DESIGN OF STABILITY-CONTROL MEASURES FOR THE MILLER CREEK DIVERSION

Submitted to

UTAH DIVISION OF OIL, GAS, AND MINING
Salt Lake City, Utah

Submitted by

U.S. FUEL COMPANY
Hiawatha, Utah

November 27, 1984

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DESIGN OF STABILITY-CONTROL MEASURES FOR THE MILLER CREEK DIVERSION

INTRODUCTION

On July 13, 1984 and August 31, 1984, U.S. Fuel Company submitted responses to the Utah Division of Oil, Gas, and Mining regarding Notice of Violation N84-4-8-8 No. 1 of 8 dealing with the Miller Creek diversion adjacent to Slurry Pond No. 1. These submittals indicated that the diversion would be riprapped to provide stability during runoff from the 100-year, 24-hour storm.

Subsequent to these submittals, it was determined that the cost of installing the riprap would be prohibitive and a letter was submitted to the Division by U.S. Fuel Company so indicating. This letter requested that additional time be allowed for U.S. Fuel Company to re-evaluate the design.

On October 5, 1984, the Division sent U.S. Fuel Company a letter concurring with the time extension and suggesting that a meeting be held onsite to examine the existing diversion and discuss alternative stability-control measures. This meeting was held on October 12, 1984 and was attended by John Whitehead and Tom Munson of the Division, Bob Eccli of U.S. Fuel Company, and Richard White of EarthFax Engineering, Inc.

The purpose of this report is to present the results of analyses and designs completed as a result of this field meeting. This submittal supersedes the previous two submittals in their entirety. Thus, the previous submittals should be purged from the files.

PEAK FLOW DETERMINATION

The diversion is considered permanent and was, therefore, analyzed in light of the peak flow from the 100-year, 24-hour storm. Determination of this peak flow was accomplished using the rainfall-runoff model developed by Hawkins and Marshall (1979) for the Division.

Model inputs and results are provided in Appendix A. The curve number for the watershed was calculated by determining the area within the watershed occupied by each distinct vegetative/land-use type. Boundaries for the various types were obtained from Exhibit IX (Vegetation Types Map) of the Permit Application Package. Curve numbers for each vegetative/land-use type were obtained from the U.S. Bureau of Reclamation (1977). A weighted-average curve number for the entire watershed was then obtained as shown in Table 1.

Table 1. Curve numbers for various vegetative/land-use types found in the Miller Creek watershed.

Vegetative/ Land-Use Type	Area (ac)	Curve Number
Aspen	930	54
Sagebrush	690	67
Mountain brush	1330	40
Pinyon-juniper	1090	70
Grass	460	81
Disturbed	30	90
Mixed conifer	3710	62
Total	8240	60

The time of concentration was calculated using the curve-number method of the U.S. Soil Conservation Service (1972). This calculation is also contained in Appendix A. The precipitation depth for the 100-year, 24-hour storm (3.18 inches) was obtained from Richardson (1971). The SCS Type B curve provided by Hawkins and Marshall (1979) was used for the analysis since this curve was considered to be most representative of conditions for the long-duration (24-hour) event.

Results presented in Appendix A indicate that the peak flow from the design precipitation event is 286 cubic feet per second. Total runoff depth is 0.40 inch, with a time to peak of 12.0 hours for the hydrograph.

STABILITY-CONTROL DESIGN

Based on the longitudinal profile and cross section, the diversion was divided into three sections of similar cross section and slope for the purpose of this analysis. These sections are noted in Figures 1 and 2. A sample of the bed material was collected from each of these sections and submitted to a laboratory for sieve analyses. Results of these analyses are contained in Appendix B.

The diversion channel is characterized by a relatively flat upper section with an average slope of 2.2 percent, a middle convex section with an average slope of 5.5 percent, and a lower concave section with an average channel slope of 2.0 percent. The channel width varies from about 6 to 18 feet. The middle section has eroded, creating vertical sideslopes on the channel with a maximum height of about 1.5 feet.

Most of the diversion is lined along the edge with a good growth of willows (approximately 3 feet tall) and grasses (up to 2 feet tall). This vegetation extends into the channel bottom in some areas. The existing stone bottom has naturally compacted and armored, creating a dense, erosion-resistant layer.

Flow velocities and depths during the design runoff event were determined using the trapezoidal-channel design package developed by the U.S. Office of Surface Mining and discussed by Weider et al. (1983). The channel roughness coefficient (Manning's n) was determined for this analysis using the systematic procedure developed by the U.S. Soil Conservation Service (1956). Results of this determination (provided in Appendix C) indicate a roughness coefficient of 0.053. Longitudinal and cross-sectional data required for the analyses were obtained from Figures 1 and 2, respectively.

Results of the instream flow analyses are presented in Appendix C and summarized in Table 2. As presented in the table, design flow velocities in the existing diversion channel vary

