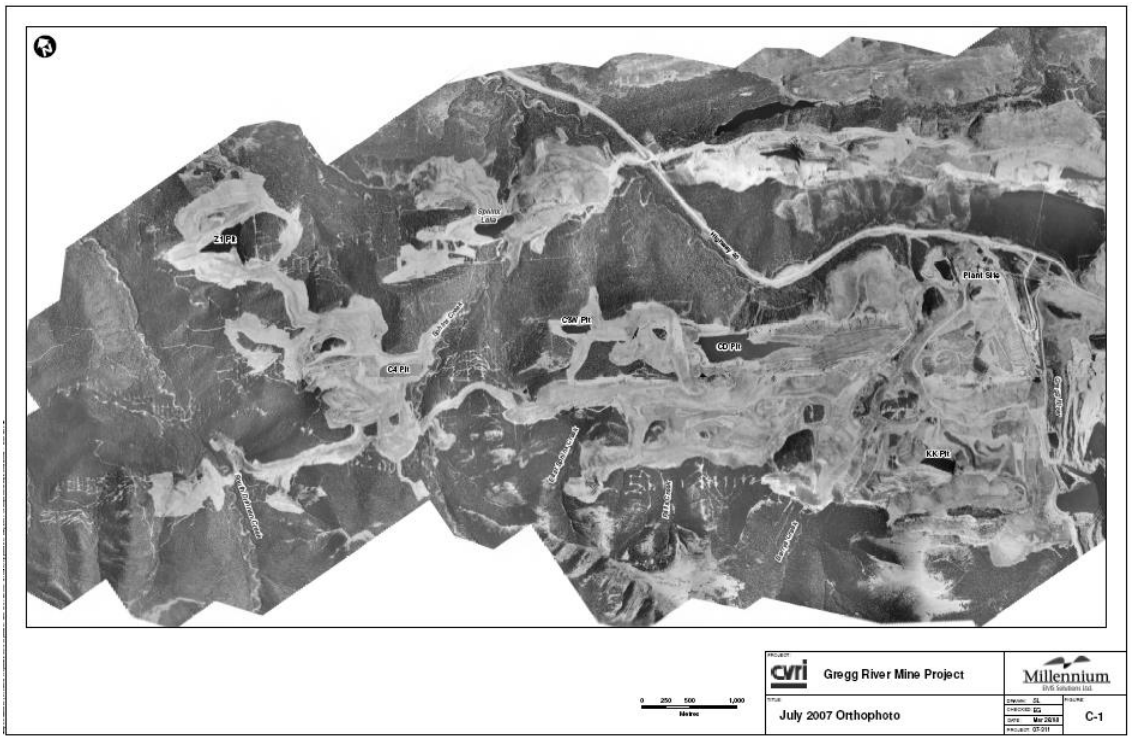

Figure 1 Gregg River Mine and adjacent Luscar Mine areas

In 1975, at the time of the initial Gregg River Mine Environmental Impact Assessment and prior to mine development, Alberta Rocky Mountain bighorn sheep were considered a species requiring protection (F.F. Slaney & Company, 1975). Some bighorn sheep were present in the mine area prior to disturbance as it made up a portion of their home range. Early in the development of the Gregg River Mine, it was evident that an opportunity existed, in conjunction with neighbouring mining disturbances, to make bighorn sheep a focus for wildlife habitat design at Mine. Recognition that the reclamation activities at the Gregg River Mine could provide all of the necessary features found in North American bighorn habitat; escape terrain to provide habitat security and high quality forage in close proximity to both of these areas, guided reclamation planning (Bighorn Environmental Design Ltd., 2003b). The high walls created by open pit mining approximate the cliffs and talus slopes in the natural range of bighorn sheep. The safety benches that are incorporated in the pit walls during mining provide protection for ewes during the lambing period. Exposed outcrops of groundwater seeps provided valuable mineral licks. In those areas selected as wildlife habitat, a seed mixture was selected that considered palatability and nutritional requirements to supply the quality forage required by bighorn sheep. Future tree planting programmes will consider data showing that most bighorn sheep observed on the site are within 300 metres of high wall escape terrain. Ungulate browse is a major cause of seedling mortality and plant survival near many high walls is found to be minimal.

Incorporating and enhancing the landscape features such as open pit high walls and extensive forest/grassland edge into the reclamation design allowed wildlife potential for other species to be maximised. By making access difficult, minimising sightlines and providing a smooth transition between the natural and reclaimed areas, the landscape became attractive to a variety of ungulates. As the ungulate populations increased and the level of human activities decreased, there was a return of the carnivores that required these species as prey.

