Kicking Horse Revegetation Trials

2005 - 2007

TERRASOL Environment Inc.

Kicking Horse Canyon Revegetation Trials

2005 – 2007 Site Works and Assessments

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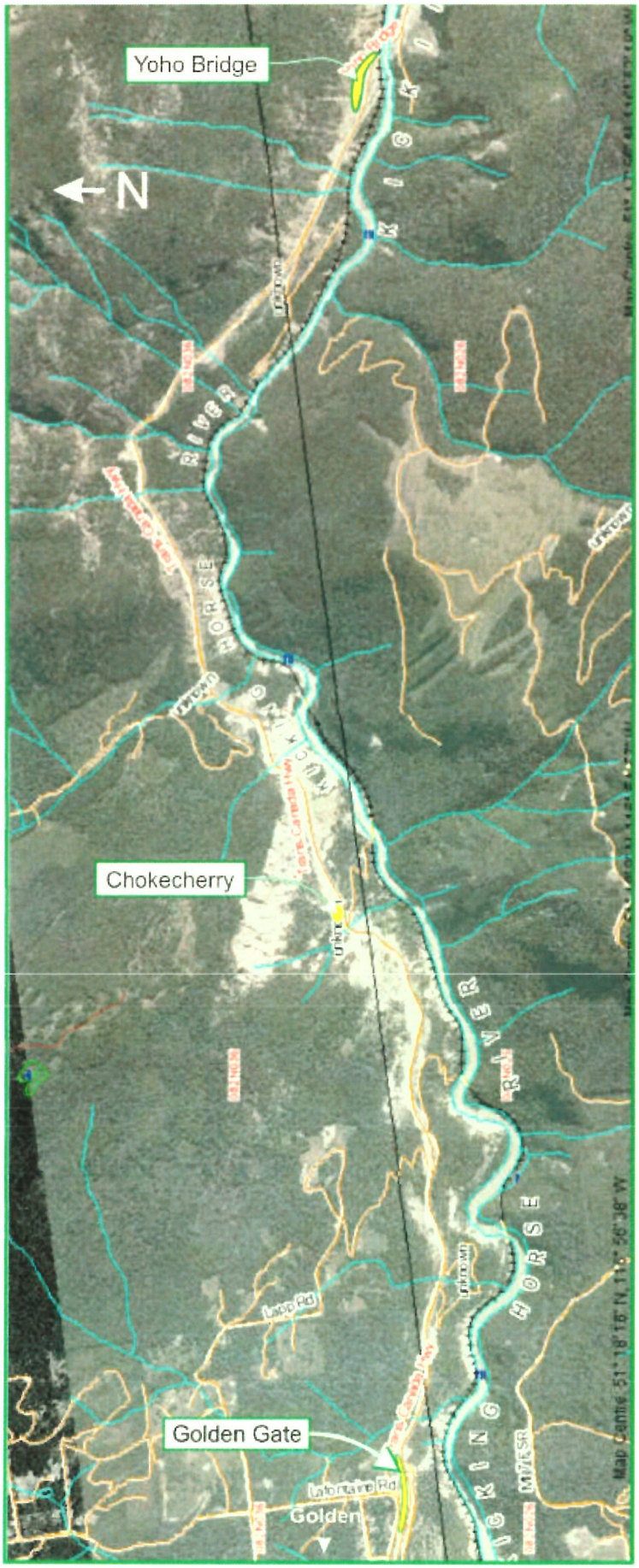
1.0 2007 Report Contents



Revegetation Trials - Kicking Horse Canyon

5.0 List of Definitions

Title	Symbol	Description
Golden Gate Site	GG	Location for reveg. trials adjacent to the community of Golden
Chokecherry Site	CC	Location for reveg. trials between the community of Golden and the 5 mile bridge
Yoho Bridge Site	YB	Location for reveg trials adjacent to (East end of) the 5 Mile Bridge
Planting Pocket	PP	Constructed of Delta Lok bags to provide an enhanced planting site. 5 PP's were built and designated – A, B, C, D, E
Live Bag Structure	LB	Constructed of Delta Lok bags to promote an enhanced planting site. 5 – LB's were built and designated - #1 - #5
Contour Cell	CCA and CCB	Constructed utilizing a fibre roll to form horizontal terraced planting sites providing increased moisture retention and additional organic matter.
Enhanced Seeding Plot	EHS	Hydroseeded plots to evaluate specialty seed species and nutrient additives. 2 – EHS plots were installed and designated #1 - #2
Sediment Lok®	SL	A "cast in place" erosion control blanket. 5 – SL plots have been installed and designated #1 - #5 evaluate specialty seed species and nutrients
Test Plot	TP	Small plots (1-2m^2) to compare individual seed specie development. TP's are designated #1, #2, #3...etc.

Random Planting	RP	Plots established to evaluate tree and shrub specie survival and development. 5 RP's were installed and designated #1 - #5
Coir Wrap Plot	CW	1 Plot installed to evaluate stability and planting site potential
Brush Layer Plots	BL	Constructed to provide information on Willow and Cottonwood cuttings survival. 2 – BL's were installed and designated #1 - #2
Exclosure	EX	Established to prevent grazing and browsing of specific sites. 3 – EX's have been installed and designated #1 - #3
Local Harvest	LH	Trees and shrubs transplanted from the immediate area. Other trees and shrubs are understood to be nursery grown.
Hydroseeded Test Plot	HSTP	Installed to provide additional data on Alkali Grass & Newhy RS Wheatgrass performance. HSTP #1 & #2/ GG Area
Exclosure Cell	EC	Similar to EX, Installed to protect plants from grazing & Browsing. EC #1 - #15/ GG, CC, YB Areas.

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7.0 Introduction:

Following is an overview of the field trials conducted over the past three seasons to assess the suitability of various plant species for establishment on disturbed roadsides in the Kicking Horse Canyon. This report will identify the varieties most capable of surviving the severe climate, soil and topographic conditions in this canyon, and offer recommendations to promote vegetation establishment and maintain growth.

8.0 Historical Review:

A selected photo history of operations, structures constructed and plant material installed in 2005 and 2006 is located in appendix II.

Before entering into assessments and discussions concerning surviving growth, a brief history of what is known about previous revegetation efforts in this area is provided. A precautionary note is suggested as this information is anecdotal with dates only approximate.

Portions of the TCH from Golden to the Yoho (5 Mile) Bridge have been relocated and reconstructed at various times. Slides, settlements, and washouts of parts of the roadway have required reconstruction since they were originally cut and filled. The first recollection of attempts to revegetate cut and fill slopes in the Kicking Horse Pass was in the mid 1960s when the cut at the South/East corner of the Yoho Bridge approach was reconstructed and hydroseeded. It is likely that other sections of the TCH in the vicinity were treated at the time while the hydroseeder was in the area. The mixture used during the period would have likely consisted of Crested Wheatgrass, Kentucky Bluegrass, Creeping red Fescue, White and Red Clover. In the early 1970's a substantial slide occurred in the Three Mile area and was reconstructed. This section was seeded with a mixture of Tall Wheatgrass, Crested Wheatgrass, Tall Fescue, Hard Fescue, Canada Bluegrass, Red Top and Rambler Alfalfa. Thereafter these small areas as well as other short sections that were repaired or were barren, received seed and fertilizer intermittently until the late 1990's using similar seed mixtures with added legume species. In 2004 the approaches to the new Yoho Bridge were hydroseeded and SedimentLok® applied with the above named seed varieties.

Initially, a brief outline of the work from the summer of 2005 to the fall of 2007 is presented, describing the operations and results from commencement to current status.
During the summer of 2005, three trial areas (identified as "Golden Gate", "Choke Cherry", and Yoho Bridge") were chosen along the TCH corridor in the section of the Kicking Horse Canyon extending from Golden to the newly constructed 5 – Mile Bridge. These trial areas were deemed to be representative of the KHC in terms of soil type, topographic conditions and local climate.

The Golden Gate Trial Area is located adjacent to the eastern approach to the community of Golden and is comprised primarily of original highway construction cutslopes varying from 2:1 to 1:1, mainly fine textured soils with minor gravel component, exposed south aspect and no apparent internal moisture.

The Choke Cherry Trial Area is located approximately midway on the Golden to 5 – Mile Bridge corridor. Similar to the Golden Gate area, the Choke Cherry area is comprised primarily of original construction highway cutslopes with slope angles ranging from 1:5 – 1:1. Soils are fine textured similar to Golden Gate, However, there is a fairly high percentage of rock, ranging in size up to 40cm in diameter. Some internal moisture is evident on the west end of this area and exposure is generally a south aspect.

The Yoho Bridge Trial Area extends from the west end of the 5 – Mile Bridge westward for approx. 300 meters. This is a newly constructed fill slope comprised of compact, fine textured soils with a high percentage of rock up to 0.5m+, interspersed through these soils. This is a stable slope with minimal surface erosion, but subject to considerable amount of rolling rock (to 40cm average), dislodged from the cliffs above this slope. This area is exposed to a generally south aspect, with no apparent internal moisture, Although precipitation was not measured, moisture is likely higher in this area compared to the Golden Gate Site as the trend in this canyon is for moisture to increase west to east as indicated by denser and more diverse vegetation.

Fall 2005

In the fall of 2005, selections of grass and legume seed (Appendix III) and selections of plant stock that were believed to be tolerant of severe climatic conditions, drought, exposure, alkaline and saline soils were installed in the three trial areas. All the species and populations that were planted and locations, are detailed in a report titled "A Summary of Initial Installations" dated October, 2005. This report also contains information on the various structures that were built to accommodate plant material in this terrain with photographs of the sites, and structures. For a brief description of the structures see List of Definitions (pages V and VI)

In addition to the structures, a number of individual seed test plots (TP's) were installed. These included 2 Enhanced Seeding Plots, 5 SedimentLok® Plots, 43 Individual grass and legume specie plots, 5 Random tree and shrub sites and 2 Hydroseeding Test Plots. Brief descriptions of these applications and test plots are given in the, List of Definitions, (5.0) the majority of these revegetation trial structures, applications and test plots were installed in October 2005. Installation dates are included in the Operations Summary (Appendix I) with additional details and information recorded in the Summary of Initial Installations 2005 report. Soil samples that were analyzed, fertilizers and plant supplements that were applied and initial evaluations of conditions and impacts that could determine plant survival were also provided in the preliminary 2005 report.

Spring 2006 – Fall 2006

Assessments of plant survival, maintenance of the structures, addition of a few more test plots and structures, were completed during this season period. Details for these activities are documented in the "Kicking Horse Revegetation Trials, 2006 Site Works and Review" report. A summary of the assessments of plant performance is shown in this narration in Tables 2, 3, 4, & 5. Most significant in these inaugural observations were the species of grasses that appeared to establish rapidly. Incidentally this data was immediately employed by incorporation of the most promising species into mixtures for the simultaneous revegetation works on the adjacent (Transpark) highway (Phase II) construction project.

In the spring of 2006, all of the fall (2005) seeded test plots were replicated and augmented with plots of eighteen additional species. (Appendix IV) The intention was to determine the more favourable seeding window (spring or fall) to seed or plant stock in this zone and introduce other tolerant varieties to the testing program. Several plant groupings were positioned in the YB trial area, and two brush layer trial sites were constructed there to further evaluate survival potential of native Willow species. Additionally three SedimentLok® plots were installed at the YB site, as the initial (2005) installations of SL at Golden Gate and Choke Cherry looked very promising. Unfortunately, the magnitude of the impact that grazing and browsing by the local sheep population would have on this YB trial area was not known at this time. Subsequent observations indicated serious potential for huge impacts on the Revegetation Trials Project. As a result a decision was made to erect three "wildlife exclosures" on the seeded areas at the Yoho Bridge Area. The exclosures were designed to prevent grazing and allow the grasses and legumes to reach maturity for identification and determination of suitability for revegetation purposes. All of the trial areas were refertilized (including kelp meal application), and the plots were watered on three occasions when low moisture conditions prevailed. Two animal repellents were applied (separately) on every shrub or tree that appeared "green" early in the growing season. Details of the above, are listed in the "2006 Site Works and Review Report". Plant development evaluations continued throughout 2006. These observations are documented in the 2006 report and appear in this account in Tables 1-9 and in the abbreviated Operations Summaries – Appendix I.

Spring 2007 – Fall 2007

In the spring of 2007, fifteen additional "wildlife (exclosure) cells" (photo#1) were installed throughout the three trial areas (GG/CC/YB). The two animal repellents were applied again early in June at the Choke Cherry site, with a designated area for each repellent, along with a "control" section between them. (Photo#2). Soil samples were analyzed in the spring, to determine the effect the fertilizers applied over the past two seasons might have had in modifying the soil characteristics. Soil samples were also obtained from control sites in the fall of 2007 with an objective to provide a more complete understanding of existing soil fertility conditions in the Kicking Horse Canyon corridor. All of the trial areas were again refertilized and "kelp meal" applied (spring 2007). Monitoring the grass, legume, tree and shrub development continued throughout the growing season. Performances of the grass and legume installations are shown in Tables 2 and 3. Shrub and tree survivals are summarized in Tables 4, 5 and 6.


Photo #1

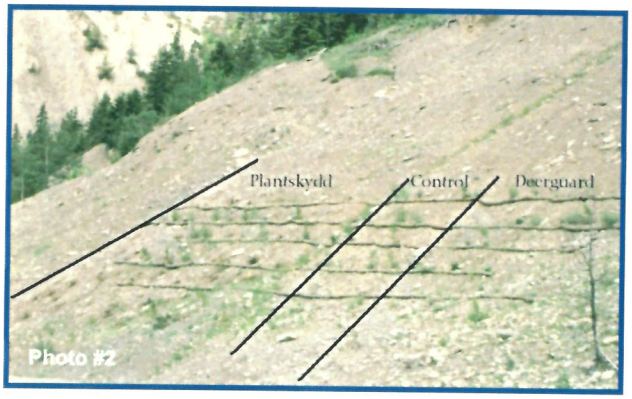


Photo #2

For a brief description of all the operations, installations and applications undertaken for this project and mentioned in the foregoing Introduction and Review, refer to the Operations Summary. (Appendix IV)

9.0 Discussion and Recommendations:

9.1 Grazing and Browsing Impacts:

Many of the initial objectives of this study have been met even though the difficulties previously described, hindered achieving the expected growth potential of some species. For instance, the Yoho Bridge Site was to be the prime study area where the majority of the plant stock, seed, structures, products and various application procedures were installed. By the fall of 2006, it became obvious that damage in this area would severely compromise future data collection. The damage by the sheep to the GG, CC and YB Trial areas, subsequently reduced the plant establishment and survivability information that was sought. During the 2005 plant installation phase of the Revegetation Trials Project, the sheep were observed browsing the newly installed plants. Small specie installations such as Oregon Grape (Mahonia) and Kinnickinnick in the LB structures were being uprooted and simply cast aside. Regardless, grazing and browsing pressures by wildlife are a reality that needs to be factored into plant establishment methods, and some valuable lessons evolved about how seriously revegetation efforts can be impacted by local ungulate populations.

