ASSESSMENTS OF THE REVEGETATION OPTIONS CONDUCTED AT THE WASTE ROCK DUMP AT CLINTON CREEK - YEAR THREE -

Island Plot #IC-8, July 26th, 2011

FOR

ASSESSMENT AND ABANDONED MINES

ENERGY MINES AND RESOURCES

BY

Laberge ENVIRONMENTAL SERVICES

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1.0 BACKGROUND

The Clinton Creek Asbestos Mine, located approximately 100 kilometres northwest of Dawson City was abandoned in 1978. The majority of the mine site has remained relatively undisturbed for approximately 30 years. Various revegetation test attempts were undertaken during the 2004 and 2005 seasons with apparent limited success. These methods included live staking along Clinton Creek in the gabion area and grass seeding in selected areas on the tailings and waste rock dump. Details can be reviewed in *Clinton Creek Mine Site Reclamation Report 2005 Dawson City, YT* prepared by Han Construction Ltd in 2005.

A revegetation test plot program was implemented on the Clinton Creek waste rock dump during mid September, 2008 by Laberge Environmental Services (Laberge Environmental Services, 2009). Three separate test plot areas were designated as well as a small live staking site near the base of the waste rock dump along the shore of Hudgeon Lake. Test plot 1 is near Porcupine Pit Lake, test plot 2 is located near the old shovel and drill, and test plot 3 is east and upslope from Hudgeon Lake (Figure 1, Appendix A). A table detailing the treatment used at each of the plots and their locations, is provided in Appendix B.

Local vegetation species were used in a variety of revegetation techniques to determine what methods would potentially be successful in increasing the naturally occurring revegetation process. The intent was to augment the natural, albeit slow, ecological succession presently taking place on the waste rock disposal area. The methodologies used are presented in Appendix C, and further details are supplied in *Clinton Creek Waste Rock Dump Trial Revegetation Techniques, September 2008,* prepared by Laberge Environmental Services, 2009.

The revegetation trial plots constructed in September 2008 were inspected on July 21, 2009 to determine the transplanted vegetation's first year survival rates as well as the overall vegetation health. These plots were again assessed on July 26th, 2011 and the findings are presented in this report.

2.0 Results

2.1 Hudgeon Lakeshore Site

A total of 55 live willow and balsam poplar live stakes were planted along the shoreline in 2008. In 2009, 12 stakes, primarily willow, appeared healthy with newly formed branches and leaves. However the majority of the remainder had been gnawed by beavers and showed no signs of life. An additional five indicated both beaver gnaw marks as well as new leaves and branches.

During the 2011 survey, all stakes were dead. Natural colonization of the riparian area by dandelions was occurring. A volunteer birch shrub and a spruce sapling were also observed (Photo #1, Appendix C).

2.2 Plot 1 near Porcupine Pit Lake

There is one vegetation island community at Plot 1 consisting of four islands. There are two individual islands situated on the north side of the access trail (see Figure 2). All islands appeared healthy with most of them exhibiting more robust growth than when last assessed in July 2009 (Photos #2 to 5). Plant diversity had increased in each of the islands as well.

Detailed descriptions of each of the islands are presented in Table 1. Propagation is a measure of success of the transplants and many of the plants within each of the islands were reproducing. A spruce tree in Plot I-1 had one cone (Photo #6), a willow in Plot IC-1B had produced a catkin, the majority of the soapberry shrubs were in berry, and most of the flowering plants (forbs and shrubs), were in bloom. There was an accumulation of leaf litter at each island since 2008, which will eventually contribute to soil production for the support of continued growth. There was little spread from the islands to the surrounding terrain at Plot 1 at this time.

TABLE 1 SUMMARY OF THE ISLANDS IN PLOT #1

Plot #	Treatment	Comments and Species (common names) Observed
IC-1A	Island within community	Overall appears healthy, soapberry in berry, 2 spruce, cinquefoil in flower, dandelion, crepis, brome, foxtail, wheatgrass.

TABLE 1	**SUMMARY OF THE ISLANDS IN PLOT #1**	
Plot #	**Treatment**	**Comments and Species (common names) Observed**
IC-1B	Island within community	Overall appears very healthy, increased growth from 2009, soapberry in berry, willow with catkin, yarrow, Jacob's ladder, kinnikinnick.
IC-1C	Island within community	Vegetation appears healthier than in 2009, 4 spruce, a small poplar, willow, shrubby cinquefoil in flower, kinnikinnick, fleabane, dandelion.
IC-1D	Island within community	Increased growth from 2009, several aspen – all healthy, 3 healthy spruce, poplar leaning a bit more than in 2009 but still healthy, shrubby cinquefoil in flower, soapberry, fireweed, many flowering crepis, dandelion, kinnikinnick.
I-1	Individual island	Overall appears fairly healthy. 3 spruce trees - one with cone, poplar and willow growing but not robust, shrubby cinquefoil, fireweed, foxtail, wheatgrass, alkali grass, aster and dandelion.
I-2	Individual island	Overall appears very healthy, increased growth from 2009. 6 spruce – 1 dead, 1 broken, kinnikinnick with berries, 2 willow, 2 aspen, soapberry with berries, shrubby cinquefoil – had flowered, rose, yarrow, fireweed, Jacob's ladder, grasses.

There was one poplar sprout within the poplar root cuttings site, Plot # PR-2. None of the live staked willows along the perimeter of the plot have survived. Seven of the initial nine willow crowns were growing, two of which appeared very healthy. The poplars that were live-staked around the periphery of the willow crown plot have not survived. The poplar trench staking was slightly more successful than the willow trench staking. Galls were present on two of the poplars.

Survival rates since 2008 have been calculated in Table 2 and compared to the 2009 observations. Survival has decreased in all treatments with the exception of the Islands.

Table 2: Plot 1 Survival Rates Near Porcupine Pit Lake Since 2008

Revegetation Method	**Percent Survival, 2009**	**Percent Survival, 2011**
Vegetative Islands	100	100
Live Staked Willows	4	0
Live Staked Poplar	12	0
Willow Crowns	89	78
Poplar Root Cuttings	6	6
Willow Trench Staking	47	20
Poplar Trench Staking	100	40

2.3 Plot 2 near Old Shovel and Drill

The layout of the various treatment methods at Plot 2 is displayed in Figure 3. For the most part, the islands on this plot were doing extremely well. The islands within the community particularly displayed increased and robust growth since July 2009. A notable example of this was Plot # IC-2B which appeared to have very low survival of any plants in 2009 yet showed robust healthy growth of several species in July 2011 (Photos #7 and 8).

The majority of the forbs were in flower and several of the grass species were in seed. Most of the islands had increased biodiversity. It is likely that plants not observed previously are growing from the seed bank that was transported in the soil during the translocations of the islands. There was a considerable increase in ground cover and biodiversity at the islands I-3 and I-4 in 2011 (Photos #9 to 12). Several of the islands showed signs of spreading beyond their initial footprint of transplant. The species included dandelion, fireweed and grass.

There are areas throughout the waste rock dump where natural colonization has been occurring with no anthropogenic assistance. One such area is the recent development of a large patch of mustard (*Descurainia* sp.) with occurrences of foxtail and dandelion (Photo #13) located approximately 100 m upslope from the island community at Plot #2, IC-2.

