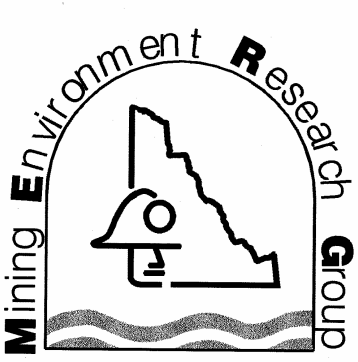
MERG Report 2003-3

Follow-up Monitoring: Shrub Trial Plots at Brewery Creek Mine and Bioengineering Trials at Noname Creek

By

Stu Withers

MERG is a cooperative working group made up of the federal and Yukon governments, Yukon First Nations, mining companies, and non-government organizations for the promotion of research into mining and environmental issues in the Yukon.



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Follow-up Monitoring

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Shrub Trial Plots at Brewery Creek Mine

and

Bioengineering Trials at Noname Creek

submitted to

Mining Environment Research Group

Stu Withers

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Non-technical Summary

Two MERG-sponsored mine reclamation projects were surveyed during the summer of 2002. These included the Brewery Creek Mine where local shrubs were planted in large open areas at the mine site in 2000, and Noname Creek near Big Creek west of Carmacks where, in 2001, live willow cuttings were used at an abandoned placer mine to stabilize an eroding gully in permafrost. Because the effectiveness of reclamation projects such as these can only be determined after several years of observation, the two mine sites were revisited in 2002 to record the successes and failures of the experimental work and to make suggestions on where improvements can be made.

At the Brewery Creek Mine, eleven species of shrubs were transplanted at three areas of the mine site in 2000. These sites included a steep north-facing slope, a steep south-facing slope, and a lower, nearly level area. All three of these areas had been graded and seeded in 1996-97, and there was a fairly thick growth of grasses and clovers at the time the shrubs were planted. To determine if this thick growth interfered with the survival of the newly planted shrubs, the grass and clover was first removed from one-half of the test plots. Two years after the test shrubs were planted it appears that the most successful transplanted species are black spruce, birch, spiraea, aspen, rose, raspberry and black currant. It is recommended that mixtures of these species be planted in small clumps throughout open areas at the mine, with the hope that these shrubs will spread throughout the rest of the area.

In 2001, 12 gully breaks and 2 drains were constructed in the upper part of a channel eroded through permafrost at the Noname Creek site. Live willow cuttings were used to stabilize the slope. The willow cuttings were collected in the fall after the leaves had fallen. During the 2002 survey it was noted that most of the willows used in this construction had survived and had sprouted new shoots and roots. Erosion had occurred, however, at a few of the gully breaks and pole drains. It is recommended that strips of geotextile be used to prevent the erosion at the gully breaks. In order to handle the water flows at spring runoff and at times of high rainfall, larger diameter pole drains should be constructed. The gully breaks and pole drains should also be constructed down the remainder of the channel.

Contents

1.0 Background

In a project funded by MERG and Viceroy Minerals Corporation, experimental plots were established at the Brewery Creek Mine in the fall of 2000 for the purpose of determining which locally-occurring shrub species would be useful for reclaiming large open disturbed areas on Yukon mine sites. Eleven species of shrubs were planted in plots at three sites with differing ecological characteristics such as elevation, slope and aspect. These sites were visited again in the summer of 2001 in order to evaluate the survival rates of these species. The results of this evaluation are summarized in a report submitted to MERG by S. Withers in March 2002.

In another MERG-funded project, bioengineering techniques were employed for stabilizing a permafrost-rich slope damaged by heavy equipment on a placer claim on Noname Creek west of Carmacks. This work, carried out in the fall of 2001, included the installation of live gully breaks and live pole drains using locally occurring species of willows. These techniques were described in a report submitted by Laberge Environmental Services in March 2002 (MERG Report 2002-1).