2.3 Forestry

The establishment of a successful end land use of forestry on the reclaimed Gregg River Mine has been a particular challenge that has had limited success. Initial tree planting programmes, which concentrated on what was believed to be appropriate tree species for the unique climatology and soils of the Mine, were unsuccessful. The trees were often planted in close proximity to those areas designed to be bighorn sheep habitat and were heavily browsed by the sheep. Other programmes to target plantings away from the sheep habitat encountered unexpected competition from the grass and legume vegetation community that inhibited tree growth. Tree establishment from nearby seed sources, either through wind borne or wildlife movement, is moderately successful.

During the most recent vegetation activities at the reclamation project, greater care was paid to targeting specific micro-site characteristics that would provide the optimal environment for maximum seedling survival. Planting was conducted as soon as the ground was frost-free, to maximise the moisture initially available to the seedlings. Trees were planted on slopes and in areas where snow and rainfall accumulation would provide the optimal moisture regimes. These areas are also expected to provide protection from the desiccating effects of the winter Chinook winds, especially during early seedling establishment.

Results of this most recent tree planting programmes are initially more encouraging; however it is too early to determine if this programme will ultimately be successful. As the areas of the end land use objective designated as forestry are quite small, the difficulty in establishing trees meeting commercial criteria through planting is not considered a project wide indication of failure in the reclamation programme.

3 Measuring success

Throughout the mining and reclamation process and into the future, vegetation establishment, wildlife populations and water quality have and will be monitored. This has, and will continue to provide valuable insights into the response of the wildlife and water to the mining process, the reclamation process, and the vegetation succession as the reclamation matures. This monitoring will also provide a measure of our success at reaching our reclamation objectives.

3.1 Water quality

The primary focus in protecting the watershed was to prevent sediment from entering the water. This was monitored from the time of the initial disturbance and it continues today. As would be expected, levels of total suspended solids in the surface water show seasonal variation rather than significant long term trends. Generally during the mining period there was an increased suspended solid load during storm events and during the annual spring freshette. The water quality monitoring following reclamation completion is reduced to sampling points where water flows from the mine site; however, regular inspections are done to identify and address areas having erosion potential. There is no observed increase in sediment load as water passes through the reclaimed mine site.

As the mining progressed, water quality and watershed protection programmes expanded to identify and manage other impacts of the operation. Water monitoring throughout mining identified elevated nitrate concentrations in surface waters affected by mining. It was determined that these nitrates resulted from residual blasting products (incomplete combustion of ammonium nitrate). It was believed that, once blasting was discontinued, and reclamation was completed, nitrate concentrations would decline. Monitoring of Falls Creek, a basin within the midst of the Gregg River Mine and containing large quantities of blasted rock, has confirmed this.

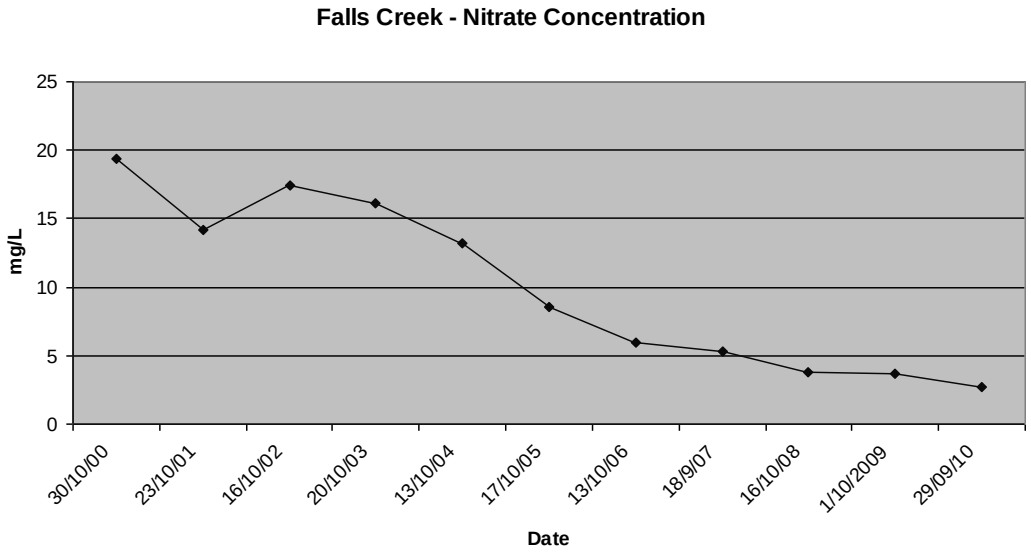

Figure 2 Nitrate concentrations in Falls Creek, 2000 to 2010

A second water quality parameter identified as having the potential to be influenced by mining is selenium. The soils, coal and rock in the Gregg River Mine area contain selenium that, once exposed to the atmosphere and water, is released in quantities that result in concentrations in excess of the water quality guidelines. In some studies excess selenium in water has been shown to have a negative impact on the aquatic environment. Although no environmental effect had been observed as a result of the elevated selenium levels in the fast flowing, cold water environments of the Gregg River Mine, a monitoring programme was implemented to determine selenium concentrations in surface water and their trends. The seasonal frequency of the monitoring programme clearly shows the effects of flow levels on concentration. As expected, the maturity of the reclamation programme in the Berry's Creek basin has decreased the quantity of surface water infiltrating into the selenium generating rock disposal areas. To date, an overall decline in average concentration has been observed (Figure 3). Monitoring will continue so that selenium concentration trends over longer timeframes can be assessed.