TABLE 3 SUMMARY OF THE ISLANDS IN PLOT #2

Plot #	Treatment	Comments and Species (common names) Observed
IC-2A	Island within community	This island is thriving; shrubby cinquefoil in flower, poplar, 3 spruce, willow, soapberry in berry, rose, fireweed, gentian in bloom, orchids, rough fescue in seed, alpine bluegrass, foxtail, dandelion, grass-of-Parnassus in flower.
IC-2B	Island within community	This island is doing much better than in 2009. soapberry in berry – part of the plant is dead, trembling aspen, Jacob's ladder in flower, fleabane – only leaves, dandelion, Hawks beard, mustard,kinnikinnick, sedge, foxtail – appears to be spreading.
IC-2C	Island within community	This island is doing much better than in 2009 and is thriving. Poplar – healthy, willow, 1 small spruce, soapberry with lots of berries, kinnikinnick, twin flower, grass, Siberian yarrow, gentian, Jacob's ladder, languid lady, fleabane, fireweed – appears to be spreading.
IC-2D	Island within community	More robust growth than in 2009. 7 aspen – healthy, rose, Kinnikinnick, aster, fleabane, dandelion, bluejoint grass, fescue.
IC 2E	Island within community	Slightly increased growth from 2009. 1 spruce, aspen, soapberry in berry – lush growth, rose with hips, high bush cranberry in berry, bedstraw, languid lady, fleabane, dandelion – appears to be spreading, golden rod – no flowers, foxtail, fescue, wheatgrass.

TABLE 3	**SUMMARY OF THE ISLANDS IN PLOT #2**	
Plot #	**Treatment**	**Comments and Species (common names) Observed**
I-3	Individual vegetation island	Much greater growth than in 2009. Several small willows, one dead willow, poplar, 2 healthy white spruce, 1 dead spruce, dandelion, hawks beard – appears to be spreading, Jacob's ladder, fleabane, dandelion, alkali grass in seed, foxtail.
I-4	Individual island	The health and growth of this island has improved considerably since 2009. 1 aspen, 1 willow, 1 spruce (healthy), 3 dead spruce, plentiful fireweed and hawks beard in flower, mustard, dandelion, alkali grass in seed and spreading.
I-5	Individual island	Very little change since 2009. 2 spruce, willow, poplar, soapberry, wheatgrass, foxtail, alkali grass.
I-6	Individual island	An increase in growth since 2009. 1 healthy large birch, 1 dead birch, willow with blotch miner, 1 spruce and seedling, 1 aspen with leaf miner, shrubby cinquefoil, twin flower, fireweed, bromegrass.
I-7	Individual island	This island is very healthy. Willow, aspen, poplar, soapberry, foxtail, bromegrass, dandelion, and goldenrod, fleabane and fireweed all in flower.
I-8	Individual island	Healthy island. Willow, poplar, aspen, spruce, fireweed, bromegrass in seed and flower, wheatgrass.
I-9	Individual island	Little change since 2009. 3 healthy spruce, poplar, aspen, soapberry, willow, fireweed, dandelion, goldenrod, bromegrass.

There continued to be no evidence of poplar growing from the root propagules and none of the live-staked willows along the perimeter were alive. Four of the original six planted willow crowns were still living but were not thriving. The surrounding poplar stakes were dead.

Four of the poplar trench stakes site survived and had healthy new growth. The willow trench staking was reduced to one surviving plant. Survival rates have been calculated for all treatments in Table 4. The survival rate of all treatments has decreased with the exception of the transplanted islands.

Table 4: Plot 2 Survival Rates Near Old Shovel and Drill Since 2008

Revegetation Method	**Percent Survival, 2009**	**Percent Survival, 2011**
Vegetative Islands	100	100
Live Staked Willows	0	0
Live Staked Poplar	0	0
Willow Crowns	67	50
Poplar Root Cuttings	0	0
Willow Trench Staking	33	7
Poplar Trench Staking	93	27

2.4 Plot 3 near Hudgeon Lake

There are two island communities at Plot 3 representing a total of 9 islands (Figure 4). Detailed descriptions of the observations on each island are summarized in Table 5. When Plot #3 was assessed in July 2009, it was observed that at some point prior to the site visit, an all terrain vehicle had driven over the island IC-3A. This had damaged some of the vegetation, however this plot had recovered significantly when assessed on July 26, 2011 (see Photos #14 and 15).

All islands exhibited a healthy state and most of them supported increased vigorous growth. An example of this occurred at Plot IC-4B (Photos #16 and 17). As with Plots 1 and 2, many of the plants were in seed or blooming. There was also evidence of several species of plants spreading from the original site of the translocated island. In 2008 prior to the installation of the islands, the ground for the sites was prepared through mechanical scarification and excavation resulting in terrain devoid of any plant life. Photographs 18 and 19 show the island community of IC-4 immediately after the islands were installed in September 2008, and in July 2011 respectively. Although the photos are small in the printed report, it can be observed that natural colonization beyond the islands has been occurring.

TABLE 5 SUMMARY OF THE ISLANDS IN PLOT #3

Plot #	Treatment	Comments and Species (common names) Observed
IC-3A	Island within community	This island has recovered well from the damage it suffered when driven over by an ATV sometime in 2008 or 2009. Poplar – prone one is dead, 1 healthy spruce, kinnikinnick, clover, foxtail, dandelion, vegetation is spreading.
IC-3B	Island within community	Increased growth since 2009. 4 spruce, willow, aspen, poplar, soapberry in berry, kinnikinnick, fireweed, aster, dandelion, Jacob's ladder.
IC-3C	Island within community	Increased growth since 2009. 2 spruce, willow, poplar with galls, soapberry in berry, shrubby cinquefoil, aster, yarrow, dandelion, plantain, wheatgrass, fescue, foxtail.
IC-3D	Island within community	Increased growth since 2009 and spreading. Aspen, spruce, willow, shrubby cinquefoil, soapberry, milk vetch in seed, death camas, fireweed, dandelion, and aster, yarrow and golden rod in flower, fescue.
IC-4A	Island within community	Healthy and similar to 2009. 3 spruce, poplar, willow, soapberry in berry, dandelion in flower, goldenrod, foxtail.
IC-4B	Island within community	Considerable increase in growth since 2009. Aspen, willow with blotch miner, rose bushes with hips, aster in flower, gentian, languid lady, Jacob's ladder, bluejoint grass, fescue.

TABLE 5	**SUMMARY OF THE ISLANDS IN PLOT #3**	
Plot #	**Treatment**	**Comments and Species (common names) Observed**
IC-4C	Island within community	Increase in ground cover since 2009. Aspen, rose in hips, kinnikinnick, low bush cranberry, fireweed, aster, bedstraw, death camas, bluejoint grass, puffball mushrooms.
IC-4D	Island within community	Increased growth since 2009. 1 small aspen, rose with hips, highbush cranberry, kinnikinnick, soapberry, fireweed, aster, bedstraw, bromegrass, fescue.
IC-4E	Island within community	Considerable increase in ground cover. Aspen, willow (one large one dead), rose, kinnikinnick, soapberry, crepis, aster in flower, fireweed, bromegrass, fescue, bluejoint grass.

