ESTABLISHMENT OF WETLAND PLANTS ON FLOODED MINE TAILINGS

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ABSTRACT

Water covers minimize the oxidation of acid generating tailings but some oxidation and release of metals may still occur. The effectiveness of a water cover could be improved by establishing wetland plants on the flooded tailings to control tailings resuspension, remove metals from the water column and develop an organic layer to consume oxygen and support sulphate reducing bacteria.

Different approaches to establishing wetland and aquatic vegetation were illustrated in field trials conducted on Rio Algom uranium tailings in Elliot Lake, Ontario and on Falconbridge nickel tailings in Sudbury, Ontario, Canada. At Rio Algom, vegetation islands of shoreline species were transplanted into 30-60 cm of water. Patches of Wool Rush and Beaked Sedge increased from 10 m^2 to 80 m^2 and 95 m^2 over five years with accumulations of 10 cm of organic material in places. In deeper water, plants were placed on the tailings in burlap bags. Submerged plants were established on Falconbridge tailings by sandwiching shoot biomass between layers of wire mesh. Five patches of Richardson's Pondweed that each initially measured 0.25 m^2, after two years covered an area 52 m^2. Wetland plant establishment was affected by the species characteristics, transplant method, pH, turbidity and nutrient status of the water column and the tailings.

INTRODUCTION

Water covers are presently considered the best available technology for acid mine drainage prevention and long term storage of acid generating tailings (Davé, 1992). There is concern that some oxidation may still occur (Aubé et al., 1995). Dissolved oxygen could be transported through the water column to the tailings by diffusion, convection or circulating currents. Tailings resuspension by wave action might expose sulphide particles to dissolved oxygen (Li et al., 1997). If sufficient oxidation of the sulphide particles occurred, the resulting acid generation and metal flux could cause a deterioration of the water cover quality.

The effectiveness of water covers could potentially be improved through the establishment of wetland vegetation on the flooded tailings. The plants and the subsequent development of an organic layer would have several benefits:

- The decomposition of the organic matter by aerobic bacteria would slow the diffusion of oxygen into the tailings (St-Germain and Kuyucak, 1998) with a subsequent decrease in acid generation.
- Metals released from the tailings and in the water column could be removed and retained in the sediment by organic complexation or be precipitated as sulphide complexes through the activities of sulphate-reducing bacteria.
- Aquatic plants and the associated root mass would stabilize and bind the tailings in order to prevent resuspension by wave or wind action and control shoreline erosion.
- Aquatic plants provide biological remedial treatment by removing metals and nutrients from the water column.
- In the case of drought, an organic layer would act as a sponge preventing oxygen diffusion onto the tailings surface as water levels dropped within a tailings impoundment.
- Aquatic plants provide esthetic enhancement and encourage the invasion by other components of a functioning ecosystem.

Flooded tailings are best suited for the establishment of two classes of wetlands: marsh or shallow water. Emergent plants (cattails, bulrushes and pickerelweed), along with grasses, rushes and sedges dominate marshes. Shallow open water wetlands contain floating plants (waterlilies, watershield and bureeds) or submerged plants (pondweed, waterweed and milfoil) (Mitch and Gosselink, 1993).

This paper examines wetland plant establishment at two sites in Northern Ontario where the stems, rhizomes and roots of various species of wetland plants were transplanted into the flooded tailings impoundment. On uranium tailings (Rio Algom Ltd.) research has focused on marsh and floating plants, while on nickel tailings (Falconbridge Ltd.) submerged plants were studied. In addition, factors affecting the growth of one species of submerged plant at the two sites were compared in a reciprocal transplant experiment.

QUIRKE MINE WASTE MANAGEMENT AREA, RIO ALGOM LTD., ELLIOT LAKE, ONTARIO, CANADA

In the early 1950's, uranium deposits were discovered in the region surrounding Elliot Lake, Ontario. Rio Algom's Quirke Waste Management Area is located approximately 16 km north of the city of Elliot Lake and contains 46 million tonnes of tailings and waste rock. Tailings deposition occurred from 1956 to 1961 and again from 1968 until 1990, when Quirke Mine closed. The tailings are classified as beach tailings which are generally medium to fine sand with 10% to 45% silt or silt tailings containing up to 15% sand size particles with both having a typical pyrite content of 5% (Rio Algom, 1995).

