

2005 Revegetation Assessment
Dewatered Freshwater Reservoir
South Fork of Rose Creek, Yukon

Assessment Report Prepared for:

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Laberge
ENVIRONMENTAL SERVICES

November 2005

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Appendix A: Site Photographs

1.0 Background

The dewatered reservoir on the south fork of Rose Creek was seeded with northern native grass species in several phases during 2003 and 2004. No legumes were seeded and no fertilizer was applied. The stem cuttings of woody species (primarily willows) were staked along the Rose Creek riparian zone, along the upper tributaries, and on the floodplains adjacent to the breached dam. All work was carried out by Arctic Alpine Seed Ltd.

Under Part E, Section 35 of Water Licence QZ03-058, an annual inspection and assessment of the success of the revegetation activities is to be undertaken. Laberge Environmental Services evaluated the success of the revegetation program during a survey in July 2005. The results are summarized in this report.

2.0 Grass Seeding Program

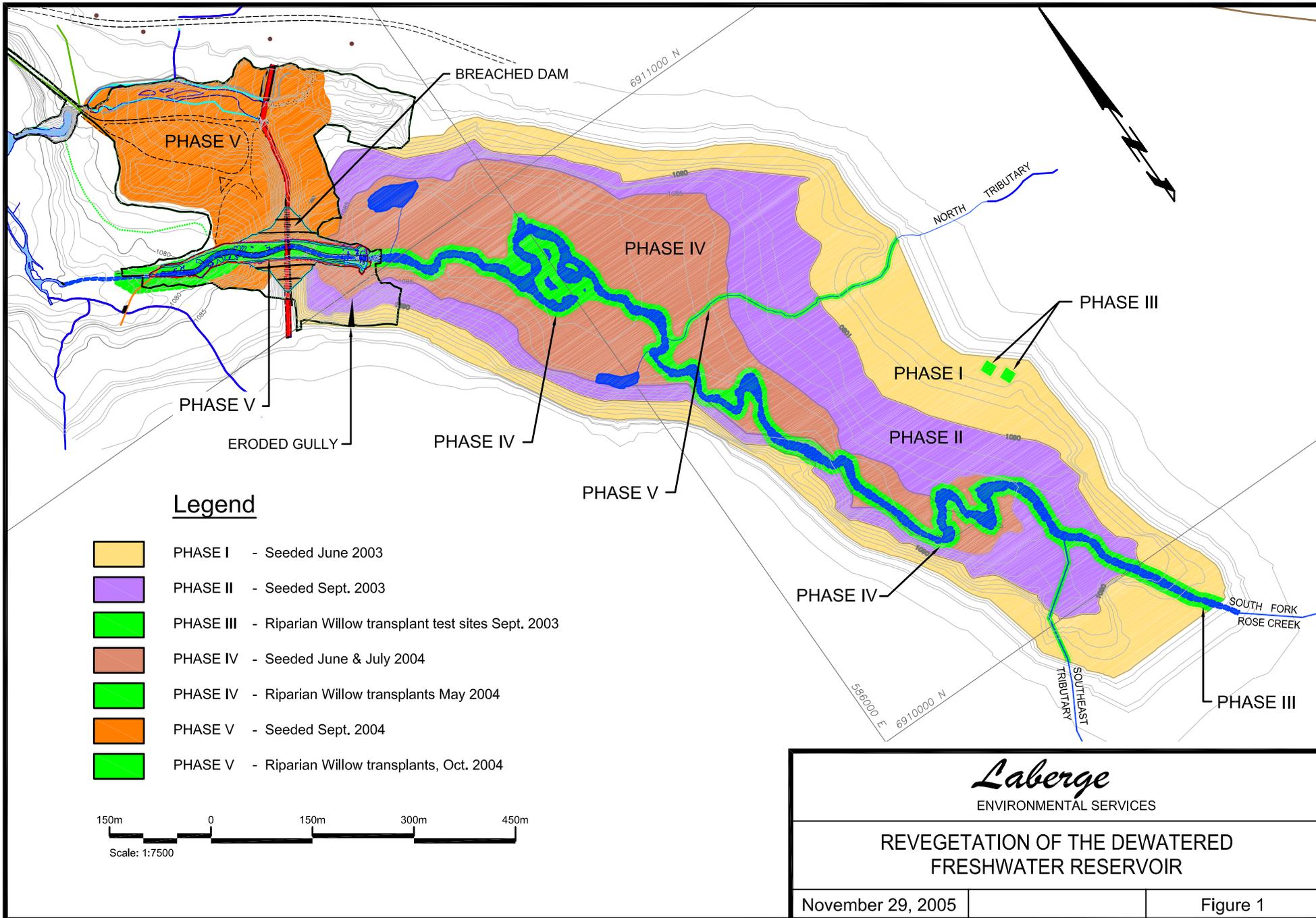
2.1 Phase I Zone

2.1.1 Seeding Program

The Phase I zone includes 17.2 ha of newly exposed shoreline between elevations of 1090 m and 1096 m seeded by Arctic Alpine Seed Ltd. in June 2003 (Figure 1).

The seed mix (Lacroix 2005) included:

Sheep Fescue	(<i>Festuca brachyphylla</i>)	25.0 lb/ha	(11.34 kg/ha)
Slender Wheatgrass	(<i>Agropyron trachycaulus</i>)	25.0 lb/ha	(11.34 kg/ha)
Violet Wheatgrass	(<i>Agropyron violaceum</i>)	13.0 lb/ha	(5.89 kg/ha)
Ticklegrass	(<i>Agrostis scabra</i>)	1.0 lb/ha	(0.45 kg/ha)
Alpine Bluegrass	(<i>Poa alpina</i>)	0.5 lb/ha	(0.23 kg/ha)
Tufted Hairgrass	(<i>Deschampsia caespitosa</i>)	0.5 lb/ha	(0.23 kg/ha)
	Total	65.0 lb/ha	(29.48 kg/ha)



Arctic Alpine Seed Ltd. reported an overall germination rate of 90% for this area in September 2003 and an overall vegetative cover of 95% in September 2004 (Arctic Alpine Seed 2005).

2.1.2 July 2005 Assessment