Five of the six willow crowns planted in plot WC-3 were alive with one crown supporting the growth of a spruce tree, shrubby cinquefoil and fireweed. None of the surrounding live-staked balsam poplars were growing. A second willow crown plot at this site, WC-4, contained two live willow crowns and the other willow crown had died since 2009. A live spruce and a small soapberry shrub were growing in the dead crown.

The poplar root cuttings showed no sign of life nor did the surrounding willow stakes.

The live trench staking fared better but mortality had increased since 2009. Four of the original 15 poplar stakes were alive (Photo #20) and three of the 15 willow stakes survived. Tansy mustard has notably invaded the plot of the dead willow stakes (Photo #21).

Survival rates have been calculated for all treatments in Table 6. The survival rate of all treatments has decreased with the exception of the transplanted islands.

Table 6:	**Plot 3 Survival Rates Near Hudgeon Lake Since 2008**	
Revegetation Method	**Percent Survival, 2009**	**Percent Survival, 2011**
Vegetative Islands	100	100
Live Staked Willows	0	0
Live Staked Poplar	16	0
Willow Crowns	100	78
Poplar Root Cuttings	0	0
Willow Trench Staking	93	20
Poplar Trench Staking	93	27

3.0 Discussion

Following three years since the trials were conducted, the 2011 assessment demonstrated that the revegetation method of using translocated islands is by far the most successful. It should be noted that there has been no human intervention since the treatments were installed in the autumn of 2008. Any success or failure of the plots is via natural causes.

Data from the weather station located on the waste rock dump at Clinton Creek indicated that the summers of 2010 and 2011 had similar rainfall amounts and patterns (Appendix E). The temperature followed a similar trend for both years (Appendix E). Moisture and growing days would definitely have been adequate for the survival and growth of vegetation since last assessed in 2009.

Table 7 summaries the average survival rate of each of the treatments when assessed in 2009 and in 2011. There continues to be 100% survival of the islands. The majority of the islands exhibited healthier and more robust growth in 2011, with an increase in biodiversity frequently a factor. It is likely that the seed bank in the transplanted soils has also contributed to the increased growth and diversity witnessed in the islands. There were a couple of islands that had changed very little since 2009, however no island was in a poorer condition than previously.

Table 7: Average Percent Survival Rates Per Method

Revegetation Method	Average % Survival Rate, 2009	Average % Survival Rate, 2011
Vegetative Islands	100	100
Willow Crowns	85	69
Poplar trench staking	95	31
Willow trench staking	58	16
Poplar root cuttings	2	2
Live Staked Poplar	9	0
Live Staked Willows	1	0

Overall, the trees transplanted with the islands appeared healthy although there were diseased individuals noted. Several of the poplars had galls, one aspen had leaf miner and two willows had blotch miner. The stress the larval stage of the respective insect may have on each individual tree is not known, however it could impact its general condition and ultimately its survival.

With the continued build up of leaf litter and decomposing dead plant material, it is hoped that the resulting soil will enable the islands to sustain themselves and spread.

The transplanting of willow crowns was the second successful treatment in 2011, replacing poplar trench staking. Although there was a 69% survival rate of willow crowns, down from 85% in 2009, the general health of most of the willow crowns was poor to moderate. The healthiest willow crowns were observed in Plot 1.

The trenched poplar stakes were next with an average survival of 31% followed by trenched willow stakes at 16%. This method was very successful when assessed in 2009. It is suspected that as each plant consumes the available nutrients it can acquire from the biomass of the stake (average length of 3m and diameter of 2 to 4 cm), it expires since there are insufficient nutrients present in the mineralized substrate of the waste rock.

Natural revegetation however is taking place in various locations within the waste rock dump with balsam poplar (*Populus balsamifera*) appearing to be the most well established tree species. However, small spruce have begun to appear as well but not in the same densities as the poplar. There is a distinct lack of forb related ground cover under the tree canopy and throughout the majority of the treeless areas. There are however, micro sites where forbs are beginning to establish in small numbers. A list of all the plants documented at the plots is provided in Appendix F.

4.0 Recommendations

Long term ongoing monitoring should continue with a minimum of two years between assessments. Coupled with the weather station data, this would allow any major changes due to climatic conditions to be recorded. As well as assessing the survival and general health of the plant communities, it is important to note if the island method encourages spreading and colonization of the immediate surrounding area.

Any future revegetation programs should include the transplanting of natural vegetation from the adjacent forest. The use of slash/brush piles is useful for helping to control erosion and providing micro sites for seeds.

5.0 References

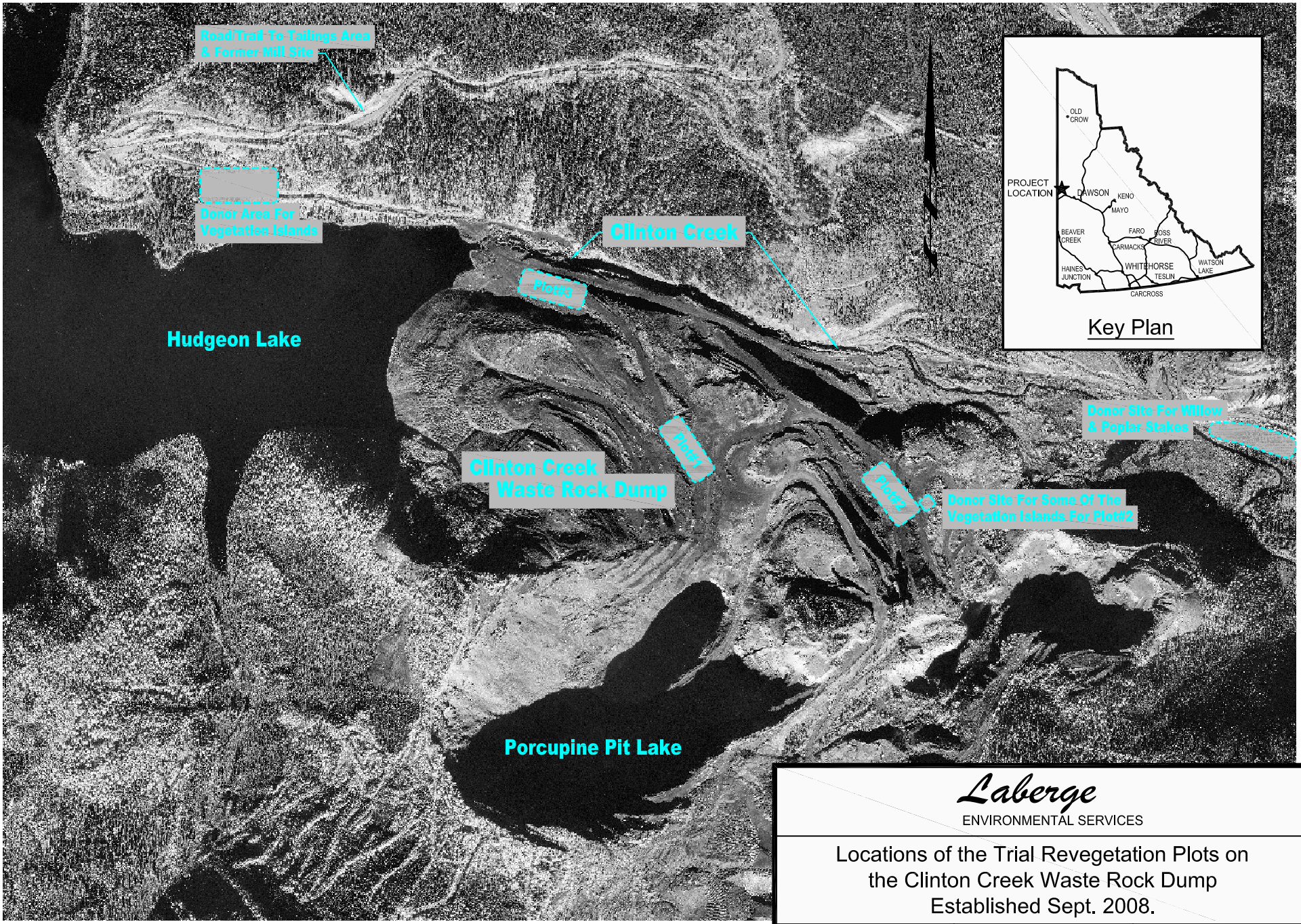
Han Construction Ltd. 2005. *Clinton Creek Mine Site Reclamation Report 2005 Dawson City, YT*. 13 pp