The Quirke Mine Waste Management Area covers 192 ha and includes five cells separated by internal dykes. To facilitate flooding, water (pH 7.0) from an oligotrophic storage lake is fed into Cell 14. This cell is the first in the series and covers approximately 64 ha. Subsequent cells are at gradually decreasing elevations, resulting in a spillway flow from west to east and a drop of 14 m at a grade of approximately 0.5%. Each cell is designed to maintain a permanent water cover with depths ranging from shallow shoreline to depths in excess of 5 m.

In 1993, the flooding of Cell 14 was completed and Laurentian University's Elliot Lake Field Research Station initiated trials to establish emergent plants along the shoreline of the Quirke Mine Waste Management Area. Trials to evaluate the establishment of emergent and floating plants in deeper water were initiated in 1995.

Method (shoreline, emergent and floating plants)

In the fall of 1993, vegetation islands of several shoreline species were planted in Cell 14 in water depths of 30-60 cm. Manna Grass *(Glyceria canadensis),* Wool Rush *(Scirpus cyperinus),* Beaked Sedge *(Carex rostrata (utriculata)),* Blue Joint Grass *(Calamagrostis canadensis),* Common Reed *(Phragmites australis),* Narrow Leaf Cattail *(Typha angustifolia)* and Common Cattail *(Typha latifolia)* were each planted in separate 10 m^2 islands consisting of stems, rhizomes and organic substrate from the source wetlands (Figure 1). Common and scientific names referred to in this paper are listed in Appendix 1.

In August 1995, forty locations in Cell 14 and ten locations in Cell 15 with water depths ranging from 0.5 to 3.0 m were planted. Burlap was cut into pieces approximately 30 cm by 60 cm, folded and sewn together to make burlap bags. Burlap containment bags were used to transplant White Water Lily *(Nymphaea odorata),* Water Shield *(Brasenia schreberi),* Bladderwort *(Utricularia cornuta),* Foating-Leaved Pondweed *(Potamogeton natans)* and Hardstem Bulrush *(Scirpus acutus).* Rhizomes and substrate were placed in the burlap bags with the top of the bag left open allowing the stems and leaves to float free. Small rocks were placed in the bags for weight and approximately 70 g of bonemeal (2-11-0) was added to the substrate. At each designated location, ten bags were grouped together. Bags were lowered over the side of the boat in deep water or set in place by persons standing on the tailings in shallow water.

Pickerelweed *(Pontederia cordata)* was planted in shallower locations (<0.85 m) by direct transplant of roots into the tailings. At each transplant site, ten Pickerelweed plants were planted at a density similar to the source sites where the physical properties of the tailings allowed. A cheesecloth bag containing approximately 70 g of bonemeal was placed in close proximity to the roots of each plant at the time of planting. Survival and biomass estimates (based on a leaf/shoot: biomass conversion) were determined at regular intervals.

Results

From 1993 to 1995, all of the shoreline emergent plant islands, except for the island planted with Mannagrass, had increased in size. Both Wool Rush and Beaked Sedge grew vigorously and formed dense patches (Figure 1). Common Reed and Cattails did not spread as rapidly but produced substantially greater aboveground biomass than the other species (Figure 2). The production amounts were 50-70% of reported values for established freshwater marshes (Mitsch and Gosselink, 1993). On the reed and sedge islands approximately 10 cm of organic material had accumulated by mid-1998. The bottom 2-2.5 cm layer was fine in texture, dark black and had a faint odour of hydrogen sulphide.

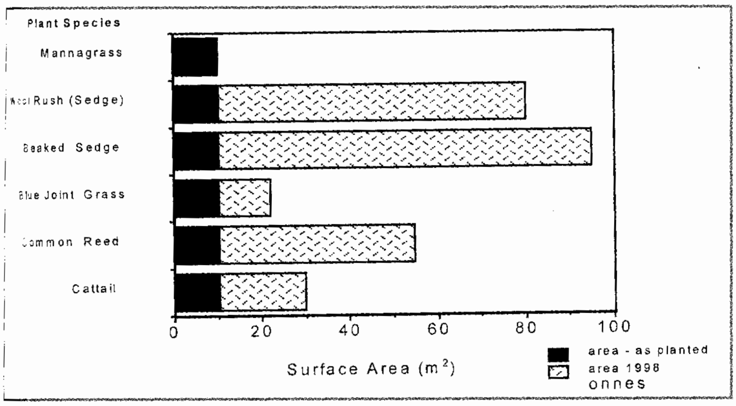

Figure 1. Change in size of shoreline vegetation islands over 5 years.