Rocky Mountain Bighorn Sheep are a prominent native ungulate resident in the Kicking Horse Canyon, particularly on the north side of the river on the south aspect slope. This of course provides early and greater forage availability. This is also the general location of the Trans Canada Highway and the proposed Phase III West Upgrade. A number of studies and subsequent reports concerning Rocky Mountain Bighorn Sheep in the east Kootenay and Kicking Horse Canyon have been undertaken in recent years (1986 – 2007) by various individuals at the request of the Golden Rod and Gun Club, Ministry of Environment and the Ministry of Transportation. This data has been reviewed in the course of compiling this Yoho Revegetation Trials Report, due to the significant impact the resident sheep herd has had on the vegetation trials.

The Golden District Rod and Gun Club estimated a resident herd of up to 50 Rocky Mountain Bighorn Sheep in the Kicking Horse Canyon when the Ministry of Transportation initiated the Yoho Revegetation Trials Project. Sand tracking (Page) 2005, and snow tracking (Harper) 2007, studies were undertaken to examine concentration, location and highway crossing patterns. Sand tracking indicated a particularly high concentration of tracks crossing at 5 Mile Bridge (Page), which unfortunately is the location of the Yoho Bridge (YB) Trial Area. In the spring of 2007 approximately half of the resident KHC Bighorn Sheep were translocated to other Bighorn Sheep ranges in BC to more effectively balance the local sheep population with the available forage. Further there are extended plans to gradually reduce the remaining sheep to numbers that will better cope with the disturbance of reconstructing the TCH. The time frame for the further reduction in population is unknown but will be accelerated when construction schedules for this section of the TCH are determined.

Incidentally, observations of all the test sites during the summer – fall 2007 growing season did not appear to indicate any lesser grazing pressure or damage on the planted stock by the reduced number of sheep.

9.2 Exclosures & Exclosure Cells (EX #1 - #3 & EC #1 - #15):

As a result of the extensive damage to the YB Trial Area by the grazing sheep herd, three exclosures were constructed on the Yoho Bridge test area in the spring of 2006 and planted with some of the "TP" varieties. The intent was to allow unimpeded grass and legume growth to maturity. However, the information provided by these installations, at this time is quite limited. Although Exclosures #1, 2 and 3 exhibit growth heights to 30cms, as compared to the surrounding slopes areas which are grazed to less than 4cm, the identifiable species are those that were seeded for erosion and sediment control prior to 2005. It is likely that over a longer period, some of the species introduced in these Revegetation Trials will develop sufficiently to permit identification and comparative evaluations. In the interim the existing growth characteristics of the initially introduced species located in these exclosures are presented in this report. The more recent introductions are denoted with an asterisk *

In the spring of 2007, two of the exclosure structures were damaged. Exclosure #1 was demolished by a rockslide and at #2, the sheep enlarged a hole in the wire to crawl beneath it to graze. Regardless at exclosure #1, the remnant rubble and debris is protecting growth from being shorn and providing limited information on what species are developing. Exclosure #2 was simply repaired and reinforced as was #3.

Fifteen additional exclosures (cells) were erected in the summer of 2007 to increase the number and variety of protected species including tree and shrub species. Growth in the 15 Exclosure Cells installed in June 2007 was quite significant. One of the most notable observations was the accelerated growth within the protection of these cells. Clearly there was sufficient available nutrient in place to boost the plants into a speedy, unimpeded growth cycle. Cell #5 (Photo#28) is one of the more striking examples showing a rapidly developing Lombardi Poplar as a result of protection from browsing. Following are locations of these installations and comments relating to their current vegetation cover. Photographs, taken Sept/Oct 2007, of each installation, are exhibited as Appendix V. This information can be used as references in the event the need for future assessments is recognized.

Cells #1 to #5 are located in the Golden Gate Trial Area	
Cell #1	Is located in HS/TP#1 and contain Fults Alkali Grass and NewhyRS Wheatgrass and remnants of previous applications Oct/07 growth assessment in the cell is 40% Vegetation cover
	- 30% Fults*
	- 5% Canada Bluegrass*
	- 5% Newhy*
Cell #2	Is located in ES#1 and contains the MOT Experimental Mix and remnants of previous applications Oct/07 growth assessment in the cell is 70% Vegetation cover
	- 40% Slender Wheatgrass*
	- 20% Canada Bluegrass*
	- 10% Hard Fescue
Cell #3	Is located in SL#1 and contains the MOT Experimental Mix and remnants of previous applications Oct/07 growth assessment in the cell is 60% Vegetation cover
	- 30% Alaska Brome*
	- 10% Canada Bluegrass*
	- 5% Blue Wildrye*
	- 5% Slender Wheatgrass
Cell #4	Is located in LB#1 Seeded to Fults Alkali Grass and Newhy RS Wheatgrass and previous applications Oct/07 growth assessment in the cell is 2% Vegetation cover
	- 1% Tall Wheatgrass
	- 1% Fall Rye
Cell#5	Is located in PP "B" seeded to Fults Alkali Grass, Newhy RS Wheatgrass, Millet, Dwarf Fall Rye, Axcella Annual ryegrass and previous applications Oct/07 growth assessment is 20% in the cell Vegetation cover
	- 5% Lombardi Poplar (1)*
	- 5% Juniper (1)*
	- 5% Snowberry(1)*
	- 3% Birdsfoot Trefoil (1)*
	- 1% Fall Rye
	- 1% Tall Wheatgrass

Cells #6 to #11 are located in the Choke Cherry Trial Area (% is Vegetation cover)	
Cell #6	Is in ES#2 seeded to the MOT Experimental Mix and previous application Oct/07 growth assessment is 60% cover
	- 35% Slender Wheatgrass
	- 10% Fescue (Hard & Idaho)*
	- 5% Tall Wheatgrass
	- 5% Canada Bluegrass*
	- 5% undeveloped, unheaded species*
Cell #7	In row 2 of the Contour Cells Oct/07 growth assessment is 30%
	- 10% Tall Wheatgrass
	- 10% Alfalfa
	- 5% Aster
	- 3% Sheperdia*
	- 1% Tall Fescue*
	- 1% Canada Bluegrass*
Cell #8	In row 3 of the Contour cells Oct/07 growth assessment is 30%
	- 10% Sagewort (2)*
	- 5% Saskatoon (1)*
	- 5% Newhy RS Wheatgrass*
	- 5% Flat Pea (2)*
	- 5% Fox Tail*
Cell #9	In RP 3 below Contour Cells Oct/07 growth assessment 20%
	- 5% Saskatoon (1)*
	- 5% Chokecherry (1)*
	- 5% Maple (1)*
	- 3% Aspen*
	- 1% Slender Wheatgrass
	- 1% Fescue*
Cell #10	On the CC B (CV) Test Plot Oct/07 Growth assessment 40%
	- 20% Crown Vetch (3)*
	- 10% Snowberry (1)*
	- 5% Tall Wheatgrass
	- 5% Red Top
Cell #11	On the SL #2 plot Seeded to MOT Experimental Mix and other previous mixtures Oct/07 growth assessment 60%
	- 60% immature grasses*

Cells #12 to #15 & Excl #1 to #3 are located in the Yoho Bridge Trial Area (% is Vegetation cover)	
Cell #12	15% Vegetation Cover
	5% Alfalfa
	5% Hard Fescue
	3% Tall Wheatgrass
	2% Red Top
Cell #13	80% Vegetation cover
	60% Mullein
	10% Newhy RS Wheatgrass
	5% Tall Wheatgrass
	5% Fescue
Cell #14	40% Vegetation cover
	20% Fescue
	5% Alfalfa
	5% Slender Wheatgrass
	5% Tall Wheatgrass
	5% Red Top
Cell #15	30% Vegetation Cover
	30% Tall Wheatgrass
Excl #1	Destroyed by Rockfall Amongst the rubble 40% Vegetation cover
	20% Fescue
	10% Alfalfa
	5% Tall Wheatgrass
	3% Red Top
	2% Red Clover
Excl #2	75% Vegetation cover
	30% Alfalfa
	20% Tall Wheatgrass
	15% Slender Wheatgrass
	10% Hard Fescue
Excl #3	60% Vegetation Cover
	40% Crested Wheatgrass
	10% Alfalfa
	5% Tall Wheatgrass
	5% Canada Bluegrass
	5% Fescue

Cells 12 to 15, and Exclosures 1 to 3 are located on the Yoho Bridge trial area. Significantly, all the structures except for Excl#1 and the Coir Wrap site, (damaged by rock fall) are 100% structurally intact after two full seasons subjected to rock fall, avalanches and marauding sheep. Assessments made Oct/07 for all remaining structures in this test area are shown.

9.3 Soil Fertility:

Table #9 Soil Analysis 2005 – 2007 Soil Fertility																
Composite Soil Samples																
Date	ID#	N	P	K	Ca	S	Mg	Fe	Cu	Zn	B	Mn	pH	EC	OM	C/N
2005	GG 1-A	0.06	<1.0	50	2450		285						8	1.3	2.8	24.5
2005	GG 1-B	0.12	<1.0	135	2900		215						8.1	0.5	4.3	21.0
2005	CC 1-A	0.01	<1.0	38	1550		315						7.9	1.7	0.8	34.5
2005	YB 1-A	0.01	<1.0	55	1550		80						8.0	1.3	0.8	34.8
2005	YB 1-B	0.01	<1.0	42	1750		175						7.8	2.1	0.5	20.3
No soil tests taken in 2006 – All sites refertilized Spring 06, Fall 06 and Spring 2007.																
2007	GG 2-A	0.03	1.0	55	1550		2.65						8.7	0.38	1.2	23.9
2007	CC 2-A	0.04	1.0	225	1500		275						8.1	0.98	0.6	8.9
2007	GG Cont					9	431	14.3	0.22	0.27	<0.2	3.71	9.3	0.91	0.2	
2007	CC Cont					>200	608	10.6	0.39	0.76	0.3	2.4	8.0	3.25	0.2	
Soil samples taken prior to refertilization operations																

NPK

- After refertilizing twice over an approximate 12 month period there is no apparent increase in N and P levels.
- K levels at the CC site showed substantial increase, however at the GG site, no increase in K levels

Ca/S (Sulphate)

- Calcium levels, although somewhat high in some cases, are not excessive
- Sulphur levels range from optimal to excessive
- Although individually the soil concentrations of Ca an S would not appear to be sufficient to negatively impact vegetation growth, there is a possibility that the presence of Calcium Sulphate may restrict plant accessibility to; phosphorus (a potential restriction on plant growth).

Cu/Zn/B

- The GG Site was found to be deficient in these micronutrients
- The CC Site indicates a deficiency in Cu and B only
- The YB site was not tested for micronutrient levels

pH

- All sites tested indicated a tendency to relatively high pH levels
- The GG site seems to trend slightly higher in pH than either CC or YB sites.

EC

- Satisfactory, although one sample analysis taken in the vicinity of the CC site indicated a cautionary level, and a sample retrieved in 2004 from fill slope/slide areas in the vicinity of the YB Trial area showed strongly saline- very high sodium levels.

OM (Organic Matter)

- All sites displayed very low levels of organic matter

C/N Ratios

- Carbon/ Nitrogen ratios are acceptable for all tested sites

Revegetation of roadside cut slopes, whether highway or forest road is a challenge. Very low organic matter/ OM levels are common occurrences, as are low or non-existent NPK levels. Frequently the pH is either high or low, and micronutrients are deficient. Toxic salinity can create difficulties in unpredictable locations. All or any combination of the above factors can vary extensively over a short section of right of way. Obviously, it is not practical, or even possible to address all of the variances in soil conditions. Therefore, it is necessary to determine nutrient and soil amendment requirements based on averages drawn from available data.

The soil analysis data gathered over 2 years for the revegetation trials project is not extensive, but adequate to indicate that in the KHC corridor, where construction activities have resulted in exposed mineral soil in the cut and fill slopes, the impediments mentioned above, are all present. The very low organic matter, low N-P-K levels and deficient micronutrients are not unusual conditions for roadside cut and fill slopes in any area of the province. The time tested and proven approach to deal with low OM levels has been the development of a vegetation mat over a multi-year period, with specified applications of NPK and micronutrients. This is generally an adequate technique to build and sustain a vegetation cover over an extended period. This will result in a consistent input of organic matter in each growing season and eventually create a sustainable environment capable of supporting more complex plant species such as shrubs and trees.

pH and EC levels are valid considerations for predicting survival potential of various plant species. In this application, the pH and EC levels indicated in the soil analysis will not pose serious difficulties to vegetation establishment, although there could be some unidentified minor locations where these levels approach toxicity. Where Calcium (Ca) and Sulphur (S) levels have rated high to excessive the high Ca/S levels may result in a calcium sulphate presence restricting plant access to nutrients, particularly phosphorus. Combined with low moisture availability, the presence of this soil constituent may prove to be a formidable obstacle to plant development.

Coincidentally, simultaneous revegetation operations on the Phase II Transpark project have indicated an unusual lack of response to refertilization efforts in some areas. Although no data is available to support a definite answer to this problem, the possible presence of calcium sulphate would certainly contribute to this dilemma.

9.4 Climate:

The lack of adequate moisture is a major factor in the inability of most plants to prosper in this Canyon. The mean annual precipitation in the section between Golden and the Yoho Bridge is likely less than half the official recorded MAP for Golden. (475mm) Analysis of vegetation species clearly indicates that precipitation increases with elevation, which is typical of many central interior valleys or canyons. The narrow Kicking Horse Canyon walls deflect most of the moisture laden clouds over top or away from the parched slopes. Further, the angle of repose on most of the cut faces are 60° - 70° and the soils in most locations are fine textured and dried concrete hard. This predetermines an accelerated runoff when rain events occur, leaving little available moisture for the plants. The majority of the cut and fill slopes have a generally southern exposure, which further adds to rapid moisture depletion. The climate is characterized as hot, very dry summers; cool winters with light snowfall, resulting in shallow snowpacks of very short duration allowing the soils to freeze. The impact of this adverse micro climate is obviously considerable, however, considering all of the above, there are plants that will survive and prevail under these conditions.