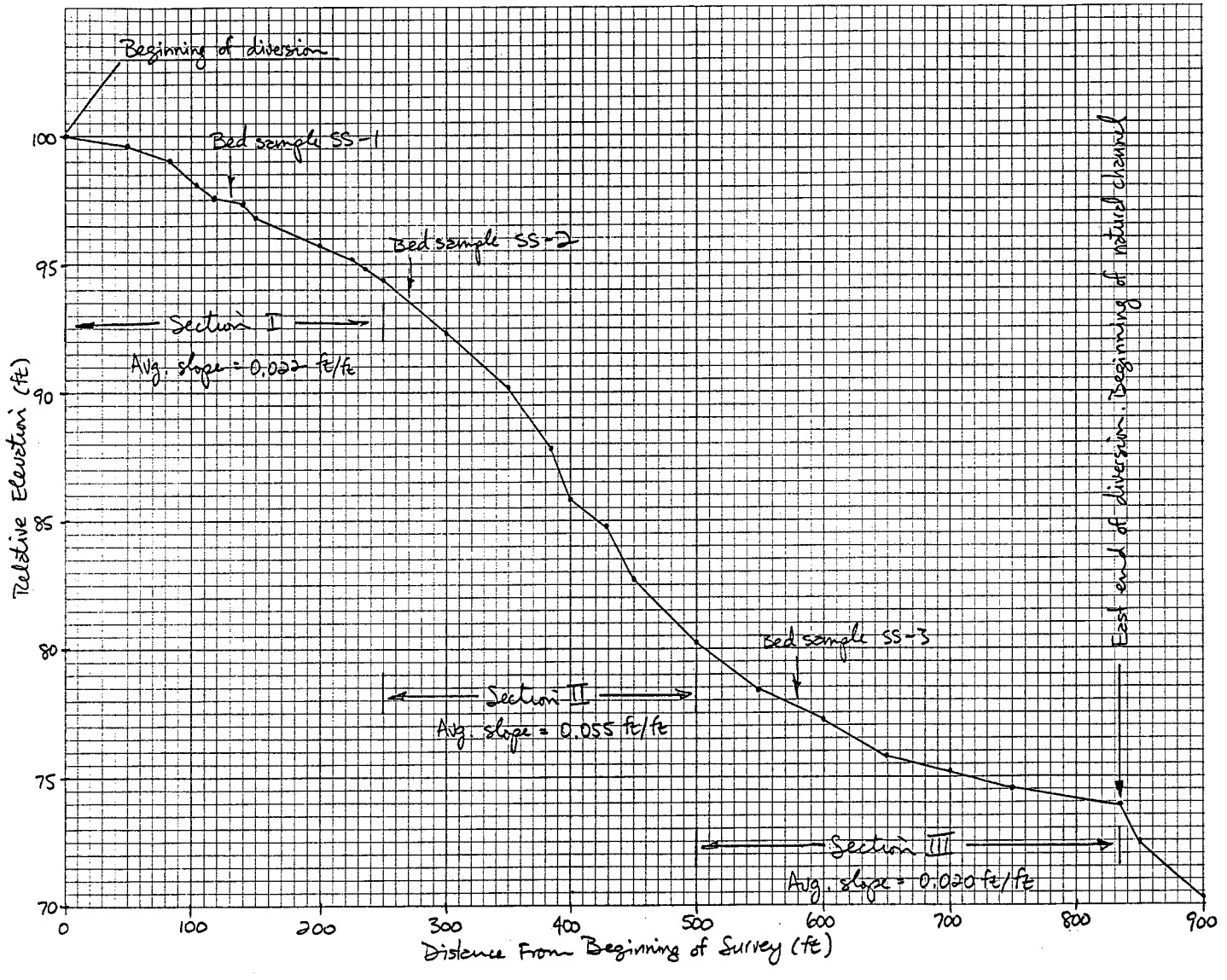

Figure 1. Longitudinal profile of the Miller Creek diversion

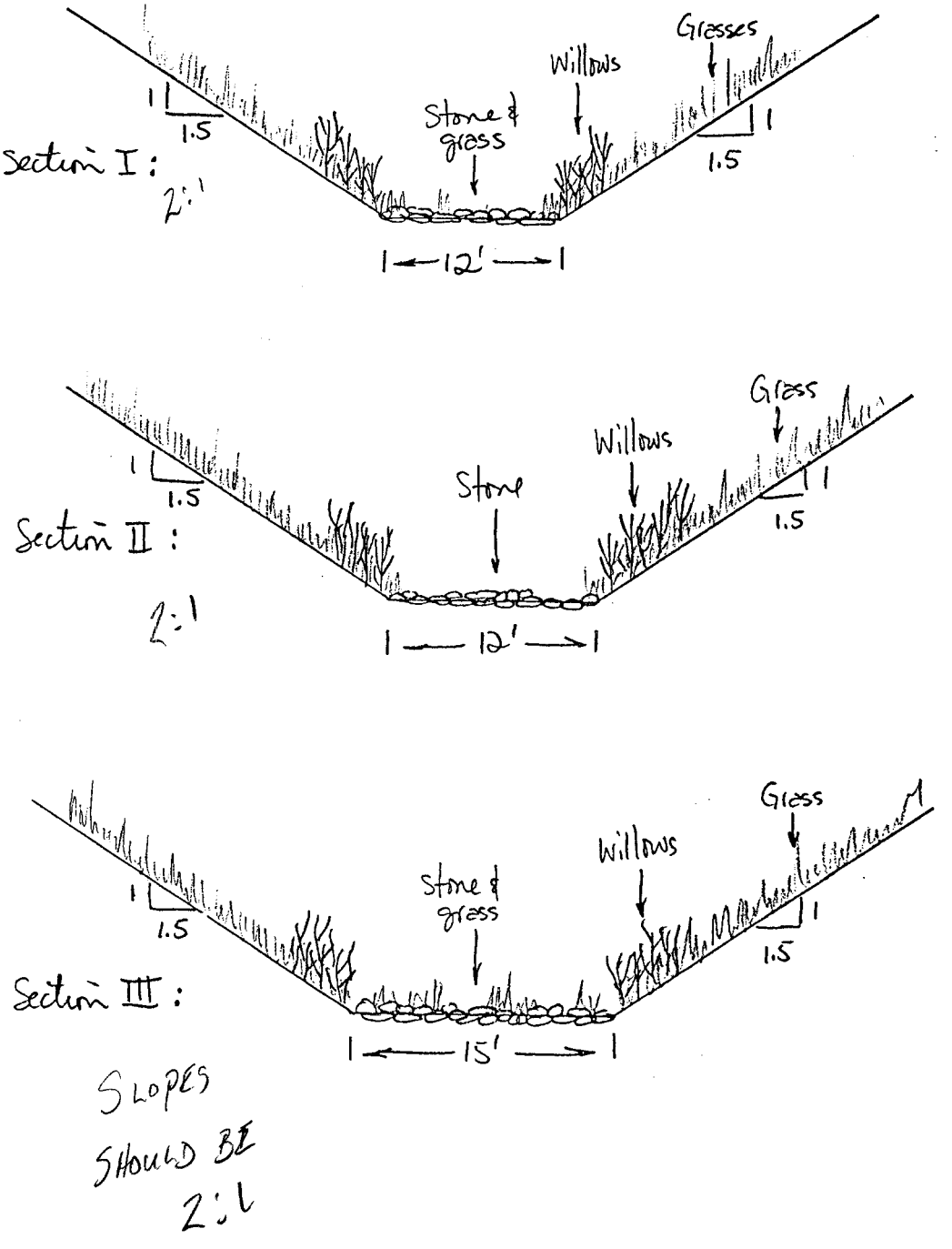

Figure 2. Representative cross sections of the Miller Creek diversion.

Table 2. Flow conditions in the diversion at the peak of the design runoff event.

Section	Flow Depth (ft)	Velocity (ft/s)	Max. Perm. Velocity (ft/s)
I	2.70	6.60	7.90
II	2.08	9.07	8.80
III	2.48	6.16	7.74

from 6.16 to 9.07 feet per second. The maximum permissible velocities shown in Table 2 were determined using a methodology presented by the U.S. Soil Conservation Service (1977) based on the particle-size distribution of the bed material. Calculations and methodologies required to determine these maximum permissible velocities are contained in Appendix C. Only the middle section of the diversion has a design velocity that exceeds the maximum permissible velocity.

To provide the required stability in the middle section of the diversion, three loose-rock check dams will be installed. The design of these check dams (using methodologies developed by Heede, 1976) is provided in Appendix C. The dams will have an effective height of 1.5 feet and will be spaced on 80-foot centers. The apron below the dams will have a length of 2.5 feet. The aprons will be embedded 6 inches into the existing channel bottom. Bank protection will be provided below the check dams by lining the channel banks with the same riprap used to construct the dams for a distance equal to the length of the apron (2.5 feet). This bank protection will be keyed into the channel banks to a depth of 1 foot.

Each loose-rock check dam will be keyed into the bottom and sides of the existing diversion. The keys will be 2 feet wide and extend 2 feet into the channel bottom and sides. Special care will be taken during installation of the check dams to minimize damage to the vegetation that is currently growing along the channel banks and bottom. Where possible, the keys will be dug with a backhoe from the bench above the channel. Where this distance is too great, the keys will be dug by hand. A backhoe will be used from the bench to initially place the rock for the dams. Final placement will be accomplished by hand.

As indicated in Appendix C, riprap used for construction of the loose-rock check dams will be graded according to Table 3. This gradation was determined using the Isbach equation (Heede, 1976) and gradation criteria developed by the U.S. Army Corps of Engineers (1970). As such, the stone size will be stable when subjected to the design velocities.

The diversion channel will be allowed to naturally aggrade behind the loose-rock check dams, thereby decreasing the effective slope of the channel. The stair-step effect that will be created by the check dams currently exists in the natural channel above and below the diversion and will, thus, be conducive with local hydraulic conditions. Appendix C indicates that the velocity in the middle section of the diversion will be lower than the maximum permissible velocity shown in Table 2.

No cleanout of the aggraded materials behind the check dams will be necessary since the purpose of the dams will be to stabilize the channel bottom rather than serve as a control device for sediment from upstream areas. The diversion will be periodically inspected to ensure that the check dams are functioning properly and that the diversion is stable with respect to erosion.

According to Chapter 10 of the Permit Application Package, Miller Creek does not support any species of fish. Hence, the loose-rock check dams will not create a deterrent to local fishery populations.

Table 3. Gradation of riprap for loose-rock check dams.

Size (in)	Percent Finer
9.0	100
7.7	80
6.5	65
4.5	50
1.9	30
0.6	15

REFERENCES

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APPENDIX A

Flow Rate Calculations

DETERMINATION OF PEAK FLOW AT MILLER CREEK DIVERSION

Methodology

Use model developed by Hawkins and Marshall (1979)

Model Inputs

Curve number (assume hydro. soil group C in all cases):

Aspen → 930 ac
- Cover = fair (field obs.)
- CN = 54

Sagebrush → 690 ac
- Cover = 50% (fair)
- CN = 67

Mountain brush → 1330 ac
- Cover = 70-80% (good)
- CN = 40 (see oak-aspen definition)

Pinyon-juniper → 1090 ac
- Cover = 55-60% (fair)
- CN = 70

Grass → 460 ac
- Cover = fair (field obs.)
- CN = 81 (herbaceous)

Disturbed → 30 ac
- CN = 90 (field obs.)

Mixed conifer → 3710 ac
- Cover = 75-90% (good)
- CN = 62

Acreage from Exhibit IX-1
Cover from field obs. and Chapter VII of PAP
CN from field obs. and tabulated values provided by the U.S. Bureau of Rec. (1977)

$$\text{Avg. CN} = \frac{(930)(54) + (690)(67) + (1330)(40) + (1090)(70) + (460)(81) + (30)(90) + (3710)(62)}{930 + 690 + 1330 + 1090 + 460 + 30 + 3710}$$

$$= 60$$

Time of concentration $\longrightarrow$ $T_c = 1.67\,L$

$$L = \frac{l^{0.8}\,(S+1)^{0.7}}{1900\,Y^{0.5}}$$

where l = hydraulic length = 31,000 ft

$$S = \frac{1000}{CN} - 10 = 6.67$$

Y = avg. watershed slope

$$= \frac{(489{,}200\text{ ft})(400\text{ ft})}{(8240\text{ ac})(43{,}560\text{ ft}^2/\text{ac})} = 0.545 \Rightarrow 54.5\%$$

$$L = \frac{(31{,}000)^{0.8}\,(7.67)^{0.7}}{(1900)(54.5)^{0.5}} = 1.16\text{ hr}$$

$$T_c = (1.16\text{ hr})(1.67) = 1.94\text{ hr}$$

Area = 8240 ac = 12.88 mi^2

Design storm $\longrightarrow$ 100-yr, 24-hr

P = 3.18 in (see Richardson, 1971)

Rainfall distribution curve $\longrightarrow$ SCS (probably most representative of long-duration storms in the area).