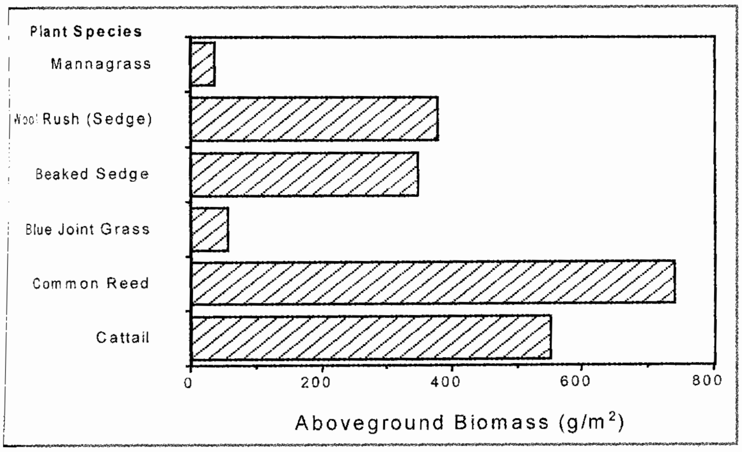

Figure 2. Aboveground biomass produced on shoreline vegetation islands.

In the 1995 floating plant program, survival rates as high as 80% were recorded for White Water Lily, 80% for Pickerelweed, 30% for Watershield and 100% for Hardstem Bulrush at individual sites in Cell 14. However, mean values (average for all sites) were slightly lower. Bladderwort and Floating–leaved Pondweed showed no transplant survival in

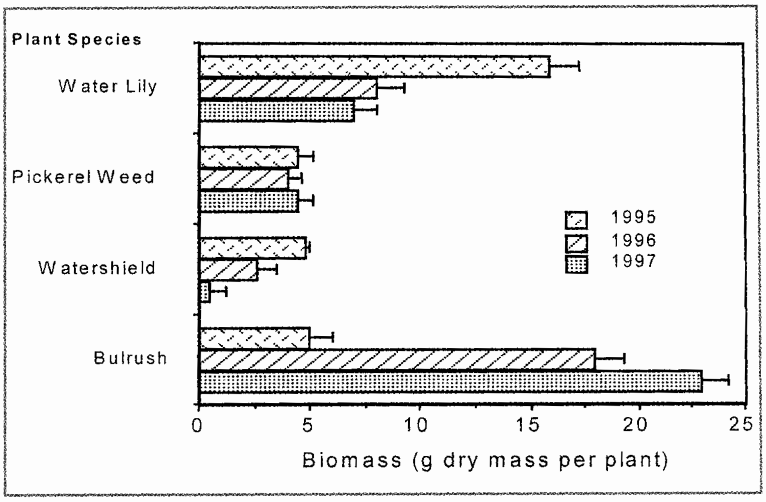

Figure 3. Mean aboveground biomass production per plant (+s.e) over 3 years.

either Cell 14 or Cell 15. A year later there was no significant difference (paired t-tests) in the number of individual plants found, except for Watershield which had almost disappeared. Over three years the amount of biomass produced per plant significantly increased for Hardstem Bulrush (Figure 3). Biomass produced by Water Lilies and Watershield decreased with time and after three years Watershield had almost disappeared from the transplant sites.

NEW TAILINGS AREA, FALCONBRIDGE LTD., SUDBURY, ONTARIO, CANADA

Falconbridge Limited's Smelter Complex is located in the town of Falconbridge approximately 15 km northeast of Sudbury, Ontario. Mining and milling at the Falconbridge site began in the late 1920's and early 1930's and ceased in 1990. The ore milled contained nickel and copper as pentandite and chalcopyrite with pyrrhotite as the main sulphide mineral with varying amounts of magnetite and pyrite.