9.5 Appropriate Growing Medium:

The utilization of compost as a means to improve the organic component on sterile cut and fill slopes in this very dry climate may create substantial growth difficulties. Compost generally has a high component of woody pieces and fibre which will require significant moisture combined with adequate nitrogen to reduce the woody constituents to useable soil material. Therefore any compost considered for this area should have maximum 5% woody fragments or fibre content, with 95% fine textured soil and a carbon/nitrogen ratio not to exceed 30 to 1 (40-1 is unacceptable).

Imported compost or topsoil may present potential for the introduction of new weed seeds to this area. Weed seed may be introduced to the compost in the sand and manure components and distributed in the application. Imported topsoil will, of course, contain seed from any weed species present in the area where the topsoil originated. In contrast, topsoil strippings stockpiled during construction and then applied to specified sites will contain root fragments and seed from the local native environment, possibly initiating some natural regeneration of the native plant community.

9.6 Seed and Seed Mixtures:

7369 – (#1) 2005 Hydroseeding Mix/ YB Trial Area		
25%	Tall Wheatgrass	
16%	Slender Wheatgrass	
16%	Axcella 2 Annual Ryegrass	
6%	Canada Bluegrass	
11%	Tall Fescue	
9%	Hard Fescue	
7%	Sheeps Fescue	
6%	Alfalfa	
3%	Alsike Clover	
1%	Redtop	
#2 MOT Experimental Mixture/ Kicking Horse Pass Experimental Mix		
40%	Violet Wheatgrass	
11%	Idaho Fescue	
10%	Blue Wild Ryegrass	
27%	Rough Fescue	
10%	Alaska Bromegrass	
2%	Canada Bluegrass	
#3 MOT Dryland Mix Applied on the YB Trial Area in 2004		
45%	Tall wheatgrass	THM 827/727
20%	Crested Wheatgrass	
15%	Alfalfa (Rambler)	
7%	Hard Fescue	
5%	Sheeps Fescue	
5%	Alsike clover	
5%	Canada Bluegrass	
2%	Red Top	
#4 MOT Mixture used in this area from 1960's to 1990's is similar to #3 except that the Alsike clover would have been replaced by red clover.		

A rapid establishment of an effective vegetative cover is essential for erosion control. In optimum conditions it would take at least a year, probably two, for natives to develop a significant vegetation cover on a slope face and more time to become a competent erosion control mat. Simply, natives evolved with changing environmental conditions, most importantly, in evolving soil properties. The soil in a cut or fill slope is basically sterile and has not had the opportunity to acquire the necessary elements to sustain any growth let alone sensitive native grasses and legumes. The surface soil on new construction, therefore needs the time to evolve to a condition where the native seeds can become established. There are however, selections of native grasses that were chosen for their ability to survive and reproduce in difficult conditions. These are referred to as Ecovars and their seed is chosen from the hardiest plants of native varieties most able to endure specific environmental conditions. Experimental trials with some of these Ecovars are currently on-going with encouraging results (Appendix III). Even these hardier progeny require careful, site specific selections to successfully achieve an effective erosion control cover.

Historically, a mixture of agronomic and native seeds has been shown to provide successful short, and long term balance to a seed mixture. Agronomic species are selected to germinate more rapidly and survive under a broader range of environmental conditions. This "Cover Crop" is designed to germinate and establish in a much shorter time than native species to provide rapid improvement of surface slope stability and soil composition, ultimately enhancing the soil conditions to a level where native species will persist and provide a long-term low or no maintenance plant community on the disturbed sites. Additionally it would be reasonable to include selected varieties of Ecovar (Native) seed with mixtures of Agronomics to encourage their development.

There are, Native Grass Varieties that were not included in these trials, primarily because seed sources could not be located.

9.7 Grasses:


Photo #20

As a result of the observations in this "Revegetation Trials Project" over the period from 2005 – 2007, some persistent grasses have been identified and for that matter, some time-tested. i.e. Tall Wheatgrass, and Canada Bluegrass. Other species such as Alaska Brome and Crownvetch may require lengthier evaluations to provide an accurate determination of their capability to survive in this environment. Regardless, those selections identified in tables 2 and 3 have given the most positive indicators to date, that they may tolerate the inhospitable conditions in the Kicking Horse Canyon.

The grasses shown in Tables 2 and 3 with ratings of 4 and 5 should be considered for inclusion in the seed mixture selections as the best varieties currently identified for this zone. At this time Alkali grass, (Photo#20) Newhy Wheatgrass, (Photo#21) Polar Northern Wheatgrass, and Tall Wheatgrass consistently came away with higher ratings for the past two growing seasons.


Photo #21

Tall Fescue, (Photo#22) Pubescent Wheatgrass and Alaska Brome rated high in some of the TP's, and could be considered as alternates.

Slender Wheatgrass is another grass specie that deserves consideration. Although in a TP #40 it didn't rate as one of the best, because of grazing and a relatively short time to establish, it was often identified during the assessments as one of the major components providing vegetal cover in the test areas. Canada Bluegrass and Hard Fescue fall into the same category. Prairie Gold Millet rated high and indicated that it could serve well as "nurse crop". On maturity it is only 25cms high and its growth loosely distributed allowing space for the perennial seeds to develop. In operational applications it did not perform as expected.

Alkali Grass has exhibited that it can thrive in the conditions presented in the Kicking Horse Canyon. Just six months after seeding, its growth rating was amongst the higher rated species. It was one of the varieties chosen for inclusion in mixtures that were applied on the adjacent Transpark construction project in 2006. It will be interesting to see how it competes with some of the more established species. Newhy Wheatgrass displayed similar desirable characteristics, as did Polar Northern Wheatgrass. All were employed in various applications in 2006 and 2007 on the above noted construction project.

Axcella Annual Ryegrass in TP #20, rated comparatively lower in most assessments, but in operational applications, established rapidly and fulfilled the requirements of a nurse crop species.

This apparent difference in results between TP Seeding and Operational Seeding would be worth some further investigation.

9.8 Legumes:

Crown Vetch, Flat Pea, Perennial Lupin, Wild Alfalfa, Birdsfoot Trefoil and Sagewort are the legumes put out to trial at these sites. Red Clover was discovered flourishing at the Yoho Bridge Site earning a commentary in this disquisition.

It is difficult to be definite about the Crown Vetch, which is supposedly unpalatable because of its Glycoside[1] content. The number of rosettes counted in July's evaluation in the CCB Plot was 14, in August – 19, and in October – 26. They are increasing in numbers but remain in the rosette or seedling stage. (Photo #23) The individuals don't appear to be grazed but the C.V. plants in the cell (exclosure) are substantially more advanced, leading one to conclude that they are being eaten. It would be interesting to look at this plot next year. This plant could be a valuable addition to slope stabilization in this area.

Flat Pea has shown that it can flourish at some locations if allowed to grow. There are two Flat Pea vines in Cell #8 that are a half meter in length. (Photo#24) However the adjacent unprotected seedlings are immediately shorn to diminutive sizes that are difficult to find. Flat Pea is another deep-rooted perennial that could be of benefit if allowed to establish.

Perennial Lupin that was planted in the fall of 2005 and spring of 2006 has not made an appearance. In most seed bulletins it is described as a specie commonly found in locations with readily available moisture and a more neutral to acidic pH. *This site may be too dry, the exposure too severe and the soil too alkaline for this specie

The Wild Alfalfa seed was in poor condition when it was planted due to poor collection procedures. This may be one of the reasons for its absence.

One Birdsfoot Trefoil plant is flourishing in Cell #5 at the Golden Gate Site. Hardly enough for a recommendation to continue it's use in this area.

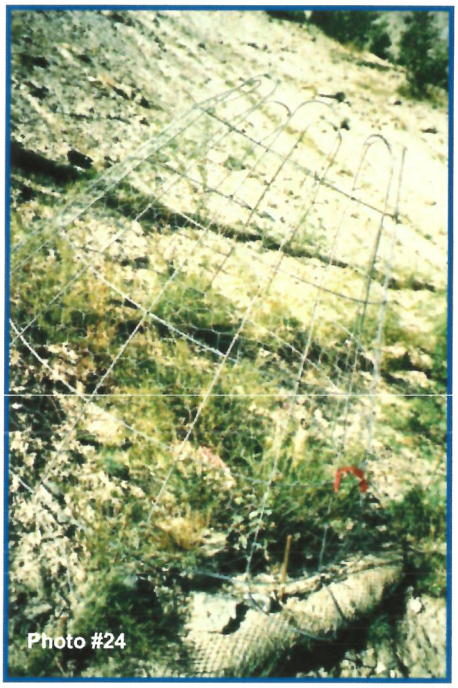


Photo #24


Photo #25

On the other hand, Sagewort is doing very well. Crowns transplanted from the "wild" in the fall of 2005 are flourishing in Contour cell A – row #4 and #5 (Photo#25) at the Chokecherry Site. Seed broadcast in this vicinity during the same period, has produced plants that are now 10 to 15cm (Photo#26) in height. This plant should be employed in selected sites in revegetation plans in this area. However, propagation should be approached with some degree of caution, as there is no long-term data available regarding the possibility for this plant to become invasive. It is apparent that on many of these older, dry, severely exposed cut and fill slopes in the Kicking Horse Canyon, no other native grasses or small shrubs have become established in 40 years. Sagewort has moved into this vacuum. The minor presence of Sagewort at the Golden Gate Trial Area and the very minimal showing at the Yoho Bridge Trial Area as compared to the vigorous population of Sagewort at the Choke Cherry Trial Area appears to indicate this plant is quite selective of soil and climate conditions. This further reinforces it's apparent non-invasive characteristic. In a literature review it is stated that this specie is found throughout all of the western provinces and U.S. states but seldom in a "coastal" environment. This implies that it will not compete with rapidly growing species and has a disinclination to establish in zones where increased moisture is available. It is also suggested in some bulletins that it may invade dry or disturbed sites. There is no evidence or document record that Sagewort to date is able to compete in a forestland or in a healthy range environment. In regard to the Kicking Horse Canyon, this plant is currently only resident from the eastern boundary of the town of Golden, east to the Yoho Bridge Test Area. It has not been found on the roadsides east of this bridge nor west or south of Golden.


Photo #26

A considerable amount of clover was discovered interspersed among the heavily grazed grasses throughout the entire face of the slope at the Yoho Bridge Site. It is without head or flower, but the characteristic halo or light color marking in the center of each leaflet, identifies it as Red Clover[2]. There is no record of this variety in any of the seed mixtures that were recently applied in this area. It may however be a carry over from mixtures applied in the 1990's (Incidentally, the soil material in the slope is a "waste" product from a neighbouring cut slope along the previous alignment). It is apparent that this variety can survive here, therefore it should be considered a candidate for a fractional portion in a seed mixture.

Alfalfa is found throughout this test area. It had been a component in seed mixtures applied twenty years ago as well as some applied in 2004. It has proven its tolerance to the conditions here and should be part of the seed prescription, keeping in mind, of course, palatability issues.

Table 1:	Grass Growth Rating Table for Test Plots					
0	No Growth					
1	Trace	1 to 10% cover				
2	Sparse, few or occasional	11 to 20% cover				
3	Fair	21 to 50% cover				
4	Good	51 to 70% cover				
5	Excellent	71 to 99% cover				

Table 2:	Grass & Legume Growth Rating at Golden Gate Trial Area							
T.P. #	Sprg/06	Fall/06	May/07	June/07	July/07	Aug/07	Oct/07	Av
#1	1	2	0*	0		0	0	
#2	2	0	0*	0		1	1	
#3	2	2	1	1	3**	2*	2*	
#4	0	4	3	4	5	5	4	
#5	0	4	3	3	3	3	3	
#6	4	5	4	4	5	5	4	
#12	2	3	2	3	3	2	1	
#13	1	2	3	3	1	4	3	
#14	1	0	0	0	0	1	1	
#15	3	4	4	3	4	4	4	
#16	3	5	4	4	5	4*	3*	
#17	n/a	4	4	4	4**	4**	3**	
ES 1	1	2	3	3	3	3	3	
SL 1 MOT Mix	2	2	4	2	4	4	4	
HSTP 1	n/a	1	3	3	4	4	3	
HSTP 2	n/a	0	0	1	1	1	1	

* Test Plot area had been exposed to severe erosion since the previous evaluation
** Test Plot area has been contaminated by its neighbouring specie

HSTP #1 and #2 contain a mixture of 70% NewHy RS Wheatgrass and 30% Alkali Grass

Table 3:	Grass & Legume Growth Rating at Choke Cherry Trial Area						
T.P. #	Spring 2006	Fall 2006	May 2007	June 2007	July 2007	Aug 2007	Oct 2007
#1 Polar Northern Whtgr ***	3	5	5	4	5	5	5
#2 Sharptail Needle & Thread gr ***	0	2	1	2	2	1	1
#3 WRPoole Western Whtgr ***	1	4	2	3	2	3	2
#4 Fults Puccinellia/Alkali gr ***	4	4	3	4		4	4
#5 AC Mallard Green needle gr ***	1	3	1	3		1	1
#6 NewHy RS Whtgr ***	1*	4	3	4*		3	3
#7 Crown Vetch *	0	2	1	0	1	1	3
#8 Flat Pea *	0	2	1	1	1	1	1
#9 Wild Alfalfa **	0	0	0	0	0	0	0
#10 Dryass (rooted seedlings) **	2	0	0	0	0	0	0
#11 Dragon Sagewort **	4	5	4	4	5	5	5
#12 Russian Wildrye gr *	0	3	1	3	3	3	2
#13 Tall Wheatgr *	4	4	4	4	3*	3	3
#14 Bluebunch Wheatgr **	2	2	1	3	3	1	1
#15 Pubescent Wheatgr **	4	3	3	4	4	3	1
#16 Alkali gr **	4	5	3	5	5	5	5
#17 Meadow Bromegr **	4	3	3	3	4	3	2
#18 Rocky Mountain fescue **	0	2	1	4	3	2	2
#19 Alpine Timothy **	3	4	1	3	3*	1	3
#20 Axcella Annual Ryegr *	1*	3	1	3	3*	1	3
#24 MOT Expmtl mix **		3	2	1	1*	1	2
#25 Prairie Gold Millet *		4	5	5	5	4*	4
#26 Dwarf Fall Rye *		3	1	1	0*	1	1
#31 Durar Hard Fescue *		3	1	0	1	2	3
#32 Basin Wildrye **		3	1	1	1	2	2
#33 Sheperdia Canadensis **		2	2	2	2	2	2
#34 Penstemen **		2	0	0	0	0	0
#35 Cottonwood (rooted seedlings) **		0		0	0	0	0
#38 Birdsfoot Trefoil **		1		0	0	0	0
#39 Kentucky Bluegr *		0		0	0	1	1
#40 Slender Whtgr * *		3		3	4	3	3
#41 Canada Bluegr **		0		0	0	1	1
#50 Turf Type Tall Fescue *		4		4	3*	3	4
FS2 MOT Mix **	3	4	3	2	4	5	4
SL2 MOT Mix **	3	3	5	4	4	4	3
* Agronomic Specie	** Native Specie				*** Ecovars		

*Test Plot area has been subjected to considerable amount of erosion since the previous evaluation

Table 3: species are named and their genus designated

- *Agronomic – non native varieties, usually cultivated varieties aimed at high forage output. The original seed stock was imported from Asia or Europe
- ** Native – In this application, they are species that evolved in the northern sectors of North America specifically within western Canada or the north western United States.
- *** Evocars – Selections of native grasses that are chosen for their ability to survive and reproduce in difficult conditions. This seed is selected from the hardiest plants of native varieties to endure specific environmental conditions.