Laberge Environmental Services, 2009. *Clinton Creek Mine Waste Rock Dump Trial Revegetation Techniques, September 2008*, Prepared for Assessment and Abandoned Mines, EMR, Yukon Government, Whitehorse, Yukon.

Laberge Environmental Services, 2009*. Assessments of the Revegetation Options Conducted at the Waste Rock Dump at Clinton Creek, Year One*. Prepared for Assessment and Abandoned Mines, EMR, Yukon Government, Whitehorse, Yukon.

APPENDIX A

FIGURES



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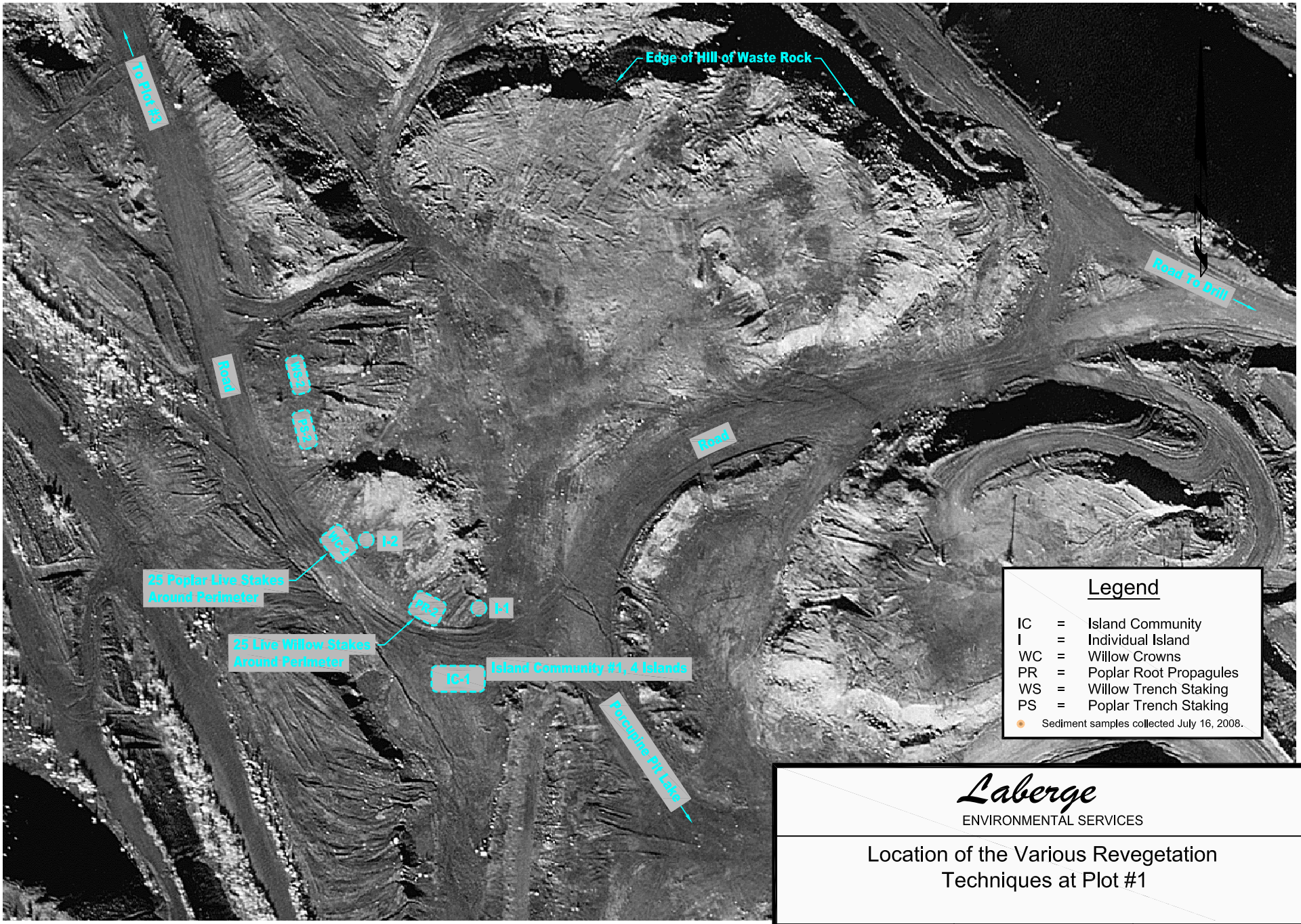
Locations of the Trial Revegetation Plots on the Clinton Creek Waste Rock Dump Established Sept. 2008.