The New Tailings Area is located about 2 km northeast of the Falconbridge Smelter and was utilized for tailings deposition between 1978 and 1988. Until 1985, about 3.2 million tonnes of tailings were deposited with an average sulphur content of 7%. Starting in 1985, low sulphur tailings (1% sulphur) were produced by removing the pyrrhotite and in 1986, coarse material was cycloned off for underground back fill. A dam was constructed across the impoundment to form the Upper Terrace, where the low sulphide slimes were deposited. Approximately 1.1 million tonnes of low sulphide tailings were deposited between 1985 and 1988 (Golder Associates, 1997).

Closure work on the New Tailings Area commenced in 1996 with the construction of new dams and dredging to facilitate flooding. Spring water flows into the Upper Terrace and Lower Terrace, which occupy areas of approximately 56 ha and 30 ha respectively. In 1997 and 1998, Noranda Technology Centre and Falconbridge Ltd. undertook field trials with submerged plants in the New Tailings Area.

The 1997 field trials were undertaken to evaluate the establishment and survival of different species of submerged plants. The objectives of the 1998 field trials were to assess the establishment of submerged plants at different sites on the Upper Terrace and Lower Terrace and to evaluate different styles and sizes of transplant sandwiches for aquatic plant establishment.

Method (submerged plants)

In the 1997 field trials Common Waterweed *(Elodea canadensis)*, Richardson's Pondweed *(Potamogeton richardsonii)*, Slender Pondweed *(Potamogeton pusillus)*, Northern Water Milfoil *(Myriophyllum sibiricum)* and Stonewort *(Chara spp.)* were transplanted. Plant material was harvested from local donor sites by collecting shoot biomass along with roots and rhizomes where feasible. For each species, five transplant mini-sandwiches 0.5 m x 0.5 m (0.25 m^2) were constructed by placing a 5 cm layer of plant biomass between two layers of chicken wire fence with 2.5 cm mesh. The positive buoyancy of the plants made it necessary to add rocks to the sandwiches for additional weight. The transplant sandwiches were randomly distributed within a 10 m^2 block on the Lower Terrace at a water depth of 0.75 m.

In 1998, 480 transplant sandwiches were established at two sites on the Upper Terrace and four sites in the Lower Terrace. Transplant sandwiches 0.25 m^2 in size were constructed for Common Waterweed, Northern Water Milfoil, Richardson's Pondweed, Slender Pondweed and Variable-Leaved Pondweed *(Potamogeton gramineus)* along with 1m^2 transplant sandwiches of Richardson's Pondweed. Modified sandwiches were constructed for Northern Water Milfoil and Slender Pondweed to evaluate the benefit of allowing the shoots to float free. Wire mesh pieces 0.5 m x 0.5 m were folded in half and then the sides were folded leaving an opening in which the roots and rhizomes of the aquatic plants were placed.

At each site, three test plots were established in which four sandwiches per species were placed in rows starting at the shoreline and extending out 10 m. Water depths ranged from 0.3 m to 1.0 m. Modified sandwiches for each species were placed in the test plots at two sites on the Lower Terrace. Plant survival and establishment were assessed in the years following transplanting.

Results

In the 1997 field trials Stonewort did not survive transplanting and the biomass had begun to break down by September 1997. At that time, few new shoots were observed emerging from sandwiches with Common Waterweed or Northern Water Milfoil and the leaves were covered with sediment. In June 1998, there was no Common Waterweed nor Northern Water Milfoil growing in the sandwiches, while Slender Pondweed growth was limited. Richardson's Pondweed had the best survival and by June 1999, a dense weed bed 52 m^2 had formed around the mini-sandwiches.

In the 1998 field trials, the sandwiches were visually evaluated in September, only a few weeks after transplanting. On the Lower Terrace, Northern Water Milfoil had produced new shoots that covered the surface of the sandwiches. Less growth was observed on the sandwiches of the other species, with Variable-Leaved Pondweed producing the fewest new shoots. In the Upper Terrace, plants produced less growth than the plants in the Lower Terrace. In June 1999, a further visual evaluation indicated that Richardson's Pondweed had produced the greatest number of new shoots and had spread the farthest from the sandwiches. Slender Pondweed produced new growth, which was restricted to the sandwich area. For both Northern Water Milfoil and Common Waterweed few new shoots were observed in the sandwiches. Variable-Leaved Pondweed growth was limited except at one transplant site in the Upper Terrace where growth rates were similar to that observed for Richardson's Pondweed.