The numbering of the Test Plots is not consecutive, but all retain their original identification numbers throughout this study. Insertion of more varieties was intended where the numbers are discontinuous, but the plan discarded when it became apparent that the current installations sufficiently encompassed the study parameters.

9.9 Seeding Windows (Optimum time of year to plant seed):

As noted in 2006 – 2007 evaluations, most of the grass legume varieties that were sown in the fall germinated and grew strikingly better than the spring replications. The more productive results from fall seeding probably indicate that some advantages are realized with the opportunity to naturally stratify the seed over winter and also the seed is in place during the first warming intervals in spring when moisture conditions are better.

Interestingly, operational hydroseeding in the fall of 2006 on the adjacent TransPark Phase II project did not result in the expected mass germination in the spring of 2007. The moisture conditions were ideal but the soil temperatures remained low well into May of that year. When temperatures finally increased sufficiently to promote germination, the spring snow melt moisture was largely gone, delaying germination further. Fortunately some significant precipitation events occurred in June resulting in germination and ultimately in acceptable growth.

The grass and legume varieties in a mixture utilized in a given operational revegetation scheme are selected to endure the particular environmental conditions. Most seeds will survive weeks of summer drought, underneath or on top of snow, or periods submerged in water with minimal loss in viability or population. The majority of species will remain intact and in place until temperature and moisture conditions evolve to promote germination. Occasionally, climate variations occur where initial seed germination is followed by periods of drought or freezing conditions. This will generally result in minor losses of one or two species. However, most seed mixtures in roadside revegetation projects will have a minimum 6 – 8 different species with 6 – 8 different germination periods, ranging from one week to two months. Therefore, untimely germination will result in damage to only a minor percentage of the complete seed mixture.

Seeding within the most desirable seeding window is not always possible. Factors, such as construction timetables, accessibility, the need for immediate sediment control, contract deadlines, maintenance issues, aesthetics, and unpredictable climatic conditions are factors that can influence the time of seed application. Considering these factors, there is obviously no definite seeding window that can be prescribed. However if no construction related constraints occur, late fall would be preferred followed by early spring as the optimum seeding windows. However if no maintenance applications are planned for the following year (i.e. refertilization) spring applications should supersede fall.

9.10 Sediment and Erosion Control:

Planning for vegetation establishment must be incorporated into construction plans with a comprehensive approach that addresses the various phases of construction activity.

Initially it is essential that all topsoil strippings be stock piled for placement on designated cut and fill slopes. Extraordinary diligence must be exercised to achieve this end, for every remnant of organic matter will be required to re-establish vegetation on sites disturbed by the future construction activities. There is a risk in this regard, of creating an interface problem where slopes are steeper than 2:1, or the primary slope material is compact and fine textured. This issue must be carefully considered and measures specified to overcome this separation potential. Further discussion and analysis of this risk would require input beyond of the scope of this report.

The 1.5 – 1 cut slopes and steeper at the Golden Gate Trial Area have sloughed annually over most of the surface area to a depth of approximately 2-10cm. The nature of this soil type permits fall – spring moisture and frost action to penetrate the surface to a shallow depth, destabilizing the zone and resulting in failure during the spring thaw. Hydroseeding has demonstrated that it cannot prevent the surface sloughing of slopes with this soil type that are steeper than 2:1. SedimentLok® has been attempted on these steeper than 2:1 slopes and has been marginally successful. Areas where these soil types exist need to be identified prior to, or at time of construction. Predetermined stabilization options must in place to provide a viable revegetation environment where results can meet the expectations of concerned parties.

Slopes steeper than 2:1 must also be considered for structural support such as Contour Cells, Planting Pockets, or other provisions to ensure stability until the plants establish. Incidentally, should the planting pocket system *** be adopted, a significant cost reduction can be realized if they are installed as the slope is being constructed. (Alternately a Contour cell installation along with a SedimentLok® treatment would better guarantee a rapid cover of vegetation at lower cost.

9.10.1 Installing a Grass Legume Cover:

Objectives:
Installing a grass/ legume cover on exposed soil materials has several objectives i.e.

- Sediment Control
- Erosion Control
- Aesthetic Improvement
- Rebuilding Organic Matter (OM)

Methods:
Two time tested and proven procedures for initiating germination and growth were utilized for the Revegetation Trials Project.

The following sections 9.10.1-A and 9.10.1-B detail information regarding the Erosion Control Revegetation Mat (ECRM) and hydroseeding options.

9.10.1-A: Erosion Control Revegetation Mats (ECRM):

When considering various options for grass/ legume establishment, Erosion Control Revegetation Mats (ECRM's) are a viable alternative for stabilizing a planting site and protecting seed until germination. Installation costs for ECRM's are generally much higher than alternate soil surface stabilization techniques such as variations of hydroseeding applications, due primarily to the high labour requirements. Correct installation procedures such as proper slope surface preparation is critical to realize the increased erosion control and plant establishment benefits required to justify the high costs of most ECRM's.

For this Revegetation Trials project, SedimentLok® was the preferred ECRM, because one of the defining traits of SedimentLok® is the ability to conform to rough and eroded slope surfaces with no requirement for surface preparation. This capability significantly reduces installation times. SedimentLok® is described as a structured sediment trapping fibre complex comprised of a mixture of fibre strands bonded together and to the soil surface, controlling erosion and sediment production and promoting development of a vegetation cover.

Generally, SedimentLok® provided visible benefits by controlling erosion and sediment, and promoting germination and plant growth. The ease of application in difficult terrain was a noticeable benefit in terms of installation time and cost.

Comparisons between those test plots where SedimentLok® was applied to those with conventional hydroseeding applications were significant. Taking into account the high level of erosion induced disturbance that occurred at the Golden Gate Site, the SedimentLok® (SL) plot there appeared to provide greater protection than adjacent hydroseeded areas, allowing more introduced species to emerge. The Chokecherry (SL#2) Site, consistently rated higher in most survivor species assessments, (except for October 2007 assessments, when the rating for SL#2 was diminished as a result of very heavy grazing). The SedimentLok® plots (#3, 4, and 5) at the Yoho Bridge Site again appeared to have a visibly more consistent and healthier turf cover than adjacent slope areas, but the grasses grazed so low, that identification of individual species was not possible, therefore limiting assessment data.

An indirect negative factor that has become apparent is the increased plant vitality in the SL Plots has resulted in more grazing focus. Ultimately this attractive vegetation cover resulted in more damage to these SL Plot sites than to the surrounding slope areas.

9.10.1-B: Hydroseeding:

Hydroseeding techniques were used to effectively install the ES, HSTP, and TP Plots and for maintenance refertilization and watering of the Trial Areas.

Hydroseeding, as noted in the introduction, has been a primary tool used to revegetate roadsides for approximately 50 years in BC. Hydroseeding has proven itself an excellent revegetation technique for delivering a cost effective and versatile method for installation of the large volumes of fertilizers, soil amendments, surface stabilizers, mulches and grass/ legume seed, all in measured volumes necessary to effectively initiate revegetation of previously inaccessible and sterile roadside terrain that characterizes the majority of BC's highway system.

There are several basic variations of component application in the hydroseeding process that require particular attention in the initial planning and specification process for an overall revegetation plan. These application variations will be encountered on any construction project in mountainous terrain, and especially in the severe post construction environment anticipated in the Kicking Horse Canyon Area from Golden to 5 Mile Bridge.

9.11 Maintenance:

The sites have been refertilized on three occasions, (spring/06 and spring/07) with formulations of 18-18-18 50% SCU and 23-3-23 SCU. Shortly after each of the spring applications, the appearance of the grasses took on an "appearance of enhancement". (Photo#17) Some of the lower rated (in terms of germination and growth) species (Tables2&3) temporarily improved, the higher rated plants continued their improvement in density and vigour (Photo#18) in most locations.

As noted in the Summary of Operations 2005 – 2007, all of the Revegetation Trial Plots were fertilized at the time of installation and then refertilized – a further 3 times. Kelp was chosen as an amendment to the fertilizer applications to help mitigate deficiencies in soil micronutrients. Kelp is a general term for varieties of ocean algae such as Ascophyilum nodosum and Fucus vesiculosus, which are also commonly referred to as seaweed. Various kelp products have been used in fertilizer applications for many years as a source of trace elements, and minerals. Kelp is also reported to stimulate microbial activity within the soil and may elevate plant resistance to frost, insect, and fungus damage. Currently Kelp applications have not provided a distinguishable effect in this short term. The supplier suggests further applications to build up the necessary levels of the essential soil constituents.

Although the grass and legume species defined as appropriate for this KHC area can endure periods of drought, watering the sites during the extended dry period in the summer of 2006 probably saved many of the tree and shrub plants now available for evaluation. Maintenance in terms of a watering program will be a definite necessity for tree and shrub plantings on the south aspect slopes, particularly for the first summer period after planting.

9.12 Trees and Shrub Species:

Early evaluations of the shrub and tree emplacements were not positive. This was generally due to the unrelenting and unanticipated grazing pressure of the resident wild sheep herd, and the harsh growing conditions. The damage by these animals has been described in the interim report "2006 Site Works and Review", as well as noted in the initial 2005 "Summary of Initial Installation" report. Regardless, some indicators of plant endurance were evident. For instance, the native Rocky Mountain Juniper, and the perennial Dragon Sagewort (Artemisia sp.) were not as heavily damaged by grazing as they were from soil/rock sloughing, horn rubbing and trampling. Additionally, Snowberry and Saskatoon Berry after severe browse damage, regenerated from their stems. Some leaf flushing was observed during spring 2006 in various brush layer installation locations. (Survival inventories are shown in Tables 4 & 5).


Photo #27

Lombardi Poplar (Photos#27&28) and the Native Rose (Photo#29) are another two that given the opportunity to grow, can survive the adverse environment in this canyon. All of these findings are, as previously documented, compromised by intense browsing impacts.


Photo #29

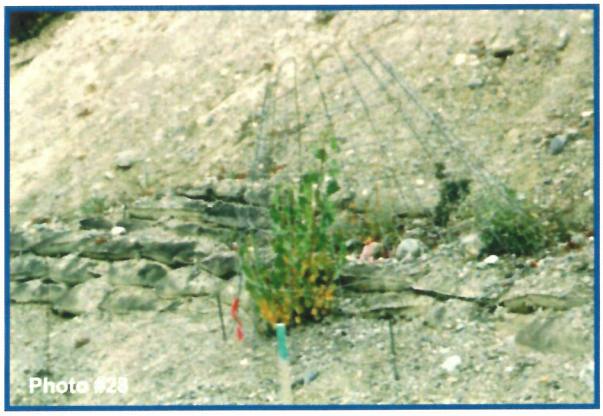


Photo #28

Rocky Mountain Juniper is the dominant surviving specie in all the test areas and specifically the Chokecherry Site. In most instances it has been mauled, trampled, and bent by rock fall, but it remains. Saskatoon and Snowberry are next as the most often located varieties. The individual plants have repeatedly been leaf stripped by the sheep, but some, it appears, have managed to survive. Silverberry is another species that rates well in the survival charts. Damage by the sheep to this specie, is minimal. Fir indicates that it can resist sheep marauding and tolerate this environment and Spruce may as well.

Rate of growth and development of most shrub and tree species in the harsh climate and soil conditions present in this KHC Canyon area is expected to be slow, particularly in the first year or two as the plants attempt to develop the necessary root structure to support measurable growth.

Table 7: Negative Impacts for Trees and Shrubs

Comparative ratings for negative factors impacting vegetation survival and development for tree and shrub species on the three trial areas.

Type of Impact		Impact Rating				
Browsing & Grazing – BG		Trial Area	Low	Moderate	High	Severe
Erosion – E		Golden Gate	R	D	E/BG/S	
Drought – D		Choke Cherry	R	S/E/D	BG	
Rocks – R		Yoho Bridge	E	D/S	R	BG
Soils – S						

Based on soil analysis, climate data and observations of surface erosion factors and browsing impacts made over the period extending from 2005 to October 2007

Table 8: Projected Long Term Survival of Tree and Shrub Species Based on Static Current Conditions (refer to "negative impacts") * No protection from browsing

% Survival Estimates:				
None – N	5–10% - P	10-30% - L	30-60% - M	>60% - H

Survival Potential Rating:			
Specie	Golden Gate	Choke Cherry	Yoho Bridge
Sagewort	M*	H*	M*
Juniper	P*	H*	L*
Douglas Fir	P	M*	P
Silver Berry	N*	L*	N*
Snowberry	N*	L*	N*
Saskatoon	N*	N*	N*
Chokecherry	N*	N*	N
Aspen	N	N*	N
Cottonwood	N*	N*	N*
Birch	N	N*	N
Douglas Maple	N	N*	N
Lombardy Poplar	N*	N	N
Spruce	P	L	M*

*The species listed in this evaluation are still surviving

With protection from browsing most of the above species can survive on most of the trial sites at minimum (L) levels

There is currently insufficient data to quantify comparative survival based on a "no sheep" model.

9.13 Re-establishing a Native Plant Environment:

Those grass, legume, tree and shrub species that display vigour in germination and growth in the revegetation trials established to date, are prioritized for future revegetation work in this area.


Photo #19

The objective of any revegetation scheme; should attempt to duplicate the successional regrowth that is taking place in the vicinity of the proposed reconstruction area. In this regard, a few kilometres West of Golden on the TCH, (Photo#19) is a 50 year old slope that depicts a successfully revegetated area as defined by an open forest habitat consummated with the appropriate "Islands" of plant species, size grouping and spacing.