Model Results

See pages 3-5 of this calc.

IDENTIFICATION: MILLER CREEK DIVERSION

INPUT SUMMARY:

STORM:	WATERSHED:
DIST. = SCS TYPE B	AREA = 12.880 SQ. MI.
DEPTH = 3.18 IN.	CN = 60.0
DURATION = 24.0 HR.	TIME OF CONC. = 1.94 HR.

UNIT HYDROGRAPH ORDINATES:

TIME (HR)	UHO (IN/HR)	UHO (CFS)	TIME (HR)	UHO (IN/HR)	UHO (CFS)
0.00	0.0000	0.00	1.81	0.4407	3663.21
0.26	0.1160	964.00	2.07	0.3711	3084.81
0.52	0.2320	1928.01	2.33	0.3015	2506.41
0.78	0.3479	2892.01	2.59	0.2320	1928.01
1.03	0.4639	3856.01	2.85	0.1624	1349.60
1.29	0.5799	4820.02	3.10	0.0928	771.20
1.55	0.5103	4241.61	3.36	0.0232	192.80

OUTFLOW HYDROGRAPH:

TIME (HR)	PPT (IN)	CUM. FLOW (IN)	DEL. FLOW (IN)	FLOW RATE (IN/HR)	FLOW RATE (CFS)
0.00	0.00	0.0000	0.0000	0.0000	0.00
0.00	0.00	0.0000	0.0000	0.0000	0.00
0.26	0.01	0.0000	0.0000	0.0000	0.00
0.52	0.03	0.0000	0.0000	0.0000	0.00
0.78	0.04	0.0000	0.0000	0.0000	0.00
1.03	0.06	0.0000	0.0000	0.0000	0.00
1.29	0.07	0.0000	0.0000	0.0000	0.00
1.55	0.09	0.0000	0.0000	0.0000	0.00
1.81	0.10	0.0000	0.0000	0.0000	0.00
2.07	0.12	0.0000	0.0000	0.0000	0.00
2.33	0.13	0.0000	0.0000	0.0000	0.00
2.59	0.15	0.0000	0.0000	0.0000	0.00
2.85	0.17	0.0000	0.0000	0.0000	0.00
3.10	0.19	0.0000	0.0000	0.0000	0.00
3.36	0.21	0.0000	0.0000	0.0000	0.00
3.62	0.23	0.0000	0.0000	0.0000	0.00
3.88	0.25	0.0000	0.0000	0.0000	0.00
4.14	0.27	0.0000	0.0000	0.0000	0.00
4.40	0.29	0.0000	0.0000	0.0000	0.00

4.66	0.31	0.0000	0.0000	0.0000	0.00
4.91	0.33	0.0000	0.0000	0.0000	0.00
5.17	0.36	0.0000	0.0000	0.0000	0.00
5.43	0.38	0.0000	0.0000	0.0000	0.00
5.69	0.40	0.0000	0.0000	0.0000	0.00
5.95	0.42	0.0000	0.0000	0.0000	0.00
6.21	0.46	0.0000	0.0000	0.0000	0.00
6.47	0.50	0.0000	0.0000	0.0000	0.00
6.73	0.54	0.0000	0.0000	0.0000	0.00
6.98	0.58	0.0000	0.0000	0.0000	0.00
7.24	0.62	0.0000	0.0000	0.0000	0.00
7.50	0.66	0.0000	0.0000	0.0000	0.00
7.76	0.70	0.0000	0.0000	0.0000	0.00
8.02	0.74	0.0000	0.0000	0.0000	0.00
8.28	0.89	0.0000	0.0000	0.0000	0.00
8.54	1.05	0.0000	0.0000	0.0000	0.00
8.79	1.20	0.0000	0.0000	0.0000	0.00
9.05	1.35	0.0000	0.0042	0.0000	0.05
9.31	1.50	0.0042	0.0106	0.0005	4.12
9.57	1.66	0.0148	0.0167	0.0022	18.42
9.83	1.81	0.0315	0.0163	0.0059	48.78
10.09	1.92	0.0478	0.0066	0.0114	94.82
10.35	1.96	0.0544	0.0070	0.0177	147.15
10.61	2.00	0.0613	0.0074	0.0240	199.77
10.86	2.05	0.0687	0.0077	0.0292	243.12
11.12	2.09	0.0765	0.0081	0.0323	268.24
11.38	2.13	0.0846	0.0085	0.0332	276.10
11.64	2.17	0.0930	0.0088	0.0339	281.94
11.90	2.21	0.1019	0.0080	0.0344	285.51
12.16	2.25	0.1099	0.0076	0.0343	285.48
12.42	2.28	0.1175	0.0078	0.0338	280.81
12.67	2.31	0.1252	0.0080	0.0328	272.75
12.93	2.34	0.1332	0.0082	0.0318	264.22
13.19	2.38	0.1414	0.0084	0.0311	258.46
13.45	2.41	0.1498	0.0086	0.0310	257.88
13.71	2.44	0.1585	0.0088	0.0312	259.64
13.97	2.48	0.1673	0.0065	0.0315	261.87
14.23	2.50	0.1738	0.0063	0.0316	262.27
14.49	2.52	0.1801	0.0064	0.0313	260.48
14.74	2.55	0.1865	0.0065	0.0309	256.48
15.00	2.57	0.1930	0.0066	0.0301	250.25
15.26	2.59	0.1995	0.0067	0.0291	241.77
15.52	2.61	0.2062	0.0067	0.0282	234.44
15.78	2.64	0.2129	0.0067	0.0275	228.37
16.04	2.66	0.2197	0.0063	0.0269	223.43
16.30	2.68	0.2260	0.0064	0.0264	219.15
16.55	2.70	0.2323	0.0064	0.0259	215.59
16.81	2.72	0.2388	0.0065	0.0256	212.80
17.07	2.74	0.2453	0.0066	0.0254	210.82
17.33	2.76	0.2518	0.0067	0.0252	209.84
17.59	2.78	0.2585	0.0067	0.0252	209.80
17.85	2.80	0.2652	0.0062	0.0253	210.10
18.11	2.82	0.2714	0.0055	0.0253	210.15
18.37	2.84	0.2769	0.0055	0.0252	209.16
18.62	2.85	0.2824	0.0056	0.0249	207.13

18.88	2.87	0.2880	0.0056	0.0245	204.04
19.14	2.89	0.2936	0.0057	0.0240	199.87
19.40	2.90	0.2993	0.0057	0.0235	195.45
19.66	2.92	0.3050	0.0057	0.0231	191.79
19.92	2.94	0.3107	0.0058	0.0227	188.82
20.18	2.95	0.3165	0.0058	0.0224	186.54
20.43	2.97	0.3223	0.0059	0.0223	184.98
20.69	2.99	0.3282	0.0059	0.0222	184.14
20.95	3.00	0.3341	0.0059	0.0221	184.04
21.21	3.02	0.3400	0.0060	0.0222	184.70
21.47	3.03	0.3460	0.0060	0.0224	185.92
21.73	3.05	0.3520	0.0061	0.0225	187.28
21.99	3.07	0.3581	0.0054	0.0227	188.63
22.25	3.08	0.3635	0.0054	0.0228	189.28
22.50	3.10	0.3689	0.0054	0.0228	189.17
22.76	3.11	0.3743	0.0054	0.0227	188.29
23.02	3.13	0.3797	0.0055	0.0225	186.65
23.28	3.14	0.3852	0.0055	0.0222	184.22
23.54	3.15	0.3907	0.0055	0.0219	182.13
23.80	3.17	0.3962	0.0044	0.0217	180.43
24.06	3.18	0.4006	0.0000	0.0214	177.96
24.31	3.18	0.4006	0.0000	0.0205	170.52
24.57	3.18	0.4006	0.0000	0.0190	158.08
24.83	3.18	0.4006	0.0000	0.0169	140.61
25.09	3.18	0.4006	0.0000	0.0142	118.09
25.35	3.18	0.4006	0.0000	0.0111	92.36
25.61	3.18	0.4006	0.0000	0.0084	69.88
25.87	3.18	0.4006	0.0000	0.0061	50.51
26.13	3.18	0.4006	0.0000	0.0041	34.26
26.38	3.18	0.4006	0.0000	0.0025	21.15
26.64	3.18	0.4006	0.0000	0.0013	11.20
26.90	3.18	0.4006	0.0000	0.0005	4.42
27.16	3.18	0.4006	0.0000	0.0001	0.84
27.42	3.18	0.4006	0.0000	0.0000	0.00
27.68	3.18	0.4006	0.0000	0.0000	0.00

OUTPUT SUMMARY:

TOTAL RUNOFF DEPTH = 0.4006 INCHES
INITIAL ABSTRACTION = 1.3333 INCHES
PEAK FLOW = 285.95 CFS (0.0344 IN/HR)
TIME TO PEAK = 12.03 HOURS
RUNOFF VOLUME CHECK = 0.4014 INCHES

