HAT CREEK PROJECT

1979 RECLAMATION REPORT

Contents

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1 Introduction

Land disturbances at Hat Creek have occurred as a result of exploration drilling, access road development and from the excavation of three test trenches (see Figure 2-1). The present drilling program was initiated in 1974 and continued until 1979 while the excavation of the test trenches occurred during 1977.

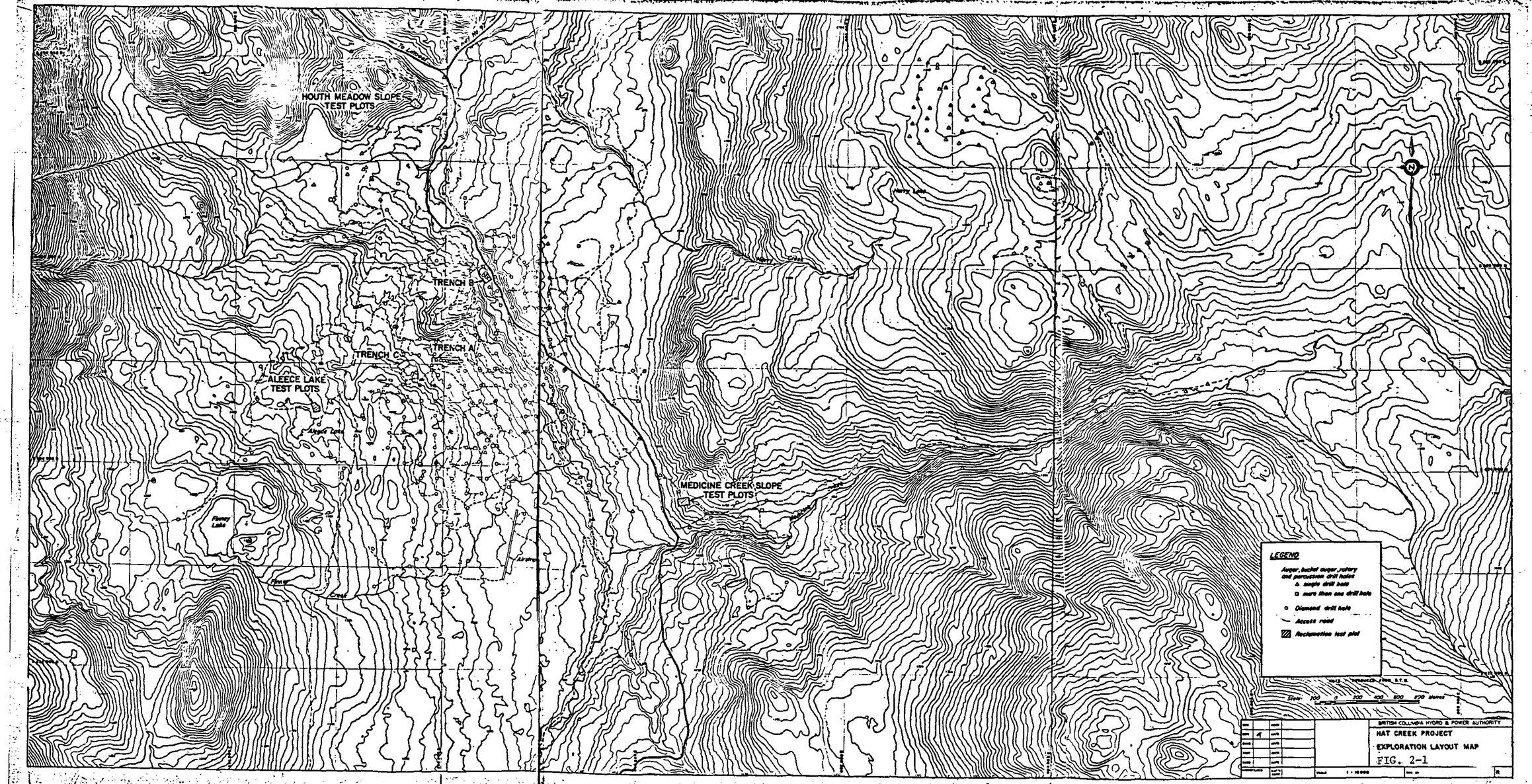
Reclamation of these disturbances has been the subject of an ongoing program since 1974. At present the program is comprised of four primary aspects, namely:

i) Test plots to evaluate a wide variety of vegetation species potentially useful at Hat Creek in combination with the various waste materials expected from mine and powerplant. The effect of a thin capping of topsoil is also being investigated. Eight plots of waste materials have been set out near Aleece Lake and seeded with three different seed mixes, each comprised of four different species.

ii) Slope test plots were established at Houth Meadows and Medicine Creek to determine the revegetation potential of slopes of different steepness, i.e. 22°, 26° and 30°.

iii) The 1977 Bulk Sample waste dumps at Trenches A, B and C have been seeded and are being used to gain data on different seeding methods, surface treatments and maintenance fertilizer requirements.

iv) Drill sites have been progressively reclaimed; this aspect was completed in the fall of 1978.


HOUTH MEADOW SLOPE TEST PLOTS
TRENCH B
TRENCH A
TRENCH C
ALEECE LAKE TEST PLOTS
MEDICINE CREEK SLOPE TEST PLOTS
Horse Lake
Finney Lake
Finney Creek
LEGEND
Auger, bucket auger, rotary and percussion drill holes
single drill hole
more than one drill hole
Diamond drill hole
Access road
Reclamation test plot
Scale: 100 0 200 400 600 800 1000 Metres
BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT
EXPLORATION LAYOUT MAP
FIG. 2-1

This report provides the results of soils sampling and analysis, fertilizer applications and surveys to assess the progress of reclamation at Hat Creek which were carried out during 1979.

2 Soils Analyses and Fertilizer Additions

2.1 Introduction

During the 1977 Bulk Sample Program, soils analyses of all waste materials were taken and the results used to devise suitable fertilizers for addition during initial seeding. Soils were again sampled and analyzed during April 1978, at Aleece Lake, Houth Meadows and the slope test plots at Medicine Creek. Based on the analytical results maintenance fertilizer additions were made to the Aleece Lake test plots. In March 1979, all waste materials being revegetated at Hat Creek were sampled and a large number of analyses run to further characterize their soils properties. Maintenance fertilizer additions were made to all areas and a 5-year program was initiated to determine long-term fertilizer requirements on waste materials at Trench A (baked clay and gritstone), Trench B (gravel), Trench C (bentonitic clay) and Houth Meadows (colluvium). A detailed assessment of all soils data has been undertaken to describe the waste materials and relate the soils properties to the results of revegetation trials.

2.2 Methods

All samples were taken as before: the soil was first loosened to a depth of approximately 15 - 20 cm with a shovel blade and sampled along the untouched surface with a heavy plastic scoop. At least four samples were taken from each soil material, composited, thoroughly mixed and placed in plastic bags for shipping to the Soil Testing Laboratory of the B.C. Department of Agriculture (BCDA) in Kelowna, B.C.

Following standard soil analyses the samples were sent to the Ministry of the Environment laboratory in Kelowna for further analyses.

Results of all tests on Hat Creek soils taken in 1977, 1978 and 1979 are shown on Table 2-1. The report from the BCDA laboratory in Kelowna recommended nutrient and soil amendments, based on the soils tests, to be applied for good growth of a grass and legume crop (see Table 2-2).

Fertilizer was applied to all the Aleece Lake plots, the slope test plots, the 3160 dump and coaly waste pile at Trench A and the topsoil and subsoil piles at Trench B. In addition to the fertilizer additions shown in Table 2, the following three areas at Trench A received applications of lime at the rate of 2242 kg/ha: a 15m x 15m plot on the coaly waste dump and plots of 23m x 10m and 35m x 20m on the non-topsoiled portion of the 3160 dump.

The remaining areas, the 3140 (baked clay) and 3120 (gritstone) dumps at Trench A, the large gravel dump at Trench B, the colluvium parent material at the Houth Meadows test area and the bentonitic clay dumps at Trench C, are being used to study the length of time that maintenance fertilizer must be applied for the establishment of self-sustaining vegetation. These latter waste materials have been divided into five sections of approximately equal area, as shown in Figures 2-2, 2-3, 2-4 and 2-5. In 1979 at each location only segments numbered 1 were not fertilized. In 1980 segments numbered 1 and 2 would not be fertilized and in 1981 segments 1, 2 and 3. This system would be continued and a detailed evaluation of revegetation success would be undertaken in 1984.

Fertilizer and soil amendment additions were made using both cyclone spreaders and a tractor mounted distributor. Applications were made during the w ek of 14 May 1979.

BSR-13B-2 ? loamy

TABLE 2-1 ~~RESULTS OF HAT CREEK SOILS~~ ANALYSES OF WASTE MATERIALS

SURFICIAL SOILS

	TOPSOIL					COLLUVIUM				
Location	Trench A	Trench A	Trench B	Trench B	Houth Mead.	Trench A	Aleece Lake	Aleece Lake	Houth Mead.	Houth Mead.
Sample Date	Jul 77	Mar 79	Jul 77	Mar 79	Apr 78	Jul 77	Apr 78	Mar 79	Apr 78	Mar 79
Texture <2.00mm %	73 (4)	75 (5)	94 (4)	85.8 (4)		61.4 (4)		67.8 (2)		66.1 (5)
CSSS Tex Class (5)	CL	CL	[illegible]	SiL		SCL		CL		Loam
% Sand (2)	31.9	26.33	42.5	21.38		47.8		28.91		46.05
% Silt (2)	39.2	34.9	35.	52.82		120.8		36.22		37.44
% Clay (2)	28.9	38.77	22.5	25.80		31.6		34.87		16.51
BCDA Tex-Feel (1)	3	4	3	4	3	5	4	5	5	5
Organic Matter (%) (1)	7.0	8.3	3.9 (1)	3.7	3.6	0.6	3.0	4.7	1.1	1.1
pH (units) 1:2 Soil/Water	7.4 (1)	7. (1)(2)	7.7 (1)	8. (1)(2)	8.3 (1)	8.7 (1)	7.6 (1)	7.7 (1)(2)	8.6 (1)	8.5 (1)(2)
1:1 Soil/Water	7.45 (2)		7.87 (2)			8.4 (2)				
1:2 Soil/CaCl2	7.13 (2)		7.35 (2)			8.4 (2)				
Sat. Extr.						7.8 (3)				
Conductivity (1)	.6	.82	.4	.28	.34	6.00	3.50	3.10	.32	.26
mmhos/cm (2)	1.39	1.95	.83	.48		10.3		3.62		.68
Saturated Extract. (3)						9.2				
Available Nutrients (1) NO_3 - N (lb/2x10^6 lb)	15	55	36	13	9	31	19	5	4	2
P	40	17	29	43	89	7	56	74	5	5
K	939	706	493	503	474	216	563	518	223	247
Ca ~~meq/100gm~~	10000+	10000+	9795	10000+	10000+	9927	10000+	10000+	9117	9161
Mg	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+
Na ppm		49		39	30		140	109	20	24
S Sulphate ppm	30+	30+	13.4	20.2	2.9	30+	30+	30+	2.3	30+
B H_2O curcumin-oxalic ppm		.56		.37	.46		.30	1.34	.38	.26
Cation Exchange (2)(3)(5) C.E.C. meq/100g	40.79	46.89	29.24	31.03		9.37		37.58		9.67
% Base Sat.	100+	100+	100	100+		100+		100+		100+
Σ Bases. meq/100g	53.05	55.54	38.73	38.24		46.12		55.56		21.99
Ca meq/100g	37.50	42.93	30.36	30.68		32.71		41.96		18.35
Mg meq/100g	13.31	11.05	7.25	6.57		11.84		12.43		3.24
Na meq/100g	.27	0.36	.34	0.28		1.29		0.19		.11
K meq/100g	1.97	1.20	.78	71		0.28		0.98		.29
Exchangeable Sodium %	0.7	0.768	1.2	0.902		13.8		0.506		1.14
Dissolved Anions & Cations (2)(3)(5) HCO_3^- meq/100g		nc		nc		33x10^-3		nc		nc
meq/litre		1.8		2.7				4.07		2.0
$CO_3^=$ meq/100g		nc		nc				nc		.1
meq/litre		0		0				0		
Cl^- meq/100g	.020		.019			.077		nc		
meq/litre		1.3		0.76				4.7		1.03
meq/100g						0.19				
SO_4 meq/100g						3.6				
sat. ext. meq/litre		30.0		0.6						11.8
1:5 s/w ext meq/litre (2)								17.9		
B meq/100g	nc		nc			2.7x10^-4				
ppm	.44		.6			1.91				
Ca meq/100g		1.21		0.23		.042		1.64		0.114
meq/litre		16.97		3.54		2.15		31.49		3.74
ppm		340		71				611		75
Mg meq/100g		0.45		0.07		1.83		1.39		0.078
meq/litre		6.34		1.15		94.65		23.05		2.55
ppm		77		14				280		31
Na meq/100g		0.01		0.05		0.58		0.45		0.034
meq/litre		1.39		.78		29.21		7.39		1.13
ppm		32		18				170		26
K meq/100g		.04		0.02		.009		0.06		.01
meq/litre		.59		.28		nc		1.02		.31
ppm		23		11				40		12
Sodium Adsorption Ratio (5)		.41		.51		4.20		1.43		0.64
Water Content at Saturation (2) Wt % g H2O / g soil(dry)		71.48		63.66				60.46		30.47