Conclusive evidence as to the success (or failure) of experimental reclamation projects such as these can only be gained through continued surveillance. The experimental plots at the Brewery Creek Mine and the bioengineering trials at Noname Creek were therefore resurveyed in the summer of 2002. The results of these surveys are contained in this report.

2.0 Shrub Trial Plots at Brewery Creek Mine

This MERG-funded research project at the Brewery Creek Mine is a component of Viceroy Mineral Corporation's multi-year reclamation program.

2.1 Summary of Work Carried Out in 2000 and 2001

A preliminary survey of the Brewery Creek Mine in July 2000 resulted in the selection of three sites for shrub propagation trials. Sites were selected to represent a range of ecological variables (elevation, slope and aspect). All three sites had already been seeded with a cover of grasses and legumes.

At each site, baseline data was collected, including topographical information (elevation, slope and aspect), soil physical properties (texture, drainage and compaction), soil pH and existing vegetation.

Soil samples were not collected for nutrient analysis during the current survey, although a 1996 analysis of plant-available nutrients in the Canadian Zone waste dump showed nitrate and sulfate levels to be low while phosphorous and potassium levels were moderate.

An inventory was also taken of the shrub species colonizing disturbed areas near each site. This information on voluntary revegetation was used for selecting species for propagation trials.

Test plots were established at the three sites in mid-September 2000, at the onset of seasonal dormancy (leaves had turned colour but had not yet fallen). At each location, six two-metre X three-metre plots were situated abutting each other in a line perpendicular to the slope.

Existing vegetation was removed from one half of each plot but was retained on the other half. Shrubs (transplants, stem cuttings and root cuttings) were collected from nearby disturbed areas and planted in the test plots, with the number of specimens placed in each half of each plot recorded. Rooting hormone (beta-indolyl-butyric acid) was applied to the semi-hardwood (previous season's growth only) willow stem cuttings and aspen root cuttings. A small amount of soil was transported with each transplant to the test plots in order to transfer mycorrhizal fungi. Black spruce seeds, provided by Forest Resources (DIAND), were sown in one plot at each test site.

Comparison plots were also established in undisturbed, forested areas nearby each test site. Five-metre X five-metre plots were situated in areas representing natural, pre-disturbance conditions. At each comparison plot, the percent cover for each species in the tree, shrub and ground cover layers was estimated and recorded.

In early July 2001, the shrub propagation trials plots were surveyed. At each plot, the number of surviving plants was recorded. The plots were surveyed again late August 2001.

For details on the plot locations, site characteristics, the shrub species used at each site, and the results of the 2001 surveys, see report submitted to MERG by S. Withers in March 2002.

2.2 2002 Site Assessment and Survey Results

On July 16, 2002, the trial plots at the Brewery Creek Mine were resurveyed. At each plot, the number of shrubs surviving in 2002 were recorded and compared with the number planted in 2000 and with the number surviving in 2001.

The results of the monitoring survey of July 2002 are as follows:

Site C-1 (Canadian Zone)

On the well-drained, north-facing site (C-1), black spruce and Beauverd's spiraea have been the most successful of the transplanted shrubs, with survival rates of 100%. The Alaska birch and prickly rose transplants also appear to be doing well on this site. None of the willow stem cuttings have survived.

A few of the black spruce germinated from seed on this site are growing, mostly on the portion of the plot that was cleared of previous vegetation.

