Innovative Closure Concepts for Xstrata′s Operations at Onaping, Ontario, Canada

Jeff Martin[1] and Joe Fyfe[2]

[1]SENES Consultants Limited, Richmond Hill, ON, CANADA, jmartin@senes.ca
[2]Xstrata Canada Corporation, Onaping, ON, CANADA, JFyfe@xstratanickel.ca

Abstract
Closure plans at Xstrata's Onaping operations were formalized in 2001. The operations include several nickel-copper mines, a mill, and tailings management facilities. Progressive rehabilitation at the Onaping operations since 2001 has resulted in a significant decline in metal and acidity loadings in the upstream portion of the Strathcona Tailings Treatment System. This is in keeping with the philosophy behind the closure plan, which is to minimize the need for long-term active water treatment at the site. Rehabilitation activities responsible for the loadings reduction include: application of a low sulphur lime-amended thickened tailings slimes cover over acid generating tailings; construction of permanent dams to submerge acid generating tailings and waste rock; management of a separate pyrrhotite tailings stream utilizing subaqueous deposition; and aggressive rehabilitation of problematic areas. Future planned rehabilitation activities include construction of additional dams to create water covers over acid generating waste rock, relocation of acid generating waste rock to underwater storage facilities in combination with lime addition, and development of vegetated organic covers over the slimes covers. The historical and planned closure concepts for the Onaping facilities are described and their performance is illustrated.

Key Words: progressive rehabilitation, low sulphur tailings, water cover.

Introduction
In 2001 a Closure Plan was completed for Xstrata's Onaping area mining facilities, as required at the time by revisions to the *Ontario Mining Act* and associated regulations. The major Xstrata facilities within the Closure Plan area are shown in Figure 1. The Closure Plan was a joint effort with Vale, as there are several facilities belonging to Vale that are located adjacent to Xstrata's facilities, and that share infrastructure. This paper addresses only the Xstrata facilities.

Since 2001, Xstrata has made significant progress in closure works at the Onaping facilities, notably in the areas of the *Low Sulphur Lime-Amended Thickened Tailings Slimes Cover* (Slimes Cover) at the Strathcona and Fecunis tailings areas, flooding of some areas of the Strathcona tailings, construction of the Cranberry waste rock storage area, and the implementation of subaqueous pyrrhotite deposition. These activities, which have followed the plans outlined in the 2001 Closure Plan, have resulted in significant reductions in metal and acidity loadings to the Strathcona Tailings Treatment System (STTS), which receives runoff from these facilities.