SURFICIAL SOILS (continued)

	TILL			GRAVELS							
Location	Med. Crk.	Med. Crk.	Med. Crk.	Aleece Lake (Glacial)	Aleece Lake (Glacial)	Aleece Lake (Glacial)	Trench B (recent)	Trench B (recent)	Trench B (recent)	Houth Meadow (recent)	Houth Meadow (recent)
Sample Date	Jul 77	Apr 78	Mar 79	Jul 77	Apr 78	Mar 79	Jul 77	Apr 78	Mar 79	Apr 78	Mar 79
Texture <2.00mm %	58.7 (4)		57 (2)	32.9 (4)		35.1 (5)	22.1 (4)		42.1 (5)		46 (5)
CSSS Tex Class (5)	Loam		SCL	SiL		SCL	SL		SL		Loam
% Sand (2)	49.4		46.79	31.7		52.13	74.7		60.09		39.84
% Silt (2)	28.7		27.18	60.9		26.23	19.2		27.22		45.50
% Clay (2)	21.9		26.03	7.4		21.64	6.1		12.69		14.66
BCDA Tex-Feel (1)	5	4	5	2	4	2	1		2	2	2
Organic Matter (%) (1)	1.2	1.6	1.9	1.7	2.0	2.4	.9		2.6	2.5	1.5 (1)
pH (units) 1:2 Soil/Water	8.2 (1)	8.4 (1)	. (1)(2)	8.0 (1)	8.3 (1)	8.3 (1)(2)	8.1 (1)		7. (1)(2)	7.7 (1)	8.0 (1)(2)
1:1 Soil/Water	8.25 (2)			8.06 (2)			8.28				
1:2 Soil/CaCl2	7.63 (2)			7.66 (2)			7.68				
Sat. Extr.	7.5 (3)			7.3 (3)			8.1 (3)				
Conductivity (1)	.32	0.44	.26	.48	.56	.30	.24		.26	.74	.24
mmhos/cm (2)	<1.0		.42	1.61		.62	.76				.78
Saturated Extract. (3)	.605			.952			.412				
Available Nutrients (1) NO_3 - N (lb/2x10^6 lb)	2	26	6	5	47	8	4		2	33	7
P	10	101	10+	11	71	100	17		32	113	104
K	366	552	537	378	452	465	195		319	247	324
Ca	8221	10000+	10000+	8926	1000+	9801	5344		6566	8207	9051
Mg	1000+	1000+	633	1000+	1000+	1000+	655		749	958	1000+
Na ppm		20	6		50	34			38	40	33
S Sulphate ppm	19.4	5.3	30+	30+	5	30+	10.[illegible]		14.1	30+	26.4
B H_2O curcumin-oxalic ppm		.53	.20		.38	.86			.49	.2>	.2
Cation Exchange C.E.C. meq/100g	13.04		9.18	16.38		21.83	11.14		15.7		17.9
% Base Sat.	100+		100+	100+		100+	100+		100+		100+
Σ Bases. meq/100g	25.98		7.11	32.62		32.79	15.43		19.87		23.20
Ca meq/100g	20.40		3.75	25.64		25.94	12.22		16.39		19.35
Mg meq/100g	4.93		2.54	6.09		5.99	2.70		2.97		3.31
Na meq/100g	.23		0.05	.35		0.10	.23		.18		.16
K meq/100g	.42		.77	.54		.76	.28		.33		.38
Exchangeable Sodium %	1.8		0.26	2.1		0.458	2.1		1.1		0.9
Dissolved HCO_3^- meq/100g	75.6x10^-3		nc	nd		nc			nc		nc
meq/litre			2.3			2.5			2.6		2.0
$CO_3^=$ meq/100g	0		0	nd					nd		0
meq/litre	0		0			0					
Cl^- meq/100g	0.016			.015		nc	.007		nc		
meq/litre			.9			2.13			.76		.94
meq/100g	.01			.009			.005				
SO_4 meq/100g	.54			.26			.009				
sat. ext. meq/litre			.40			2.0					1.2
1:5 s/w ext meq/litre (2)									.9		
B meq/100g	3.9x10^-4			1.5x10^-4			7.2x10^-4				
ppm	.14			.12			.26				
Ca meq/100g	.117		.145	.163		0.14	.060		.13		.09
meq/litre	3.87		3.34	6.19		3.19	2.2		5.29		3.24
ppm			672			64			106		65
Mg meq/100g	.059		.029	.106		0.062	.022		.05		.03
meq/litre	1.96		.66	3.91		1.40	1.03		2.06		1.07
ppm			8			17			25		13
Na meq/100g	.038		.0095	.067		0.0899	.015		.025		.03
meq/litre	1.25		.22	1.71		2.04	.7		1.04		1.22
ppm			5			47			24		28
K meq/100g	.005		.018	.003		.017	.002		.09		.005
meq/litre	nc		.41	nc		.38	nc		.36		.18
ppm			16			15			14		7
Sodium Adsorption Ratio (5)	0.73		.16	0.76		1.35	0.55		.54		0.83
Water Content at Saturation (2)			.37			44.06			24.33		28.60

SURFICIAL SOILS (continued) / NON-SEAM WASTE

	BAKED CLAY				BENTONITIC CLAY				GRITSTONE (sandstone, claystone)			
Location	Trench A	Aleece Lake (3140')	Aleece Lake	Aleece Lake	Trench A	Trench C	Aleece Lake	Aleece Lake	Trench A	Trench A	Aleece Lake	Aleece Lake
Sample Date	Mar 79	Jul 77	Apr 78	Mar 79	Jul 77	Mar 79	Apr 78	Mar 79	Jul 77	Mar 79	Apr 78	Mar 79
Texture <2.00mm %	51.4 (5)	55.4 (4)		50.7 (5)		73.1 (2)		60.8 (2)	96.2 (4)	62.5 (2)		91.2 (2)
CSSS Tex Class (5)	SL	SL		SCL	Clay	Clay		Clay	Loam	CL		SiCL
% Sand (2)	54.40	49.9		54.01	21.9	22.78		22.46	43.5	26.85		17.37
% Silt (2)	26.25	43.9		25.87	33.7	29.24		29.62	33.0	39.56		45.77
% Clay (2)	19.35	6.2		20.12	44.4	47.98		47.92	23.5	33.59		35.86
BCDA Tex-Feel (1)	2	2	2	4	5	5	4	5	5	5	5	5
Organic Matter (%) (1)	0.1	.8	.7	1.0	0.9	1.2	0.7	1.3	0.5	2.8	2.3	2.0
pH (units) 1:2 Soil/Water	7.2 (1)	7.6 (1)	8.0 (1)	8. (1)(2)	7.4 (1)	7. (1)(2)	8. (1)	7. (1)(2)	8.4 (1)	7. (1)(2)	8.1 (1)	8. (1)(2)
1:1 Soil/Water	7.2 (2)	7.7 (2)			7.40 (2)				8.28 (2)			
1:2 Soil/CaCl2		7.5 (2)			7.44 (2)				7.48 (2)			
Sat. Extr.		7.7 (3)			7.9 (3)				8.1 (3)			
Conductivity (1)	.26	3.3	.9	.58	8.6 -	4.0	3.8	3.5	3.00	3.15	1.30	3.00
mmhos/cm (2)	.40	3.68		1.63	3.43	5.15		2.53	4.68	3.96		3.43
Saturated Extract. (3)		3.42			2.79				2.81			
Available Nutrients (1) NO_3 - N (lb/2x10^6 lb)	15	2	3	20	5	67	7	55	1	33	35	160
P	95	32	44	56	10	86	47	[illegible]	22	86	80	26
K	1000+	801	724	678	982	886	776	966	542	613	753	697
Ca	4755	9370	8927	8562	9059	8717	10000+	10000+	3593	4383	5153	4855
Mg	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+
Na ppm	94		150	141		2050	2050	2200		685	980	845 -
S Sulphate ppm	30+	30+	30+	30+	30+	30+	30+	30+	30+	30+	30+	30+
B H_2O curcumin-oxalic ppm	.49		>.2	1.0		.66	.76	.24		.36	1.15	0.11
Cation Exchange C.E.C. meq/100g	38.77	33.57		35.5	45.40	47.34		47.20	21.1	30.00		33.49
% Base Sat.	75.3	100+		100+	100+	77.7		83.9	100+	79.7		84.4
Σ Bases. meq/100g	29.20	48.40		40.72	56.35	36.77		39.61	21.74	23.91		28.61
Ca meq/100g	19.06	30.82		31.34	28.10	21.00		29.41	9.41	13.80		15.70
Mg meq/100g	7.326	13.92		7.61	13.92	11.32		5.98	8.82	9.07		12.11
Na meq/100g	0.602	1.87		0.53	12.67	3.28		-2 .80	2.40	[illegible].73		[illegible].91
K meq/100g	2.21	1.79		1.24	1.66	1.17		1.22	1.11	1.06		1.26
Exchangeable Sodium %	1.6	5.6		1.5	27.9	6.9		?	11.4	?		?
Dissolved HCO_3^- meq/100g	nc	18.1x10^-3		nc	nd				nd	nc		nc
meq/litre	1.1	nc		1.6		nd		1.1		2.3		2.4
$CO_3^=$ meq/100g		nd			nd				nd	nc		nc
meq/litre	0			.3		nd		0		0.3		0.1
Cl^- meq/100g		.24			nd				.005	nc		nc
meq/litre	.63			2.24		nd		2.1		1.03		.90
meq/100g		.01			.11				.013			
SO_4 meq/100g		1.3			4.6	nc		nc	1.6	nc		nc
sat. ext. meq/litre	4.0											21.2
1:5 s/w ext meq/litre (2)				4.5		0.9		15.6		5.1		
B meq/100g		<4.4x10^-4			670x10^-4				<7.2x10^-4			
ppm		.38			.25				.14			
Ca meq/100g	0.105	.798		.53	.797	1.54		0.87	.474	.575		0.56
meq/litre	1.95	25.25		10.18	5.79	8.73		4.79	9.18	8.68		5.69
ppm	39			204		175		96		174		114
Mg meq/100g	0.044	.463		.24	.538	.93		0.33	.366	0.507		0.382
meq/litre	.82	14.65		4.69	3.91	5.27		1.81	7.10	7.65		4.77
ppm	10			57		64		22		93		58
Na meq/100g	0.068	.31		0.20	.30	8.13		3.71	.90	1.64		1.88
meq/litre	1.26	9.78		3.87	21.52	46.09		20.43	17.59	24.70		25.[illegible]
ppm	29			89		1060		470		570		540
K meq/100g	.02	.018		.03	.11	.36		.13	.059	0.11		0.127
meq/litre	.33	nc		.49	nc	2.02		.74	nc	1.66		1.46
ppm	13			19		79		29		65		57
Sodium Adsorption Ratio (5)	1.07	2.19		1.42	9.77	17.42		11.25	6.10	8.67		10.27
Water Content at Saturation (2)	53.69			51.72		176.36		181.46		66.24		80.14