SITE COMPARISON - RECIPROCAL TRANSPLANT EXPERIMENT

The sediment characteristics and water column chemistry of the Falconbridge New Tailings Area and Rio Algom's Quirke Waste Management Area were compared in a reciprocal transplant experiment.

Method

Sediments from the two tailings impoundments, a metal contaminated lake (Robinson) and a control lake (Depot) were collected and placed in 12 cm wide by 20 cm deep plastic pails. Six pails for each sediment type were placed in Cell 14 at the Quirke Waste Management Area, the Lower Terrace at the New Tailings Impoundment and Robinson Lake. Ten, 15 cm stems of Richardson's Pondweed were placed in each pail. After 60 days, the plants were harvested and the new shoots and roots (below-sediment plant structures) were separated from the old tissue, rinsed with distilled water, dried at 50 ºC for 24 hours and weighed.

Results

The biomass results are presented in Table 1. One-way analysis of variance by site indicated that at Falconbridge, Richardson's Pondweed produced significantly greater total biomass ($F=13.43$, $P<0.0001$) and total number of stems ($F=16.89$, $P<0.0001$) than at the Robinson Lake or Rio Algom sites. When Richardson's Pondweed growth on the different sediments was examined by one-way analysis of variance, significantly more total biomass ($F=14.27$, $P<0.05$) was produced on Depot Lake sediment than on Rio Algom sediment. The root:shoot ratio at Rio Algom was significantly ($F=9.18$, $P<0.0001$) greater than for Falconbridge and Depot Lake sediments.

		Site					
	Sediment	Falconbridge		Rio Algom		Robinson	
Total Biomass (g)	Falconbridge	4.46	(1.31)	2.75	(1.46)	3.38	(2.32)
	Rio Algom	2.69	(0.44)	1.93	(0.49)	1.96	(0.85)
	Depot	7.60	(2.88)	2.46	(2.28)	2.44	(1.96)
	Robinson	5.75	(1.09)	1.86	(1.15)	2.00	(0.30)
Root:Shoot Ratio	Falconbridge	0.57	(0.13)	0.18	(0.03)	0.44	(0.96)
	Rio Algom	1.09	(0.22)	0.39	(0.06)	0.99	(0.26)
	Depot	0.43	(0.04)	0.26	(0.06)	0.60	(0.21)
	Robinson	0.64	(0.06)	0.38	(0.14)	1.01	(0.53)

Table 1. Means and standard deviations for Richardson's Pondweed total biomass and root:shoot ratio (after 60 days).

DISCUSSION

Plant selection

The physical characteristics of the flooded tailings impoundments, which included shallow shoreline areas, deep areas between 1 and 6 m, and large surface areas influenced the type of aquatic plants that could be successfully established. Emergent and floating plants are best restricted to shallow water (<0.6 m) where they can act as wind and wave breaks to prevent shoreline erosion and enhance the appearance of the site. In deeper water, submerged aquatic plants are effective because they spread rapidly by rhizomes or fragments, tolerate a wide range of water depths and are easier to transplant than emergent plants. At Brenda Mine, near Kelowna, B.C., three years after the establishment of 850 sandwiches containing submerged aquatic plants in an 80 ha tailings impoundment, the vegetative cover was 60%-100% in areas 1 to 3 m deep and 20%-80% in areas 3.0 to 4.5 m deep (St-Germain et al., 1997).

Due to the large size of tailings impoundment areas, rapid establishment of the vegetative cover is essential, therefore the main criteria used to assess transplant success is the rate at which the aquatic plants spread. In the shallow area at Rio Algom, Beaked Sedge and Wool Rush spread rapidly due to the branching nature of the rhizomes and were more successful than Common Cattail and Common Reed although these produced more biomass. At Falconbridge, Richardson's Pondweed spread rapidly by rhizomes from the site of establishment.

As with any natural body of water, wetland species will eventually invade the flooded tailings impoundment. At Rio Algom, at least 13 species have been observed in Cell 14 since the induction of the transplanted species (Beckett et al., 1999), while several species have also invaded the New Tailings Area since it was flooded. The objective of the transplanting program is to rapidly establish a vegetative cover over the entire tailings impoundment to achieve the benefits that the plant cover would provide. The transplanting program introduces larger volumes of plant material than would naturally invade the site, speeds up the revegetation process and utilizes species best suited for the site conditions which may not otherwise have naturally invaded the site.