The July 2005 assessment of the Phase I seeding showed a >90% vegetative cover for most of the area seeded, with occasional patches of sparser growth. The Phase I zone is dominated by a dense growth of Sheep Fescue with lesser amounts of Ticklegrass, Alpine Bluegrass and Tufted Hairgrass. Both species of Wheatgrass are scarce in most of the Phase I zone, but are more prevalent in those patches with lighter vegetative cover. It is apparent that Wheatgrass cannot compete well in the areas with a dense growth of Sheep Fescue (such as occurs in most of the Phase I zone). All the seeded grass species observed in the Phase I zone in July 2005 were in seed.

The dense cover of seeded grasses, along with a thick layer of grass litter (primarily the previous year's growth of Sheep Fescue), has inhibited the growth of naturally occurring pioneering plant species in the Phase I zone. Some Yellow Cress (*Rorippa palustris*) and Tansy Mustard (*Descurainia incana*) have colonized areas that have a less dense vegetative cover.

It should be noted that many of the pioneering species observed in the Phase II and Phase IV zones were also seen in the Phase I zone prior to the seeding program (Lacroix 2005). These post-disturbance primary successional species "kickstart" biological processes in the soil and allow for colonization by the seeded grasses. These pioneering species were slowly "thinned out" as the seeded grasses successfully colonized this zone.

2.2 Phase II Zone

2.2.1 Seeding Program

The Phase II zone includes 17.5 ha of newly exposed shoreline between elevations of 1086 m and 1090 m seeded by Arctic Alpine Seed Ltd. in September 2003 (Figure 1).

The seed mix (Lacroix 2005) included:

Sheep Fescue	(<i>Festuca brachyphylla</i>)	25.0 lb/ha	(11.34 kg/ha)
Slender Wheatgrass	(<i>Agropyron trachycaulus</i>)	25.0 lb/ha	(11.34 kg/ha)
Violet Wheatgrass	(<i>Agropyron violaceum</i>)	13.0 lb/ha	(5.89 kg/ha)
Ticklegrass	(<i>Agrostis scabra</i>)	1.0 lb/ha	(0.45 kg/ha)
Alpine Bluegrass	(<i>Poa alpina</i>)	0.5 lb/ha	(0.23 kg/ha)
Tufted Hairgrass	(<i>Deschampsia caespitosa</i>)	0.5 lb/ha	(0.23 kg/ha)
Total		65.0 lb/ha	(29.48 kg/ha)

Arctic Alpine Seed Ltd. reported an overall germination rate of 80% for this area in September 2004 (Arctic Alpine Seed 2005).