SEAM WASTE / ANTHROPOGENIC

	CARBONACEOUS SHALE				COAL WASTE				FLY ASH		
Location	Trench A	Aleece Lake	Aleece Lake	Aleece Lake	Trench A	Aleece Lake	Aleece Lake	Aleece Lake	Aleece Lake	Aleece Lake	Aleece Lake
Sample Date	Mar 79	Jul 77	Apr 78	Mar 79		Jul 77	Apr 78	Mar 79	Jul 77	Apr 78	Mar 79
Texture <2.00mm %	82.2 (5)	~~81.6~~ (4)		89.5 (5)	67.5 (5)			73.2 (5)	100%		100%
CSSS Tex Class (5)		Silt-Loam			Clay	Clay			SiL		SiL
% Sand (2)					18.72	13.9			32.3		22.1
% Silt (2)					32.71	30.0			58.7		69.53
% Clay (2)					48.56	56.10			9.0		8.37
BCDA Tex-Feel (1)	3	6	3	3	4	6	6	6	3	2	3
Organic Matter (%) (1)	18	30+	18	20	18	30+	30+	30+	2.8	1.2	1.4
pH (units) 1:2 Soil/Water	4.3 (1)(2)	4.5 (1)	4.5 (1)	5.0 (1)(2)	4. (1)(2)	5.0	4.0	3.7	7.1 (1)	9.1 (1)	8. (1)(2)
1:1 Soil/Water		4.25 (2)				4.81 (2)		3.7 (2)	8.01 (2)		
1:2 Soil/CaCl2		4.16 (2)				4.68 (2)			7.87 (2)		
Sat. Extr.		5.0 (3)				7.3 (3)					
Conductivity (1)	5.0	3.0	3.7	3.3	4.0	3.2	5.0	4.0	2.95	0.32	2.5
mmhos/cm (2)	5.06	3.2		3.37	4.22	4.68		4.22	3.96		2.53
Saturated Extract. (3)		3.12				4.21					
Available Nutrients (1) NO_3 - N (lb/2x10^6 lb)	160	96	83	92	25	16	7	16	55	8	102
P	68	16	20	46	35	17	17	74	56	38	40
K	303	235	326	439	383	591	284	376	165	111	173
Ca	8196	5965	6160	9859	6897	4432	3982	4369	3292	3097	2936
Mg	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	[illegible]	[illegible]	[illegible]
Na ppm	120		70	88	182		90	70		20+	26
S Sulphate ppm	30+	30+	30+	30+	30+	30+	30+	30+		17.6	30+
B H_2O curcumin-oxalic ppm	1.29		1.44	1.26	1.49		3.50	2.54	8.0+	11.09	10.54
Cation Exchange C.E.C. meq/100g	76.79	86.41		93.13	42.34	60.79		77.57	9.28		5.43
% Base Sat.	44.09	48.1		63.24	100+	67.63		27.39	100+		100+
Σ Bases. meq/100g	24.56	41.55		40.27	42.62	41.11		21.25	14.12		10.22
Ca meq/100g	25.15	26.77		32.33	27.34	23.70		12.61	11.61		9.07
Mg meq/100g	8.51	13.66		7.08	13.74	14.94		7.55	1.68		.20
Na meq/100g	[illegible].16	.60		.29	.70	.78		.34	.46		.10
K meq/100g	[illegible].80	.52		.57	.86	1.69		.75	.37		.35
Exchangeable Sodium %	?	0.7		0.3	1.7	1.3		0.4	5.0		1.8
Dissolved HCO_3^- meq/100g		3.8x10^-3				12.8x10^-3					
meq/litre	.5			.8	1.1			0.2			1.1
$CO_3^=$ meq/100g		0				nd					
meq/litre	0			0	0			0			0
Cl^- meq/100g		.01				.019			.011		
meq/litre	2.78	.013		1.66	.85			.76			1.21
meq/100g						.033					
SO_4 meq/100g		1.5				2.6					
sat. ext. meq/litre											
1:5 s/w ext meq/litre (2)	155.6			30.6	151.2			65.4			30.4
B meq/100g		8.8x10^-4				.2x10^-4					
ppm		2.57				4.01			10.69		
Ca meq/100g	2.74	1.19		2.60	0.61	1.046		1.91			1.37
meq/litre	35.48	3.24		35.43	28.44	25.54		28.94			22.95
ppm	711			710	570			380			460
Mg meq/100g	1.65	.631		1.03	0.53	1.18		1.74			0.40
meq/litre	21.40	16.05		13.99	24.69	28.81		26.34			6.75
ppm	260			170	300			320			82
Na meq/100g	1.21	.089		.19	.20	.22		.19			.10
meq/litre	15.65	2.26		2.57	9.13	5.30		2.83			1.65
ppm	360			59	210			65			38
K meq/100g	0.08	.008		0.34	.02	.061		.06			.08
meq/litre	4.00	nc		4.60	.95	nc		.87			1.36
ppm	39			180	37			34			53
Sodium Adsorption Ratio (5)	2.93	0.83		0.52	1.77	1.02		0.54			.43
Water Content at Saturation (2)	77.18			73.48	21.45			66.15			59.62

nd – no data

nc – no calculation

(1) B.C. Ministry of Agriculture

(2) B.C. Ministry of Environment.

(3) B.C. Research for CMJV.

(4) Bulk Sample Field Lab.

(5) Calculations

What do: SL Clay etc mean

? -2.0 ---

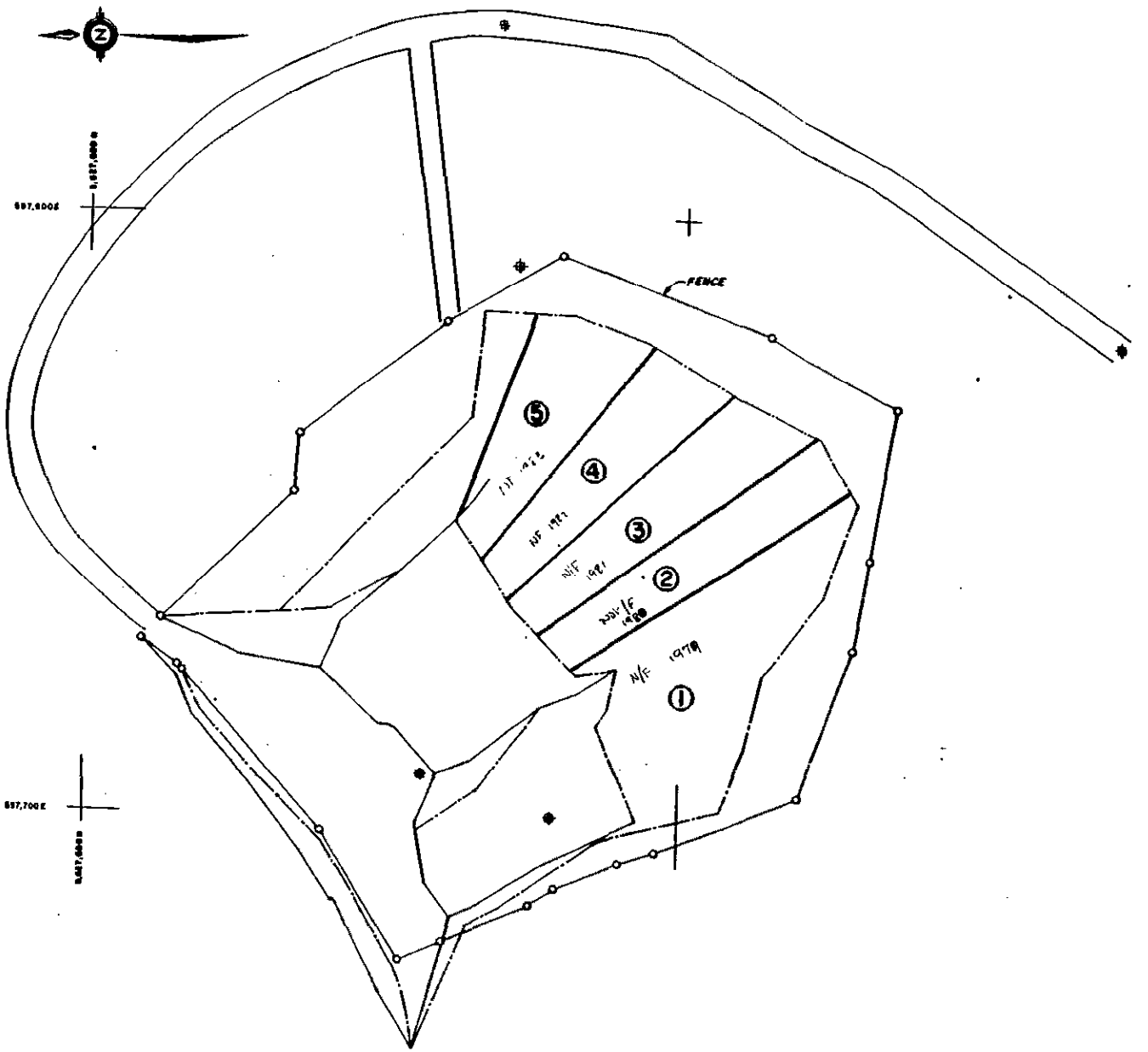
CSSS

Table 2-2

FERTILIZER ADDITION RATES ON RECLAMATION TEST AREAS

Test Area Description	Fertilizer Additions* (kg/ha)			
	11-48-0-0	46-0-0-0	0-0-62-0	0-0-0-21
Aleece Lake				
Colluvium	47	62	0	0
Glacial Gravel	47	62	0	0
Baked Clay	93	51	0	0
Gritstone	163	34	0	16
Bentonitic Clay	93	51	0	16
Coal Waste	47	62	0	0
Carbonaceous Shale	93	51	0	0
Fly Ash	42	23	84	
Houth Meadows				
Gravel Slopes	47	62	0	16
Parent Material	280	6	0	16
Medicine Creek				
Till	47	62	0	16
Trench A				
3160' Carbonaceous Shale	47	62	0	
3140' Baked Clay	47	62	0	16
3120' Gritstone	47	62	0	16
Coaly Waste	117	45	0	
Trench B				
Gravel	140	40	0	16
Subsoil	140	40	0	16
Topsoil	93	50	0	16
Trench C	16-20-0-0	46-0-0-0	0-0-62-0	0-0-0-21
Bentonitic Clay	112	34	0	16

* Numbers indicate percent by weight of N, P_2O_5, K_2O and Boron respectively.



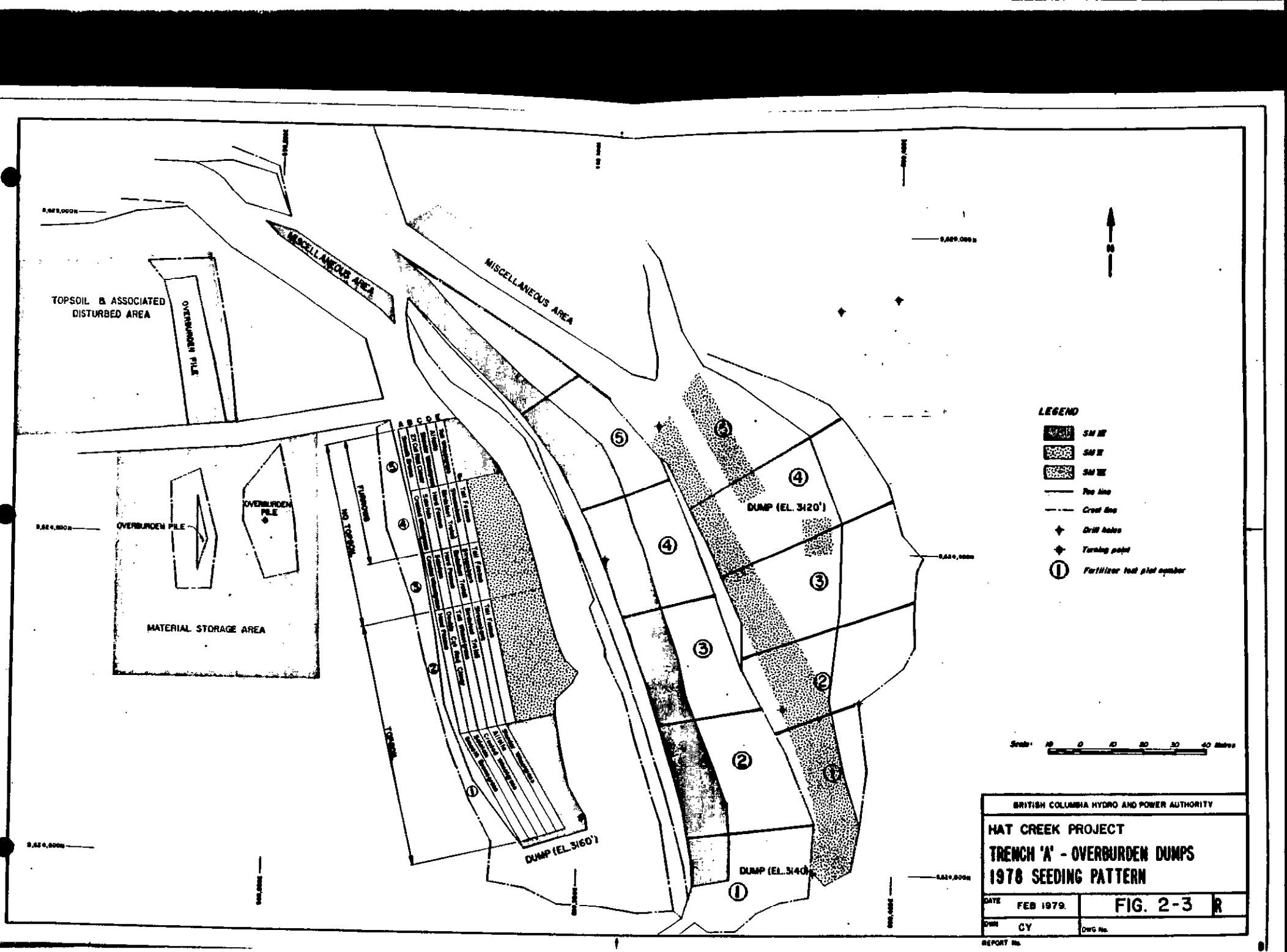
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