APPENDIX B

Results of Sieve Analyses

GARCO TESTING LABORATORIES

P.O. Box 7006 - 532 West 3560 South
Salt Lake City, Utah 84115
Phone 266-4498

October 26, 1984

Earth Fax Engineering, Inc.
6542 South 670 West
Murray, Utah 84107

Material: Pit Run

Tests: Sieve Analysis, ASTM C-117
C-136

Date of Tests: October 19, 1984

Test Results

Lab # 5388

Identification: SS-1

SIEVE #	% PASSING
6 "	100
4½ "	65.9
3 "	55.2
2½ "	39.0
2 "	33.9
1½ "	27.8
1 "	21.5
3/4"	18.2
1/2"	14.4
3/8"	12.7
#4	9.1
#8	7.2
#16	5.9
#30	5.1
#50	3.9
#100	2.3
#200	1.4

Lab # 5389

Identification: SS-2

SIEVE #	% PASSING
8 "	65.6
4 "	57.7
3 3/4"	45.6
3 "	42.1
2½ "	36.2
2 "	24.9
1½ "	19.5
1 "	15.0
3/4 "	12.8
1/2 "	10.5
3/8 "	9.2
#4	6.1
#8	4.3
#16	3.2
#30	2.5
#50	1.8
#100	1.0
#200	.6

LAB # 5390

Identification: SS-3

SIEVE #	% PASSING
6 "	100
4 "	81.0
3 "	71.5
2½ "	62.4
2 "	45.5
1½ "	37.7
1 "	27.3
3/4"	21.3
1/2"	16.2
3/8"	13.3
#4	9.4
#8	7.4
#16	6.0
#30	5.2
#50	4.1
#100	2.6
#200	1.7

Sincerely,

Doug Watson

Doug Watson
Manager

APPENDIX C

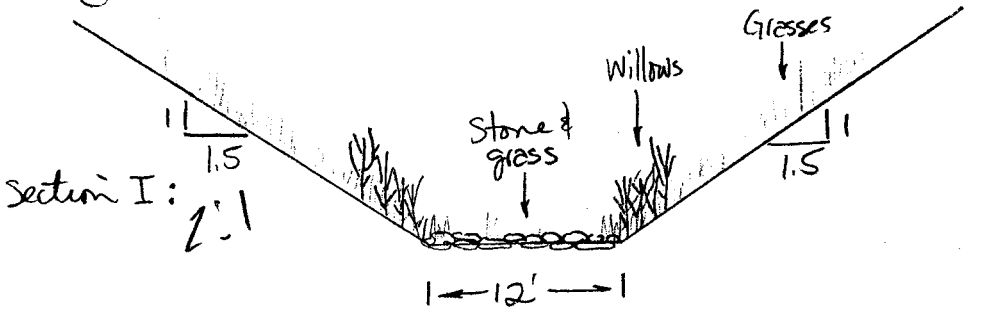
Design of Stability-Control Measures

DESIGN OF MILLER CREEK PERMANENT DIVERSION

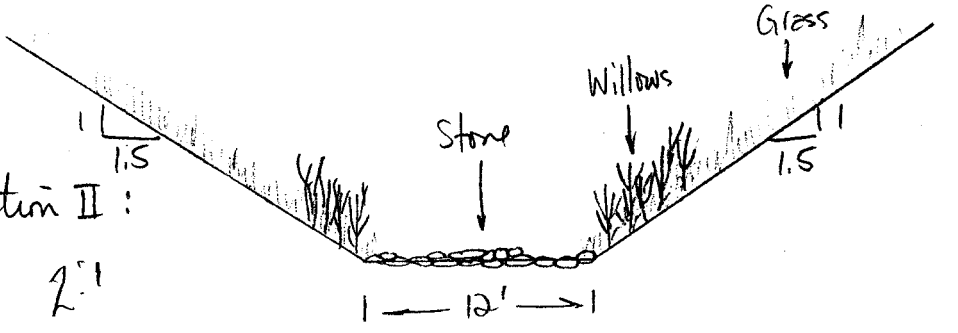
Existing Profile

Stream profile → see page 2 of this calc. This profile also shows the locations where bed (gravel) samples were collected for size-fraction analyses.

Existing Cross Sections



Section I: 2:1



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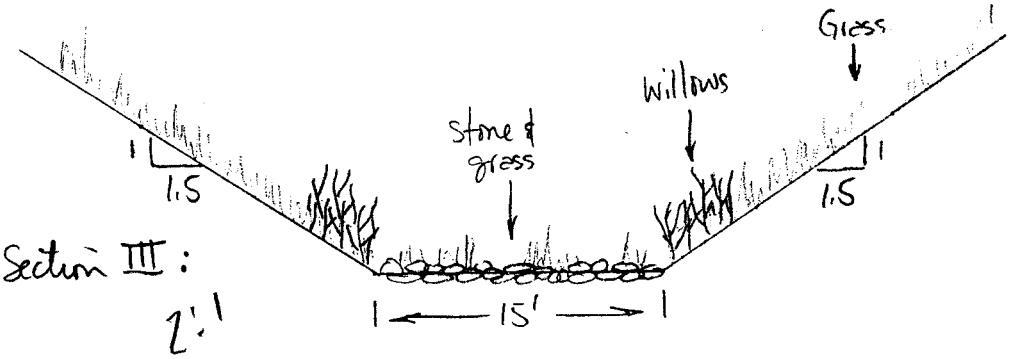
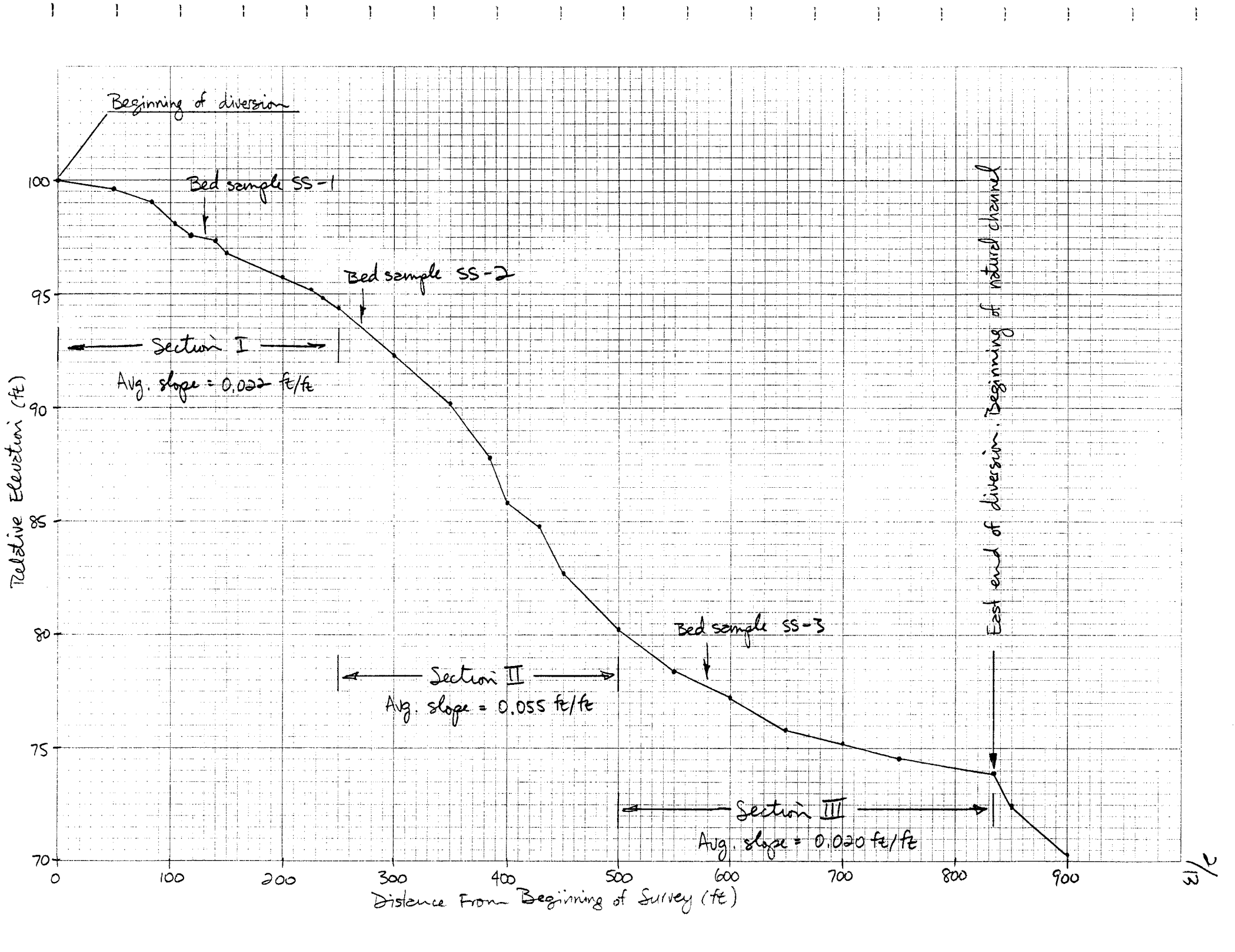