Protection and punctual watering for a minimum first and second growing seasons, combined with timely fertilizer re-applications are necessary requirements to establish a functional grass/ legume cover for adequate erosion and sediment control, and to begin rebuilding the organic matter (OM) component. When soil surface stability is achieved through the establishment of a effective grass/ legume cover, a natural successional regeneration of native tree and shrub species will take place as depicted in photo #19. However, this natural colonization is very much dependant on local climate conditions, particularly available moisture, and as a result some sites will require a considerable number or years to re-establish. A high moisture, west coast type climate will require as little as 5 years for native tree and shrub species to naturally invade the site (generally with alder species). In contrast, a low precipitation interior climate may require 15 – 20 years or longer to regenerate. This evolving environment exemplifies natural succession to climax species as occurs in natural regeneration of native environments following naturally occurring disturbances such as forest fires, landslides, flooding etc.

Clearly, if reestablishment of the native plant environment within a reasonable time frame is the desired objective, a planting program needs to be instituted with an accompanying maintenance plan to ensure plant survival.

9.14 Golden Gate Trial Area (GG):

Adverse soil conditions, erosion and the sheep herd have been serious impediments to plant establishment at this trial area. (Table 7 and 8) Drought and the harsh southern exposure have also contributed significantly to plant failures. Nonetheless, some worthwhile information has been derived from the surviving plant species.

Table 2 recognizes five grass species that have acclimatized to these conditions and developed to maturity. This includes at least one of the constituents in the MOT Experimental mix (Refer to section 8.6 seed mixtures - MOT exp. Seed mix), Alaska Brome which has flourished in SL#1 plot. (Photo#8) The other specie that has shown it can prevail in this environment is Alkali Grass. In the HS/TP #1 plot, it is prolific. The plants in HSTP #1 are however "dwarfed", (photo #9) but are numerous and not grazed. Incidentally, this short growing sub-specie was sourced from another supplier and is identified as (D. spicata var. stricta) [3]


Photo #8


Photo #9

The tree and shrub installations did not fare as well, but again erosion decimated a large percentage of the planted stock before it had a chance to begin growth and the sheep browsed the survivors. Although survivor numbers are low, (as shown in Table 4) Snowberry, Juniper, Saskatoon and most of the original species planted in the various plots, are generally represented. Missing, are some species that had been expected to survive such as Paper Birch, Trembling Aspen, Douglas Maple, Oregon Grape, Rooted Cottonwood, Sagewort, Douglas Fir and Kinnikinnick which cannot be found at this site, (however only two specimens of Sagewort were planted, so their chances of making an appearance were somewhat reduced).

The majority of plants which were planted in October 2005, were represented and appeared healthy in June 2006. In reviewing Table 4,(for plants in the GG Trial Area) it is evident that as the 2007 season progressed, the number of individual plants of some species, diminished. For example, in R.P. #1, three Chokecherry plants were found early in the growing season, later, only one remained. In the Brush Layer installations where a few stems flushed in June, none were located in October. A combination of sheep damage and drought were the most probable causes for their demise. If the sheep had allowed the plants to develop, they may have had sufficient composition to subsist.

The installed (2005) planting structures, PP-A and PP-B are still in good structural condition even though there has been considerable sheet erosion over and around the structures. Given protection from the sheep, these structures especially the planting pockets (PP) are capable of enhancing plant survival and growth (Table 4). The effective protection provided by the "Exclosures and Exclosure Cells", is underlined by the deterioration of all the plants in the unprotected RP #1 and #2 sites. The LB #1 and LB #2 structures remain in good condition (structurally sound), but the 100% plant loss is a consideration. As noted in section 8.1, Browsing and Grazing, an unquantified number of these plants were uprooted by the sheep. The exposed nature of these LB structures may increase the drought problems associated with this very dry site.

Table 4: Golden Gate (GG) Trial Area Surviving Tree & Shrub Inventory

Location	Specie	April 2006	May 2007	June 2007	July 2007	Aug 2007	Oct 2007
RP#1	Birch	7					
	Aspen	5					
	Douglas Maple	2					
	Juniper	2	1	1	1	1	1
	Chokecherry	2		3	1	1	1
	Saskatoon	2		4	2	2	2
	Fir	1			1	1	1
	Alder	8			5	6	6
RP#2	Birch	4					
	Aspen	5					
	Douglas Maple	5					
	Juniper	2		1	1		1
	Chokecherry	3			1		
	Saskatoon	2		1	1		1
	Snowberry	1					
	Alder	3		1			
PP-A	Juniper	1	1	1	1	1	1
	Saskatoon	1		1	1		
	Snowberry	1	1	1	1	1	1
	Rose	2					
	Rooted Cottonwood	16					
	Brush Layers	19	1	1	1	1	
	Dryas	1					
	Sagewort	1					
PP-B	Juniper	1	1	1	1	1	1
	Saskatoon	1					
	Brush Layers	10		5	5	2	2
	Sagewort	1					
	Birdsfoot Trefoil					1	1
LB-1	Kinnikinnick	4					
	Dryas	8					
	Sagewort				1		
LB-2	Kinnikinnick	7					
	Dryas	6					
	Spruce	1					

9.15 Choke Cherry Trial Area (CC):

This CC Trial Area is a moderately stable slope area on a comparative elevation (Table 7) with the YB and GG Areas. Some compaction due to sheep traffic along each cell (row) planting area will likely have an increasingly negative impact on plant development. These cells (rows) provide excellent paths of travel while grazing and browsing on the bio-buffet. The contour cell structures will biodegrade eventually, probably more rapidly than the PP and LB structures, but at this time (2007) there is little evidence of decomposition. In the dry climate typical of the Kicking Horse Canyon, the structural integrity of the contour cells will likely remain stable for several years, generally ample time for secure plant establishment.

This site has provided and will probably continue to provide most of the sought after information for which this project was initiated. Examples of the hardier plants can be located here with the "Contour Cell" construction, performing as was intended (Photo#10) to provide a stable surface environment for plant development. Most of the stock that was initially planted here is currently represented. Unrepresented are Cottonwood and Dryass. The reasons for their demise are uncertain but the harsh environment and grazing pressure would have been major contributing factors. The sheep herd has had significant observed but not quantified negative influence on most of the plants in this trial area.

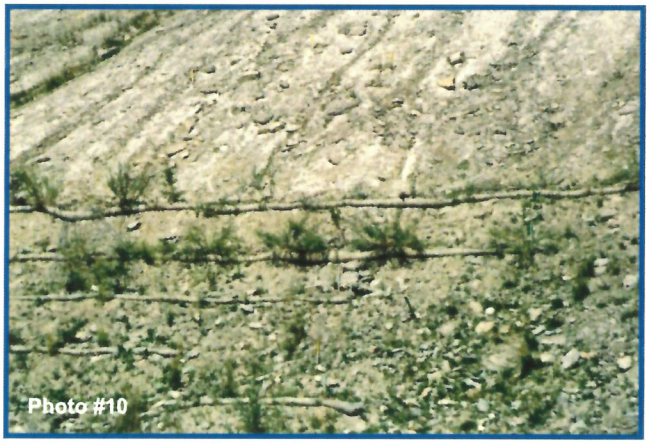


Photo #10


Photo #11

In this regard, one of the animal repellents had an effect on the treated plants. Although inexplicable, where the same species are situated side by side, both treated with the same product, in the same time period, one will be shorn, the other untouched. At the Choke Cherry Trial Area, the product "Plantskydd" (Photo#11) has limited to some degree the damage caused by grazing sheep.

Observations in October 2007 reveal that less damage occurred in the test area where this product (Plantskydd) was applied. The number of plants at the entire Choke Cherry trial area has not noticeably reduced but the amount of obvious damage in the "plantskydd" area has decreased. It is hypothesized that to control the browsing damage, the product would need to be applied consistently during the growing season. As new growth emerged, immediate treatment would be required in order to discourage the sheep from browsing the new growth.

Sagewort, (Photo#12) Juniper, and Fir seem to be the only species the sheep are not grazing. Although some damage is caused by trampling and horn rubbing, the number of Juniper that were originally installed are for the most part, still in place. In the case of the Sagewort, the current plant numbers have increased. This is attributed to Sagewort seed that was broadcast in the fall of 2005, is now in active growth.(Photo#13) The count of Fir seedlings is assumed to have been reduced by drought, exposure and uprooting, as there is no evidence of grazing on the surviving Fir seedlings.


Photo #12


Photo #13

It is worthwhile noting that the initial planting size of Fir averaged 12-15 cm compared to Juniper which averaged 40-50cm ht. The smaller Fir seedlings were more susceptible to uprooting than the larger Juniper plants, although the size of the juniper made them more attractive for horn rubbing and head scratching activities. In the 2 years since planting some Juniper plants have grown as much as 20cm, while the Douglas Fir has grown a max 5cm in height.

Several other shrub and tree varieties are surviving, although their development has been radically slowed for reasons already stated. (See Table 5)

The Alkali Sacaton grass crowns are flourishing and surprisingly, many have developed 30cm stalks with seed heads, indicating some resistance to grazing. The Alkali grass in HSTP#1, (Photo#14) at the Golden Gate Site, have "headed" and similarly are not grazed. Evidently these two species are less palatable.

The Basin Wild rye crowns have not performed quite so well. They have not matured due to the fact that they have been vigorously grazed, but at least half of the crowns remain. There are likely more survivors, but the existing plants are shorn so low, they are lost in the straw and rubble.


Photo #14

Three of the six varieties in the MOT Experimental Mix (see section 8.6 – Seed and Seed Mixtures) have been positively identified at this site. Alaska Brome in ES#2 has "headed out" in totals not quite as numerous as those in SL#1 at Golden Gate, but is a significant component in the total cover. Canada Bluegrass is present in fair numbers and a few sprigs of Blue Wild rye were found. The other three grass species in this mixture have not matured sufficiently at the latest evaluation, (Oct. 2007) to be distinguishable. In a like manner, not a single specie of this mixture has matured at the SL#2 site. These sites are no more than a 100m apart, but SL#2 is aligned to a more south-easterly aspect. Within the protected "cell", the plants are robust, but none fully developed to the seed production stage. (Photo#16) The cause may be the same mysterious phenomenon recently described at the Mines Reclamation Conference (References) where a specie will mature and produce large amounts of seed when grown in a particular area, but produce no seed in another area.[4] There are five identified grass species at this site that are rated as "good" or "excellent" (see Table 3).

Photo #16

The Contour Cell Sites A and B were the only constructed installations on this Choke Cherry Trial Area, and are still intact after 2 years. The Contour Cells have demonstrated a capability to provide an effective stable growing environment for the various plant species. On the basis of planting area provided, the contour cells are substantially more cost effective than the Planting Pockets and Live Bag installations.

Table 5:	Choke Cherry (CC) Trial Area Surviving Tree & Shrub Inventory						
Location	Specie	April 2006	May 2007	June 2007	July 2007	Aug 2007	Oct 2007
RP#3	Saskatoon	7		6	5	4	4
	Juniper	5		7	6	6	6
	Cottonwood	3		1	1	1	1
	Snowberry	3		3	4	3	3
	Aspen	2		2	2	2	2
	Chokecherry	7		2	3	3	3
	Fir	14		7	8	7	7
	Birch	6		2	2		1
	Silverberry	2		3	2	2	2
	Pine	6					
	Douglas Maple	4		3	2		1
	Rose	1		1	1	1	1
	Alder	12		3	5	2	2
CC-A							
Row 1	Snowberry			3	2	3	2
	Silverberry	5		5	5	5	5
	Sagewort	4		4	4	4	4
Row 2	Saskatoon	5		6	4	4	4
	Snowberry	3		3	3	2	2
	Juniper	7		7	6	6	6
	Silverberry	3		3	3	3	3
	Rose	3		1	2	2	1
Row 3	Saskatoon	6		5	5	4	4
	Snowberry	1		1	1	2	2
	Juniper	4		7	7	6	6
	Flat Pea			7	4	2	2
	Rose	4		2	1		2
	Sagewort			3	3	2	2
Row 4	Saskatoon	6		6	5	3	3
	Snowberry	1		1	1	2	2
	Juniper	6		6	6	5	5
	Silverberry	3		2	2	1	1
	Sagewort			4	4	12	12
Row 5	Saskatoon	3		3	3	3	3
	Snowberry	3		3	3	3	2
	Juniper	3		3	3	2	2
	Silverberry	2		2	1	1	1
	Rose	3		1	1	1	1
	Sagewort			12	12	16	16
CC-B							
Row 1	Juniper	2		2	2	2	2
	Snowberry	3		3	2	3	3
	Rose	1					
	Crown Vetch			7	8	9	20
Row 2	Juniper	1		1	1	2	1
	Snowberry	1		1	1		
	Rose	1		1	1	1	1
	Crown Vetch			3	6	7	4
Row 3	Juniper	1		1	1	1	1
	Snowberry	1		1	1	1	1
	Rose	1		1			
	Crown Vetch			1	2	3	2
	Saskatoon			2	2	2	

9.16 Yoho Bridge Trial Area (YB):

A major difficulty encountered in compiling data for this trial area was attempting to identify the grass species comprising the vegetation cover. The three exclosures erected on the YB Trial Area were intended to permit development of species for identification. Although growth is significant (30cm compared to 4 cm outside exclosures), the competition from earlier seeded varieties has slowed development of the introduced "trial" species.

In general the YB Trial Area has been subjected to such severe grazing pressure outside of the exclosures that only a few of the introduced and previously seeded grasses could be isolated and identified from all of the other shorn plants. Sparsely scattered seed heads of NewHy RS Wheatgrass, Tall Wheatgrass, Slender Wheatgrass, Canada Bluegrass, Hard Fescue and Alfalfa were found amongst the boulders and debris on this slope. Red Clover and Alfalfa crowns are common throughout the area. Except for the Newhy RS Wheatgrass, these are the progeny from the original blend seeded in this area in 2004, and possibly some remnant from earlier applications dating back to the 1960's.


Photo #6

The native Rocky Mountain juniper is the only woody specie that has endured at this site. The specimens are not pretty and have grown little since they were planted. (Photo# 6). The sheep use them as horn rubbing posts resulting in significant branch and stem damage.

Remarkably three (of 5) Spruce seedlings, harvested from the "wild" in 2005, have withstood the onslaught of the sheep and the elements. One is located in L.B.5, the other two on the perimeter of the Coir Wrap Site (Photo#7). All the spruce are ungrazed but there is apparent damage by rockfall. These plants do not appear to have grown since being transplanted approximately one year ago. This lack of immediate growth is not unusual, given the adverse nature of the climate and soil conditions in the Kicking Horse Canyon.