Mar. 2, 2009	Scale: 1:10,000	Figure 1



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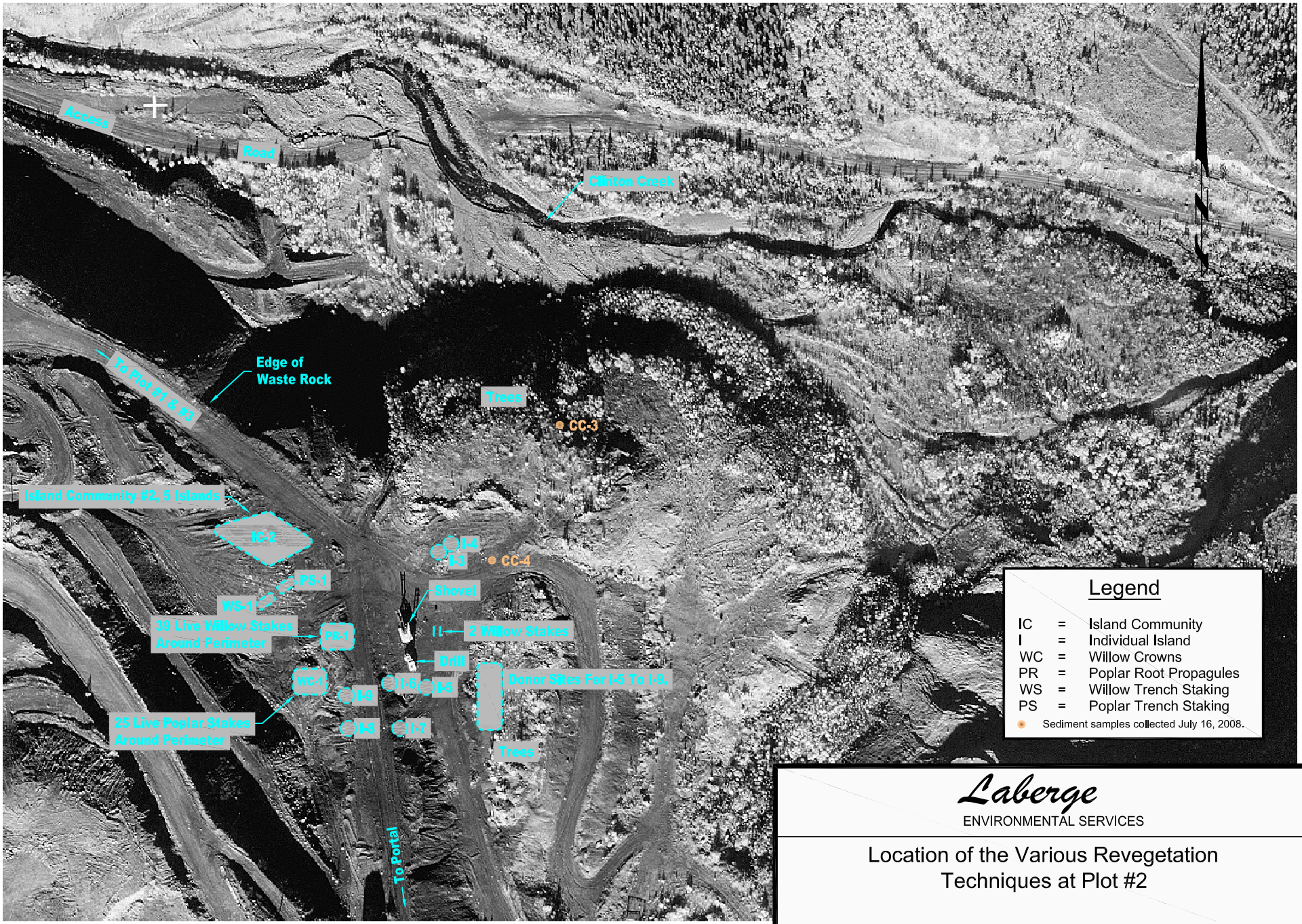
Location of the Various Revegetation Techniques at Plot #1

Mar. 2, 2009	Scale: 1:1,500	Figure 2



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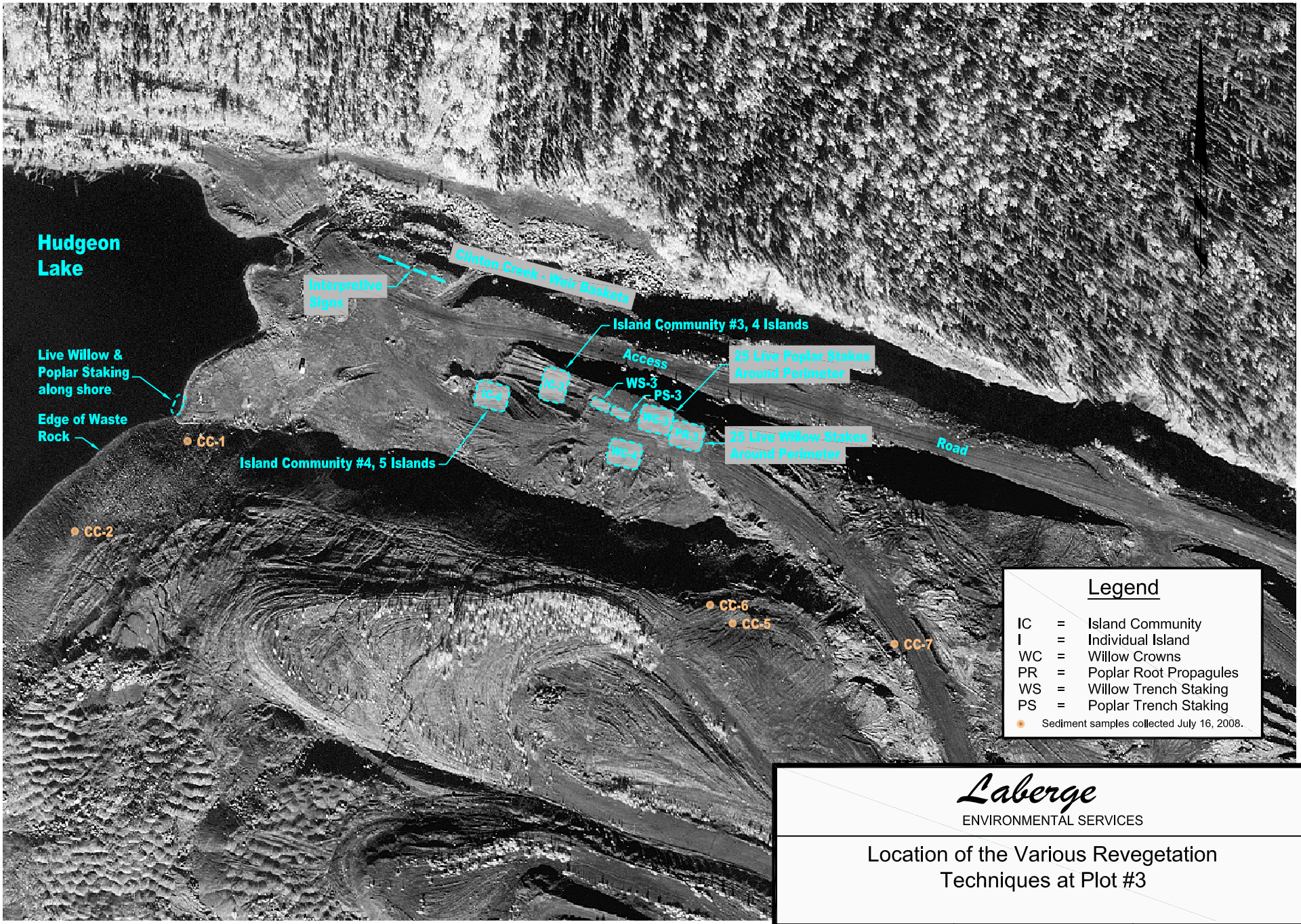
Location of the Various Revegetation Techniques at Plot #2

Mar. 2, 2009	Scale: 1:2,500	Figure 3



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Location of the Various Revegetation Techniques at Plot #3