Section III: 2:1


Beginning of diversion
Bed sample SS-1
Bed sample SS-2
Bed sample SS-3
Section I
Avg. slope = 0.022 ft/ft
Section II
Avg. slope = 0.055 ft/ft
Section III
Avg. slope = 0.020 ft/ft
East end of diversion. Beginning of natural channel
Relative Elevation (ft)
Distance From Beginning of Survey (ft)
100
95
90
85
80
75
70
0
100
200
300
400
500
600
700
800
900

Selection of Roughness Coefficient (Existing Conditions):

Use systematic procedure provided by U.S. SCS (1956)

Step	Description	Remarks	Modifying Value
1	Basic n	Coarse gravel and stone	0.028
2	Surface irregularity	Slightly eroded & scoured side slopes	0.005
3	Variation in shape	Gradual	0.000
4	Obstructions	Negligible	0.000
5	Vegetation	Willows on banks 3 to 5 ft tall. Grasses flexible (1 to 2 ft tall) on banks & bottom	0.020
6	Meandering	Minor	0.000
7	n value	Sum of above	0.053

Flow Velocity During Design Runoff Event (Existing Conditions):

Determine using TRAP1 as obtained from OSM (see Weider et al., 1984)

Section I → Flow depth = 2.70 ft
$A = 43.3\ ft^2$
$P = 21.7\ ft$
$R = 1.99\ ft$
$V = 6.60\ ft/s$

Section II → Flow depth = 2.08 ft
$A = 31.5\ ft^2$
$P = 19.5\ ft$
$R = 1.62\ ft$
$V = 9.07\ ft/s$

Section III → Flow depth = 2.48 ft
A = 46.5 ft²
P = 23.9 ft
R = 1.94 ft
V = 6.16 ft/s

Size-Fraction Distribution of Bed Material

See curves on page 5 of this calc.

Permissible Velocities

Base permissible velocity on d_{75} of bed material and charts provided by U.S. SCS (1977). Assume sediment-laden flow. → see page 5 of this calc. → see page 6 of this calc.

For Section I (Bed sample SS-1):

d_{75} = 5.0 in = 127 mm

Basic velocity = 11.2 ft/s

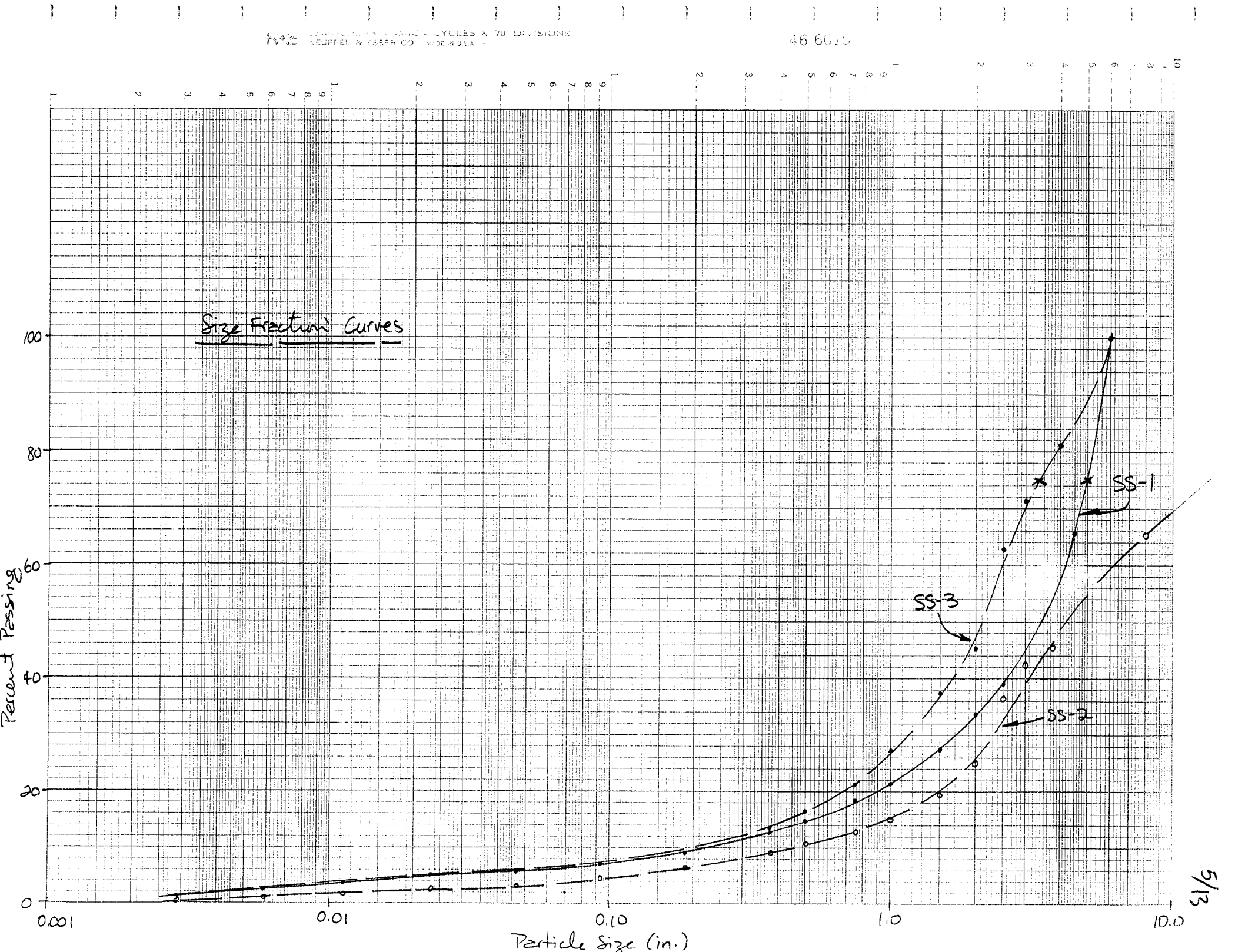
Allowable velocity = (Basic velocity) × D × A × B

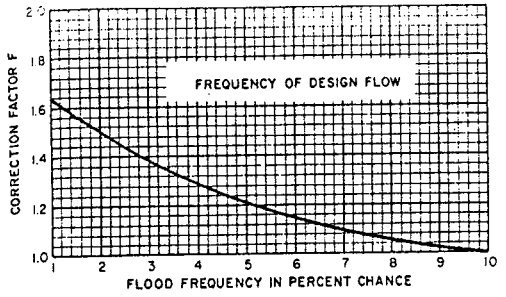
D = 0.98 (based on flow depth of 2.61 ft)
A = 1.00 (straight channel)
B = 0.72 (2:1 side slopes)

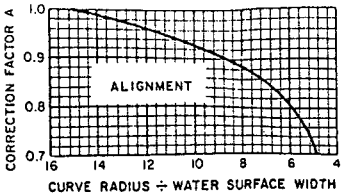
Allowable velocity = (11.2 ft/s)(0.98)(1.00)(0.72)
= 7.90 ft/s

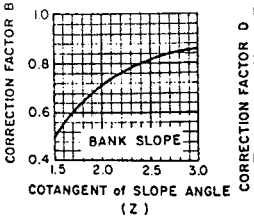
Actual velocity = 6.60 ft/s

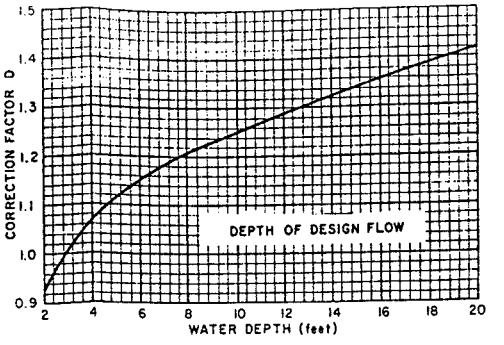
Actual velocity < Allowable velocity. Therefore, section requires no additional armoring.

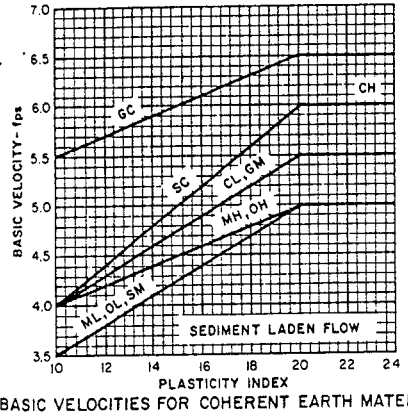

Size Fraction Curves
SS-1
SS-3
SS-2
Percent Passing
0
20
40
60
80
100
0.001
0.01
0.10
1.0
10.0
Particle Size (in.)