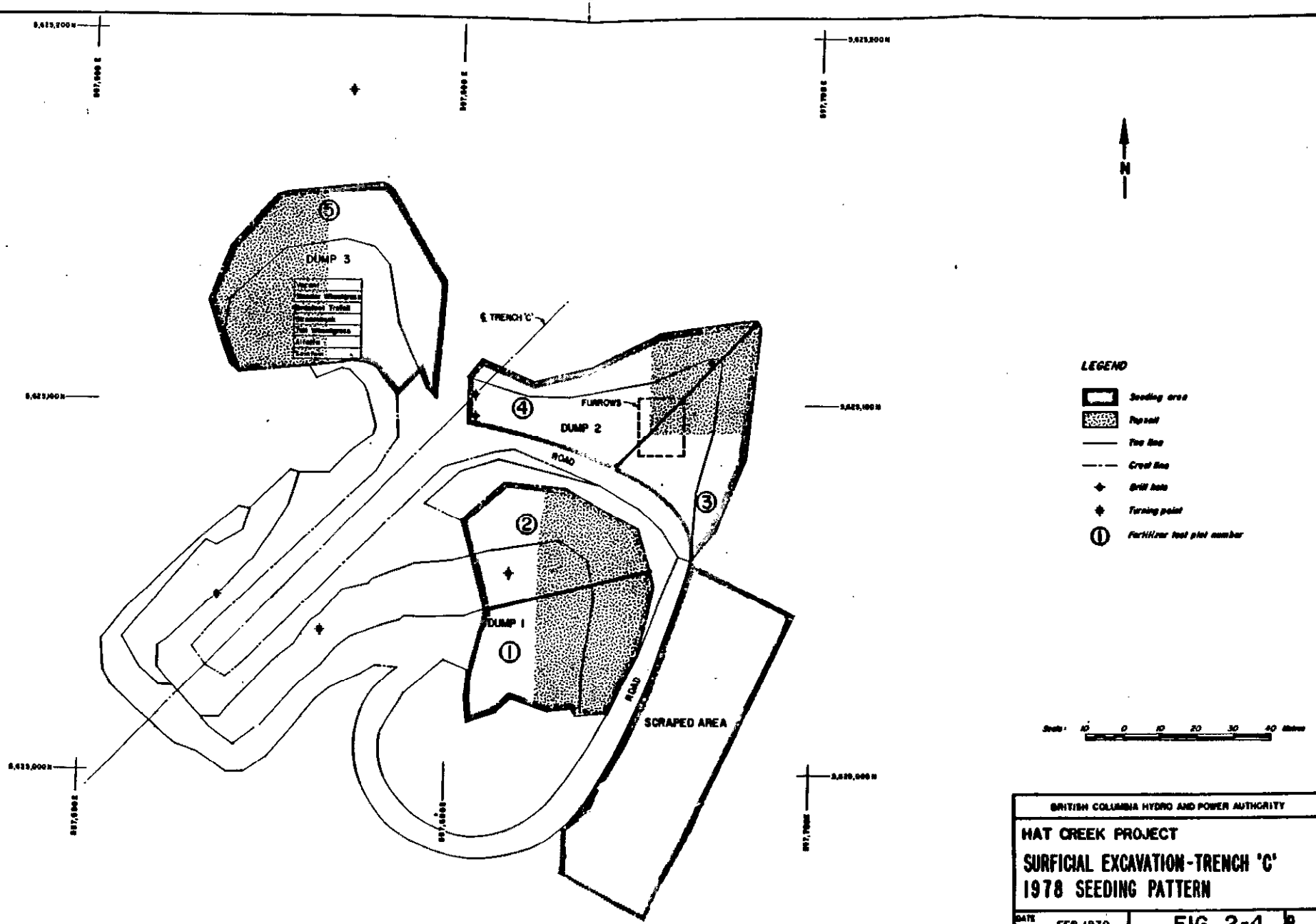
NAT CREEK PROJECT

HOUTH MEADOWS REVEGETATION TEST PLOTS

DATE	FIG. 2 - 2	R
MAY 1979		
DRWN CY	DWG No.	

REPORT No.


MISCELLANEOUS AREA
MISCELLANEOUS AREA
TOPSOIL & ASSOCIATED DISTURBED AREA
OVERBURDEN PILE
OVERBURDEN PILE
OVERBURDEN PILE
MATERIAL STORAGE AREA
TOE DRAIN
TOE DRAIN
DUMP (EL. 3120')
DUMP (EL. 3160')
DUMP (EL. 3140')
N
LEGEND
SM III
SM II
SM I
Toe line
Crest line
Drill holes
Turning point
Fertilizer test plot number
Scale: 40 0 40 80 120 160 Metres
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
TRENCH 'A' - OVERBURDEN DUMPS
1978 SEEDING PATTERN
DATE FEB 1979.
FIG. 2-3
R
DWN CY
DWG No.
REPORT No.



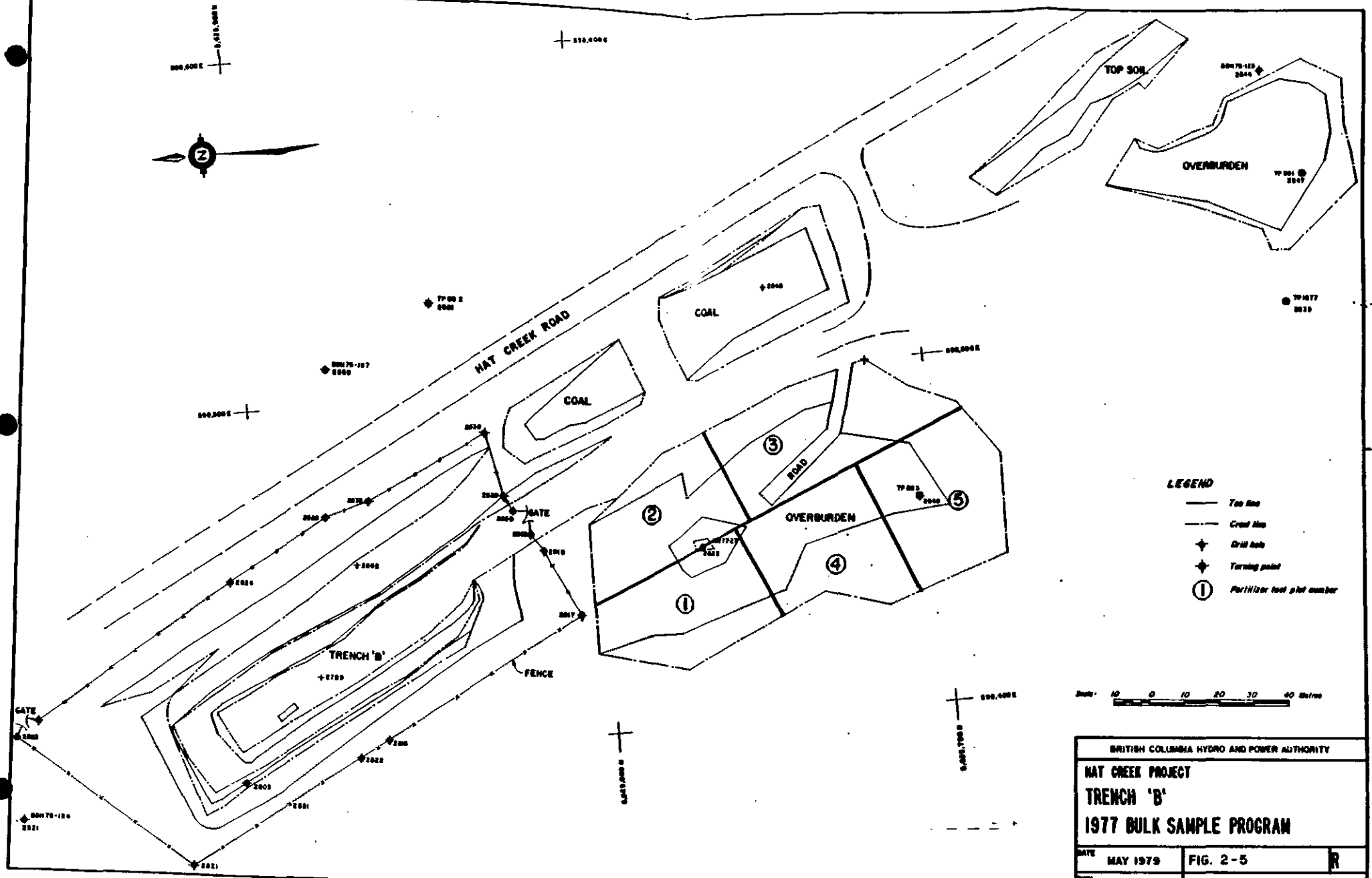
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

SURFICIAL EXCAVATION-TRENCH 'C'
1978 SEEDING PATTERN

DATE	FEB 1979	FIG. 2-4 R
DWN	CY	DWG No.

REPORT No.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

TRENCH 'B'

1977 BULK SAMPLE PROGRAM

DATE	MAY 1979	FIG. 2-5 R
DWN	CY	DWG No.

REPORT No.

3 Vegetation Surveys

3.1 Introduction

In the spring of 1977 a reclamation test program was initiated using waste materials from the Bulk Sample Program. The success of this work was assessed quantitatively during 1978 and additional remedial measures were taken to improve the reclamation where necessary. In June and September 1979, additional environmental studies and field programs were carried out in order to provide a evaluation of the revegetation test program. This section summarizes the results of those field studies and presents an assessment of the success of the revegetation program through this past growing season.

3.2 Aleece Lake

a) June 1979

Vegetation Sampling Methods

The Aleece Lake test plots contain 46 populations*. Each population was sampled qualitatively by estimating the total percent ground cover and by giving values of percent cover (by number) for each of the seeded species. Weed species (invaders) were identified and their percent cover was also estimated. A description of each plant species was recorded (e.g. flower development, appearance, colour, etc.). Each population (e.g. bentonitic clay, Seed Mix II with topsoil) was rated relative to one of four arbitrary classes**:

---

* 3 seed mixes on 7 materials with 2 surface treatments plus 2 seed mixes on 1 material with 2 surface treatments.

"excellent"

"good"

"satisfactory"

"poor"

** In some cases intermediate classes were assigned; these classes are designated by a + or - sign as follows: Good^{+}, etc.

This rating takes into consideration the overall appearance or condition of the vegetation (e.g. health, maturity) and the yield or productivity (i.e. percent ground cover).

Visual Growth Assessment Results

The following results were found to be consistent on all eight materials tested at Aleece Lake:

Seed Mix I

Natural reseeding of fall ryegrass was not successful and only an occasional plant was observed. Clearly fall rye seeds are more successful or vigorous when tilled under the soil. However, foraging of the seeds by rodents and birds is suspected of contributing to heavy losses of fall rye seeds.

It may be that the occasional fall rye plant was the result of the germination of seeds planted in the fall of 1977, rather than from natural reseeding.

Crested wheatgrass was the dominant vegetation on all test plots. Crested wheatgrass generally exhibited better performance on the topsoil portions of the plots, especially on the poorer materials. The percentage of plants which indicated maturity varied from plot to plot much the same as the first year's results.

Generally, the presence of a reproductive structure on a plant indicates a more healthy condition. However, many factors are responsible for the inducement of reproductive structures and it is not possible to say categorically that the absence of these structures reflects a poor health condition.

Canada bluegrass did not make a major appearance on any of the materials. Present results showed no appreciable increase in Canada bluegrass success and this would appear to confirm the previous year's conclusion that this species should be rejected for further use at Hat Creek because of very poor emergence success and growth.

Drylander alfalfa exhibited improved success on some of the "better" soil materials and was typically absent on the poorer materials such as coal waste and carbonaceous shale where it is suspected that the high acid levels inhibited germination. It may be that this effect is present even on the topsoil treated portions since the plot was rototilled before seeding.

Seed Mix II

Slender wheatgrass appeared to be the dominant species in Seed Mix II on all soil materials except baked clay where sainfoin was more dominant. This appearance may have been caused by the state of maturity of this grass making it easier to identify categorically than Russian wild rye. This species exhibited improved growth on the topsoil portions of the poorer materials.

Russian wild rye appeared less abundant on several of the materials compared with that which occurred in the initial year. It is suspected that the juvenile plants which were relatively abundant in the summer of 1978 were not able

to maintain growth once the end of the seedling stage was reached; winter kill may also have been a factor.

Sainfoin generally exhibited improved performance in the spring of 1979. Those plants which overwintered are now beginning to mature and becoming well established. In the first summer after germination sainfoin was found to be most productive on the fly ash plot with topsoil. Examination of this same plot in the spring of 1979 indicated no major improvement, and possibly even decreased productivity. It is thought that the topsoil initially promoted successful germination but that once the roots penetrated through into the fly ash growth was inhibited.

Sainfoin produced excellent results on the baked clay, colluvium and glacial gravels both with and without topsoil. The plants were generally less eminent on the other soils but nevertheless indicate good overwintering potential and persistent growth.

Sweet clover exhibited similar results to those which occurred in the first summer. This legume is less successful than sainfoin but showed good results on the better materials such as glacial gravels, baked clay and colluvium.

Generally the legumes of all seed mixes showed better performance on the perimeters of the plots where they were better established in the first year and competition from other species was reduced.