Wetlands contain a variety of plant species even though the site may be dominated by only a few species. The composition of the plant community will vary as conditions in the wetland changes with time. It is important, therefore, to introduce a variety of species into the transplanting program. The criteria used to select wetland species for establishment on flooded tailings could include:

- Preference for species native to the area
- Selection of species with a wide geographic area
- Selection of species tolerant of low nutrient conditions
- Availability of species near the test site or in commercial nurseries
- Rate of vegetative spread and production of biomass

Transplant methods

In the study, emergent plants were transplanted at the shoreline sites by placing stems, rhizomes and organic substrate in islands directly on the tailings. In deeper areas, rhizomes and substrate were placed in the burlap containment bags with the top of the bags left open to allow the stems and leaves to float free. Both transplant methods were effective for establishing emergent plants.

Floating plants were transplanted by placing rhizomes and substrate in the burlap containment bags with the top of the bag left open allowing the stems and leaves to float free. This method had proven effective for emergent plants but was not as suitable for floating plants, which have frailer stems and less extensive rooting systems. With this technique, the plant biomass tended to be lost from the transplant area due to wind and wave action. In Cell 14, there was no establishment of Floating-Leaved Pondweed at the transplant sites, however, it has become abundant elsewhere within Cell 14.

Two transplant methods were utilized to establish submerged plants. The basic sandwich technique involved enclosing the plants in wire mesh, whereas the modified sandwich technique involved containing the roots and rhizomes in the wire mesh with the tops left open to allow the stems to float free. At Falconbridge there appeared to be no difference in transplant success using the basic sandwich or modified sandwich technique. However, the basic sandwiches were simpler and faster to construct than the modified sandwiches. Modified sandwiches were only suitable for submerged plants that could be harvested with large masses of roots and rhizomes (Northern Water Milfoil or Variable-Leaved Pondweed) and would not work for species that do not produce large root systems (Richardson's Pondweed or Common Waterweed).

Several sizes of sandwiches have been utilized in previous transplant trials on tailings. At Brenda Mine (copper/molybdenum) 1.0 m x 1.0 m sandwiches were used. On Heath Steele Mine tailings (zinc/lead) 0.33 m x 3.0 m rectangular sandwiches were employed because the longer perimeter provided a greater area from which the plants could spread (St-Germain et al., 1997). At Falconbridge, 0.5 m x 0.5 m mini-sandwiches were used because this size was easier to handle and had better surface contact with the tailings than the larger sized sandwiches. In theory it would also be beneficial to have 10 smaller sandwiches than five larger sandwiches with the same amount of plant biomass, as this would provide more points of establishment in the tailings from which the plants could spread. The difference in establishment and spread rate is being examined for 1.0 m^2 versus 0.25m^2 transplant sandwiches.

Water column chemistry and sediment characteristics

Wetland plant establishment on flooded tailings can be affected by many factors. Wave action, water column characteristics (pH, depth, turbidity and chemical composition) and the physical and chemical properties of the sediment influence plant growth and establishment (Hutchinson, 1975).

In the reciprocal transplant experiment the high root:shoot ratio and low biomass production for Richardson's Pondweed growing on Rio Algom tailings indicated sediment nutrient deficiencies (Barko et al., 1991). Sediment analysis indicated low nitrogen levels in Rio Algom tailings (0.11 mg/g) compared to the 1993 transplant donor sites (2.60 mg/g). Bone meal amendments were effective at increasing nitrogen and phosphorus levels in the plant tissue (Pappin Willianen et al., 1997). Fertilizing was required at Brenda Mine to overcome sediment nutrient deficiencies before aquatic plant establishment (St-Germain et al., 1997). The use of paper mill sludge that is rich in nutrients improved plant growth in Cell 14 (Tisch et al., 1999, Beckett et al., 1999). At Falconbridge, wetland plants have been established without fertilizer amendments, but nutrients are naturally added to the system from the springs flowing into both terraces and from a sewage pond that drains into the Upper Terrace.