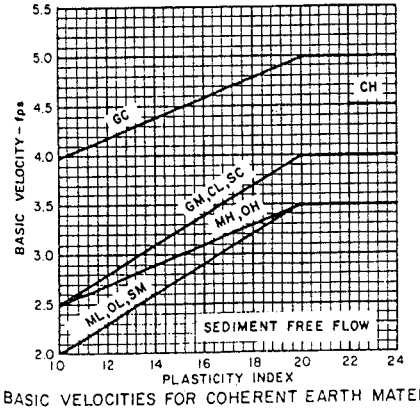




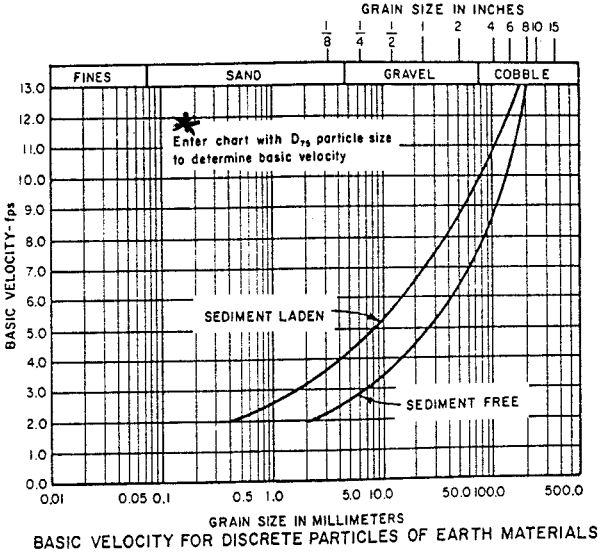




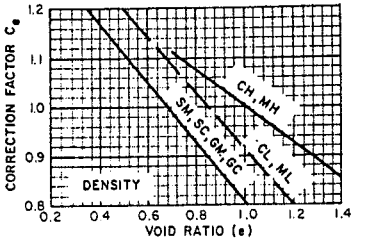
BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)



BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)



BASIC VELOCITY FOR DISCRETE PARTICLES OF EARTH MATERIALS (v_b)



NOTES:

1. In no case should the allowable velocity be exceeded when the 10% chance discharge occurs, regardless of the design flow frequency.

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS	
CHANNEL BOUNDARY MATERIALS	ALLOWABLE VELOCITY
DISCRETE PARTICLES	
Sediment Laden Flow	
$D_{75} > 0.4$ mm	Basic velocity chart value x D x A x B
$D_{75} < 0.4$ mm	2.0 fps
Sediment Free Flow	
$D_{75} > 2.0$ mm	Basic velocity chart value x D x A x B
$D_{75} < 2.0$ mm	2.0 fps
COHERENT EARTH MATERIALS	
PI > 10	Basic velocity chart value x D x A x F x C_e
PI < 10	2.0 fps

FIGURE 6-2

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS

Revised -

6/13

For Section II (Bed sample SS-2):

d_{75} = 13 in = 330 mm

Basic velocity = 13.0 ft/s

D = 0.94 (flow depth = 2.03 ft)

A = 1.00 (straight)

B = 0.72 (2:1 side slopes)

Allowable velocity = (13.0 ft/s)(0.94)(1.00)(0.72)
= 8.80 ft/s

Actual velocity = 9.07 ft/s.

Actual velocity > Allowable velocity. Therefore, additional work required.

For Section III (Bed sample SS-3):

d_{75} = 3.4 in = 86 mm

Basic velocity = 11.2 ft/s

D = 0.96 (flow depth = 2.41 ft)

A = 1.00 (straight)

B = 0.72 (2:1 side slopes)

Allowable velocity = (11.2)(0.96)(1.00)(0.72) = 7.74 ft/s

Actual velocity = 6.16 ft/s

Actual velocity < Allowable velocity. Therefore, no additional armoring required.

Check Dam Design for Section II

Determine necessary stone size from the Isbach eq. (Heede, 1976):

$$W = (2.44 \times 10^{-5})\, V^6$$

where $W = d_{65}$ stone weight (lb)
V = velocity (ft/s)

$$W = (2.44 \times 10^{-5})(9.07 \text{ ft/s})^6 = 13.6 \text{ lb}$$

According to the U.S. Army Corps of Engineers (1970)

$$d_s = \left[\frac{6 W_s}{\pi \gamma_s}\right]^{\frac{1}{3}}$$

where γ = stone unit weight (assume 165 lb/ft^3)
d_s = equivalent-volume spherical stone diameter (ft)

$$d_{65} = \left[\frac{(6)(13.6)}{(\pi)(165)}\right]^{1/3} = 0.54 \text{ ft} = \underline{6.5 \text{ in}}$$

Stone gradation (based on curve on page 9 of this calc. and U.S. Army Corps of Engineers [1970] criteria):

See curve on page 10 of this calc.

Designation	Size (in)	Percent Finer
d_{15}	0.6	15
d_{30}	1.9	30
d_{50}	4.5	50
d_{65}	6.5	65
d_{80}	7.7	80
d_{100}	9.0	100

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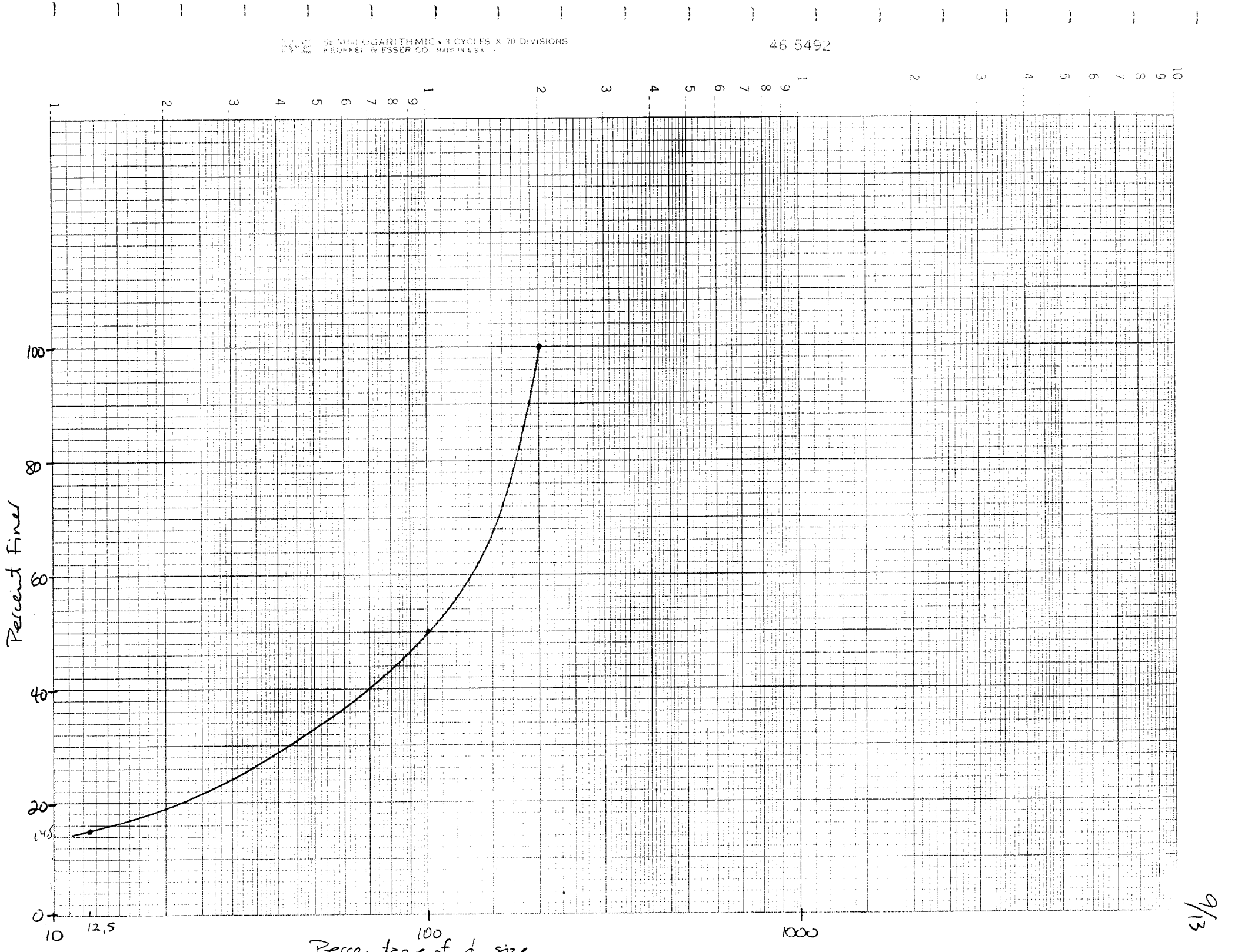
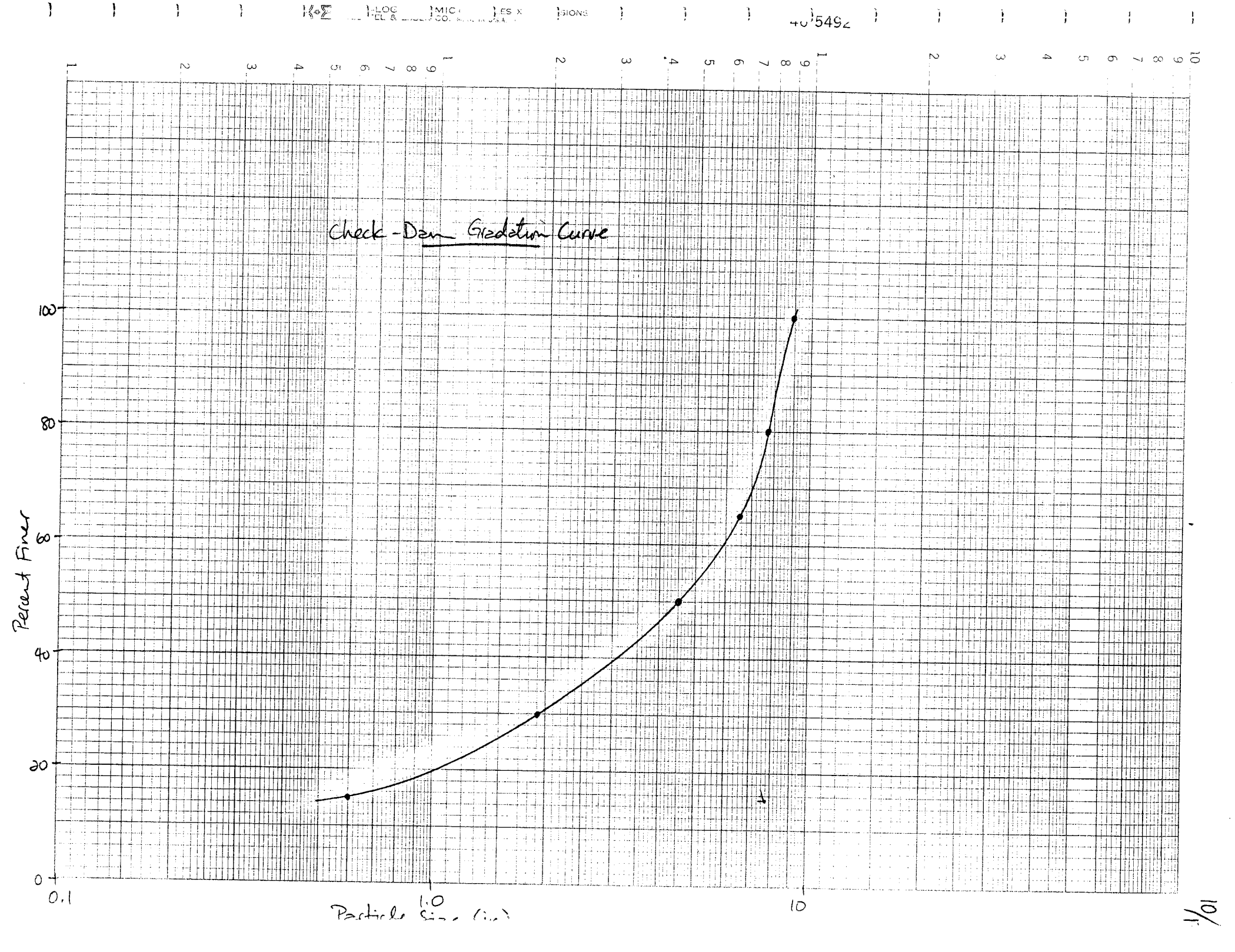