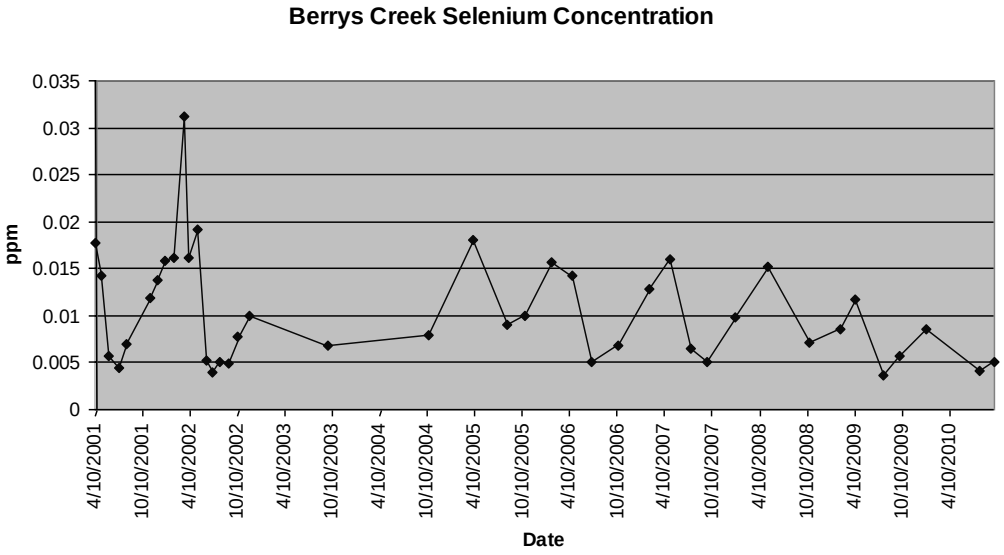

Figure 3 Selenium concentrations in Berry's Creek, 2000 to 2010

3.2 Wildlife

An indication of the success or failure in the creation of wildlife habitat is the presence or absence of wildlife, species diversity, population numbers and population trends. Wildlife monitoring over the Gregg River mining and reclamation phases provides a clear picture of the response of wildlife to both mining and the subsequent reclamation (Figure 4).

Although the bighorn sheep were the focus in creating wildlife habitat, other species utilise similar forage and landscape characteristics. Specific landscape enhancements were made to increase suitability for other species.