Photo #7

The PP-C, D, E, and LB #1 & #2 are structurally sound, as are the BL #1and #2, coir wrap and SL #3, #4 and #5 installations. As noted above, the only surviving woody species are Juniper, which are located in the PP structures, and spruce located in the coir wrap and LB structures. All the Juniper in the RP #4 and #5 planting sites have failed (including all other tree and shrub species). Apparently, the PP's provided a sufficiently enhanced environment to permit limited survival to date. All other woody species planted in all other structures and installations have failed.

A substantial accumulation of rocks 6 – 20cm in size have been deposited in the structures over a 24 month period. This rate of accretion is not expected to abate, as their origin is from the undisturbed zones well above any construction disturbance (see Table 8 – Negative Impacts). The impact the rolling rocks have had on the survival of the woody species at the YB Trial Area is not clearly evident at this time. However the observed accumulations of rocks since 2005 indicates that tree and shrub survival on this particular slope area (YB Trial Area), may have limited success even if the sheep were removed from the equation. This negative impact situation appears unique to this YB Trial Area. Of course grasses and legumes, with their relatively rapid rates of re-establishment and growth appear unaffected by this rolling rock phenomenon; but are significantly affected by the grazing impact.

The three SedimentLok® plots at the YB Trial Area have a visibly more lush grass and legume cover than the surrounding hydroseeded (2004) slope areas, even though the cover has been grazed to a <4cm ht. as observed October 2007. As a result of the higher quality grass/ legume cover, the sheep are focusing their grazing activities on these plots resulting in an over grazed situation, i.e. plants uprooted and heavy trampling damage (9.1 Grazing and Browsing Impacts).

Table 6	Yoho Bridge (YB) Trial Area Surviving Tree and Shrub Inventory		
Location	Specie	April 2006	October 2007
LB 3	Kinnikinnick	16	1
	Strawberry	9	
	Spruce	3	
	Common purslane		1
LB 4	Kinnikinnck	6	
	Dryas	10	
	Strawberry	25	
	Grass crowns		A few
LB 5	Kinnikinnick	12	
	Dryas	6	
	Strawberry	11	
	Spruce	2	1
	Mullien	1	
	Grass crowns		A few
PP C	Juniper	2	
	Aspen	1	
	Silverberry	1	
	Saskatoon	1	
	Snowberry	1	1
	Rose	1	
	Brush layer stakes	21	
	Mullein	7	
PP D	Crown vetch rosette		1
	Snowberry		1
	Juniper		2
	Brush layer Stakes	21	
PP E	Juniper	2	1
	Snowberry	2	
	Saskatoon	1	
	Rose	1	
	Grass crowns		A few shorn
COIR WRAP	Spruce	5	2
	Rooted cottonwood	7	
	Kinnikinnick	3	
	Brush layer stakes	5	
	Grass crowns		A few
	Mullein		1
BL	Sagewort		1

100% of the RP Plantings and the majority of the structural plantings have failed. Most probably due to excessive browsing impact and additionally significant impact from the rocks rolling down slope (A late fall – early spring situation likely related to frost action)

10.0 Conclusions:

10.1 Grass and Legume Plantings:

Establishing an effective Grass/Legume cover in this Kicking Horse Canyon will require specific attention to a number of important considerations:

10.1.1 A suitable Grass/ Legume Seed Mixture
10.1.2 An effective Fertilizer Analysis and Application
10.1.3 The most appropriate site specific application for temporary surface stabilization
10.1.4 Organic Matter (OM)
10.1.5 Seeding Windows
10.1.6 Suitable equipment availability for successful completion of operational requirements.
10.1.7 Engaging a construction related planning process that ensures all potentially inaccessible sites will be addressed.
10.1.8 A maintenance program that will ensure long term survival.

10.1.1 A Suitable Grass/ Legume Seed Mixture

Following are suggested species selections that have shown survival capabilities both historically and within the context of this revegetation trials project. There is no doubt that some additions and deletions to the following lists will be required subject to ongoing site evaluations.

Suggested Grasses & Legumes selections for current use based on trial data to date.

Species	
Newhy Wheatgrass	Axcella Annual Ryegrass shows promise to function well as a Nurse Crop. It is recognized that these seed specie selections may require some future changes as long term survival and aggressiveness of particular species becomes more apparent.
Polar Northern Wheatgrass	
Tall Wheatgrass	
Slender Wheatgrass	
Tall Fescue (Turf Type)	
Alkali Grass	
Hard Fescue	
Canada Bluegrass	
Alfalfa (Rambler)	
Red Clover (Single Cut)	
Red Top	

10.1.2 An effective Fertilizer Analysis and Application

As detailed in the Soil Fertility discussion, fertilizer analysis and applications must deal effectively with a broad range of nutrient deficiencies. High NPK analysis fertilizers with a minimum 50% PSCU component should be chosen with the inclusion of appropriate micronutrients and soil amendments as necessary to enhance the development of a favourable plant environment.

Following are suggested fertilizer analysis formulations that could be used in combination.
Starter Fertilizer:

-	13-26-6 PSCU	
-	12-12-24 + 0.2B + 0.5Cu + 0.5Zn 50% PCSCU	

Maintenance Fertilizer:

-	23-3-23 PSCU \	50/50
-	18-18-18 PSCU /	

Further evaluations will likely result in refinements to these fertilizer suggestions.

10.1.3 Hydroseeding is the most effective site specific application for temporary surface stabilization. It is the recommended primary methodology for planting grass and legume seed in Kicking Horse Canyon. A variety of hydroseeding applications will need to be employed, each designed to address the anticipated variety of exposure, topographic and soil stability related issues.

Specific areas where the effectiveness of hydroseeding as a surface stabilizer is in doubt, may require the installation of an ECRM as a logical upgrade for temporary erosion and sediment control until establishment of the grass/legume cover.

Fine textured soils such as those located at the Golden Gate Trial Area may require additional surface erosion prevention measures. Contour cells installed at specified slope intervals determined by the steepness and length of the slope, and utilized in combination with an appropriate Hydroseeding or SedimentLok ® application is a proven procedure for erosion and/or sediment control at sensitive sites.

10.1.4 Building Organic Matter (OM)

Large scale application of organic matter, (i.e. compost, top soil strippings) to slope areas in excess of 2:1 is not recommended unless potential stability problems can be satisfactorily addressed. The time tested and proven effective process to regenerate the soil profile for most sites is the establishment and maintenance of a healthy and vigorous grass/ legume plant community.

10.1.5 Seeding Windows

Evaluations of the Revegetation Trials and the operational seeding of the adjacent construction project in the Kicking Horse Canyon, indicate that late fall is the optimum seeding window. Very early spring may be considered as a productive alternate.

As noted in the Discussion 9.9 "Seeding Windows" – correctly specified seeding operations to meet construction scheduling demands, can be conducted at any time during the summer months with a reasonable expectation of acceptable results. However, germination may not occur until the following spring. Maintenance refertilization, and overseeding must be factored into this time table.

10.1.6 Schedule Suitable equipment availability for successful completion of operational requirements.

10.1.7 Failure to consider the requirements of a revegetation plan when executing the construction phase of a project may result in substantial cost increases and compromise the effectiveness of the overall revegetation plan.

Procedures to rapidly establish a grass/legume plant community require ready access to the designated sites particularly in sensitive areas.

Hydroseeding processes should be planned for access to within 40m of all prescribed application areas. Procedures are available to deal with areas beyond the 40m access limit, but would result in cost increases.

ECRM installations are very access sensitive, primarily due to high labour requirements. Distances from point of vehicle access and difficult access due to rough terrain must also be considered. There is generally a way to "get the job done", however, the costs can rise exponentially.

10.1.8 Successful establishment of grasses and legumes in the Kicking Horse Canyon will require a well planned and executed maintenance program. The primary focus for maintenance should be refertilization (9.3 "Soil Fertility") and overseeding of planted areas, conducted over a minimum 2 year period after planting. Watering (9.1.1 "Maintenance") is probably not cost effective on a general area basis, but may be considered in a critical site situation.

Note: As mentioned previously in the Discussions, the 2 year duration of these Revegetation Trials is a limiting factor to providing more exact recommendations for materials and methodology. Also, the potential for significant variances in environmental conditions dictates a requirement for generalization and averaging.

10.2 Tree & Shrub Plantings:

10.2.1 A successful establishment of native tree and shrub contribution to the revegetation of construction disturbance in this difficult climate and soils environment will require planning and execution of several initiatives:

+ Choosing suitable tree and shrub species
+ Ensuring compatibility with the revegetation plan
    - competition
    - locations
+ Supply of appropriate growing medium
+ Optimum planting schedule
+ Planting Stock
+ Planting procedures and structures
+ Maintenance requirements
    - fertilizers / watering

10.2.2 Choosing Suitable Tree and Shrub Species:

The native environment has been radically altered by construction in terms of soil type, exposure and moisture availability requiring a suitable species selection. Suggestions are contained in this report – Specifically Tables 4 & 5 identify those among the living and the most persistent species. In summary Rocky Mountain Juniper is the dominant survivor. In most cases it has been mauled, trampled, and bent by rock fall, but it remains in place. Saskatoon and Snowberry are next as the most often located varieties. The individual plants have been repeatedly leaf stripped by the sheep, but many survived. Silverberry is another that rates well in the charts. Fir and Spruce indicate that they can withstand the sheep and tolerate this environment. Outside the charts, and beyond the sheep grazing area, Lombardi poplar and the Native Rose are found thriving in close proximity to this Revegetation Trial Area.

10.2.3 Maintaining Compatibility with the Revegetation Plan:

Potential competition with the grass/ legume cover should be satisfactorily mitigrated by following the island planting concept. Also the dry, exposed nature of most sites is expected to naturally generate a relatively spaced grass/ legume cover of low to moderate height. Only minor competition effects would be anticipated while still adequately addressing sediment/ erosion control and aesthetic concerns.
Locations of planting islands/ structures, need to take advantage of available natural soil moisture occurrences and all available protection that might reduce exposure impact.

10.2.4 Supply of Appropriate Growing Medium:

The preferred choice for a reliable growing medium would be stockpiled topsoil strippings from the immediate construction site. A portion of these strippings should be screened for use in tree and shrub planting activities and any proposed landscaping activities. Topsoil strippings utilized for the planting islands would not have to be screened and could have some large size wood debris which would provide a stabilizing effect and perhaps some exposure protection for newly installed plants. However, care must be taken to avoid any concentration of chip size and smaller wood fragments, which would result in the difficulties noted in the discussion (– section 9.5 "Appropriate Growing Medium")

10.2.5 Optimum Planting Schedule:
Tree and Shrub planting activities should not be conducted during the period from June 1 – September 30.

10.2.6 Planting Stock:

Ideally, trees and shrubs selected for planting in this area, would be 2 years old stock, hardened off for 1 year prior to planting. One year old stock hardened off for 90 days prior to planting might survive. Planting stock originating from local seed sources should be investigated. Local, contract growing of planting stock for the Kicking Horse Canyon construction should be a consideration. Container size, except for ground covers such as Kinnickinnick would be 1-2 gal size/ no seedling/ plug sizes.

10.2.7 Planting Procedures and Structures:

- It was apparent in these revegetation trials, that the planting pocket (PP) structure is effective in providing stability and a favourable "Growing" environment, (if the sheep are not part of the equation). It should be noted however, that planting pockets are proportionately costly to install relative to the planting area provided.

- The Live Bag (LB) Structures utilized in this revegetation trials project, provided adequate stability, but appeared prone to difficulties with drought. The LB structure is comparatively economical to install, but requires some modifications with regard to planting procedures and construction.

- Contour Cells were found to be the most cost effective means of providing stable tree and shrub planting sites in these revegetation trials. The stability of contour cells when installed on certain soil types and slope angles, are factors that need to be carefully considered.

- Brush Layers and any other structure or planting utilizing willow or poplar species must be installed only in areas where internal soil moisture is evident through the months of June, July and August. Watering will not be adequate to provide sufficient moisture for long term survival of the Willow species incorporated in the structures.

- The Coir Wrap installation rates some where between Contour Cells and Planting Pockets of installation costs (primarily labour). These structures, if correctly installed will provide improved stability and moisture retention to a planting site.

- Planting Islands are defined for this project as irregularly shaped, naturally located (no pattern) sites with defined boundaries. Planting Islands would be site enhanced with the addition of a minimum 30cm depth of acceptable growing medium. On slopes steeper than 3:1, the OM layer thickness should be specified on a per site basis due to potential instability problems. Mitigation efforts could include anchored logs, roots, stumps, rocks, etc. and/or contour cells – again specified on a per site basis. Some of these stabilization efforts would also provide exposure protection for new tree and shrub installations.

    - The viability of all planting structures could be improved by incorporating exposure protection for the plants.

- If the Bighorn Sheep have access to the planting areas, it will be necessary to provide collective or individual protection for all the planted tree and shrub species except Juniper and Sagewort. (section 9.1 Grazing and browsing Impacts) Tree and Shrub development to a height where top leaders are above browsing access is a reasonable assumption to ensure plant survival, although no supportive data is available in this short term. Shorter growing species such as Snowberry will relentlessly be susceptible to browse damage.

- Plant installation for individually located plants should require a 50% larger than container size planting hole. Backfilled with preferred growing medium and installed in a minimum 6 cm depth moisture retention depression. Plant installation within the preferred option, Planting Islands, require the planting hole be excavated through the planting medium and minimum 10 cm depth into the parent material (original mineral soil), with a surface moisture retention depression of minimum 6 cm depth. An appropriate nutrient and if necessary a soil amendment should be included with each planting.

10.2.8 Maintenance:

A defined maintenance schedule covering a minimum 2 year period after installation is a necessary requirement to ensure a reasonable survival. (section 9.1.1 Maintenance) The maintenance schedule needs to address both watering and fertilizer/ soil amendment requirements based on current on-site evaluations of plant health. As noted in the Discussion and Recommendations portion of this report, there are significant challenges to deal with such as very low to non existent NPK levels, micronutrient shortage, high pH levels and chemical soil compositions. All possibly restricting nutrient availability to the plants. (section 9.3 Soil Fertility)

* Each form of stress (negative impact) in this severe climate is cumulative, ultimately resulting in plant failure.
* The maintenance schedule should also incorporate some variations to reflect changes in topography and exposure (i.e. Flat areas vs. 3:1 Slope vs. 1:1 Slopes).