Seed Mix III

Streambank wheatgrass is the dominant species of Seed Mix III on all eight materials at Aleece Lake. This grass shows excellent overwintering success even on the poorer

materials such as carbonaceous shale and coal waste. Although these materials generally exhibit unacceptable reclamation success this grass should improve the ground cover in the long term since it is expected to spread to new sites by virtue of its vigorous, rhizominous rooting system. Excellent results were displayed on the better soil materials. Streambank wheatgrass has demonstrated that it is one of the better plant types tested at Aleece Lake.

Smooth bromegrass indicated basically the same general trends as streambank, although this grass was found to be less productive overall. The best results were found to occur on the gravels, colluvium and baked clay materials while less vigorous production occurred on the other materials. These observations were essentially similar to those noted in the first year. Smooth bromegrass is a highly recommended reclamation species at Hat Creek.

Double cut red clover exhibited similar trends to those found in the initial year. It does not appear to be a highly successful legume on even the better materials. The best results were obtained on the edges of plots of the better materials, where the plants have persisited through the winter; some exhibited flower development. The reasons for this success of the legumes (sweet clover and double cut red clover in particular) around the perimeters of the plots are presumed to be the result of reduced competition from the grasses.

Canada bluegrass (Rubens) was unsuccessful at Hat Creek. This species was similar in performance to the common variety tested in Seed Mix I. Either the seeds were not viable or suitable conditions for germination never existed. Although not expected, it may develop later if more favourable conditions for germination come about.

The Soils As Growth Media

Essentially the same conditions prevailed in the spring of 1979 as those after one year although cover, for the most part, has increased. The best growth was exhibited on the glacial gravels, baked clay and colluvium. Moderate improvement was observed on the sandstone and bentonitic clay, while results on the non-topsoil portions of the carbonaceous shale, coal waste and fly ash showed some improvement but continued to be unsatisfactory.

Topsoil results in better, sustained vegetative growth on the poorer materials while there was basically no difference in reclamation success between the topsoil and bare portions on the better materials.

Invader Species

Surprisingly, weed species were substantially less productive and less dominant compared to the previous year. Most weed species tend to be both less abundant and exhibited markedly less vigorous growth than last year.

The agronomics are beginning to demonstrate their effectiveness in sustained and persistent growth on the test plots at Aleece Lake. The weed species (mostly annuals) are now having to compete with the well established agronomic species (perennials).

A summary of the overall success of the reclamation effort on the eight materials at Aleece Lake is given in Table 2-3.

Table 2-3

Summary of Overall Success of Reclamation on Aleece Lake Test Plots

MATERIAL		SEED MIX I	SEED MIX II	SEED MIX III
SURIFCIAL				
Colluvium	without topsoil	excellent	excellent	excellent
	with topsoil	good+	excellent	excellent
Baked Clay	without topsoil	good+	excellent	excellent
	with topsoil	good+	excellent	excellent
Glacial Gravels	without topsoil	good	good	excellent
	with topsoil	good+	excellent	excellent
NON-SEAM WASTE				
Gritstone	without topsoil	good	good	satisfactory
	with topsoil	good	excellent	excellent
Bentonitic Clay	without topsoil	satisfactory	satisfactory	satisfactory
	with topsoil	satisfactory	satisfactory	satisfactory
SEAM WASTE				
Coal Waste	without topsoil	poor	poor	satisfactory
	with topsoil	satisfactory	poor	good+
Carbonaceous Shale	without topsoil	poor	poor	poor
	with topsoil	good	satisfactory	satisfactory
ANTHROPOGENIC				
Fly Ash	without topsoil	satisfactory	poor	-
	with topsoil	good	good+	

Note: Rating includes consideration of degree of cover, maturity of plants and plant condition.

b) September 1979

Vegetation Assessment Method

Each test plot was inspected and the following data noted:

- The relative abundance of each seeded species and the abundance of weeds;
- The total percent ground cover according to the following index: 1 = 0 - 25%,
  2 = 26 - 50%,
  3 = 51 - 75%, and
  4 = 76 - 100%;
- General comments on the condition of the plants.

In addition the populations of the test plots were ranked from 1 to 6 (except on fly ash 1 to 4) according to their performance, i.e. a population ranked 1 was best and that ranked 6 (4 on fly ash) worst.

Visual Growth Assessment Results

Seed Mix I

Crested Wheatgrass is the dominant species of Seed Mix I on all eight test plots. This species has become quite well established and generally provides good ground cover, and a high proportion of mature plants.

Alfalfa is the only other seeded species of Seed Mix I that has become established at Aleece Lake. The success of alfalfa is generally related to those areas where competition from other plants is reduced. In such areas the size of the alfalfa is significantly increased.

Seed Mix II

The grasses Russian wild rye and slender wheatgrass appear to compete successfully with th legumes, particularly

sainfoin, in providing a good balance of grass/legume ground cover. Sweet clover is the least successful and more variable of the species tested in Seed Mix II. Overall this legume was not highly successful (abundant) but in some areas had obtained excellent size. Since sweet clover is a biennial it is suspected that this legume will largely die out. Establishment through natural reseeding is not expected to be particularly successful. Sainfoin is a highly successful legume which consistently exhibited good results except in areas of excessive grass ground cover.

Seed Mix III

Streambank wheatgrass and smooth bromegrass are both successful grass species and appear to compete well with one another; streambank is generally the more abundant of the two due to its ability to spread rapidly (by rhizomes) and form dense ground cover. Smooth brome was less successful especially on the poorer materials.

Double cut red clover has not been a successful legume, exhibiting poorer performance than sweet clover. It is present in limited quantities around the periphery of the plots where competition from other species is absent.

Waste Materials

Surficials

Colluvium

After two growing seasons there was essentially no perceptible difference in performance of the seed mixes between the topsoil and non-topsoil portions of the plot. The only major difference between the topsoil areas and the non-topsoil areas was a greater abundance of native species on the topsoil side.

The colluvium plot exhibits the greatest ground cover of all the Aleece Lake plots. The vegetation consists almost entirely of grasses which are forming a very dense mat over the surface. The legumes sainfoin, alfalfa and sweet clover are much reduced in abundance compared to other plots. In the case of sainfoin there was a marked decrease in abundance from the June 1979 evaluations.

The vegetation appears relatively healthy considering the lack of moisture. A high proportion of the established vegetation is in the flowering or seeding state.

Native species are present but not abundant.

Cover estimates for Seed Mix I are less than the other two seed mixes. This is presumed due to a carry-over from the excessive competition from the fall rye in the first year.

Population		Rating	Cover Index
Seed Mix III w/o TS	similar	1	4
Seed Mix III w TS	similar	2	4
Seed Mix II w/o TS	no difference	3	4
Seed Mix II w TS	no difference	4	4
Seed Mix I w/o TS	similar	5	3
Seed Mix I w TS	similar	6	3

Glacial Gravels

The vegetation is healthy, mature and exhibits good ground cover. Grass (crested wheatgrass) is the dominnant vegetation on Seed Mix I. Seed Mix II exhibits a good balance (diversity) of grass and legume. As with the colluvium results there is no major difference in seed mix performance between the topsoil and non-topsoil. Grasses are the dominant vegetation in Seed Mix III. Double cut red clover exhibited its best performance (good abundance) of all the test plots on the glacial gravels.

Native species are not paricularly abundant on the topsoil, however there were a number of large thistle plants (around the edges in particular) on the glacial gravel plot which are disseminating a very large amount of seed. Thistle plants are very tolerant of harsh conditions and establish very quickly. Should these seeds germinate it may lead to a significant reduction in the performance of the agronomic species.

Population		Rating	Cover Index
Seed Mix II w/o TS	very similar	1	4
Seed Mix II w TS	very similar	2	4
Seed Mix III w TS	very similar	3	4
Seed Mix III w/o TS	very similar	4	4
Seed Mix I w/o TS	very similar	5	3
Seed Mix I w TS	very similar	6	3

Baked Clay

The results on the baked clay plot are basically identical to those obtained on the glacial gravels with some minor exceptions: Alfalfa showed greater abundance on both topsoil and non-topsoil, and double cut red clover exhibited poorer success on the baked clay. Vegetation is healthy, mature and forms a good ground cover on both topsoil and non-topsoil.

Population		Rating	Cover Index
Seed Mix II w/o TS	similar	1	4
Seed Mix II w TS	similar	2	4
Seed Mix III w/o TS	similar	3	4
Seed Mix III w TS	similar	4	4
Seed Mix I w/o TS	similar	5	3
Seed Mix I w TS	similar	6	3

The vegetation cover is usually less for Seed Mix I, due to the fact that there is only one grass species, while both Seed Mix II and III have two grass species that have become established.

Non-Seam Waste

Gritstone Plot

Seed mix performances are substantially better on the topsoiled areas, where the ground cover is more uniform and the condition of the vegetation is improved (better plant heights, less dry, etc.). Sainfoin exhibits particularly good performance on the non-topsoil where it is the dominant species.

Smooth brome is the dominant species of Seed Mix III on the non-topsoil material and smooth brome show decreased success on the topsoiled portions of the plot.

Weed species are moderately abundant on the topsoil, especially on the Seed Mix III topsoil.

Generally the vegetation on the gritstone plot is healthy and indicates good maturity.

Population	Rating	Cover Index
Seed Mix II w TS	1	3
Seed Mix III w TS	2	3
Seed Mix I w TS	3	2
Seed Mix II w/o TS	4	2
Seed Mix III w/o TS	5	2
Seed Mix I w/o TS	6	2

Bentonitic Clay

Vegetation is consistently better on the topsoil sides of the populations. The plants are greater in size and more abundant than on the raw material. Overall, there is not a high proportion of mature plants on the bentonitic clay, and in addition there is a significant amount of chlorosis, especially on the raw material. Native species invasion is low.

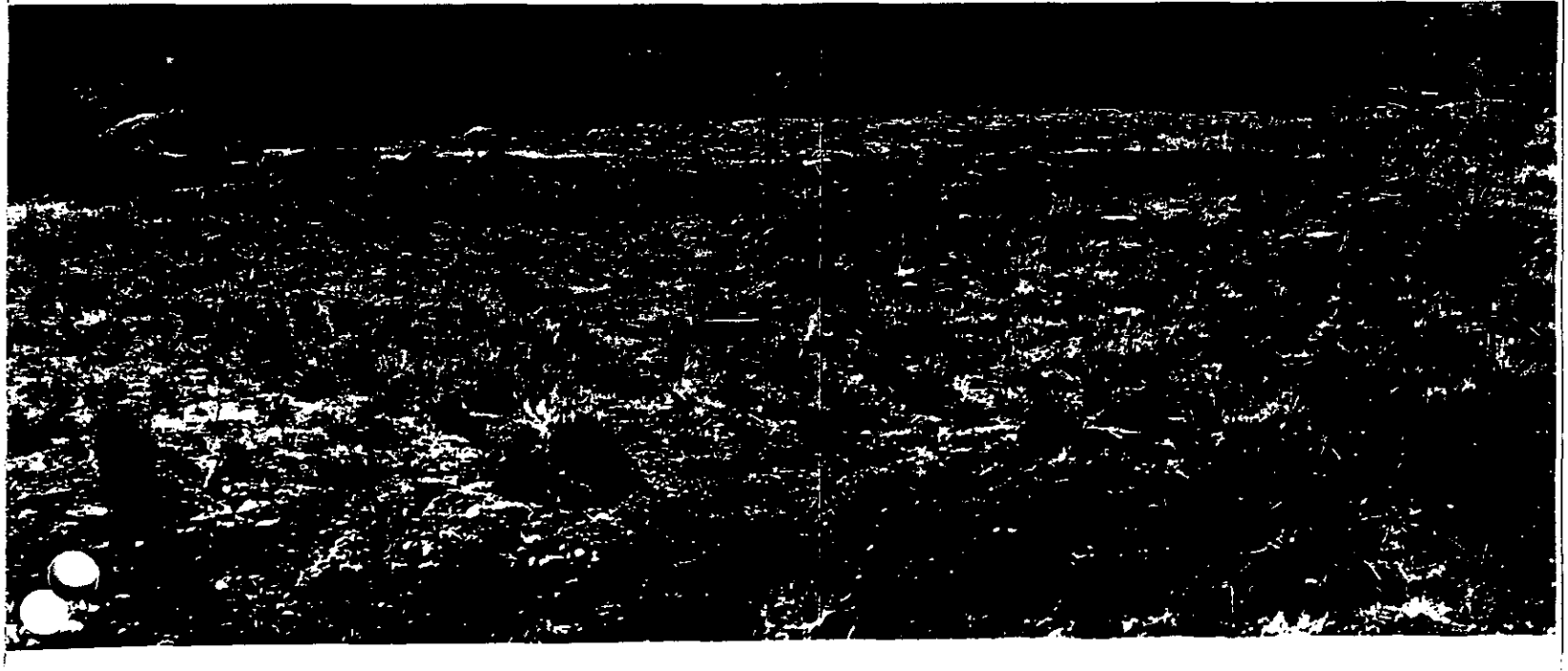
Population		Rating	Cover Index
Seed Mix II w TS	very much similar	1	3
Seed Mix I w TS		2	3
Seed Mix III w TS		3	3
Seed Mix III w/o TS	very much similar	4	2
Seed Mix II w/o TS		5	2
Seed Mix I w/o TS		6	2

Seam Waste

Coal Waste

Vegetation is better established on the topsoil sides of each seed mix. Generally the plants are larger and ground cover is much improved on the toposil. Vegetation does not appear to have been severely affected by the dry summer, since most plants appear relatively healthy, even on the raw material.