Site C-1 (Canadian Zone)							
Plot	***Species***	***Cleared Area***			***Vegetated Area***		
		Number Planted 2000	**Number Surviving 2001**	**Number Surviving 2002**	**Number Planted 2000**	**Number Surviving 2001**	**Number Surviving 2002**
A	Alaska birch Transplants	**15**	**15**	**15**	**18**	**16**	**15**
B	Bebb's willow Stem cuttings	**10**	**0**	**0**	**10**	**0**	**0**
C	Prickly rose Transplants	**13**	**13**	**13**	**12**	**9**	**9**
D	Black spruce Transplants	**11**	**11**	**11**	**11**	**11**	**11**

E	Beauverd's spiraea Transplants	**8**	**8**	**8**	**6**	**6**	**6**
F	Black spruce Seeds	**4 grams**	**___**	**___**	**4 grams**	**___**	**___**

Site C-2 (Canadian Zone)

On the well-drained, south-facing site (C-2), the Alaska birch and black currants have all survived on the portion of the plots where the seeded grasses and legumes had first been removed. Most of the trembling aspen and raspberry transplants are also surviving but appear to be suffering from lack of moisture. Only one of the willow stem cuttings has survived. A heavy growth of seeded legumes (alfalfa and alsike clover) has evidently retarded the growth of the shrubs transplanted on the uncleared portion of the plots.

Very few of the black spruce germinated from seed on this site have survived.

Site C-2 (Canadian Zone)							
Plot	***Species***	***Cleared Area***			***Vegetated Area***		
		Number Planted 2000	**Number Surviving 2001**	**Number Surviving 2002**	**Number Planted 2000**	**Number Surviving 2001**	**Number Surviving 2002**
A	Black currant Transplants	**9**	**8**	**8**	**6**	**5**	**3**
B	Black spruce Seeds	**4 grams**	**___**	**___**	**4 grams**	**___**	**___**
C	Raspberry Transplants	**8**	**8**	**7**	**7**	**7**	**5**
D	Alaska birch Transplants	**10**	**10**	**10**	**7**	**5**	**5**
E	Trembling aspen Transplants	**10**	**10**	**8**	**8**	**6**	**1**
F	Little-tree & Bluegreen willow Stem cuttings	**10**	**0**	**0**	**10**	**1**	**1**

Site LP-1 (Below Leach Pad)

The survival rate of the shrubs planted on the nearly level area below the leach pad (LP-1) is lower than at the other two sites. The surviving five trembling aspens established from root cuttings are growing well on the half of the plot cleared of previous vegetation (seeded grasses and clover has now reinvaded this area), but only one remains growing on the uncleared half of the plot. Most of the rose transplants and a few of the dwarf birch transplants are also growing well on the cleared half of the plot.

None of the willow stem cuttings have survived, and none of the black spruce seeds have germinated.

Site LP-1 (Below Leach Pad)							
Plot	***Species***	***Cleared Area***			***Vegetated Area***		
		Number Planted 2000	**Number Surviving 2001**	**Number Surviving 2002**	**Number Planted 2000**	**Number Surviving 2001**	**Number Surviving 2002**
A	Trembling aspen Root cuttings	**11**	**5**	**5**	**11**	**1**	**1**
B	Blue-green willow Stem cuttings	**10**	**0**	**0**	**10**	**0**	**0**
C	Prickly rose Transplants	**10**	**8**	**8**	**11**	**3**	**3**
D	Bebb's & Little-tree willow Stem cuttings	**8**	**0**	**0**	**9**	**0**	**0**
E	Dwarf birch transplants	**7**	**5**	**4**	**8**	**3**	**2**
F	Black spruce Seeds	**4 grams**	**___**	**___**	**4 grams**	**___**	**___**

2.3 Conclusions and Recommendations

Two years after the shrub trial plots were established at the Brewery Creek Mine, the following conclusions can be made:

- The thick growth of grasses and legumes that has been seeded on some areas of the Brewery Creek mine is retarding the natural colonization by shrub species as well the survival and growth of the transplanted shrubs. Alfalfa, in particular, appears to have the effect of choking out shrub species.

- Establishing willows through the direct planting of stem cuttings does not appear to be effective on these sites, although several species occur in this area and are naturally colonizing many disturbed areas at the Brewery Creek Mine. Although planting stem cuttings is a widely used bioengineering technique for stabilizing slopes, particularly in riparian areas, the establishment of cuttings on drier, well drained sites requires greenhouse propagation in order to develop adequate root systems before planting.