2.2.2 July 2005 Assessment

Although the rate of seed application was the same for both Phase I and Phase II (29.48 kg/ha), the July 2005 assessment showed only an estimated 70% vegetative cover for much of the area seeded in the Phase II zone. There were also patches of ground with less cover including a few higher knolls that were nearly bare. This possibly results from inconsistencies in the rate of seed application, variations in soil nutrients, or the movement of seeds by wind or water before germination. It was also noted that large numbers of birds flocked to the site during the fall seeding (Lacroix 2005). It was believed they were feeding on the disbursed seeds.

On the southeast side of the former reservoir, the Phase II seeding zone is dominated by Sheep Fescue and Ticklegrass, with lesser amounts of Wheatgrass and Tufted Hairgrass. There is little evidence of Alpine Bluegrass in this area. Very dense stands of Ticklegrass are found in some depressions, probably from the very small seeds of Ticklegrass being washed into these lower areas.

The Phase II seeding zone on the northwest side of the former reservoir generally has a more evenly distributed growth of grass species (Sheep Fescue, Wheatgrass, Alpine Bluegrass and Ticklegrass) with a more patchy distribution of Tufted Hairgrass. Dense stands of Tufted Hairgrass occur in this area (the seeds of tufted Hairgrass are also very small and therefore easily windblown). One small area is dominated by a dense stand of Wheatgrass.

All grass species seeded in the Phase II zone were in seed at the time of the July 2005 survey.

The less dense vegetative cover in the Phase II seeding zone has allowed for the natural colonization of the area by pioneering plant species, including Balsam Poplar (*Populus balsamifera*), willows (*Salix* spp.), chickweed (*Stellaria* sp.), Yellow Cress (*Rorippa palustris*), Tansy Mustard (*Descurainia incana*), Fireweed (*Epilobium angustifolium*), Willowherb (*Epilobium ciliatum*), Alpine Milk-vetch (*Astragalus alpinus*), Annual Hawk's-beard (*Crepis tectorum*), Mastadon Flower (*Senecio congestus*), Scorpion-weed (*Phacelia franklinii*), Smooth Brome (*Bromus inermis*), Blue-joint (*Calamagrostis canadensis*), Foxtail Barley (*Hordeum jubatum*), sedges (*Carex* spp.) and rushes (*Juncus* spp.).

2.3 Phase IV and Phase V Zones

2.3.1 Seeding Program

The Phase IV zone includes approximately 17 ha of the newly exposed bottom of the former freshwater reservoir and was seeded in June and early July 2004 by Arctic Alpine Seed Ltd. Phase V includes the dam area, the disturbed site downstream of the dam, and the floodplains adjacent to the dam breach and this zone was seeded in September and October 2004 (Figure 1).

The seed mix (Lacroix 2005) used for these areas, excluding the floodplains, included:

Sheep Fescue	(<i>Festuca brachyphylla</i>)	25.0 lb/ha	(11.34 kg/ha)
Slender Wheatgrass	(<i>Agropyron trachycaulus</i>)	25.0 lb/ha	(11.34 kg/ha)
Violet Wheatgrass	(<i>Agropyron violaceum</i>)	13.0 lb/ha	(5.89 kg/ha)
Ticklegrass	(<i>Agrostis scabra</i>)	1.0 lb/ha	(0.45 kg/ha)
Alpine Bluegrass	(<i>Poa alpina</i>)	0.5 lb/ha	(0.23 kg/ha)
Tufted Hairgrass	(<i>Deschampsia caespitosa</i>)	0.5 lb/ha	(0.23 kg/ha)
Total		65.0 lb/ha	(29.48 kg/ha)