10.3 Reasonable Expectations for a Revegetation Program:

10.3.1 Grass and Legumes: (limited or no ungulate grazing):

Limited precipitation/ moisture availability in the Kicking Horse Canyon will result in extended periods between planting and germination and development to maturity. (section 9.4 Climate) Mature vegetation in majority of the areas is expected to be a relatively sparse cover of primarily bunch grass species types requiring several years to evolve to a natural self sustaining environment (assuming appropriate maintenance).

10.3.2 Trees and Shrubs: (limited or no ungulate browsing):

Very little growth in the first 2 years can be expected as the plants become naturalized to the environment. Survival during the initial 2-3 year period will depend on planting stock quality, planting procedures, maintenance, and especially moisture availability. Observable growth should be evident after 2-3 years, but is expected to be minimal, and will vary according to species type.

Appendix I – Operations Summary: Brief details of the various applications, structures, test plots, maintenance and evaluations conducted for the Revegetation Trials – Kicking Horse Canyon Project, October 2005 – October 2007.

Golden Gate Operations Summary

October 2005	2006	2007
Construct PP A & B		
➢ Install plants	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
➢ Fertilizer 18-18-18 @ 400kg/ha	➢ Surviving plant Inventory	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
➢ Install Grass & Legume TP's on perimeter of the structures	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Fall Plant Inventory
➢ Install Willow stakes in back wall of each PP	➢ Water on 3 occasions in June/July	
	➢ TP survival Assessment	
	➢ Remove debris	
	➢ Apply straw mulch to PP-B	
	➢ Apply Anti Browse	
	➢ Fall Plant Inventory	

GG Trial Area

October 2005	2006	2007
Obtain Soil Sample		
GGI - A \ Composite GGI – B /		GG2 – A Composite (June)
		GC Cont. (Nov.) West End

GG Trial Area

October 2005	2006	2007
Install EHS #1		
➢ Conventional Hydroseed Slurry mix *Ministry of Transportation experimental seed mix (Refer to Sec. 9.6 for species)	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
➢ Fertilizer 18-18-18 50% SCU @ 400kg/ha	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Water 3 times (June/July)	➢ Fall Plant Inventory
	➢ Fall Plant Inventory	

GG Trial Area

October 2005	2006	2007
Install Grass/Legume TP's		
➢ Apply conventional Hydroseed application to stabilize (no seed)	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
➢ Fertilizer 18-18-18 50% SCU @ 400kg/ha	➢ Replicate all 2005 TP's	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Install new TP's	➢ Fall Plant Inventory
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	
	➢ Water 3 times (June/July)	
	➢ Fall Plant Inventory	

GG Trial Area

October 2005	2006	2007
Construct LB #1 & #2		
➢ Install plants in selected bags (Topsoil filled)	➢ Spring Evaluation & Impact Assessment	➢ Spring/Fall Evaluation & Impact Assessment
➢ Fertilizer 18-18-18 @ 400kg/ha	➢ Remove debris	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
➢ Install Grass & Legume TP's on perimeter	➢ Surviving Plant Inventory	➢ Fall Plant Inventory
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m2	
	➢ Water on 3 occasions in June/July	
	➢ Apply Anti Browse	
	➢ Fall Plant Inventory	

GG Trial Area

October 2005	2006	2007
Install SL #1		
➢ Fertilizer 18-18-18 @ 400kg/ha	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m²	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Water on 3 occasions in June/July	➢ Fall Plant Inventory
	➢ Fall Plant Inventory	

GG Trial Area

October 2005	2006	2007
Install Random Planting #1 & #2		
➢ Fertilizer 18-18-18 @ 400kg/ha	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m²	➢ Apply Anti Browse
	➢ Water on 3 occasions in June/July	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Apply Anti Browse	➢ October Plant Inventory
	➢ Fall Plant Inventory	

GG Trial Area

October 2005	2006	2007
	Install HSTP #1 & #2 (October)	
	➢ Fults Alkali Grass @ 15kg/ha Newhy Rs Wheatgrass @ 25kg/ha	➢ Spring Evaluation & Impact Assessment
	➢ Fertilizer 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
		➢ Fall Plant Inventory

GG Trial Area

October 2005	2006	2007
		Install Exclosure Cells
		➢ #1, #2, #3, #4, #5 Refer to table June 07
		➢ October Plant Inventory

Choke Cherry Operations Summary

October 2005	2006	2007
Construct Contour Cell Plots A & B		
➢ Install Plants	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
➢ Install various grass & legume TP's adjacent to & between cells	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Anti Browse Treatment (June)
➢ Fertilizer 18-18-18 50% SCU @ 400kg/ha	➢ Water 3 times (June/July)	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
➢ Apply straw mulch to entire site **	➢ Install Grass Crowns	➢ October Plant Inventory
	➢ Anti Browse Treatment with control rows (Spring)	
	➢ Fall Plant Inventory	

CC Trial Area

October 2005	2006	2007
Obtain Soil Sample		
CC1 - A Composite		CC2 - A Composite (June)
		CC Cont. (Nov.) East End

CC Trial Area

October 2005	2006	2007
Install ES #2		
➢ Conventional Hydroseed slurry mix (Ministry of Transport experimental seed mix (refer to table #?))	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
➢ Fertilizer – 18-18-18- 50% SCU @ 400kg/ha	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Water 3 times (June/July)	➢ October Plant Inventory
	➢ Fall Plant Inventory	

CC Trial Area

October 2005	2006	2007
Install RP #3		
➢ Fertilizer – 18-18-18- 50% SCU @ 400kg/ha	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Apply Anti Browse
	➢ Water 3 times (June/July)	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Apply Anti Browse	➢ October Plant Inventory
	➢ Fall Plant Inventory	

CC Trial Area

October 2005	2006	2007
Install Grass/Legume TP's		
➢ Apply conventional Hydroseed application to stabilize (no seed included) *Refer to Sec 9.6 for species list	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Water 3 times (June/July)	➢ Fall Plant Inventory
	➢ Replicate all 2005 TP's	
	➢ Install new TP's *Refer to Apx. IV For species list	
	➢ Apply conventional Hydroseed application to stabilize TP's (no seed included)	
	➢ Fall Plant Inventory	

CC Trial Area

October 2005	2006	2007
Install SL #2		
➢ Fertilizer 18-18-18 50% SCU @ 400kg/ha	➢ Spring Evaluation & Impact Assessment	➢ Spring Evaluation & Impact Assessment
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU
	➢ Water 3 times (June/July)	➢ Fall Plant Inventory
	➢ Fall Plant Inventory	

CC Trial Area

October 2005	2006	2007
		Install Exclosure Cells
		➢ #6, #7, #8, #9, #10, #11 Refer to June 07
		➢ October Plant Inventory

Yoho Bridge Operations Summary.

*This YB Site was Hydroseeded at completion of slope construction – September 2004.(mix #3)

October 2005	2006	2007
Construct PP-C,D,E		
➢ Install Plants	➢ Spring/Fall Evaluations & Impact Assessment	➢ Spring Evaluation & Impact Assessment
➢ Fertilizer 18-18-18 50% SCU @ 400kg/ha	➢ Surviving Plant Inventory	➢ Fall Plant Inventory
➢ Install grass & legume TP's on perimeter	➢ Fertilizer 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	
➢ Install willow stakes in back wall	➢ Apply Anti-Browse agent.	
	➢ Water 3 times June/July	
	➢ TP survival assessment.	
	➢ Install 10 rooted Cottonwood along base of each PP	
	➢ Apply straw mulch	
	➢ Kelp @ 10kg/1000m^2	

YB Trial Area

October 2005	2006	2007
Obtain Soil Sample		
YBI-A \ Composite YBI-B /		

YB Trial Area

October 2005	2006	2007
Construct LB #3, 4, 5		
➢ Install Plants in selected bags (topsoil)	➢ Spring/Fall Evaluations & Impact Assessment	➢ Spring Evaluation & Impact Assessment
➢ Fertilizer 18-18-18 50% SCU @ 400kg/ha	➢ Surviving Plant Inventory	➢ Fall Plant Inventory
➢ Install grass & legume TP's on perimeter	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	
	➢ Water 3 times (June/July)	
	➢ Apply Anti-Browse agent.	
	➢ TP survival assessment.	
	➢ Install additional plants (3 local harvest spruce)	
	➢ Apply straw mulch to ½ of plots.	

YB Trial Area

October 2005	2006	2007
Install random planting #4, #5		
➢ Fertilizer 18-18-18 50% SCU @ 400kg/ha	➢ Spring/Fall Evaluations & Impact Assessment	➢ Spring Evaluation & Impact Assessment
	➢ Surviving Plant Inventory	➢ No surviving plants located
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	
	➢ Water 3 times (June/July)	
	➢ Apply Anti-Browse agent.	

YB Trial Area

October 2005	2006	2007
	Install BL Plots #1 & #2	
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Spring Evaluation & Impact Assessment
	➢ Install Plants (2 local harvest spruce)	➢ Fall Plant Inventory
	➢ Apply straw mulch to ½ of plots	
	➢ Water 3 times (June/July)	

YB Trial Area

October 2005	2006	2007
	Install Coir Wrap Plot	
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Spring Evaluation & Impact Assessment
	➢ Install Plants (2 local harvest spruce)	➢ Fall Plant Inventory
	➢ Apply straw mulch to ½ of plot	
	➢ Water 3 times (June/July)	

YB Trial Area

October 2005	2006	2007
	Install SL #3, #4, #5	
	➢ Refertilize 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Spring Evaluation & Impact Assessment
	➢ Water 3 times (June/July)	➢ Fall Plant Inventory

YB Trial Area

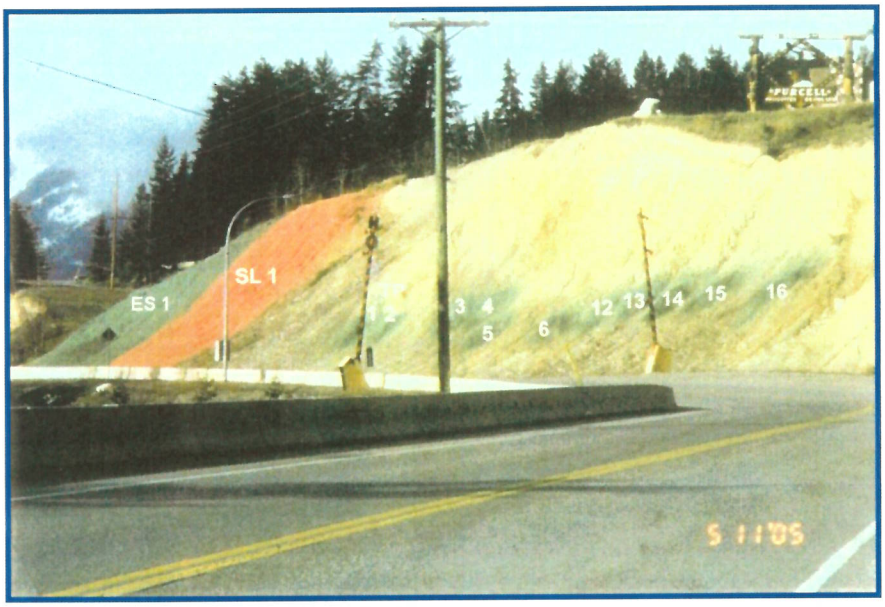
October 2005	2006	2007
	Install Exclosures #1, #2, #3	
	➢ Fertilizer 250kg/ha 18-18-18 50% SCU 250kg/ha 23-3-23 SCU Kelp @ 10kg/1000m^2	➢ Spring Evaluation & Impact Assessment
	➢ Overseed - Millet @ 15kg/ha	➢ Fall Plant Inventory
	➢ Water 3 times (June/July)	

YB Trial Area

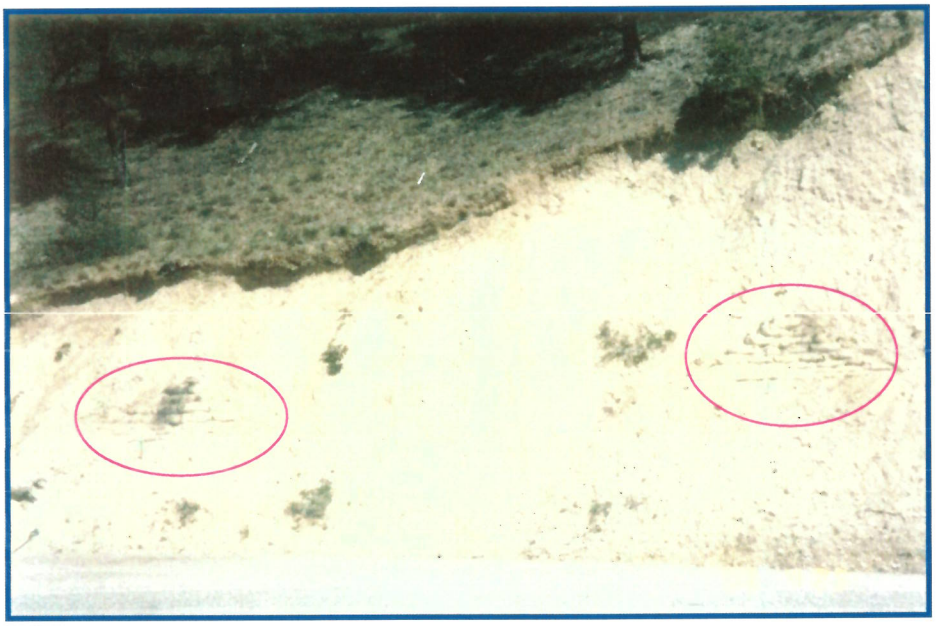
October 2005	2006	2007
		Install Exclosure Cells
		➢ #12, #13, #14, #15 / June 2007
		➢ October Plant Inventory

Appendix II – Photo Review for 2005 – 2006: A historical selection of Revegetation Trials Photos for October 2005 – August 2006.

Golden Gate Photo History



October 2005
ES #1 / SL #1 / TP's
Western portion of plot layout for the GG Trial Area. Grass and Legume TP's have been stabilized with mulch and tackifier.