Streambank wheatgrass exhibited striking success on the non-topsoil material where the grass attained considerable size and good abundance.



Population	Rank	Cover Index
Seed Mix III w TS	1	3 (small plants)
Seed Mix I w TS	2	2
Seed Mix II w TS	3	2
Seed Mix III w/o TS	4	1
Seed Mix II w/o TS	5	1
Seed Mix I w/o TS	6	1 (large plants)

Carbonaceous Shale Plot

This material demonstrated the poorest vegetation performance of all the materials tested. The raw material was essentially devoid of any growth except for the odd patch of grass growing in a depression, or where the vegetation from the topsoil is encroaching onto the bare material. Seed Mix II was completely bare of any growth. Vegetation performance on the topsoil was much improved over the non-topsoil but was still unsatisfactory. The cover was not uniform, and the plants exhibited poor maturity and health. Crested wheatgrass exhibited the best success of any of the applied species. Weed species were present but not abundant on the topsoil.

Population		Rating	Cover Index
Seed Mix I w TS		1	2
Seed Mix III w TS		2	2
Seed Mix II w TS		3	2
Seed Mix III w/o TS	very similar	4	1
Seed Mix I w/o TS		5	1
Seed Mix II w/o TS		6	1

Anthropogenic

Fly Ash Plot

The best results were seen on the topsoil sides of both seed mixes. Seed Mix II generally provided better ground cover than Seed Mix I, except on the raw fly ash. Vegetation on the fly ash was chlorotic and dried-out. Only the largest

of the legumes exhibit flowering. Vegetative cover on the non-topsoil portions of the fly ash was patchy, especially on the Seed Mix II side, where the ground cover was unsatisfactory.

Native species were not particularly abundant on the fly ash plot and were present only on the topsoiled half.

Population		Rank	Cover Index
Seed Mix II	w TS	1	3
Seed Mix I	w TS	2	3
Seed Mix I	w/o TS	3	2
Seed Mix II	w/o TS	4	1

3.3 Slope Test Plots

All plots at Houth Meadows and Medicine Creek were seeded in the fall of 1977 using a single seed mix. A small area of parent material at the Houth Meadows test area was seeded by harrow whereas the remaining areas were all hydro-seeded.

a) June 1979

Vegetation Sampling Methods

Two 0.1 square metre (0.1 m^2) quadrats were sampled, at random locations, along the upper and lower portions of each of the six sloped populations. The total number of plants of each seeded species was recorded for each of the quadrats. Weed species were counted and identified. The total percent ground cover was determined. The average plant heights and condition of the vegetation were also recorded. Each population was then assigned a reclamation value according to the same criteria as outlined in Section 3.2 of this report.

Visual Growth Assessment Results

Houth Meadows

Basically there was no significant difference in the success of the reclamation on the three different slopes with respect to plot slope. There was, however, a recognizable difference in the degree of reclamation success between the non-topsoil and topsoil treated portions of the slopes. On all three test slopes the vegetation exhibited better productivity and ground cover on the non-topsoil treated portions. These results can be attributed to the absence of weed competition on the bare material. The addition of topsoil resulted in a substantial decrease in the number of plants produced and their productivity (biomass), and, although invader species

were not nearly as abundant as in the first year, the effects of this competition have been clearly felt by the seeded agronomic species.

Fall rye grass was an unsuccessful reseeder at Houth Meadows, where the grass was all but completely absent. The occasional fall rye grass plant was observed, but it is suspected that their presence was a result of germination of seeds of the initial seed mix rather than from seeds dispersed from the plants themselves.

The major vegetation components on the sloped plots were crested wheatgrass and alfalfa. Crested wheatgrass was more abundant while the alfalfa was more productive (biomass). These results were as expected; however, it was expected that in time the wheatgrass would become the dominant vegetation type, while the alfalfa would become less productive.

Vegetation cover on the sloped plots was patchy (as observed after the first year), due to an uneven dispersal of the seed mixture. The loss of fall rye grass, and possibly some winter kill of alfalfa, have resulted in slightly poorer ground cover conditions compared to last year, especially on the topsoil, but not significantly so. Eventually the continual radiation of agronomic species will result in a more evenly distributed ground cover. Owing to this unevenness in vegetation cover it is not possible to detect any significant difference in growth between the upper and lower portions of the slopes. Theoretically the lower portions should reflect better growth due to the increased water runoff, however, this effect was not found to be consistent between the slopes.

Examination of the slopes indicated that erosion does not appear to be a significant factor in the second year.

Reclamation Values by Population

30° slope	Topsoil Portion	-	"poor" reclaim
30° slope	Non-topsoil Portion	-	"satisfactory" reclaim
26° slope	Topsoil Portion	-	"poor" reclaim
26° slope	Non-topsoil Portion	-	"satisfactory^{+}" reclaim
22° slope	Topsoil Portion	-	"poor" reclaim
22° slope	Non-topsoil Portion	-	"satisfactory^{+}" reclaim

The level areas at the base of the sloped plots at Houth Meadows were also examined.

The harrow-seeded section exhibited poorer productivity than the hydro-reseeded portion. This effect (which is the exact opposite of the first year results) can be attributed to the loss of the fall rye, which was the dominant species on the harrowed area last year. The harrowed area did, however, show a good balance between grass and legume. On the hydro-seeded level area drylander alfalfa was present almost

exclusively and exhibited excellent productivity and over-wintering success in response to the absence of competition from fall rye during the initial year and perennial crested wheatgrass.

Medicine Creek

The greatest productivity was observed on the 30° slope, i.e. the plants are more abundant as well as larger. The individual test plots exhibited fairly uniform vegetative cover over the entire length of the slopes, however, the dry-lander alfalfa appeared to be more productive on the lower levels.

Crested wheatgrass, the dominant species on the test plots, exhibited excellent results, while the alfalfa appeared less vigorous. The fall rye grass, the dominant species in the first year, was not present in the second year. The reasons for the relatively poor productivity of the alfalfa (in comparison to Houth Meadows) are not clear. One possible explanation would be undue competition from the crested wheat-grass.

Erosion does not appear to be a major concern at Medicine Creek after two years.

There was evidence of substantial rodent populations at Medicine Creek. Disturbance of the soil by the rodents, through nesting cavities, may eventually lead to some localized waterborne erosion problems. It is suspected that the rodents are also responsible for some losses in plant productivity.

Although the testing area is fenced off, it appears that some disturbance by deer and horses may have occurred.

The results at Medicine Creek and Houth Meadows were essentially similar, with the exception of the reduced

productivity of drylander alfalfa at Medicine Creek. Vegetative cover is less patchy at Medicine Creek.

Overall, the results indicate that successful revegetation of dump faces comprised of in situ till with slopes up to 30° has been achieved in the second year after initial seeding.

Reclamation Values by Population

22° Slope	-	"good" reclaim
26° Slope	-	"good" reclaim
30° Slope	-	"good" reclaim

b) September 1979

Vegetation Sampling Methods

Plots were inspected and qualitatively assessed as to the progress of reclamation.

Visual Growth Assessment Results

Houth Meadows

The only major difference that can be seen between the September assessment and the June assessment is that the vegetation is much drier, and consequently browner, in the late summer. This can be attributed to the extremely dry summer conditions which have prevailed. Although this lack of moisture is evident in the condition of the vegetation on the test plots, it should be pointed out that the native vegetation in the surrounding areas is also suffering from lack of moisture.

The following statements can be made of the three test slopes at Houth Meadows:

- The abundance of individual species, total cover, and condition of vegetation showed consistently better results on the non-topsoil sides of the slopes. Drylander alfalfa is the dominant species on the non-topsoil slopes. Crested wheatgrass is the major seeded species on the topsoil sides of the slopes.

- The poor growth of agronomics on the topsoil is thought to be related to the competitive effects of native species which were extremely abundant.

- Crested wheatgrass exhibited substantially more browning than does alfalfa. This may be, however, the nature of the grass at this particular time of year (late summer).

- Invader species were essentially insignificant in terms of abundance and size on the non-topsoil portions of the plots.

- Vegetative cover was relatively uniform throughout the slope of the plot, although the relative abundance of the species may vary slightly in localized areas.

- Two areas of localized erosion were noted:

    1. At the top of the 30° topsoil slope, and
    2. on the lower 1/3 portion of the 26° non-topsoil slope.

This erosion may be attributable to any one, or a combination, of the following:

1. Heavy rainfall - 1 inch in 4 hours was recorded in the past two weeks. At the top of the 30° topsoil slope the land is contoured in such a way as to collect moisture which then cascades down the waste dump face. This is

causing the erosion channel on the 30° slope.

2. Rodent disturbance (nesting cavities are abundant throughout the area).

Medicine Creek

This test area exhibited slightly different results from those observed at Houth Meadows:

- At Houth Meadows there was a better balance between crested wheatgrass and alfalfa abundance whereas at Medicine Creek crested wheatgrass was clearly the more abundant. Those alfalfa plants present at Medicine Creek were generally very small.

- The ground cover was much more uniform, and the vegetation appears to be less dry at Medicine Creek.

- Weed species were not numerous at Medicine Creek.

- Erosion, other than that caused by rodent nesting, was not apparent on any of the three slopes.

3.4 Bulk Sample Program Waste Dumps

Waste materials extracted from Trench A were dumped to form three benches at elevations of 3120' (gritstone), 3140' (baked clay) and 3160' (carbonaceous shale). At Trench B the topsoil, subsoil and gravel were stockpiled separately while the waste material from Trench C, i.e. bentonitic clay, was dumped in three waste dumps adjacent to the trench.

a) June 1979

Vegetation Sampling Method

Revegetation success was assessed qualitatively.

Plant species were identified and their average plant height and condition of health were noted.

Visual Growth Assessment Results

Trench A

3160' Dump Surface

The best germination success occurred in the furrowed area to the north end of the dump where the moisture was clearly better retained. Germination was disappointing on the topsoiled portion of the dump. Although germination success among seed mixes was very similar the potential for good ground cover did not appear good. Vegetation was absent on the non-topsoil, non-furrowed portion of the dump.

3160' Dump Face

Vegetation success on the dump face has considerably improved in comparison to the first year results. Crested wheatgrass exhibited excellent growth and maturity. Alfalfa was very abundant but the plants were small and immature. Canada bluegrass was present but not abundant. Invader species were essentially absent.

No noticeable difference in vegetation success was evident between the 26° and 34° slopes. The waste material of this dump face is essentially the same as that on the surface, i.e. carbonaceous shale. The fact that revegetation was successful on the untreated face but not on the surface is difficult to explain. It is probable that more moisture

collecting microsites existed on the slope thus facilitating germination.

Vegetative cover was generally uniform over the bench face except in areas that had been disturbed by cattle; no major erosion was noted on the slopes but several areas showed signs of rill erosion.

3140' Dump Surface

The dump surface, which was reseeded in the fall of 1978, exhibits satisfactory growth. Most germination occurred in the furrows left by the harrow. All five species in the seed mix (IV) exhibited some success, but the sainfoin, wheatgrasses and smooth brome indicated best results.

3140' Dump Face

In the fall of 1978 there was a high concentration of juvenile plants which were expected to develop further in the spring of 1979. Examination of the 3140' dump faces indicates that that has occurred. Crested wheatgrass was the dominant species although the grass/legume ratio was satisfactory. Vegetative cover was relatively uniform over the dump faces. There was no apparent difference in productivity between the two dump faces of slopes 26^{o} and 34^{o}.

Despite much evidence of cow grazing and surface disturbance growth on the dump face is quite satsifactory.

3120' Dump Surface

Vegetative growth (Seed Mix VI) on the newly seeded area at 3120' indicates similar success as on the 3140' bench surface. There is an abundance of juvenile vegetation, especially grasses. Birdsfoot trefoil did not appear to be a successful legume.

Similarly to the 3140' bench surface the initial germination success on the 3120' surface appeared in the furrowing of the soil surface left by the drag harrow.

Growth on the dump surface area which was not reseeded in 1978 was less than satisfactory. Crested wheatgrass exhibited the best success of the species in Seed Mix I, however, the vegetation growth on the clayey material was patchy and exhibited moisture stress. Vegetation has persisted in small depressions where moisture could collect.

3120' Dump Face

Vegetation success on the claystone dump faces was more satisfactory than on the dump surface. Crested wheatgrass showed surprisingly good growth. Alfalfa, the only other species growing, was less abundant and not as productive. Vegetative growth on the slopes occurred in furrows and ruts where moisture collection was more effective. No major difference was evident between the 20^{o} and 30^{o} slopes. On the 38^{o} slope vegetation cover was very patchy with some good stands. However, there were large areas which were completely devoid of vegetation. Erosion was not observed to be a major problem.