9/13


Check-Dam Gradation Curve
Percent Finer
100
80
60
40
20
0
0.1
1.0
10
Particle Size (in.)

Effective height of spillway → 1.5 ft (depth of eroded section of the channel).

Check dam spacing (see Heede, 1976):

$$S = \frac{H_e}{KG\cos\alpha}$$

where S = spacing (ft)
H_e = effective height (ft)
K = empirical constant = 0.3
G = gully slope (ft/ft)
α = gully slope (°)

For Section II, $H_e = 1.5$ ft, $K = 0.3$, $G = 0.055$, $\alpha = 3.1°$ } $S = \underline{\underline{91.0 \text{ ft}}}$

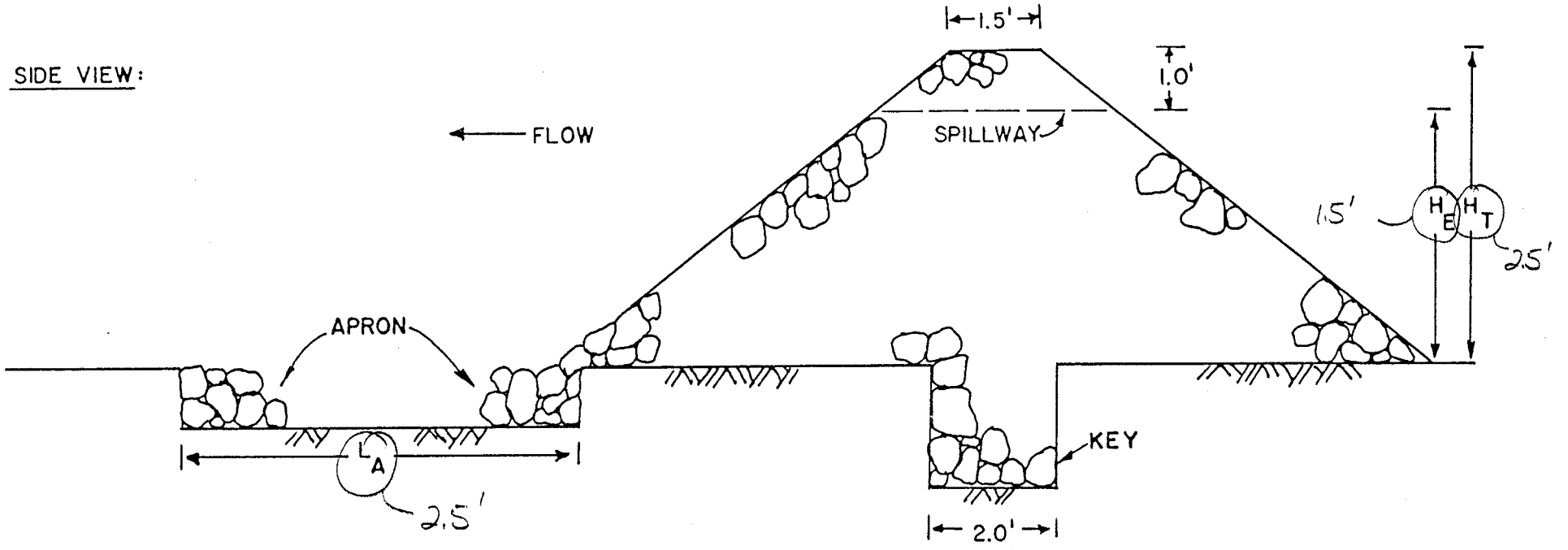
Length of Section II → 250 ft. Use <u>three</u> check dams:

One at station 5+00
One at station 4+20
One at station 3+40
} 80 ft between, 90 ft from upper dam to beginning of section.

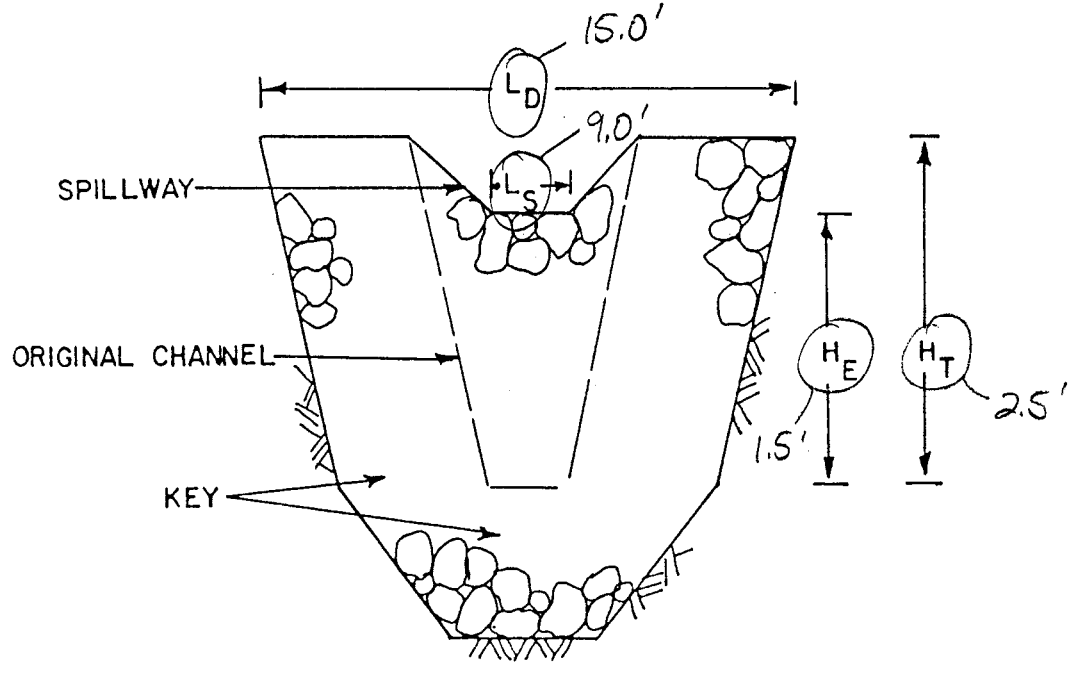
Apron length → 1.5 × effective height = (1.5)(1.5 ft)
= 2.25 ft
Use 2.5 ft.