The seed mix (Lacroix 2005) used for the floodplains included:

Sheep Fescue	(<i>Festuca brachyphylla</i>)	4.00 kg/ha
Violet Wheatgrass	(<i>Agropyron violaceum</i>)	4.00 kg/ha
Ticklegrass	(<i>Agrostis scabra</i>)	1.00 kg/ha
Tufted Hairgrass	(<i>Deschampsia caespitosa</i>)	1.00 kg/ha
Total		10.00 kg/ha

2.3.2 July 2005 Assessment

The July 2005 assessment of the valley bottom showed that the vegetative cover varied from 30% to 60%. The seeded grasses were growing mostly in depressions, probably the result of seeds having been carried there by wind or water before germination. Some of the lowest areas were totally bare. These areas were likely still under water at the time of seeding.

The dominant grasses found in the valley bottom were Wheatgrass, Alpine Bluegrass and Ticklegrass. Sheep Fescue and Tufted Hairgrass were not so common in this area. The grasses observed on the valley bottom were not as well developed as those on the higher valley sides (Phase I and Phase II zones). The Wheatgrass and Ticklegrass plants were just beginning to form seed. Alpine Bluegrass plants were stunted in growth and with very few plants in seed.

Yellow Cress (*Rorippa palustris*) and Mastadon Flower (*Senecio congestus*) are the dominant colonizing plant species of the valley bottom. Other plants colonizing this zone include willows (*Salix* spp.), Shepherd's-purse (*Capsella bursa-pastoris*), Grass-of-Parnassus (*Parnassia palustris*), Foxtail Barley (*Hordeum jubatum*), Alpine Knotweed (*Polygonum viviparum*), Golden Saxifrage (*Chrysopenium tetandrum*), Blue-joint (*Calamagrostis canadensis*), Common Timothy (*Phleum pratense*), Alkali Grass (*Puccinellia* sp.), Trisetum (*Trisetum spicatum*) and rushes (*Juncus* spp.).

The July 2005 assessment of the floodplains adjacent to the dam breach showed that the vegetative cover ranged from 10% to 30%. The vegetation includes Sheep Fescue, Tufted Hairgrass and Ticklegrass, with lesser amounts of Wheatgrass. The growth form of these grass species was low, with only a few plants of each species in seed at the time of the assessment. Some natural regeneration of willows (*Salix* spp.) is occurring.

These floodplains were flooded during the 2004 spring seeding program and it appears they were again under water during the 2005 spring freshet. Loss of seeds during the 2004 flood undoubtedly accounts for the lower vegetative cover in these areas.

The 2005 assessment of the dam showed a cover of 40% to 50% cover on the upper part of the dam. Seeded species included Sheep Fescue, Alpine Bluegrass, Ticklegrass and Wheatgrass. There was no evidence of Tufted Hairgrass. Natural revegetation included Yellow Cress (*Rorippa palustris*), Fireweed (*Epilobium angustifolium*), Foxtail Barley (*Hordeum jubatum*), Tansy Mustard (*Descurainia incana*) and willows (*Salix* spp.).

The lower part of the dam had an approximately 60% vegetative cover, including primarily Sheep Fescue and Wheatgrass, with lesser amounts of Alpine Bluegrass, Ticklegrass and Tufted Hairgrass. Yellow Cress (*Rorippa palustris*), Hawk's-beard (*Crepis elegans*), willows (*Salix* spp.) and a few sedges (*Carex* spp.) are naturally colonizing this part of the dam.

The sides of the dam breach had sparse (about 10%) vegetative cover. Seeded species included Sheep Fescue, Ticklegrass and Wheatgrass.

The areas seeded downstream of the dam also had a very sparse (< 10%) vegetative cover at the time of the 2005 assessment. Seeded species included Tufted Hairgrass, Ticklegrass and Wheatgrass. Plant species naturally colonizing this area included Felt-leaf Willow (*Salix alaxensis*), Balsam Poplar (*Populus balsamifera*), Jacob's Ladder (*Polemonium pulcherrimum*), Alpine Milk-vetch (*Astragalus alpinus*), River Beauty (*Epilobium latifolium*), Fireweed (*Epilobium angustifolium*), Bear Root (*Hedysarum alpinum*), Common Yarrow (*Achillea millefolium*), Common dandelion (*Taraxacum officinale*) and Foxtail Barley (*Hordeum jubatum*).