Spring 2006
Surface Erosion each spring has been substantial as indicated by these barely visible LB #1 & 2 structures (April)

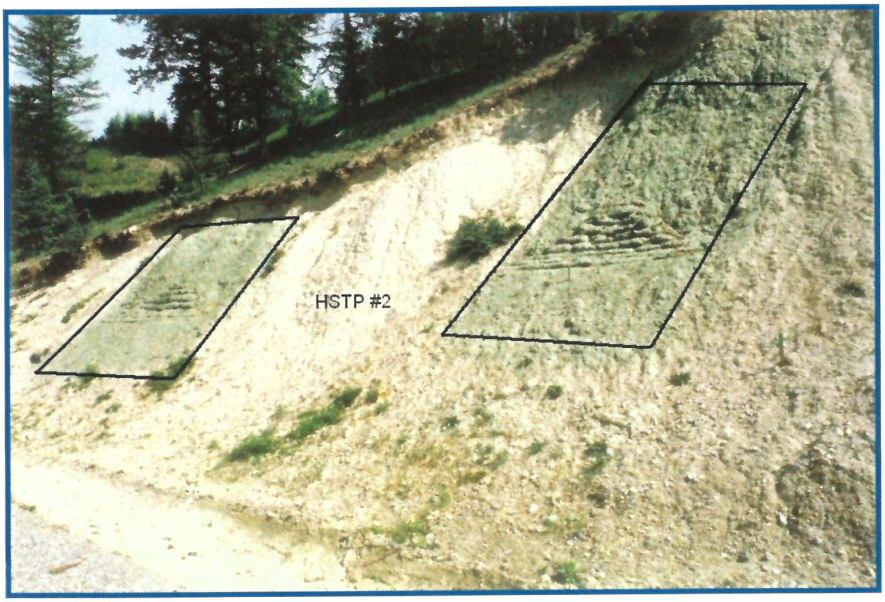
GG Photo History

June 2006
Surface Erosion of steep cutslopes at the GG Trial Area.
These cutslopes vary from 2:1 to 1:1

Spring 2006
Severely browsed Douglas Maple attempting to re-establish from base of plant

GG Photo History

October 2006
Installed HSTP #2 Stabilized with mulch and tackifier GG Trial Area.



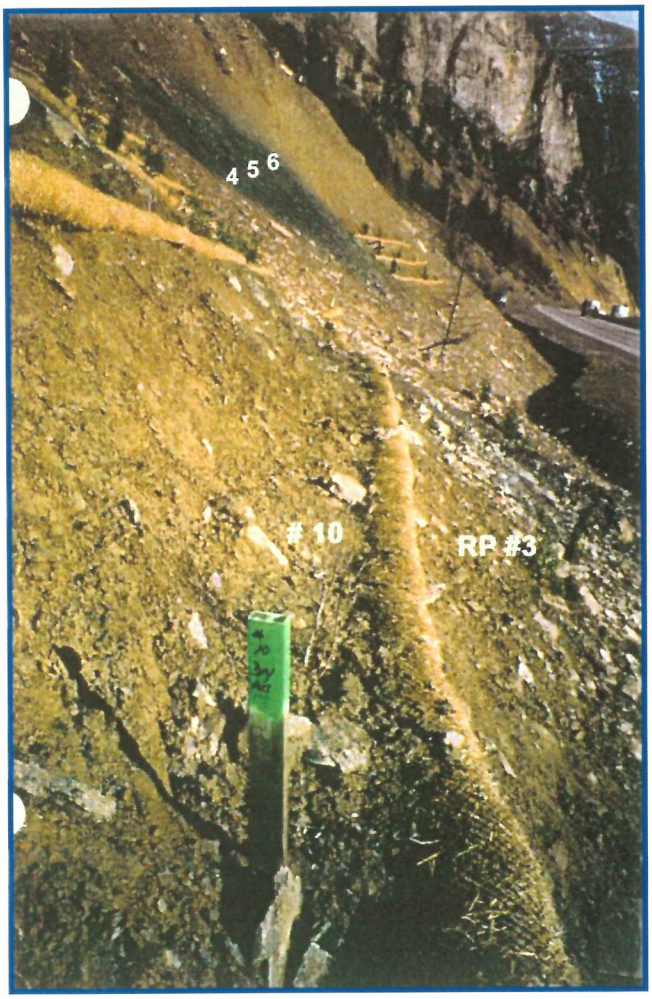
June 2006
Trembling Aspen Leafing out RP #2

GG Photo History

June 2006
Leaf Development
on Brush Layers
PP-B

Appendix II

Choke Cherry Photo History



October 2005

CC – A & CC-B Prior to mulching with straw.

October 2005
CC-A Installation and Planting
Prior to Straw Mulch Application.

CC Photo History

Spring 2006
Grass & Legume TP replications were stabilized with a mulch & tackifier application

June 2006
Watering CC Trial Area

Spring 2006
A successful grass specie test plot on the CC Trial Area.

CC Photo History

June 2006
TP #4
Successful Germination

Appendix II

Yoho Bridge Photo History

June 2006
BL #2 Installed on YB Trial Area

June 2006
SL #3 Installed on YB Trial Area
EX #2 Centrally located.

August 2006
SL #3 – YB Trial Area
Note the concentration of
sheep on the SL plot

YB Photo History

2006
Coir Wrap Plot – October
Note the accumulation of rocks primarily deposited over the 2005 - 2006 winter season.

The spruce is a local transplant in the spring of 2006

Fall 2006
Ex #2 Displaying growth development inside the exclosure as compared to heavily grazed slope

Appendix III:

The following individual seed species were planted into separate test plots in October 2005 and replicated in spring 2006.

GRASS AND LEGUME SPECIES PLANTED (FALL 2005)		
ID#	Species	*Agronomic Species ** Native Species ***Ecovars
#1	AC Polar Northern Wheatgrass	***
#2	AC Sharptail Needle & Thread Grass	***
#3	WR Poole Western Wheatgrass	***
#4	Fults Puccinellia (Weeping Alkali Grass)	***
#5	AC Mallard Green Needle Grass	***
#6	Newhy RS Wheatgrass	***
#7	Crown Vetch	*
#8	Flat Pea (Lathyrus sylvestrus)	*
#9	Wild Alfalfa (Psoralea tenuiflora)	**
#10	Dryas (rooted seedlings)	**
#11	Common Sagewort (roots and seed)	**
#12	Russian Wild Ryegrass	*
#13	Tall Wheatgrass	*
#14	Bluebunch Wheatgrass	**
#15	Pubescent Wheatgrass	**
#16	Alkali Grass	**
#17	Meadow Bromegrass	**
#18	Rocky Mountain Fescue	**
#19	Alpine Timothy	**
#20	Axcella Annual Ryegrass	*
#21	Beach Pre (Lathyrus japonicus)	**
#22	Kicking Horse Pass Experimental mix (MOT Mix)	**

Appendix IV:

Incidentally, in these replications, appropriate inoculant was incorporated with the seed of Crown Vetch, Flat Pea, Perennial Lupine and Birdsfoot Trefoil before applications into each individual Test Plot.

At the Coir Wrap site, #28 was seeded. At Choke Cherry, inoculated Crown Vetch seed (#7) was replicated on the entire eastern ½ of Contour Cell Plot B. As well, inoculated Flat Pea seed (#8) was replanted on the eastern ½ row 8 in Contour Cell Plot A.

GRASS AND LEGUME SPECIES ADDED TO THE TRIALS (SPRING 2006)		
ID#	Species	
#24	Ministry of Transportation Mix	
#25	Prairie Gold Millet	
#26	Dwarf Fall Rye	
#28	Enhary Wood Bluegrass	
#29	Durar Hard Fescue	
#30	Intermediate Wheatgrass	
#31	Alkali Sacaton	(grass crowns)
#32	Basin Wild Rye	(grass crowns)
#33	Sheperdia Canadensis	(seedlings)
#34	Penstemen	(seedlings)
#35	Cottonwood	(rooted seedlings)
#36	Wild Strawberry	(rooted seedlings)
#37	Perennial lupine	
#38	Birdsfoot Trefoil	
#39	Kentucky Bluegrass	
#40	Slender Wheatgrass	
#41	Canada Bluegrass	
#42	Red Top	
#50	Turf Type Tall Fescue	

Appendix V:

2007 Photo Record of Exclosures #1-#3 and Exclosure Cells #1-#15

EX #1 08/07
YB Trial Area/ W. End

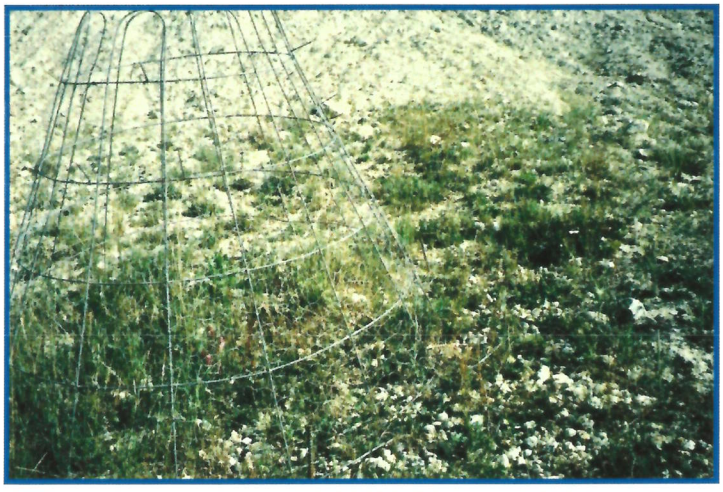
EX #2 10/07
YB Trial Area/ SL #2

EX #3 10/07
YB Trial Area/ E. End

EX & EC Photo Record

EX CELL #1 10/07
GG Trial Area

EX CELL #2 10/07
GG Trial Area



EX CELL #3 10/07
GG Trial Area

EX & EC Photo Record

EX CELL #4 10/07
GG Trial Area/ HSTP #2

EX CELL #5 10/07
GG Trial Area/ PP-B

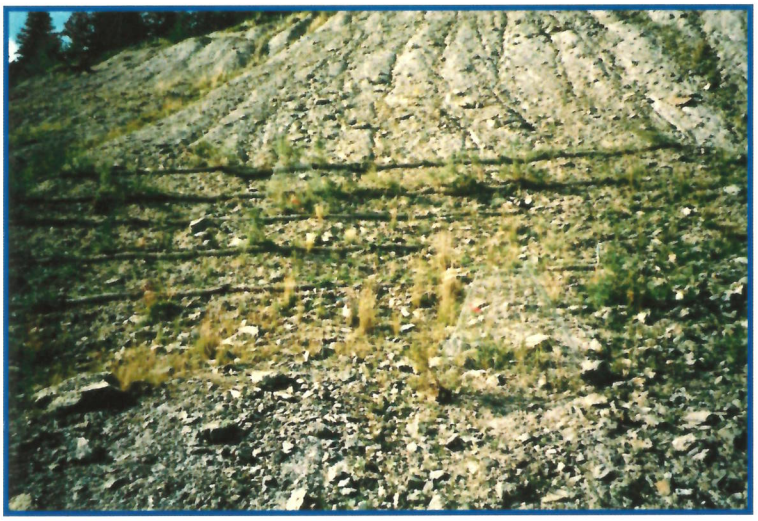
EX & EC Photo Record

EX CELL #6 10/07
CC Trial Area/ ES #2

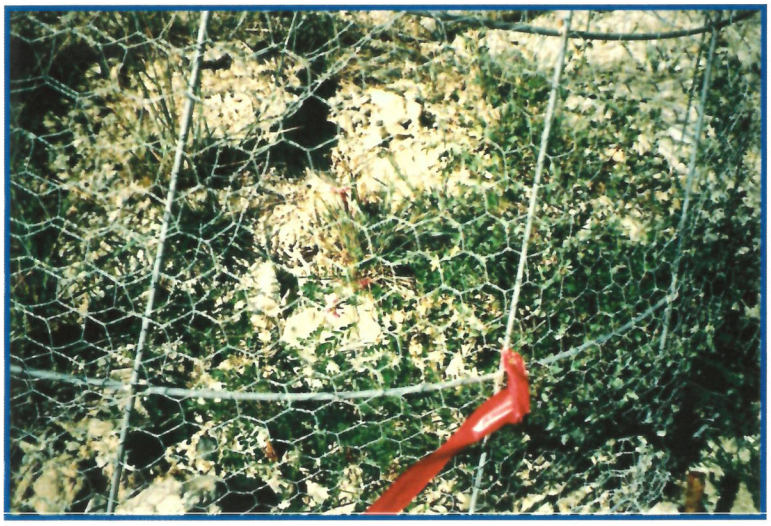
EX CELL #7 10/07
CC Trial Area/ CC-A

EX CELL #8 10/07
CC Trial Area/ CC-A

EX & EC Photo Record



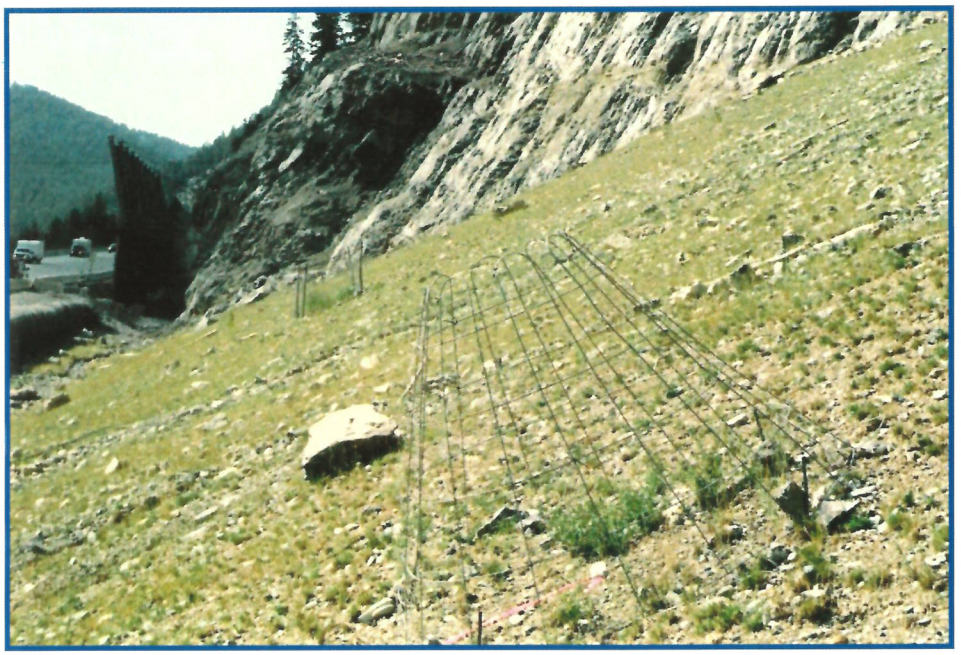
EX CELL #9 10/07
CC Trial Area/ RP #3



EX CELL #10 10/07
CC Trial Area

EX CELL #11 10/07
CC Trial Area

EX & EC Photo Record



EX CELL #12 10/07
YB Trial Area/ SL #1

EX CELL #13 10/07
YB Trial Area/ PP-C