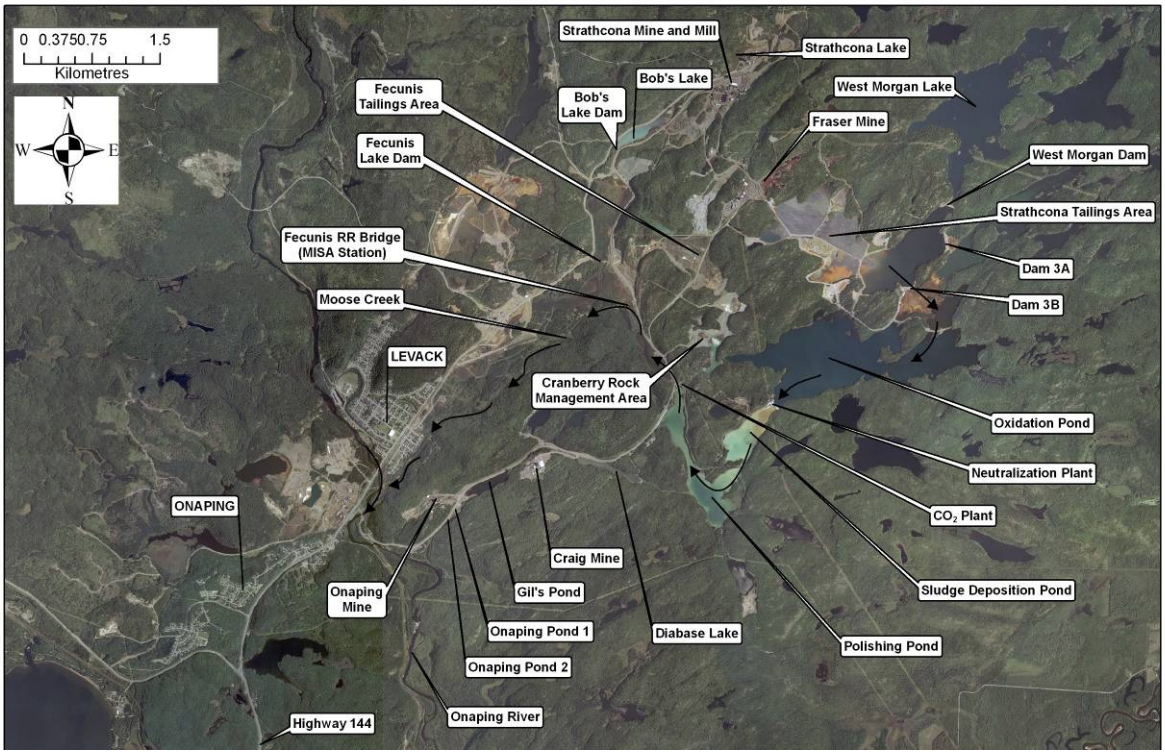

Figure 1. Xstrata Facilities within the Onaping Closure Plan Area

Site History and Closure Plans

Xstrata facilities include the:

- Fecunis mine, mill, and tailings;
- Strathcona mine, mill and tailings;
- Onaping mine;
- Fraser mine; and
- Craig mine.

Fecunis mine, mill and tailings

The Fecunis Mine is the oldest Xstrata facility in the area, operating from 1953 to 1986. The adjacent Fecunis Mill operated from 1959 to 1975. The mill and most of the surface facilities have been removed and decommissioned. The closure plan as of 2001 included:

- construction of three dams in the Cranberry Rock Management Area to flood the waste rock disposal area (completed);
- upgrading Fecunis Tailings Dam to a permanent closure structure and installation of a spillway;
- application of the Slimes Cover over the existing Fecunis Tailings Area (currently in progress);
- flooding of waste rock at the Cranberry Rock Management Area;
- capping remaining openings to surface;
- subaqueous disposal of remaining waste rock in the yard area;
- raising Fecunis Dam to accommodate waste rock from the Fecunis Mine;
- removal of the remaining buildings; and
- revegetation of the yard and tailings area.

A schematic of the Fecunis tailings area and Cranberry Rock Management area is provided as Figure 2.