It should be noted that the grass seeds used during the 2004 seeding had been stored at the mine since the fall of 2003. It is possible that the cold temperatures in the unheated warehouse could have compromised the seeds viability, and thus may have also contributed to the lower vegetative cover on those sites seeded in 2004 (Denis Lacroix, 2005).

2.4 Vitality of Seeded Grass Species

The seeded grass species all appeared to have normal growth forms at the time of the 2005 assessment. All species showed greatest vigor on the upper valley sides (Phase I and Phase II zones – two growth seasons), where the average plant heights were:

Sheep Fescue	85 cm
Tufted Hairgrass	80 cm
Wheatgrass	75 cm
Ticklegrass	40 cm
Alpine Bluegrass	35 cm

On the valley bottom, the riparian areas, the dam sides and the dam breach, all seeded species had a lower growth form (one growth season).

All seeded grass species were in seed in the Phase I and Phase II zones at the time of the assessment. The growth of all species on the valley bottom appeared seasonally retarded and few plants were yet in seed.

The average rooting depths of the seeded grass species on the valley bottom were:

Sheep Fescue	68 mm
Tufted Hairgrass	98 mm
Wheatgrass	65 mm
Ticklegrass	67 mm
Alpine Bluegrass	63 mm

3.0 Shrub Establishment Program

3.1 Shrub Harvest and Establishment

Stem cuttings from locally occurring species of shrubs (primarily willows) were harvested from a site downstream of the breached dam and staked at a number of sites in the dewatered reservoir (Figure 1). These included a willow transplant test site at the south-east end of the reservoir (Phase III program, September 2003), willow stem cutting transplants along the riparian zone on the main channel of Rose Creek (part of the Phase IV program, May 2004) and willow stem cutting transplants along the two main tributaries as well as on the floodplains adjacent to the dam breach (Phase V program, September and October 2004).

The shrub species selected were:

Diamond-leaf Willow	(<i>Salix pulchra</i>)
Felt-leaf Willow	(<i>Salix alaxensis</i>)
Scouler's Willow	(<i>Salix scouleriana</i>)
Barclay's Willow	(<i>Salix barclayi</i>)
Trembling Aspen	(<i>Populus tremuloides</i>)
Balsam Poplar	(<i>Populus balsamifera</i>)
Soapberry	(<i>Shepherdia canadensis</i>)
White Spruce	(<i>Picea glauca</i>)

3.2 July 2005 Assessment

The staked willows on the floodplains upstream and downstream of the dam breach had a survival rate of 80% to 95% at the time of the 2005 assessment. The most successful species were Diamond-leaf Willow, Felt-leaf Willow and Balsam Poplar. These are commonly used reclamation species.

The staked willows (mostly Diamond-leaf Willows and Felt-leaf Willows) in the 10 m wide Rose Creek riparian zone also had a high rate of survival (80% to 90 %).

A much lower rate of survival (10% to 30%) was noted for the willows staked along the upper tributaries. These willows appeared to be Gray-leaf Willows (*Salix glauca*) collected from the nearby shrub zone along upper Rose Creek. The stem cuttings of Gray-leaf Willows are not recommended as reclamation species (Collet, 2002).

4.0 Natural Revegetation

A considerable number of plant species are naturally colonizing the dewatered reservoir as discussed in previous sections. This colonization of plant species is least common in the Phase I seeding zone where the seeded grass species have the densest vegetative cover, and is most common in the valley bottom where the seeded grasses have a sparse cover.

The plant species colonizing the dewatered reservoir are pioneering species normally found on disturbed sites in this region. The most common species are those from the Mustard Family, including Yellow Cress (*Rorippa palustris*) and Tansy Mustard (*Descurainia incana*), along with Mastadon Flower (*Senecio congestus*) and willows (*Salix* spp.).