Trench B

Topsoil Pile

The agronomics were doing poorly on the topsoil pile. The growth of the agronomics was obviously inhibited by the invader species which were exceedingly abundant. Crested wheatgrass, alfalfa and Canada bluegrass are all present but the plants are small and it is not expected that the revegetation success of the topsoil pile will be improved except in the long term. The presence of weed species is overwhelming.

Subsoil Pile

The revegetation success on the subsoil pile was very satisfactory. Invader species, which were relatively abundant in the first year, are less prominent than the agronomics.

Vegetation cover was excellent. Crested wheatgrass and alfalfa were the major vegetation on the plot. Canada bluegrass exhibited improved success over the last year for reasons which are unknown. The bluegrass plants were juvenile and this suggests that the conditions which induce germination may have been better this year, while the seeds remained dormant in the first year.

Gravel Pile (Harrow-seeded Area)

Growth on the gravel pile was excellent. Crested wheatgrass and alfalfa are the only vegetation species on the plot. Vegetative cover was essentially uniform over the entire area. It is evident that gravels at Hat Creek can be utilized as one of the major reclamation materials.

Gravel Pile (Hydro-seeded Area)

This area showed particularly good reclamation success for the drylander alfalfa. This was expected after initial examination of the area last year. Alfalfa has exhibited excellent success wherever fall ryegrass was not the dominant species in the initial year. In this hydro-seeded area the alfalfa and crested wheatgrass were in approximately equal quantities, with the alfalfa plants exhibiting excellent productivity (biomass).

Trench C

Three waste dumps at Trench C were seeded and fertilized in September 1978. The seed mixes applied were selected on the basis of the Aleece Lake results. This section of the report presents a summary and discussion of the early spring growth results at Trench C.

Dump 1

Vegetation on the level area was very patchy with growth clearly better in the small depressions. Vegetative cover appeared to be better on the topsoiled areas. Growth results on the bentonitic clay at Aleece Lake indicated similar improved success on the topsoil side.

On the slopes growth on the topsoiled portion although patchy was consistently better than on the bare material. With topsoil cover the slopes were clearly more prone to erosion.

Dump 2

Germination success of Seed Mix VI was noticeably better in the furrowed areas at Dump 2. There was no apparent difference in reclaim success between the non-topsoil and topsoil portions of the level area. Weed species were more abundant on the topsoil portion but were not excessively productive. The three wheatgrasses and alfalfa exhibited good abundance of juvenile plants.

Growth on the bentonitic clay slopes indicated similar species diversity as the level areas but better individual plant productivity. This was the same general trend found at all test areas at Hat Creek. The sloped areas have ruts and channels which trap water and promote germination.

Dump 3

Early spring growth was not outstanding on the Dump 3 area at Trench C. Overall, the grasses indicated much better success on the topsoil portions. The legumes appeared to be doing well on the bare material. At this early stage it is not possible to predict the reclamation potential of Trench C.

Of the new seed species selected for testing at Hat Creek the hard fescue and tall wheatgrass appeared to be

taking well. Birdsfoot trefoil was selected as a legume with acid tolerance, however, it was proved unsuccessful in all areas tested. It is suspected that this species may not be sufficiently drought-tolerant for use at Hat Creek.

b) September 1979

Vegetation Sampling Method

Vegetation was assessed in the same way as in June 1979.

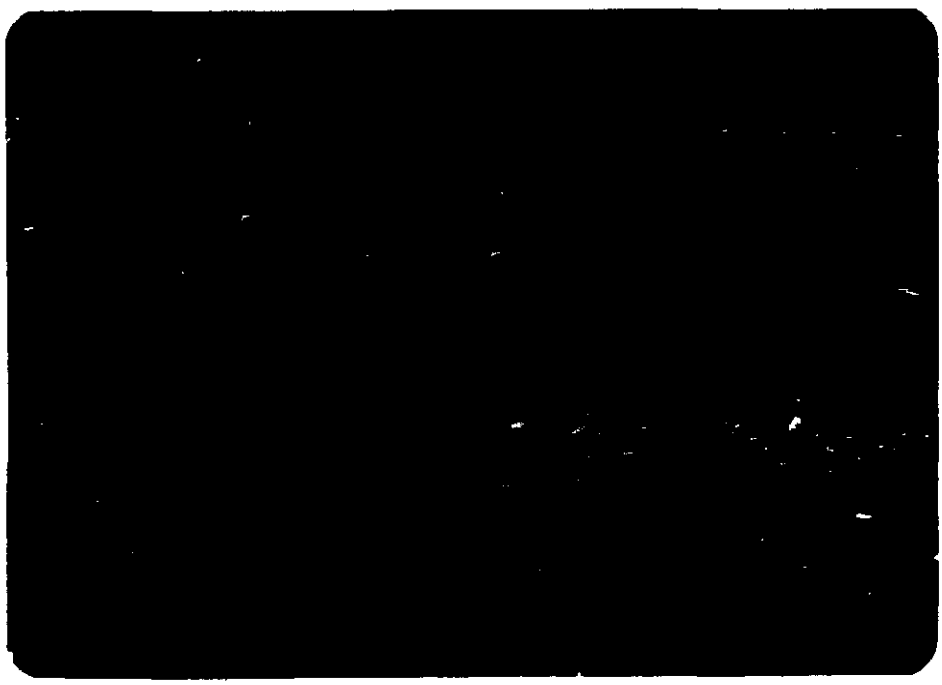
Trench A

3160' Dump Surface

Of the five areas seeded (1978) on the carbonaceous shale waste dump only two areas showed satisfactory growth. These areas, i.e. seeding pattern areas 4 and 5 (see Figure 2-3 "1978 Environmental Field Programs") had been furrowed while the other three had not, and growth was restricted almost entirely to these furrows. All 11 species tested showed some success (tall wheatgrass, slender wheatgrass, crested wheatgrass, tall fescue, hard fescue, streambank wheatgrass, birdsfoot trefoil, sainfoin, alfalfa, double cut red clover and smooth brome) although the grasses exhibited the best results. Double cut red clover exhibited poor success and only one birdsfoot trefoil plant appeared.

The relative success of the vegetation growing in the furrows is thought to be attributed to the ability of the furrows to trap water. The carbonaceous shale is hydrophobic; normally when water collects in puddles on the surface it does not easily wet the soil below approximately 5 mm.

Seeding pattern area 3 is completely devoid of any vegetation. This area is that in which the carbonaceous shale was seeded "as is" without either topsoil addition or furrows.



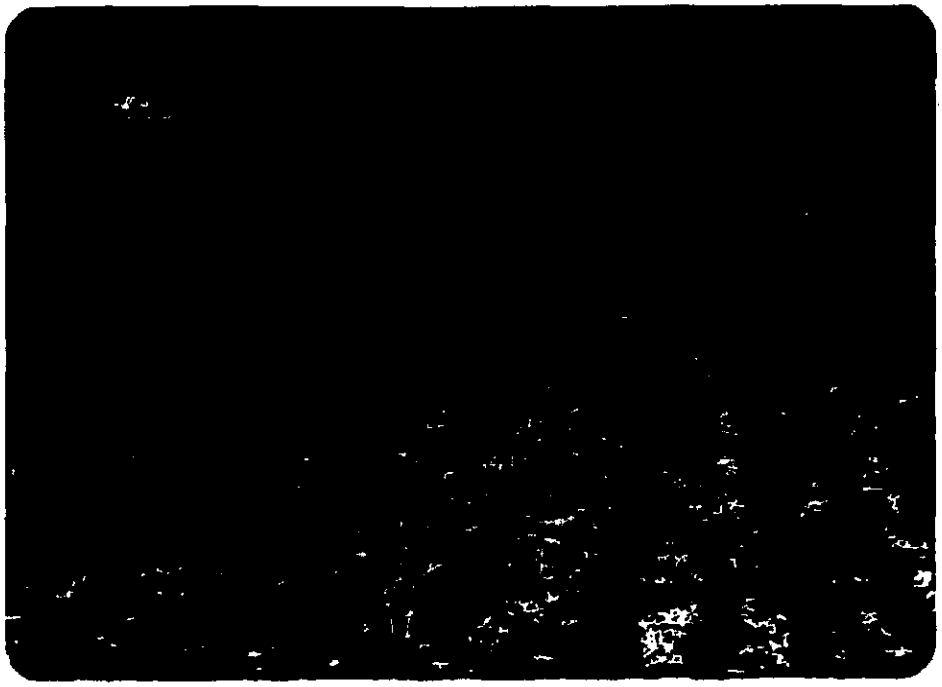
Seeding pattern areas 1 and 2 have a surficial capping of topsoil (approximately 15 cm) but do not have furrows. Agronomic species sown showed poor success compared to other areas sown in 1978 and compared to the furrowed areas on bare carbonaceous shale. This was disappointing in view of the effort and cost of adding topsoil. In addition to poor cover the plants were generally small and immature. Weed species were relatively abundant compared to the seeded species though their quantities were not nearly sufficient to provide the same level of competition as on the Trench B topsoil pile or the topsoiled portion of the Houth Meadows dump. The weed species were generally large and mature. All agronomic species tested exhibited some success, with the exception of birdsfoot trefoil.

3160' Dump Face

Vegetation success was good on the dump face. Crested wheatgrass and alfalfa were about equal in abundance but overall the slopes were somewhat patchy and erosion channels (waterborne) were fairly significant. Overall the vegetation appeared in a healthy condition. Weed species were not particularly abundant on the slopes.

3140' Dump Surface

The vegetation on the baked clay dump surface exhibited excellent success. Ground cover was very high and uniform throughout. Of the three grasses (smooth brome, crested wheatgrass and slender wheatgrass) and two legumes (sainfoin and alfalfa) applied, sainfoin appears to be the more successful species, while alfalfa exhibited poorest success. Canada bluegrass was also present at the northern end of the dump presumably from the initial seeding in 1977.



3140' Dump Face

The dump face has shown consistent improvement in vegetation success. The ground cover is relatively uniform, and the vegetation (crested wheatgrass and alfalfa) is green and has a high proportion of mature plants. Weed species are present but not abundant. Wind and/or waterborne erosion was not observed to be significant on the slopes. This dump face has been previously (May - June 1979) disturbed by cattle and consequently exhibits some patchy areas of ground disturbance and grazing.

3120' Dump Surface

Vegetation success on the claystone material is mixed, with some large areas of poor success. The vegetation that did become established (i.e. crested wheatgrass and alfalfa) is somewhat stunted, chlorotic and very dry. Overall the condition of the vegetation on this portion is unsatisfactory. The surface material is clayey and dries to a very hard crust which appears to inhibit plant development. Judging by results at Aleece Lake, however, this material

should not be too difficult to revegetate.

On the baked clay (western portion of 3120' bench surface) vegetation success is much better. Although Seed Mix VI was applied on the 3120' Bench Surface, the results are basically similar to that obtained on the baked clay at 3140'. The three grasses (streambank, slender and tall wheatgrass) exhibited good germination success but are still somewhat juvenile, whereas the legumes (alfalfa and birdsfoot trefoil) showed limited success. Typically, birdsfoot trefoil did not develop at all, and alfalfa showed scattered success.

3120' Dump Face

The claystone/gritstone dump faces exhibited vegetation success primarily in ruts left by bulldozers. Ground cover was variable with relatively good cover on the 20° and 30° slopes while cover on the steepest, the 37° slope, was scattered and generally unsatisfactory. The vegetation that has become established was somewhat stunted and very dry. Crested wheatgrass was more abundant than alfalfa.

Trench B

Topsoil Pile

Native species growth has been quite intense during the past two years and this has led to the situation where the establishment of the agronomics has been almost negligible. Both crested wheatgrass and drylander alfalfa are present on the topsoil pile but in very low proportions and they are stunted and immature.

Subsoil Pile

The condition of the vegetation on the subsoil pile was similar to that of the gravel pile. There was a good balance of grass and legume with an overall uniform ground cover. At the time of inspection the crested wheatgrass was browning, while the alfalfa was still green and healthy, with some minor chlorosis. A relatively high abundance of weed species was also noted.

Gravel Pile

On the harrow seeded portion the crested wheatgrass and alfalfa appeared healthy and were basically equally abundant. The ground cover was good. On the hydro-seeded area the alfalfa was the better established species, being on occasion over 70 cm high. Crested wheatgrass appears to be more dried out than the alfalfa. The alfalfa exhibited chlorotic lower leaves.