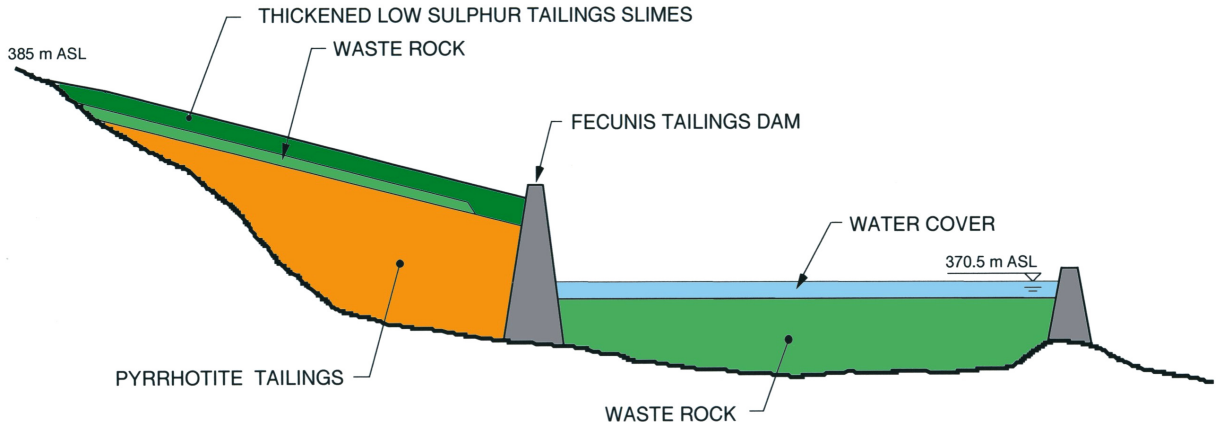

Figure 2. Schematic Section through Fecunis Tailings Area at Closure

Strathcona mine and mill

The Strathcona Mine and Mill were developed in the late 1960s and currently remain in production. As of 2001, the closure plans for these mine included removal of assets and capping openings to surface. For the mill site it was determined that most effective closure plan will be to flood the majority of the surface works in order to minimize the need to relocate potentially metal leaching/acid rock drainage (ML/ARD) generating waste and to reduce contaminant releases from the site. This will involve construction of a small dam and spillway, but not until after both Xstrata's facilities and Vale's adjacent Coleman Mine close.

With respect to the tailings, the western-most portions (Areas 1 and 2) were to be capped with the Slimes Cover to minimize ML/ARD production. The Slimes cap has been completed but the area has not yet been revegetated. The Slime cap covers an area of approximately 65 ha to a minimum depth of 1.5 m. The eastern-most portion (Area 3) was to be flooded to minimize ML/ARD production and select areas of tailings were to be relocated to one metre below the surface of the Oxidation Pond. These activities have also been completed. A schematic of the Strathcona tailings area at closure is provided as Figure 3.

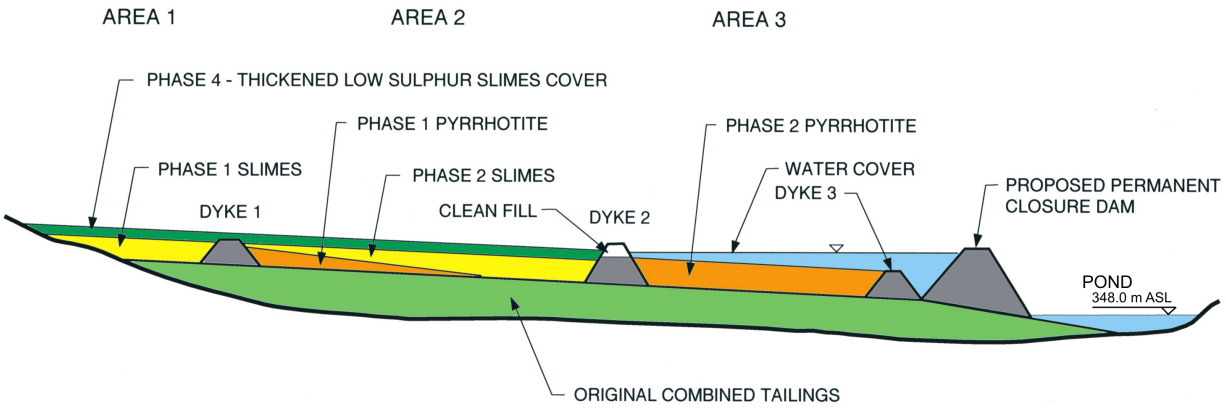

Figure 3. Schematic Section through Strathcona Tailings Area at Closure

The remaining major closure plan items include:

- ongoing effluent treatment until water quality is acceptable for discharge without treatment;
- construction of permanent dam at the outlet of the STTS after an interim treatment period; and
- decommissioning of the treatment plant.

Other mine facilities

The other Xstrata facilities in the area include:

- Onaping mine – developed late 1950s;
- Fraser mine – developed mid 1970s; and the
- Craig mine – developed 1980s/1990s.

The closure plans for these mines are simpler and include the following elements:

- cap shafts and raises;
- remove buildings and infrastructure; and
- removal of waste rock for subaqueous disposal in the Cranberry Rock Management Area.