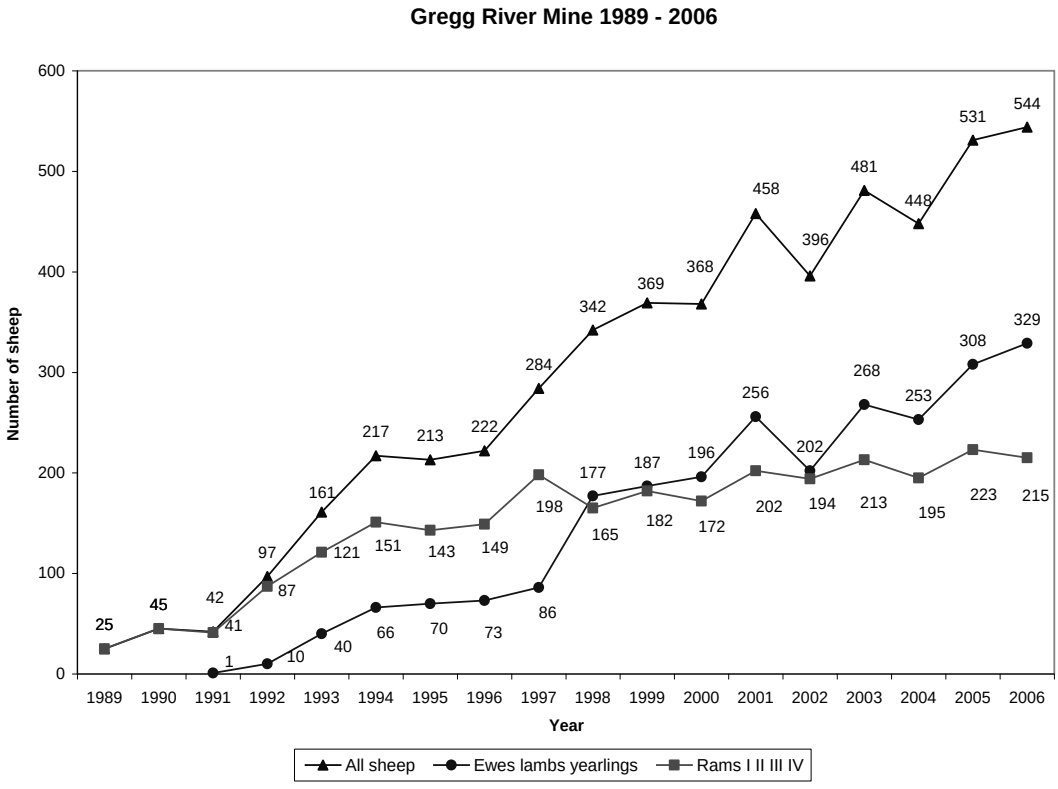

Figure 4 Maximum count of bighorn sheep during the pre-rut

During the early mining at Gregg River, sightings of elk were very rare. After mining completion and early in the reclamation process there were occasional elk sightings at the western extremities of the project. More recently large elk herds are commonly seen on many areas of the mine site, most commonly near the forest edge. Deer are very common on all of the reclaimed mine site. They were often seen on the mine site throughout the mining phase and have since flourished in the reclaimed areas of the site.

Winter track surveys conducted during reclamation identified use of the reclaimed area by a variety of small mammals including marten, mink, weasel, lynx, hare, squirrel, vole and mouse (Bighorn Environmental Design Ltd., 2003a). A single breeding bird survey identified 36 bird species (Bighorn Environmental Design Ltd., 2004). A number of bird species considered sensitive were observed.

Gray wolf, cougar, coyote, red fox and grizzly bears have all been observed (Bighorn Environmental Design Ltd., 2008) on the reclaimed Gregg River Mine site. With the completion of reclamation, reduced human activity, and the presence of a diverse variety of prey including ungulates and high concentrations of small mammals, carnivore use has increased. Evidence of carnivore success is most often observed in early spring when the ungulate population is weak from the winter that closely follows the rut.

In 2002, the Endangered Species Conservation Committee recommended that the Alberta grizzly bear population be designated as Threatened (Government of Alberta, 2010). This recommendation was based on the grizzly bear's small population size, slow reproductive rate, limited immigration from populations outside Alberta and increasing human activity on the landscape. It has been long been recognised that landscape access by humans increases the risk of mortality to bears. To mitigate this risk the reclamation plan deliberately limited access. This was done in a number of ways including; the elimination of all roads, the elimination of water crossings including fords and the construction of an extremely rough surface. With the completion of reclamation the mine site has remained posted for trespassing, access is not permitted without permission. Grizzly bears on the reclaimed mine site have done very well (Ursus Ecosystem Management Ltd., 2005). The combination of high quality animal proteins and rich reclamation vegetation along with an absence of firearms and automobiles has resulted in rapid reproduction and reduced mortality.

3.3 Aquatic life

Although none of the 5 end pit lakes on the site were intended to host a fish population, CD Lake was populated through recruitment from the outlet stream. Athabasca Rainbow trout, a native trout species, which is designated as Threatened in Alberta (Government of Alberta, 2009) has become established in the only end pit lake having surface outflow.

The second of 2 limnological studies (Pisces Environmental Consulting Services Ltd., 2011) on end pit lakes on the Gregg River Mine site was recently completed and observed that the lakes appear to be developing biotic communities that are comparable with natural mountain lakes having similar morphometry. The study did acknowledge that assessing the progress of a younger water body towards target values can be complicated by the inherent inability of an immature lake to exhibit functional equivalency to an older system. Over time, young water bodies typically progress from low nutrient, chemically imbalanced waters to a more fertile, chemically balanced state. Additional limnological studies to be performed at 5 year intervals will establish whether or not a sustainable natural biotic community has been created.

4 Conclusion

The initial monitoring during and following the reclamation programme at the Gregg River Mine indicates that equivalent land capability has been achieved as determined by the creation of successful wildlife habitat and effective protection of water quality. Longer term monitoring is expected to confirm that the foundational work completed by the Gregg River Mine reclamation project has created a successionally and sustainable terrestrial and aquatic ecosystem.

Acknowledgements

The reclamation to wildlife habitat at Gregg River Mine was heavily influenced by the research and ongoing monitoring of wildlife response to reclamation by Beth MacCallum of Bighorn Environmental Design Ltd.; her work in the Alberta Foothills has been invaluable in shaping this reclamation landscape.

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