Colonization of the site by undesirable invasive species does not appear to be a problem. The small amounts of Foxtail Barley (*Hordeum jubatum*), Annual Hawk's-beard (*Crepis tectorum*) and Common Dandelion (*Taraxacum officinale*) found on the site are to be expected in any disturbed site in this region. The non-native grass species, Common Timothy (*Phleum pretense*) and Smooth Brome (*Bromus inermis*) are common in the area and have probably been transported through the importing of hay for horses.

5.0 Evidence of Erosion

The only significant soil erosion was noted on the south side of the reservoir just upstream from the breached dam at northing 6911165 and easting 585552. At this point, a gully has occurred on the steepest part of the slope, in the Phase I seeding zone (see Photos 5 and 6). The deepest part of the cut is about 2 m. Groundwater seepage, at an estimated 2 litres/sec, enters the cut approximately half way down and fans out through mud on the lower slope, in the Phase II seeding zone.

Elsewhere throughout the dewatered reservoir, only minor occurrences of soil erosion were observed during the 2005 assessment.

6.0 Summary

- All seeded grass species are growing well, with the densest and most robust growth occurring in the Phase I seeding zone. All grass species are producing seed in most areas.
- The dense growth of grass in the Phase I zone, although inhibiting the colonization by naturally occurring plant species, is significantly preventing soil erosion on the upper steep slopes.
- The only site with significant soil erosion is the gully described in Section 5.0.
- The non-uniformity in the growth of seeded grasses throughout some areas of the dewatered reservoir is probably the result of seed disbursement by wind or water before germination, or by inconsistencies in seeding methods. This non-uniformity in growth patterns is not currently causing problems in the prevention of soil erosion.
- Much of the dewatered reservoir is being colonized by pioneering plant species. This is most obvious on the valley bottom where the growth of seeded grasses is not so dense.
- The invasion of the area by unwanted invasive plant species is so far not a significant problem.
- The stem cuttings of woody species, particularly willows, are surviving well on the floodplains adjacent to the dam breach and in the Rose Creek riparian zone. The survival rate of the cuttings staked on the upper tributaries and in the test sites (Phase III) is poor.

7.0 Recommendations

Overall the site is doing very well and the only additional work recommended is the treatment of the gully that has formed on the south side of the reservoir as described in Section 5.0. This erosion cut could possibly be restored through the use of common bioengineering techniques. The optimal time for the construction of bioengineered structures is late summer / early fall.

Although growth is sparse on the breached walls, additional seeding is likely unnecessary. This area has only had several months to become established (it was seeded in the fall of 2004) and growth is likely to increase over time. Annual monitoring of this area will indicate whether the seeding was successful.

8.0 References

Arctic Alpine Seed Ltd. 2005. Anvil Range Mining Complex, Faro, Yukon. Former Fresh Water Supply Reservoir. Reservoir Site Revegetation and Rose Creek Riparian Zone Rehabilitation. Project Report 2003-2004. Prepared for Deloitte & Touche Inc.

Collet, Dominique. 2002. Willows of Southcentral Alaska. Prepared for the Kenai Watershed Forum and funded by U.S. Fish and Wildlife Service.

Lacroix, Denis. 2005. Personal comments, emails and notes. (Mr. Lacroix was Arctic Alpine Seed's site manager for the freshwater reservoir revegetation project during the 2003 and 2004 field seasons).