- The propagation of black spruce from seeds is not effective in areas where the seedlings must compete with a dense cover of grasses and legumes. Black spruce transplants, by comparison, appear to grow well on both seeded and clear areas.

In order to further determine the effectiveness of locally occurring shrub species in assisted revegetation programs at Yukon mine sites, it is recommended that those species that have so far been demonstrated to be successful in the trial plots be established in strategically located “islands” at the Brewery Creek Mine. This native-species island model has been successfully tested at other mine sites, most notably at the Mesa/Wolverine open pit coal mine near Tumbler Ridge, B.C. (Bittman 1997).

The placement of an array of islands results in diverse communities of native species embedded within the matrix of seeded agronomic species. The role of the islands is to allow for the dissemination of seed by wind and other natural means to the areas reclaimed with agronomic species, therefore facilitating natural succession and naturally revegetating the land to a self-sustaining state.

The configuration of islands can range from a random planting of a few species to larger areas with more diverse plant communities.

The species recommended for planting in islands at the Brewery Creek Mine include:

Northerly facing sites	black spruce transplants
	Alaska birch transplants
	Beauverd's spiraea transplants
	prickly rose transplants
Southerly facing sites	trembling aspen transplants
	Alaska birch transplants
	black currant transplants
	raspberry transplants
Near level sites	dwarf birch transplants
	trembling aspen transplants
	prickly rose transplants
	black spruce transplants

In order to increase the diversity of the plant communities in these islands, seeds of locally occurring, native forbs and grasses could also be collected and planted along with the shrub transplants

3.0 Bioengineering Trials at Noname Creek

This project was initiated when slope failure and gullying were observed along the eastern slopes of Noname Creek, a tributary to Big Creek. This disturbance resulted from improper placer mining and road construction techniques at the site during the summers of 1999 and 2000, and the very high rainfalls of 2000.

3.1 Summary of Work Carried Out in 2001

Following a reconnaissance survey of the Noname Creek area in July 2001, a site was chosen for the bioengineering field trials. This site is an eroded gully that had recently been formed as a result of heavy tracked mining equipment moving up and down the slope. The gully is one to two meters deep and up to eight metres wide. The water flowing in the gully during the summer season is primarily the result of melting permafrost. This water drains into Noname Creek. No stream had existed at the site of this gully prior to the disturbance.

The bioengineering works were constructed in mid-September 2001. Dormant willow cuttings were collected from the nearby Big Creek riparian zone. The willow species used were *Salix arbusculoides* and *Salix alaxensis*. The upper, new growth was removed from each dormant cutting, leaving only the leaving a leaf bud near the distal cut line. The willow cuttings were installed within 24 hours from the time they were collected.

Twelve gully breaks were installed on the upper reaches of the gully, spanning a linear distance of about 100 metres. These breaks consisted of wattle fences constructed across the gully. At each break, a shallow trench was excavated across the drainage channel and dormant willow cuttings were laid in an overlapping lattice formation and butted into the sidewalls of the gully. They were anchored in place with black spruce stakes collected from the nearby slope.

Two live pole drains were constructed in the upper gully. These consisted of bundles of dormant willow cuttings laid in shallow trenches excavated in the bottom of the drainage channel parallel to the direction of flow. The bundles of willows, about 0.2-0.3 m in

diameter, were lashed with binder twine, laid in the trenches and backfilled with local soil.

Live willow cuttings were also staked into the bottom of the drainage channel between the gully breaks. These dormant cuttings, approximately 40 cm long, were inserted into the soil such that only about one-quarter of the length was left above ground. They were randomly spaced at about 0.5 m.

For a complete description of these installations, see report submitted to MERG by Laberge Environmental Services in March 2002.