Tailings Management at the Fecunis and Strathcona Sites

In order to create the Slimes Cover described above at the Fecunis and Strathcona sites, some changes to tailings management were instituted. This included segregation of tailings streams that were previously co-mingled. The three streams were:

- pyrrhotite tailings, containing approximately 30% sulphide sulphur;
- cyclone underflow tailings used for backfill, containing 2 to 3% sulphide sulphur; and
- cyclone overflow slimes, containing 0.4 to 1.0 % sulphide sulphur.

The pyrrhotite tailings are now flooded or placed subaqueously. The cyclone underflow is used underground for support. This comprises about 25% of total tailings generated. The cyclone overflow (Slimes Tailings) are used as cover for historically placed tailings as described above. Waste kiln dust from a lime supplier is added to the tailings prior to deposition to ensure the tailings are not acid generating over the long term.

Progressive Closure Activities to 2011

Strathcona site

Since the Closure Plan was submitted in June 2001, Xstrata has made significant progress in closure works at Strathcona, most notably in the areas of the Strathcona *Amended Slimes* cover, flooding of some areas of the Strathcona tailings, and the implementation of subaqueous pyrrhotite deposition. These activities, which have followed the direction provided in the closure plan, have resulted in significant reductions in loadings to the STTS. Progressive rehabilitation measures that have been implemented at Strathcona since 2001 are listed below:

2001	Deposition of pyrrhotite tailings into the Oxidation Pond commenced.
Yearly	Sludge is dredged from the sludge deposition pond each summer and placed in the Oxidation Pond.
2002	Installation of thickener at the west end of the Strathcona tailings as part of the system to produces the Slimes Cover.
2002	Completion of Closure Dams 3A and 3B and Closure Spillway at the Strathcona Tailings Area in order to provide a water cover over pyrrhotite tailings contained in Area 3, on the downstream east side of the Strathcona Tailings Area.

2003	Water cover over Area 3 of the Strathcona Tailings in place.
2003 to 2007	Placement of the Slimes Cover over Areas 1 and 2 of the Strathcona Tailings Area.
2004	Exposed and partially oxidized tailings from Area 4 (downstream of the dams at Area 3) was dredged from below Dam 3B and relocated underwater in the Oxidation pond.
2007	Additional dredging below Dam 3B was carried out to complete removal of tailings above the water level in this area.
2007	Waste rock road removed in preparation for placement of Slimes Cover.
2008 to 2009	Construction of perimeter ditching for erosion control on Strathcona Tailings.
2009 to 2011	Active participation in Green Mines Green Energy Program, testing potential for biofuel crop production on mining impacted lands.

Fecunis site

In addition to the progressive rehabilitation work conducted at Strathcona, work at the adjacent Fecunis tailings area has been undertaken. From 2001 through 2005, dams were constructed to allow for storage of waste rock below a water cover at the Cranberry Rock Management Area, This area is used as a central waste rock repository by Xstrata for both fresh waste rock from underground as well as waste rock being relocated as part of progressive rehabilitation.

In preparation for application of the Slimes Cover the Fecunis tailings area, the Fraser ring road was removed in 2007, and the waste rock it was made from was disposed in the Cranberry Rock Management Area. Application of the Slimes Cover to the Fecunis tailings area commenced in December 2007. Construction of berms and perimeter ditching on Fecunis Tailings was undertaken in 2011 and 2012 to allow for placement of the Slimes Cover to continue.

Summary of closure activities

In summary, Xstrata has carried out the following key progressive rehabilitation and closure activities at the Strathcona and Fecunis sites:

- Since 2001 – deposition of pyrrhotite tailings into Oxidation Pond;
- 2002 – constructed Strathcona closure dams to create a water cover over pyrrhotite tailings;
- Dredging of historical pyrrhotite tailings beach;
- Since 2003 – placing Slimes Cover over Strathcona and Fecunis tailings;
- 2004/2005 – Cranberry closure dams – central waste rock repository and subaqueous waste rock management system; and
- Ongoing clean-up of waste rock and tailings outside of areas to be covered by water or slimes.