Significant differences in the amount of biomass produced at the Falconbridge site compared to the Rio Algom site in the reciprocal transplant experiment indicate that the water column was influencing plant growth. Unlike emergent and floating plants which take all of their nutrients directly from the sediment, submerged plants primarily uptake nitrogen, phosphorus, iron, manganese and micronutrients from the sediment, while calcium, magnesium, sodium, potassium, sulphate and chloride uptake is from the open water (Barko et al, 1991). Of the six nutrients that submerged plants uptake directly from the water column, in Cell 14 only potassium (<0.20 mg/l) was below the level considered low (1.00 mg/l) in a nutrient study (Smart and Barko, 1988).

The low nutrient levels in the water column resulted in greater water clarity which increased light penetration and influenced submerged plant growth (Hutchinson, 1975). At Falconbridge, it was observed that size of leaves and stem length of Richardson's Pondweed increased with water depth. However, growth is affected by turbid conditions, which reduces light penetration.

CONCLUSIONS

Trials at Rio Algom and Falconbridge indicated that wetland plants could be successfully established in flooded tailings to develop an organic layer to improve the effectiveness of the water cover. The organic layer assists in the biological uptake of oxygen, which slows the diffusion of oxygen into the tailings and subsequently decreases acid generation. Metals released from the tailings and in the water column could be removed and retained in the sediment by organic complexation and be precipitated as sulphide complexes through the activities of sulphate-reducing bacteria.

The species selected for a transplant program would be very site specific and would be influenced by species avaiblity near the test site with a preference for species native to the area that have a wide geographic distribution. In the studies at Falconbridge and Rio Algom the species that were successfully established had aggressive growth habits and spread by rhizomes. Reeds and sedges were suitable for the shallow shoreline sites and submerged plants were best suited for deeper water.

It is recommended that transplant trials be conducted before a full-scale transplanting program is undertaken. Trials would identify site conditions (pH, turbidity and nutrient deficiencies) that could restrict plant growth and allow remediation methods to be developed to alleviate these conditions. The most practical and cost effective transplant method and the plant species most suitable for use could be determined through the trials.

When decommissioning existing tailings impoundments or designing new tailings facilities consideration should be given to improving the site potential to support wetland plants. Ponds can be designed with a range of water depths that would be suitable for shoreline, floating and submerged plant species. Creating bays, which would help protect plants from wave action and provide different site conditions, could enhance shorelines. The creation of islands within the tailings impoundment would improve the esthetic appearance of the site and provide wildlife habitat.

Using different transplant techniques, a variety of wetland plants have been established on flooded mine tailings. The growth rates, accumulation, and decomposition of organic matter in flooded tailings environments needs to be studied for the various wetland species. The amount of oxygen consumed, how effectively the metals are bound in the sediments and the establishment of sulphate-reducing bacteria should also be examined. Monitoring the long-term changes in the wetland species on flooded tailings will increase the understanding of wetland development and restoration.

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		Appendix				
		Location or treatment				
Species		Rio Algom		Falconbridge		Reciprocal
Common name	Scientific name	Shoreline	Deep Water	1997 Trial	1998 Trial	Transplant Experiment
Blue Joint Grass	Calamagrostis canadensis	•				
Beaked Sedge	Carex rostrata (utriculata)	•				
Common Cattail	Typha latifolia	•				
Narrow leaf Cattail	Typha angustifolia	•				
Manna Grass	Glyceria canadensis	•				
Wool rush	Scirpus cyperinus	•				
Common Reed	Phragmites australis	•				
Fragant Water Lily	Nymphaea odorata		•			
Watershield	Brasenia schreberi		•			
Horned Bladderwort	Utricularia cornuta		•			
Floating-Leaved Pondweed	Potamogeton natans		•			
Pickerelweed	Pontederia cordata		•			
Hardstem Bulrush	Scirpus acutus		•			
Richardson's Pondweed	Potamogeton richardsonii			•	•	•
Common Waterweed	Elodea canadensis			•	•	
Slender Pondweed	Potamogeton pusillus			•	•	
Northern Water Milfoil	Myriophyllum sibiricum			•	•	
Stonewort	Chara spp.			•		
Variable-Leaved Pondweed	Potamogeton gramineus				•	

Appendix 1. Species used in various trials on Uranium Tailings at Quirke Mine Waste Management Area and Nickel Tailings at New Tailings Area.

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