3.2 2002 Site Assessment and Survey Results

The bioengineering installations at Noname Creek were surveyed on July 12, 2002. This evaluation included a structural assessment of the live gully breaks and live pole drains installed in the fall of 2001, and a preliminary assessment of their ability to survive spring runoff, trap sediment and reduce further gully erosion. The apparent survival and new growth of the willow cuttings were also noted.

The results of the monitoring survey of July 2002 are as follows:

Live Gully Breaks

Almost all of the willow cuttings in the 12 gully breaks are surviving, with most showing new growth. Although there was no water running in the gully at the time of the survey, there appeared to be adequate soil moisture to support the growth of these willow species.

All of the gully breaks have remained structurally sound, and most have trapped sediment during the spring runoff. In some cases, however, channels have been eroded under the wattle fences, resulting in a failure to trap sediment. These breaches in the gully breaks have occurred in the narrower, steeper sections of the gully.

Graminoids, paricularly blue-joint reed grass (*Calamagrostis canadensis*) and sedges (*Carex* spp.), have colonized areas where sediment has been trapped behind the gully breaks

Live Pole Drains

The two live pole drains have remained intact, although some erosion is occurring at the drain inlets and along the sides of the drains. The willow cuttings used for constructing these drains have sprouted and are rooting. New shoots and leaves have sprouted from the uppermost cuttings (those not covered with the backfilled soil).

Live Stakes

All but a few of the live willow stakes have survived. Those not surviving are the ones planted on the higher, drier sides of the gully. One of the stakes was pulled out in order to examine the new roots.

There is evidence of considerable browsing by rodents on the new willow leaves and shoots. This has occurred on both the gully breaks and the willow stakes. Fresh moose tracks were also observed in and around the gully at the site of the bioengineering installations.

3.3 Conclusions and Recommendations

One year after the bioengineering trials at Noname Creek were initiated, the following conclusions can be made:

- The willow cuttings used for this bioengineering project have survived and produced abundant new growth during the first growing season after installation. The species selected for this work (*Salix arbusculoides* and *Salix alaxensis*), collected from lower down the valley at Big Creek, have so far adapted to this upland site.

- Although the gully breaks have remained structurally sound, and most have been effective in trapping sediment, a few have been breached by erosion channels. Methods for preventing this breaching should be investigated.

- The pole drains have also remained intact, although erosion has occurred, mostly at drain inlets. Methods for stabilizing inlets to the pole drains should be investigated.

In order to further determine the effectiveness of bioengineering techniques for stabilizing eroded slopes in areas underlain with permafrost, it is recommended that the following additional experimentation be carried out at the Noname Creek site:

- The erosion channels occurring underneath some of the gully breaks is the most obvious problem noted so far at the Noname Creek trial site. Laying strips of biodegradable geotextile along the upstream bases of the gully breaks may be an effective and relatively easy way of preventing this breaching.

- Stabilization of the inlets to the live pole drains should be improved through the placement of rocks or coarse gravel. As the peak flows from spring runoff and high rainfall events are not known for this drainage, experimentation with larger diameter pole drains, or two to three pole drains laid in parallel, would be useful. It would also be beneficial to experiment with different levels of soil compaction around these installations.

- Bioengineering works were installed only in the upper reaches of the erosion gully. It is recommended that this work be applied to the entire length of the gully, down to its confluence with Noname Creek.

References

Bittman, K.K. 1997. High Elevation Native Species Island Model for Mine Reclamation. Quintette Operating Corporation, Tumbler Ridge, B.C.

Laberge Environmental Services. 2002. Experimental Trials for Restoring Disturbed Sites in Permafrost Areas Using Bioengineering Techniques. Prepared for the Mining Environment Research Group. Whitehorse, Yukon.

Withers, S. 2002. Shrub Trial Plots – Brewery Creek Mine. Prepared for the Mining Environment Research Group, Whitehorse, Yukon.