Performance of Rehabilitation Measures and Strathcona Tailings Treatment System

Average annual pH, as wells as concentrations of iron, nickel and copper are shown in Figure 4 for the Oxidation Pond, upstream of lime addition. As can be seen, pH has increased from pH 3.2 in 2000 to a near neutral pH by 2007. In response, iron and copper levels have dropped considerably. Nickel levels have also decreased, but not to the same extent. This is to be expected since a higher pH is required for nickel to precipitate to the same extent.

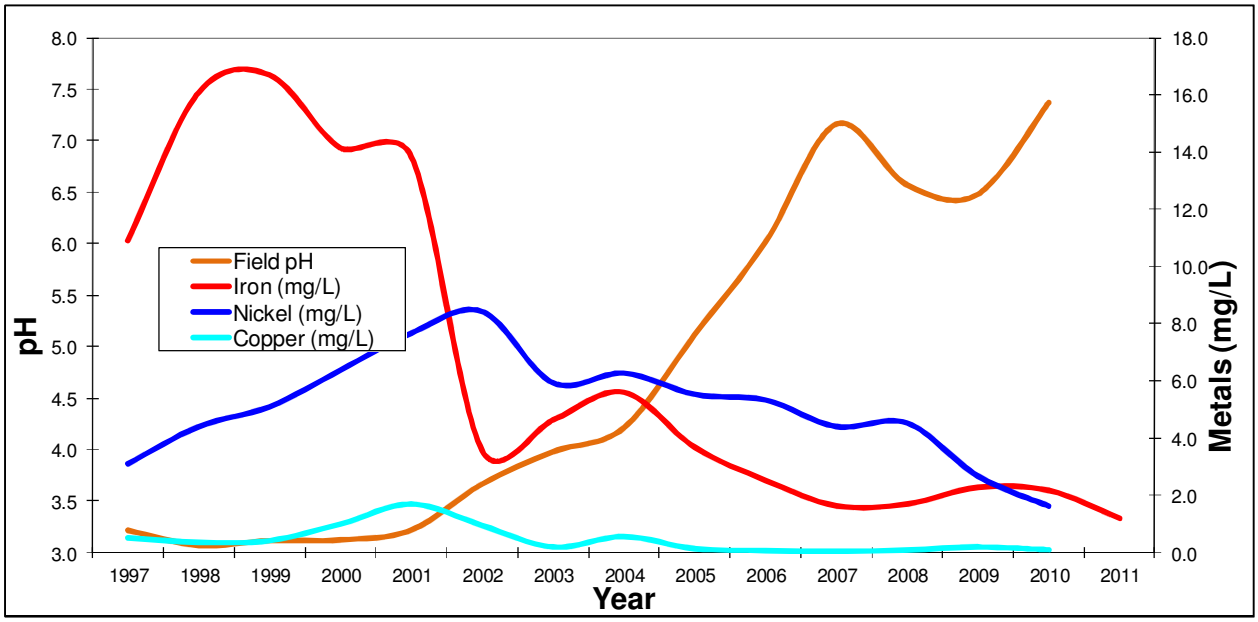

Figure 4. Water Quality in the Oxidation Pond Upstream of Lime Addition

Figure 5 illustrates annual flow through the STTS, as well as annual lime use. Lime use has declined since 2001. It is likely that this is due mainly to effects from the progressive rehabilitation measures implemented since 2001. It should be noted that Xstrata's STTS is currently treating Vale's and Quadra FNX's mine water and tailings effluent from their Levack-area operations. This input currently appears to be a major contributor to the remaining lime demand in the system, and will likely increase in significance until Vale implements their own treatment system, which is planned for closure of their operations. Xstrata will continue to monitor lime use to determine the influence that progressive rehabilitation and changes to tailings management strategies is having on the system.