Mar. 2, 2009	Scale: 1:2,500	Figure 4

APPENDIX B

TABLE OF LOCATIONS OF ALL PLOTS ON THE CLINTON CREEK WASTE ROCK DUMP

LOCATIONS OF ALL PLOTS ON THE CLINTON CREEK WASTE ROCK DUMP

PLOT #	PLOT DESCRIPTION	LATITUDE/LONGITUDE		DATE PLANTED
PLOT #1:	***Plots on Top***			
IC-1	Island community (4)	64° 24.891'	140° 43.235'	Sept 9, 2008
I-1	Individual island	64° 25.903'	140° 43.285'	Sept 9, 2008
I-2	Individual island	64° 25.913'	140° 43.327'	Sept 9, 2008
WC-2	Willow crowns (9)	64° 26.912'	140° 43.338'	Sept 10, 2008
PR-2	Poplar root propagules (16)	64° 26.902'	140° 43.305'	Sept 10, 2008
WS-2	Willow trenched stakes (15)	64° 26.939'	140° 43.352'	Sept 10, 2008
PS-2	Poplar trenched stakes (15)	64° 26.930'	140° 43.350'	Sept 10, 2008
--	Live willow stakes around perimeter of PR-2 (25)	64° 26.902'	140° 43.305'	Sept 11, 2008
--	Live poplar stakes around perimeter of WC-2 (25)	64° 26.912'	140° 43.338'	Sept 11, 2008
PLOT #2:	***Plots near Drill Site***			
IC-2	Island community (5)	64° 26.891'	140° 42.872'	Sept 9, 2008
I-3	Individual island	64° 26.891'	140° 42.771'	Sept 9, 2008
I-4	Individual island	64° 26.893'	140° 42.765'	Sept 9, 2008
I-5	Individual island	64° 25.856'	140° 42.779'	Sept 9, 2008
I-6	Individual island	64° 26.855'	140° 42.804'	Sept 9, 2008
I-7	Individual island	64° 26.844'	140° 42.796'	Sept 9, 2008
I-8	Individual island	64° 26.846'	140° 42.822'	Sept 9, 2008
I-9	Individual island	64° 26.853'	140° 42.826'	Sept 9, 2008
WC-1	Willow crowns (6)	64° 26.857'	140° 42.850'	Sept 10, 2008
PR-1	Poplar root propagules	64° 26.869'	140° 42.833'	Sept 10, 2008
WS-1	Willow trenched stakes (15)	64° 26.878'	140° 42.875'	Sept 10, 2008
PS-1	Poplar trenched stakes (15)	64° 26.822'	140° 42.863'	Sept 10, 2008
--	Live willow stakes around perimeter of PR-1 (25)	64° 26.869'	140° 42.833'	Sept 11, 2008
--	Live poplar stakes around perimeter of WC-1 (25)	64° 26.857'	140° 42.850'	Sept 11, 2008
PLOT #3:	***Plots near Hudgeon Lake***			
IC-3	Island community (4)	64° 27.094'	140° 43.664'	Sept 9, 2008
IC-4	Island community (5)	64° 27.091'	140° 43.701'	Sept 9, 2008
WC-3	Willow crowns (6)	64° 27.064'	140° 43.603'	Sept 10, 2008
WC-4	Willow crowns (3)	64° 27.076'	140° 43.619'	Sept 10, 2008
PR-3	Poplar root propagules	64° 27.080'	140° 43.585'	Sept 10, 2008
WS-3	Willow trenched stakes (15)	64° 27.039'	140° 43.631'	Sept 10, 2008
PS-3	Poplar trenched stakes (15)	64° 27.037'	140° 43.624'	Sept 10, 2008

APPENDIX C

DESCIPTION OF THE METHODS USED AT CLINTON CREEK

(taken from Laberge Environmental Services, 2009)

2.0 METHODS

A Caterpillar 320 tracked excavator equipped with a finishing bucket was used to remove vegetation islands and provide appropriate excavations for transplanting. All vegetation used on these plots was dormant when planted in September 2008. The vegetation islands and root stock were transported from the donor sites to the planting locations using both a pickup truck and small trailer. Live stakes were hand cut and trimmed to appropriate lengths (one to two metres) depending on whether the staking was installed vertically or in trenches. Following transplanting, each plot was watered with approximately 200 litres of lake water using an ATV transported water tank and transfer pump. Watering appeared to provide adequate soil to root/stem contact following soil placement.

2.1 Donor areas

Donor areas were chosen based on vegetation availability, quality, species mix, soil substrate and proximity to the transplanting sites. Vegetation islands were primarily obtained from the northwest side of Clinton Creek along the upslope side of the road shoulders leading to the tailings area. The upslope road shoulder was chosen as opposed to the down slope roadside to minimize future potential road bed/shoulder runoff erosion. Live staking material was selected, hand cut and collected along the mine access road.

2.2 Vegetation Islands

Vegetation island dimensions were approximately 1.5 meters square by 0.5 meters thick depending on substrate material cohesiveness and the success of removal and placement with the bucket. Vegetation islands were transplanted into individual plots as well as grouped together to form communities of four to five islands. Vegetation island communities were created with the intent of determining whether these communities may have a synergistic effect on the ability to survive and propagate.

Individual vegetation islands consisted of a variety of small trees, shrubs, forbs, grasses and moss. Shrub species included kinnikinnick (*Arctostaphylos uva-ursi*), soapberry (*Shepherdia canadensis*), wild rose (*Rosa acicularis*), and shrubby cinquefoil (*Potentilla fruticosa*). Forbs included fireweed (*Epilobium angustifolium*), dandelion (*Taraxacum officinale*) and various other native species. Willow (*Salix spp*.), spruce (*Picea spp.*), poplar (*Populus spp.*) and birch (*Betula papyrifera*) seedlings in varying species densities were the dominant tree species. Grasses and moss were also present in varying densities. Individual species densities were not tallied.

2.3 Root Propagule and Live Stake Test Plots

Five meter square test plots were demarcated, mechanically scarified and excavated for transplanting willow crowns and poplar bare root cuttings. Each five meter by five meter plot had either willow crowns (root wads) or bare balsam poplar root cuttings planted approximately 25-35 cm below surface. Live stakes approximately one meter long were then hand planted using planting dibbles around the periphery of each plot and trimmed to approximately 15-20 cm above the surface. Heavy compaction and the presence of

large subsurface rocks and other debris in areas outside the scarified areas made live staking difficult by hand or often impossible. Therefore live stakes were planted in the scarified soil. Willow plots received poplar live stakes and poplar plots received willow stakes. This planting method will simplify future determination of the particular planting method without confusing species and planting method.

2.4 Trench style live staking

Trench excavations approximately two to three meters long by 0.5 meter deep sloping to ground level were created to transplant two meter long willow and poplar stems. This method was implemented to determine the success of using a more mechanized transplanting procedure, thereby expediting the transplanting process. This is compared to individual hand live staking which is time consuming if instituted on a large scale and proved difficult due to physical limitations such as soil compaction and large rock fragments.

2.5 Live staking along Shoreline

A combination of willow and poplar live stakes was hand-planted near the base of the waste rock pile and lakeshore where an erosion gully had begun to form. Live stakes were approximately one meter long and inserted fairly easily into the fine sediments leaving 15 to 20 cm of each stake above ground level. This trial was initiated to determine the survivability of live stakes in a more moist soil condition. It is intended that the growth of these live stakes will provide added soil stability and reduce future erosion in this specific area.