APPENDIX A

SITE PHOTOGRAPHS, JULY 21, 2005



Photo #1 : Facing north from the valley bottom, Phase I in background

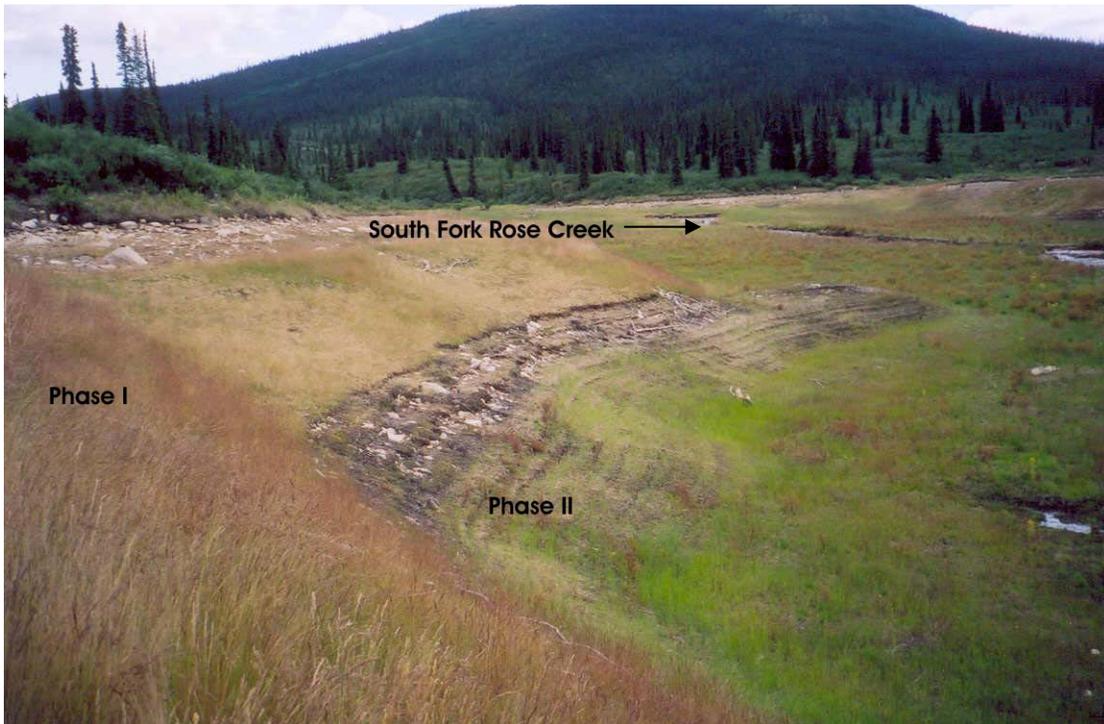


Photo #2 : North east end of reservoir showing Phases.



Photo #3 : Robust growth in Phase I, sheep fescue dominating.



Photo #4 : Facing west towards breached dam through Phase II, Phase I in upper right.



Photo #5: Eroded gully formed on south west side of reservoir.



Photo #6 : Erosion in gully below groundwater seepage point, looking to valley floor.



Photo #7 : Rose Creek riparian zone along the valley floor looking towards the breached dam.



Photo #8 : Natural colonization of willows in the original riparian zone west of the north tributary area.



Photo #9 : Successful willow transplants in the flood plain of the breached area. Note the entrapment of debris at the bases of the willows resulting from high water events.



Photo #10 : High survival rate of transplanted willows was also observed in the riparian zone. This photo was taken just upstream of the breach.