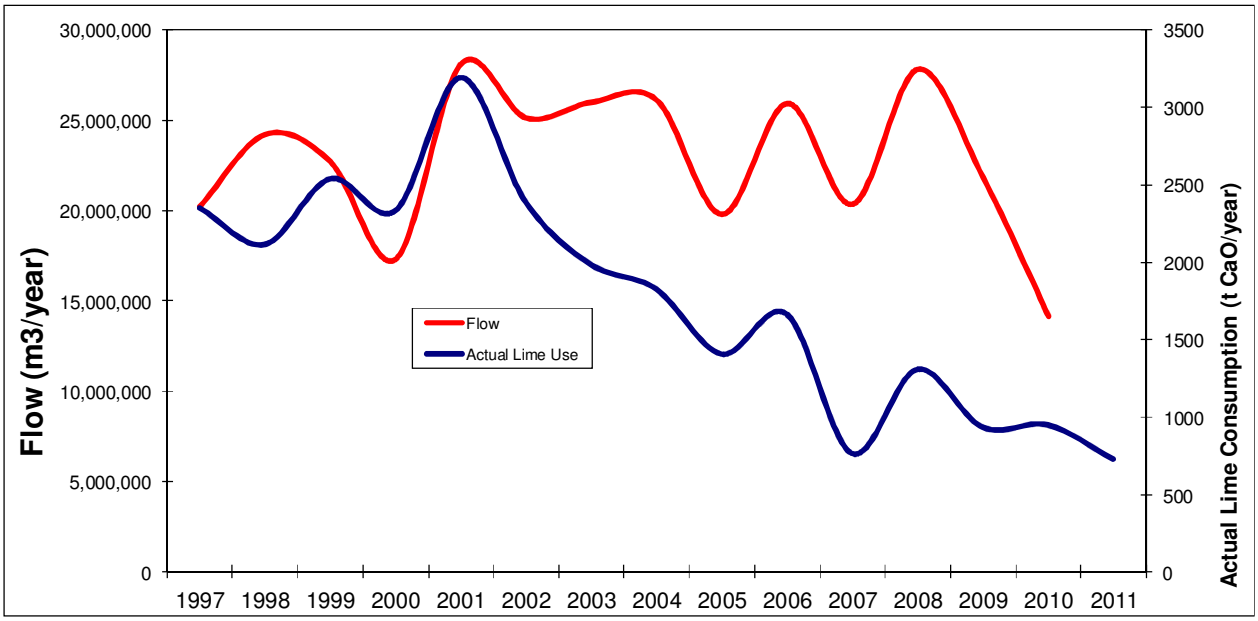

Figure 5. Flow and Lime Use at the Strathcona Tailings Treatment System

The performance of the STTS continues to be excellent, as is illustrated in Figure 6, where annual average effluent quality is compared to monthly average MISA limits. Average annual nickel levels in the treated effluent are low, and typically have been in the range of 0.06 to 0.08 mg/L nickel since the early 1990s. Copper was typically below 0.02 mg/L in the 1990s and is now typically around 0.01 mg/L.