APPENDIX D

PHOTOGRAPHS, JULY 26TH, 2011

Photo #1; There is no survival of the live staking at Hudgeon Lake, however volunteer dandelion, birch and spruce are colonizing the riparian area.

Photo # 2; Plot I-2 on July 21, 2009.

Photo #3; Plot I-2 on July 26, 2011. Note the increased growth of the aspen and undergrowth.

Photo #4; Plot IC-1B on July 21, 2009.

Photo #5; Plot IC-1B on July 26, 2011. Note the robust growth of the soapberry bush plus the introduction of yarrow plants.

Photo #6; The spruce tree in plot I-1 had produced a cone, July 26, 2011.

Photo #7; Minimal growth at IC-2B, July ’09

Photo #8; Increased growth of vegetation at IC-2B. Note spreading of dandelion and foxtail beyond island perimeter, July 26, 2011.

Photo #9; Minimal growth at I-3, July 21, 2009.

Photo #10; Considerable increase in ground cover at I-3 on July 26, 2011.

Photo #11; Minimal growth at I-4, July 21, 2009.

Photo #12; Considerable increase in growth and biodiversity at I-4 on July 26, 2011.

Photo #13; A large and expanding patch largely composed of Tansy mustard (*Descurainia sp*.) naturally colonizing the area upslope of the island community IC-2 at Plot #2.

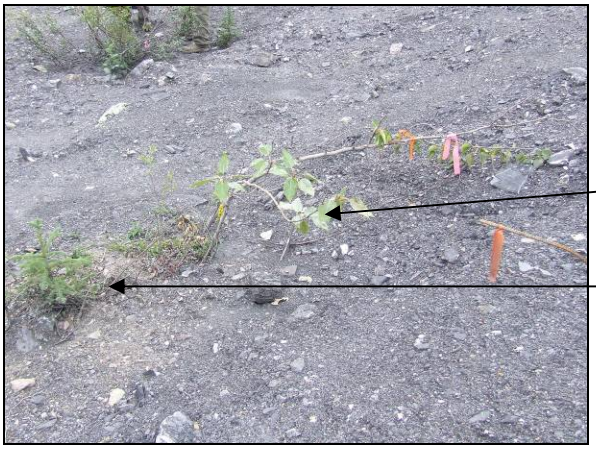


Photo #14; Plot IC-3A on July 21, 2009.

Photo #15; Increased growth on Plot IC-3A on July 26, 2011, with some spreading of dandelion and grass. Note the increased growth of the spruce tree and the straightening of the poplar.

Photo #16; Plot IC-4B on July 21, 2009.

Photo #17; Substantial increase in growth on Plot IC-4B on July 26, 2011 with some spreading of dandelion in the foreground.

Photo #18; When the islands were transplanted in Sept 2008, the area was previously worked up resulting in an absence of growth.

Photo #19; All the plants visible outside of the islands in community IC-4 have colonized naturally since September 2008. Photo taken July 2

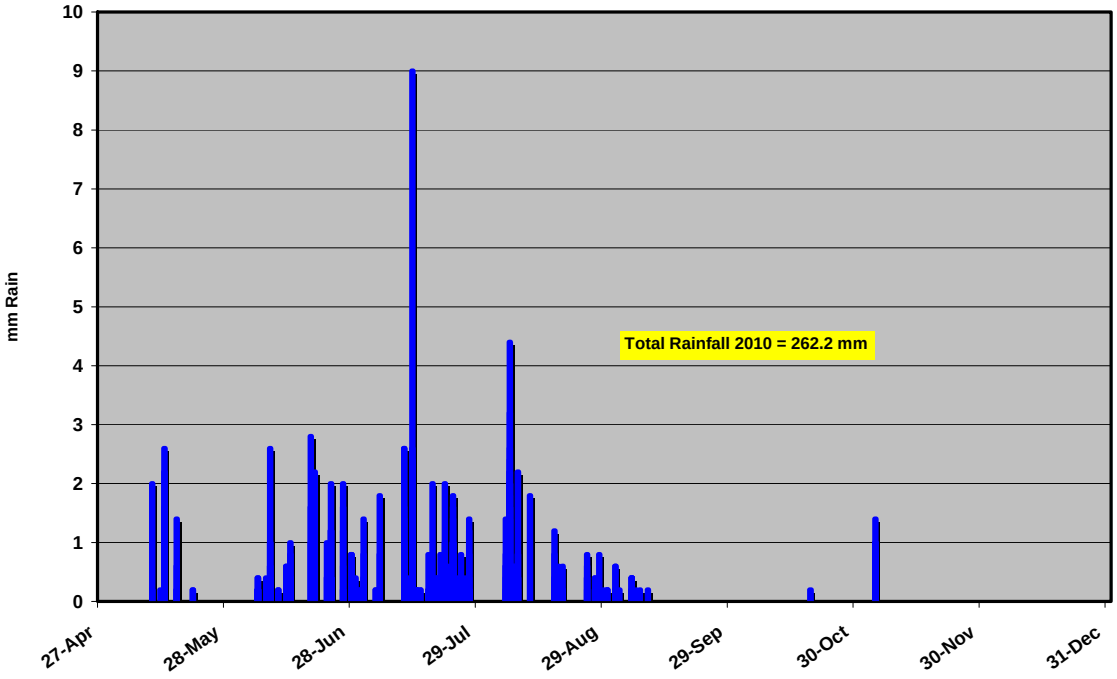
Photo #20; Some survival of the poplar trenched stakes, Plot PS-3. Invasion of tansy mustard in some of the plot, July 26, 2011.

Photo #21; Some survival of the willow trenched stakes, Plot WS-3, on July 26, 2011. Prolific growth of tansy mustard and some foxtail within the plot.