Trench C

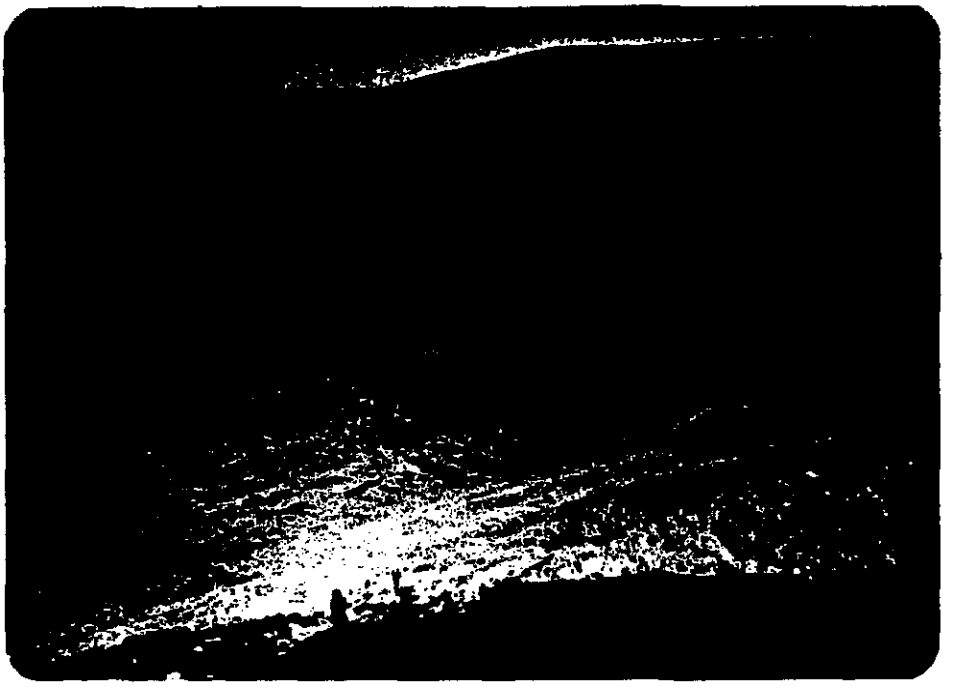
Dump 1

Despite the relative lack of moisture this past summer, there has been substantial germination success on the topsoil surface of Dump 1. All species showed some success except birdsfoot trefoil. Generally the plants were small, somewhat dried-out and juvenile. The topsoil dump face exhibited much the same plant diversity and ground cover as the dump surface, but overall the grasses were larger and healthier.

Vegetation success on the non-topsoil dump face and surface was poor. Ground cover was very patchy and the vegetation generally drier and smaller than on the topsoil.

Dump 2

The furrowed area in the centre of Dump 2 showed the most encouraging results, both on the topsoil and non-topsoil, presumably for the same reasons as on the 3160' Dump at Trench A, i.e. improved moisture collection. Alfalfa and juvenile grass species were quite abundant; birdsfoot trefoil did not develop. There is a substantial abundance of weed species on the topsoil areas of Dump 2. Apart from the furrowed areas vegetation did not develop well on the non-topsoiled dump surface. Those plants that did develop exhibited much dryness, chlorotic leaves, and were small.



Vegetation success on the dump slopes was generally much better compared to the level area. Apart from one area of topsoil where results were poor, there was little difference between topsoiled and non-topsoiled dump faces.

Erosion did not appear to be significant on any of the dump faces.

Dump 3

Six species (three grasses and three legumes) were applied in separate rows on both the raw waste and topsoiled waste material on Dump 3. Of these species, sainfoin exhibited the best results. This legume is a highly successful revegetation species in all areas where it has been applied. Alfalfa showed moderate success on the topsoil, but mixed results on the non-topsoil.

Tall wheatgrass and streambank wheatgrass had similar success: good abundance on the topsoil and no germination on the raw material.

Birdsfoot trefoil did not develop on either topsoil or non-topsoil.

Slender wheatgrass indicated slightly poorer results than the other wheatgrasses.

The non-topsoiled area adjacent to the rows showed poor results. Large areas were completely bare of vegetation while some smaller areas had patches of vegetation.

The topsoiled area adjacent to the rows indicated satisfactory results. The major species that have become established were streambank wheatgrass, tall wheatgrass and alfalfa. Dump 3 slopes showed similar results to those obtained on Dumps 1 and 2.

Coal Waste Pile

Although generally patchy on the top, this dump exhibited some areas of good cover of crested wheatgrass. Alfalfa was less abundant and generally smaller and more immature.

Vegetative growth appears somewhat better on the slopes of the coal waste pile where the vegetation (crested wheatgrass) was greener, larger and more abundant. No major erosion was observed on the coal waste though rill erosion is evident on the east side of the dump.

3.5 Drill Sites

Extensive exploratory drilling has been carried out in the Hat Creek Valley since 1974. Drill sites and roads have been reclaimed progressively since then with all disturbed areas reclaimed by the fall of 1978.

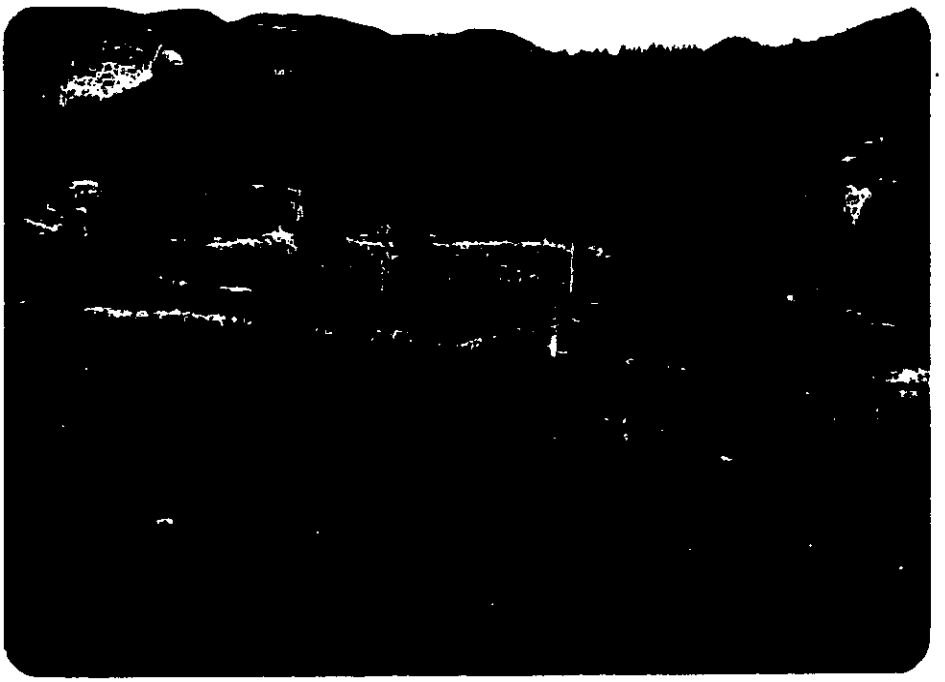
During the spring of 1979, 19 drill sites disturbed in different years were randomly selected and the progress of reclamation evaluated. With few exceptions drill sites have been reclaimed to a satisfactory level. Roads were also revegetated except for those that were still in use.

Details of those sites inspected are given below: Overall ratings of excellent, good, satisfactory and poor were assigned. Factors taken into account were overall cover; type of vegetation, weeds/agronomic; balance of legume/grass species; condition of plants, size, maturity.

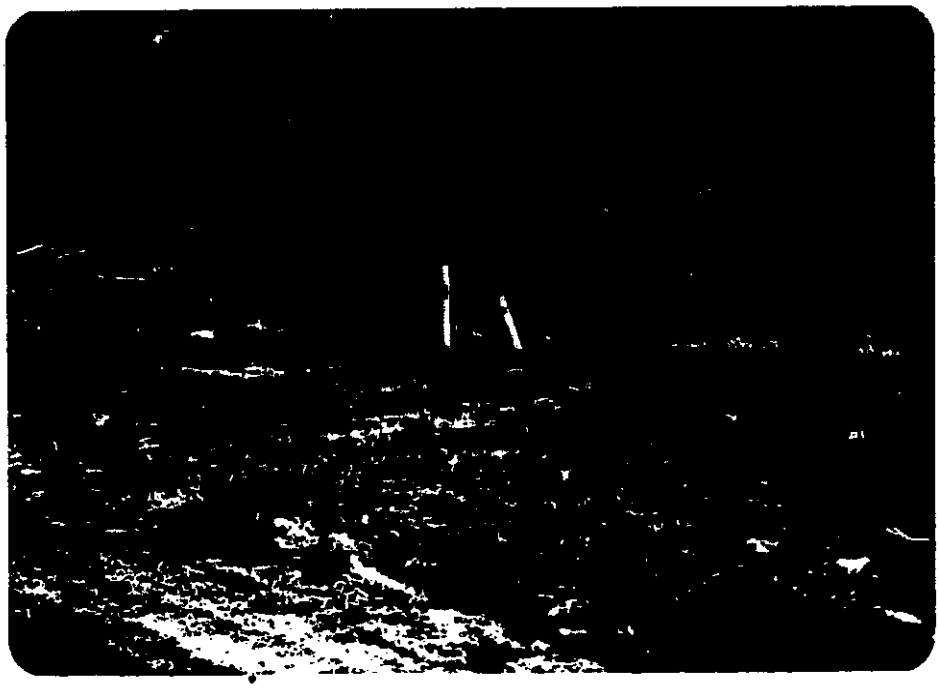
Drill Hole	Overall Evaluation	Other Comments
DDH 74-29	Satisfactory+	Grass dominated - few legumes, also lots of weeds.
DDH 74-44	Good	Good mix of grass and legume.

Drill Hole	Overall Evaluation	Other Comments
DDH 75-49	Good	Alfalfa and crested wheatgrass dominant; some brome grass; native species invading well.

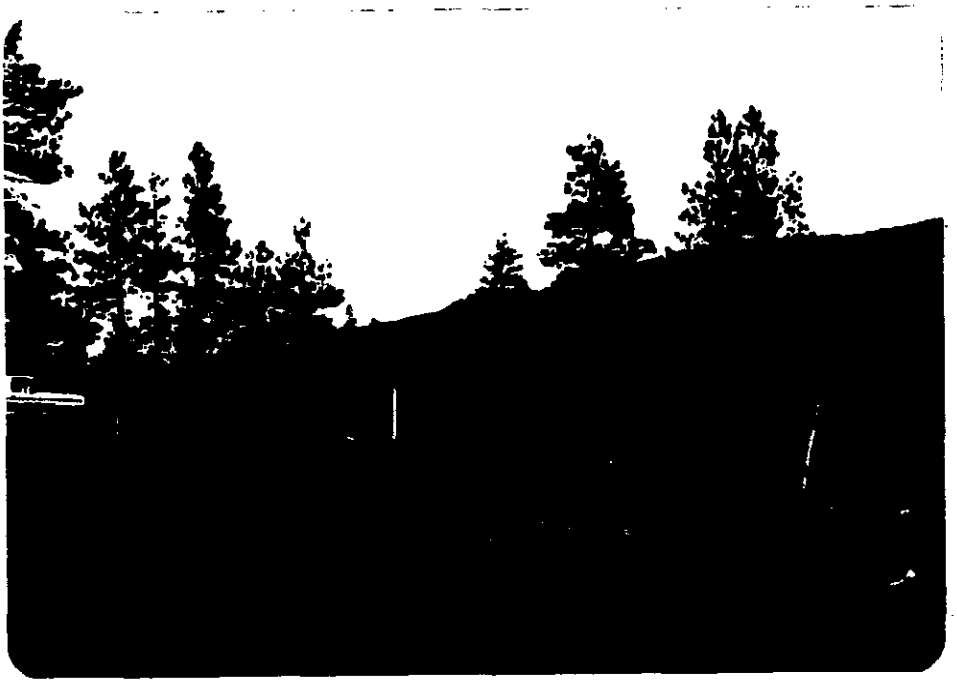
DDH 76-130/ 76-206	Excellent	Crested wheatgrass and brome grass in excellent condition - clover and native legume, weedy milk vetch, present.



Drill Hole	Overall Evaluation	Other Comments
DDH 76-145	Excellent	Almost all grasses - no legume.
DDH 76-154	Poor	Some fall rye and slender wheatgrass but mostly weeds.
DDH 76-159	Satisfactory	Crested wheatgrass mature and healthy; alfalfa in limited quantities - large quantity of weeds.
DDH 76-162	Satisfactory	
DDH 76-251	Excellent	Fall rye dominated. Long term potential may suffer from first year dominance by fall rye.
DDH 76-803	Satisfactory	Alfalfa shows excellent results - good invasion by native species - patchy.



Drill Hole	Overall Evaluation	Other Comments
DDH 76-813	Excellent	Smooth brome, crested wheatgrass and streambank show excellent results. Alfalfa outcompeted.
DDH 76-814	Excellent	Alfalfa (dominant) and smooth brome, crested wheatgrass and streambank show excellent results.
RH 77-18, 53, 58	Poor+	Both crested wheatgrass and alfalfa present but in small quantities. Fall rye present.



DDH 77-39	Satisfactory	Grasses present but mostly immature - similarly alfalfa.
RH 77-66	Satisfactory	Rotary holes were not re-seeded since disturbance is only minor.
DDH 78-860	Good+	Grass dominated (crested wheatgrass and smooth brome). Alfalfa present but small in size.