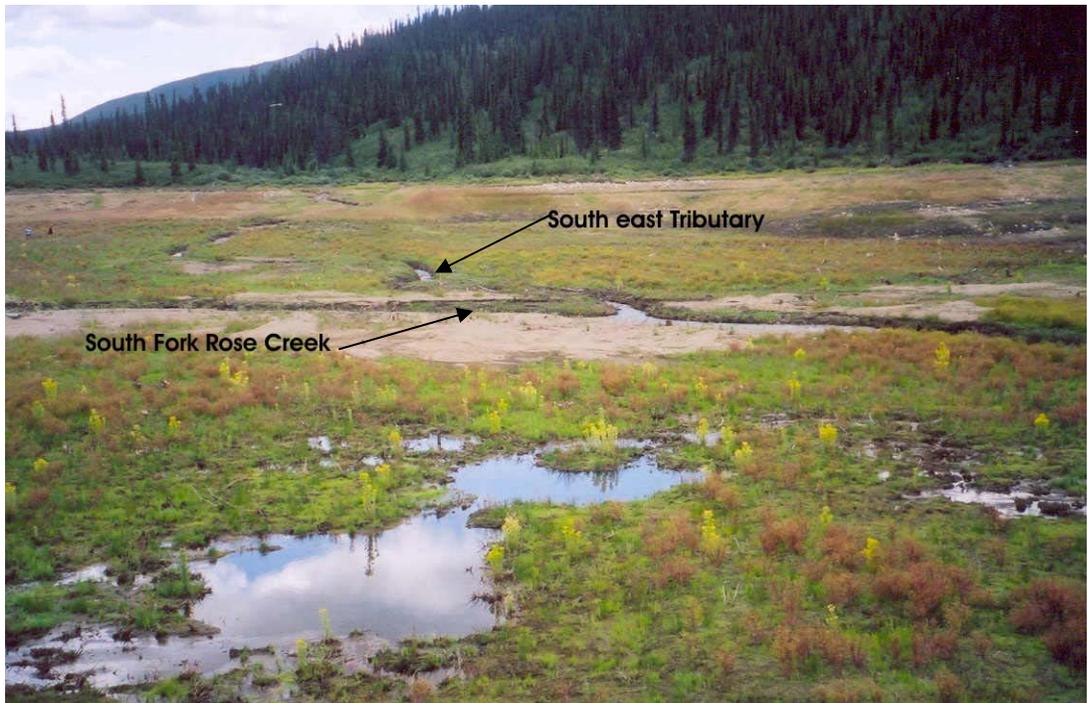


Photo #11 : Confluence of the South Fork and the South east tributary at the east end of the reservoir.

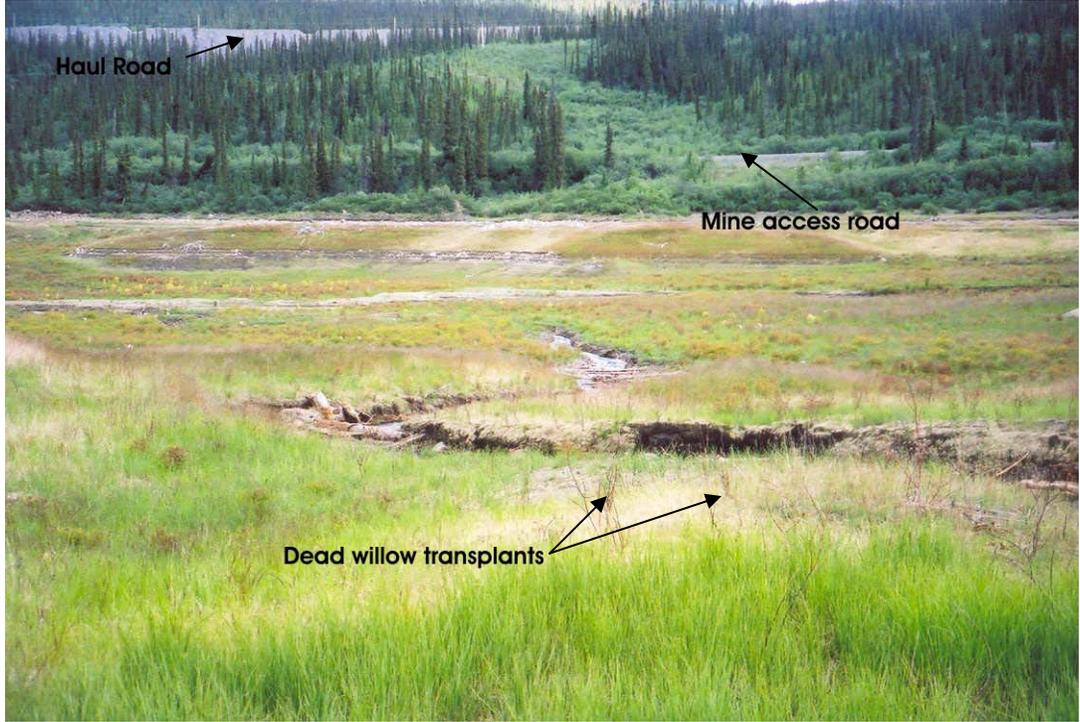


Photo #12 : Looking down S.E. tributary. Most of the willow transplants did not survive in this area.



Photo # 13: Freshwater Reservoir prior to breaching. Draw down has occurred to at least the Phase I level. Summer 2003.



Photo # 14: The dam has been breached and dewatering has occurred. Summer 2004.



Photo # 15: The dewatered reservoir just upstream of the breached dam. Summer 2004.



Photo # 16: The south east end of the dewatered reservoir. Summer 2004.