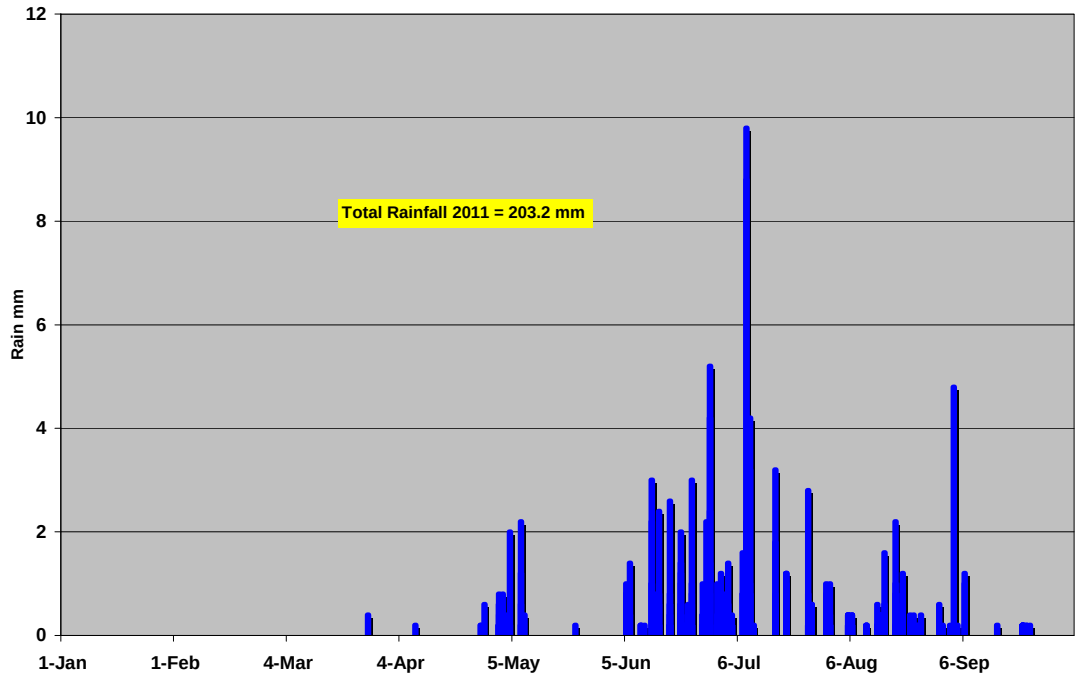
APPENDIX E

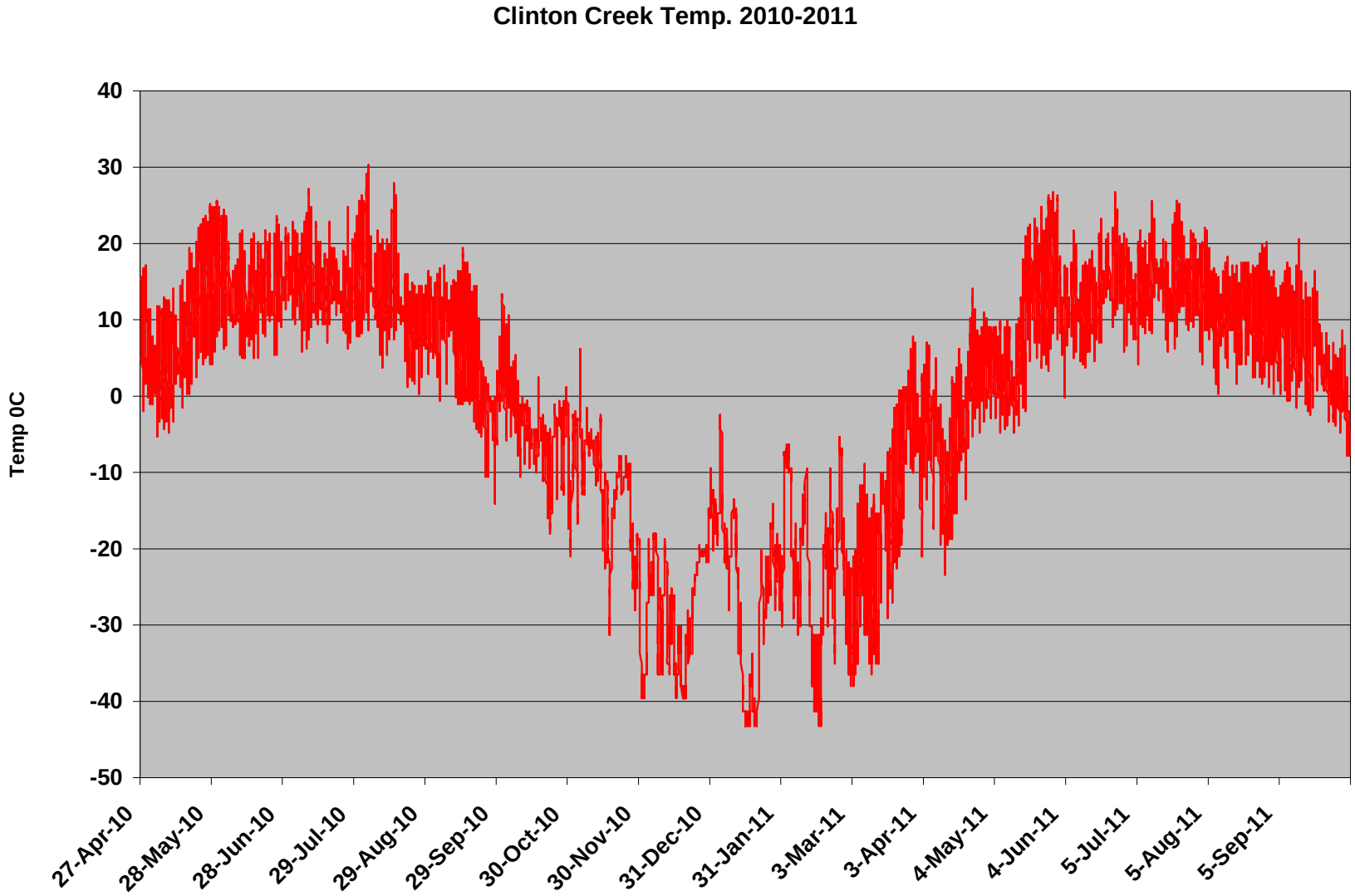
RAINFALL AND TEMPERATURE

Clinton Creek Rainfall 2010



Clinton Creek Rainfall 2011




Clinton Creek Temp. 2010-2011
Temp 0C
40
30
20
10
0
-10
-20
-30
-40
-50
27-Apr-10
28-May-10
28-Jun-10
29-Jul-10
29-Aug-10
29-Sep-10
30-Oct-10
30-Nov-10
31-Dec-10
31-Jan-11
3-Mar-11
3-Apr-11
4-May-11
4-Jun-11
5-Jul-11
5-Aug-11
5-Sep-11

APPENDIX F

LIST OF ALL PLANTS USED AND IDENTIFIED

AT ALL OF THE PLOTS

LIST OF PLANTS DOCUMENTED AT THE PLOTS

Common Name	Scientific Name
White Spruce	*Picea glauca*
Balsam Poplar	*Populus balsamifera*
Aspen	*Populus tremuloides*
Willow	*Salix spp*
Soapberry	*Shepherdia canadensis*
Rose	*Rosa acicularis*
Shrubby cinquefoil	*Potentilla fruticosa*
Low bush cranberry	*Vaccinium vitis-idaea*
High bush cranberry	*Viburnum opulus*
Kinnikinnick	*Arctostaphylos uva-ursi*
Twinflower	*Linnaea borealis*
Death camas	*Zygadenus elegans*
Tansy mustard	*Descurainia sophia*
Vetch	*Astragalus sp*
Clover	*Trifolium hybridum*
Fireweed	*Epilobium angustifolium*
Dandelion	*Taraxacum officinale*
Yarrow	*Achillea millefolium* and *Achillea sibirica*
Fleabane	*Erigeron acris*
Aster	*Aster sibiricus*
Goldenrod	*Solidago sp*
Gentian	*Gentianella amarella*
Languid lady	*Mertensia paniculata*
Plantain	*Plantago major*
Bedstraw	*Galium boreale*
Jacob’s ladder	*Polemonium pulcherrimum*
Hawk’s beard	*Crepis tectorum*
Crepis	*Crepis nana*
Foxtail	*Hordeum jubatum*
Bluejoint grass	*Calamagrostis canadensis*
Bromegrass	*Bromus sp*
Fescue	*Festuca sp*
Wheatgrass	*Agropyron sp*