Appendix A: 2002 Photographs – Brewery Creek Mine Project

Beauverd's spiraea transplants at Site C-1 July 2002

Prickly rose transplants at Site C-1 July 2002

Trembling aspen transplants
at Site C-2 July 2002

Alaska birch transplants
at Site C-2 July 2002

Dwarf birch transplants
at Site LP-1 July 2002

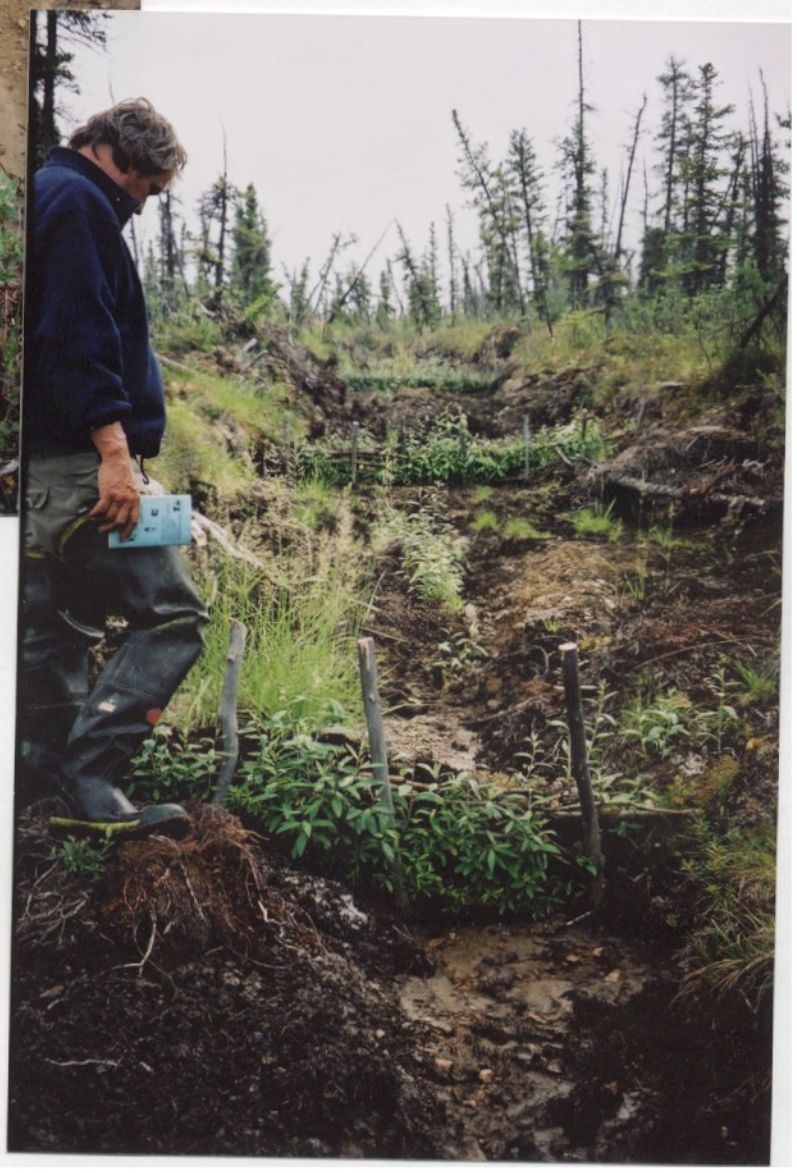
Prickly rose transplants at Site LP-1 July 2002

Appendix B: 2002 Photographs – Noname Creek Project

Live gully break with trapped sediment July 2002

Live gully break with trapped sediment July 2002

Live gully break (note growth of blue-joint reed grass in trapped sediment) July 2002



Live gully breaks (note lower one has been breached underneath) July 2002

Live pole drain

July 2002

Live pole drain

July 2002

Live pole drain exposed to show new roots July 2002

Live pole drain showing erosion to side of drain July 2002

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