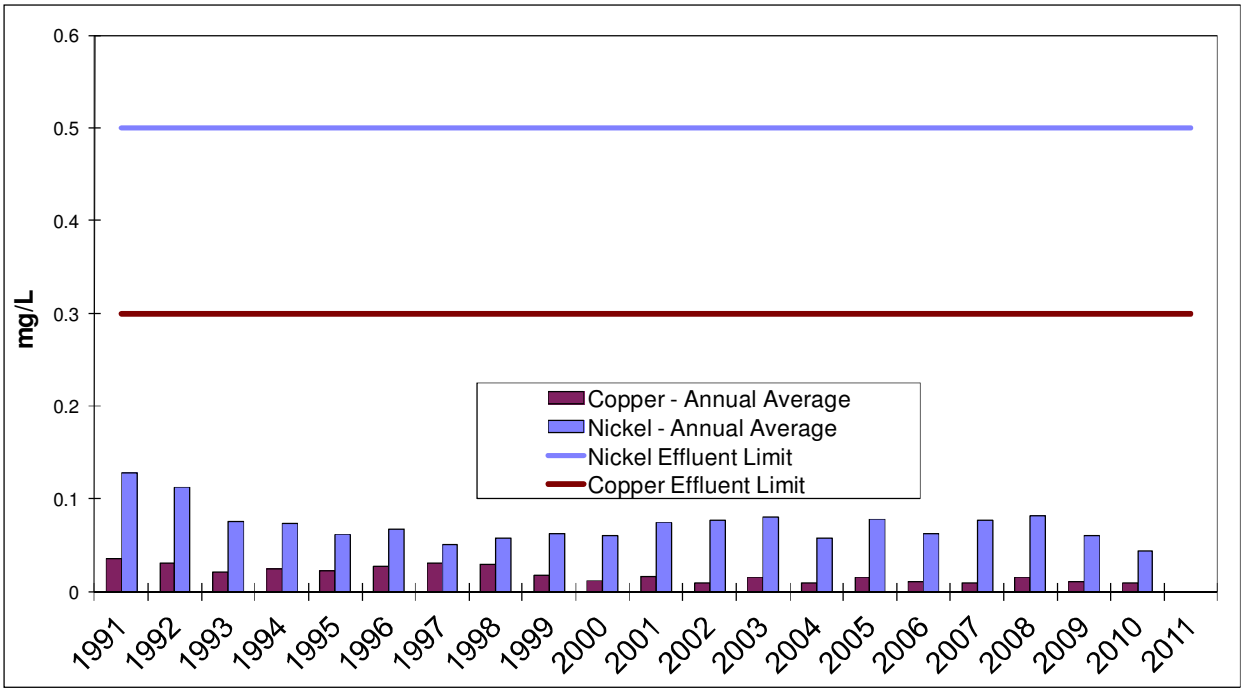

Figure 6. Performance of the Strathcona Tailings Treatment System

Future Closure Activities

Future closure activities that will be carried out at Xstrata's Onaping facilities include:

- completion of Slimes Cover over Fecunis tailings;
- additional closure dams to flood waste rock/tailings (when operations cease);
- relocation of waste rock to subaqueous storage locations in combination with liming;
- revegetation of tailings areas, potentially utilizing biosolids, as described below;
- mine water management, which may involve bulkheads, and neutralization during flooding; and
- upon completion of slimes placement over the Fecunis tailings, there is a potential opportunity to cover Strathcona tailings Cell #3 with a Slime Cover (instead of the current water cover) for long-term risk mitigation.

Green Mines Green Energy Program to test municipal compost over slimes cover

Xstrata is part of a consortium developed by the CANMET Mining and Mineral Sciences Laboratories of Natural Resources Canada. The consortium is investigating the use of paper mill biosolids, source-separated municipal solid waste compost, and other wastes, as cover materials on mine tailings at the Strathcona site. The long-term aim of the project is to develop a productive land use for mine tailings, such as the establishment of energy crops that can be harvested for production of biofuels.

Field trials started at the Strathcona tailings in 2009 (Tisch 2012). The goal of the trials is to gather scientific data on that will determine the impact (if any) of municipal compost on the underlying tailings and tailings effluent, and to assess the feasibility of establishing energy crops such as corn, canola, soy or switchgrass. The cover material was placed to a depth of approximately one metre, and was composed of ground woody materials from land clearing, compost from leaf/yard materials, and compost from source

separated organic substrates. Groundwater, surface water, and seepage from the plots are being monitored, as well as oxygen concentration within the cover and potential greenhouse gases. A report on the testwork is to be released later this year and at that time additional information will be available on the performance of the cover. An example of the test cover is shown in Figure 7.

Figure 7. Test of Municipal Compost over Strathcona Slimes Cover

Conclusion

The closure measures that Xstrata has implemented since 2001 have resulted in considerable improvement to water quality upstream of the effluent treatment system for the Onaping facilities. Future closure activities will likely result in further improvement to water quality. Together these activities suggest that Xstrata's goal to eventually decommission the STTS is achievable.

References

Tisch, B., Hargreaves, J., Beckett, P., Lock, A., and Spiers, G. (2012) Post-Mining Agriculture for Biofuels on Mine Tailings: An Overview of Results from the Green Mines Green Energy (GMGE) Initiative. In, Proceedings of the 9th International Conference on Acid Rock Drainage. May 20 - 26, 2012, Ottawa, Canada.