Dam dimensions → see page 12 of this calc.

SIDE VIEW:



FRONT VIEW:



SCALE: 1" = 2.5'

3/81

Effect of Check Dams on Velocity

According to Heede (1976), the slope of the deposits behind a check dam is 70% of the slope of the original channel if the channel slope is less than 20%. Hence, for Section II of the diversion channel, the new channel slope between check dams will be:

$$\text{Slope} = (0.70)(0.055\ \text{ft/ft}) = 0.038\ \text{ft/ft}$$

Using the remaining channel characteristics, TRAP1 results are:

Flow depth = 2.32 ft/s
Area = 35.9 ft^2
Wetted Perimeter = 20.4 ft
Hydraulic Radius = 1.76 ft
Velocity = 7.97 ft/s

This velocity is less than the maximum permissible velocity for the section (see page 7 of this calc.). Hence, the aggraded channel will be stable.

RE-EXAMINATION OF THE MIDDLE FORK YARD SLOTTED CROSS DRAIN AND SEDIMENTATION POND

Submitted to

UTAH DIVISION OF OIL, GAS, AND MINING
Salt Lake City, Utah

Submitted by

UNITED STATES FUEL COMPANY
Hiawatha, Utah

September 26, 1984

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TABLE OF CONTENTS

RE-EXAMINATION OF THE MIDDLE FORK YARD SLOTTED CROSS DRAIN AND SEDIMENTAQTION POND

INTRODUCTION

On August 14, 1984, U.S. Fuel Company submitted a letter to the Utah Division of Oil, Gas, and Mining outlining their concerns regarding a slotted cross drain that the Division requested be installed across the haul road at the entrance to the Middle Fork yard near Hiawatha, Utah. Primary concerns with the slotted cross drain have been:

1. Required closure of the haul road during installation of the slotted cross drain.

2. Problems with the integrity of the road at the cross drain follwing installation.

3. Increased inflow to the sedimentation pond due to inflow through the cross drain from undisturbed areas that were not included in the original design of the pond.

4. The lack of need for the cross drain since the existing site grading forces water originating on distrubed areas (the yard and truck turnaround) to flow into the pond as the site currently exists.

This August 14 letter was followed by a letter dated August 17, 1984 from EarthFax Engineering, Inc. to the Division submitting plans (under protest for U.S. Fuel Company) for the slotted cross drain.

Subsequent to these submittals, the Division sent a letter to U.S. Fuel Company dated September 11, 1984 outlining certain concerns with the slotted cross drain as designed and addressing pond-capacity concerns that have arisen due to site changes. This report addresses the concerns raised by the Division in the September 11 leter.

SLOTTED CROSS DRAIN

The August 17, 1984 submittal noted that the headwall and wingwall of the slotted cross drain should be riprapped using the same riprap designed for use on the inflow and outflow channels of the Middle Fork road sediment traps. The adequacy of this riprap was questioned in the September 11 letter from the Division.

The adequacy of the riprap was checked by determining the maximum shear stress against the riprap on the headwall and the wingwall using formulas presented by Anderson et al. (1970).

These values were then compared with the critical shear stress (that shear at which there is a general movement of particles) for the riprap of concern. Results of these calculations are contained in Appendix A of this report along with plan and elevation views of riprap installation. As noted in Appendix A, the maximum shear on the headwall and wingwall would be less than the critical shear, indicating that the riprap, as previously designed, would be stable.

Velocity calculations for the inlet and outlet of the slotted cross drain are also given in Appendix A. As noted, the velocity at the inlet would be 1.0 foot per second, with an outlet velocity of 3.2 feet per second.

Appendix A also provides drawings showing the trash rack configuration that would be installed at the inlet of the slotted cross drain. An 18-inch culvert is assumed for the slotted cross drain as suggested in the September 11 letter from the Division.

Although this and the August 17 submittal indicate that a properly-sized slotted cross drain can be installed at the entrance to the Middle Fork yard, it is re-emphasized that U.S. Fuel Company does not feel that such a drainage device is needed to meet the requirements of the regulations. As noted previously, site grading precludes runoff from disturbed areas from bypassing the pond. Recent surveying of the area near the pond confirm this. Hence, this and previous information submitted to the Division regarding the slotted cross drain is for the review of the Division only and should not be considered part of the operations plan of U.S. Fuel Company until the issue of the necessity of the drain is resolved.

← BULL! LET'S LET THE H_2O SHOW THE FLOW PATH FROM & ON THE RD. ID

SEDIMENTATION POND CAPACITY

Following design of the sedimentation pond, several site changes occurred that altered the drainage area that contributes to the pond. These changes included an increase in the size of the disturbed area above the pond and removal of a diversion north of the bath house that previously diverted runoff from an undisturbed area to the bypass culvert that passes beneath the Middle Fork yard. Thus, the size of the undisturbed area that contributes to the pond has also been increased.

← BUNK! THE PRESENT AMOUNT OF DISTURBED AREA IS THE SAME SHOWN ON THE ORIGINAL PLANS. ID

Appendix B contains the result of calculations to determine the adequacy of the existing pond size. As noted in this appendix, the area that contributes to the pond currently consists of 9.9 acres of disturbed area and 50.0 acres of undisturbed area. Runoff from the 10-year, 24-hour storm from these areas amounts to 1.80 acre-feet. Using a sediment-storage volume of 0.1 acre-foot per acre of disturbed area, the total storage volume required for the pond is 2.79 acre-feet.

A topographic survey of the Middle Fork pond following construction indicated that the pond was built larger than it was designed. As noted in Appendix B, the pond presently has a capacity of 3.62 acre-feet at the spillway crest. Hence, the pond is sufficiently large to handle the excess runoff to the pond due to changes in site characteristics. However, due to the increase in the sediment storage volume, the inlet on the dewatering tube will be raised 1.6 feet (to elevation 8037.4 feet) to place it above the maximum sediment storage level. This will be accomplished by cutting the 4-inch PVC dewatering tube immediately below the intake elbow, gluing an additional 4-inch section (1.6 feet in length) with couplings to the standpipe, and gluing the elbow section to the top of the addition. PVC cement will be used for all gluing in accordance with manufacturers instructions.

CONCLUSIONS

Riprap for the headwall and wingwall of the slotted cross drain, as originally designed, would be stable. Velocities at the inlet and outlet of the cross drain would be 1.0 and 3.2 feet per second, respectively.

The Middle Fork sedimentation pond is adequately sized for increases in the drainage area due to changes in the site since the original design. The intake of the dewatering device will be raised to a level above the maximum sediment storage level.

REFERENCE

Anderson, A.G., A.S. Paintal, and J.T. Davenport. 1970. Tentative Design Procedure For Riprap-Lined Channels. National Cooperative Highway Research Program Report 108. Highway Research Board. National Academy of Sciences. Washington, D.C.

APPENDIX A

Slotted Cross Drain Calculations

FINAL DESIGN OF MIDDLE FORK YARD SLOTTED CROSS DRAIN

Calculation Reference

Refer to previous design calculations prepared and submitted to DOGM on 17 Aug 1984 concerning the slotted cross drain. Also refer to the letter from DOGM dated 11 Sep 1984 outlining deficiencies in the previous design.

Riprap for Headwall and Wingwall

The previous design suggested the use of riprap for erosion protection at the culvert inlet that was sized for use with the inlet and outlet channels of sediment traps to be installed adjacent to the Middle Fork Road (see designs submitted 17 Aug 1984 in response to Notice of Violation N84-4-8-8, No. 8 of 8).

As a check against the adequacy of this riprap, use the shear stress concept presented by Anderson et al. (1970). According to Anderson et al. (1970):

$$\tau_c = 4 d_{50}$$

where τ_c = critical shear stress, or the shear at which there is a general movement of particles (lb/ft^2)
d_{50} = median particle diameter (ft)

The shear stress at any point along the headwall or wingwall can be determined from the figure presented on page 2 of this calc. In this figure, τ_o is the local boundary shear at any point in the bend, (lb/ft^2), $\bar{\tau}_o$ is the mean boundary shear in a straight cross section leading to a bend (lb/ft^2), B_s is the surface width of the flow section (ft), and R_o is the mean radius of the bend (ft).

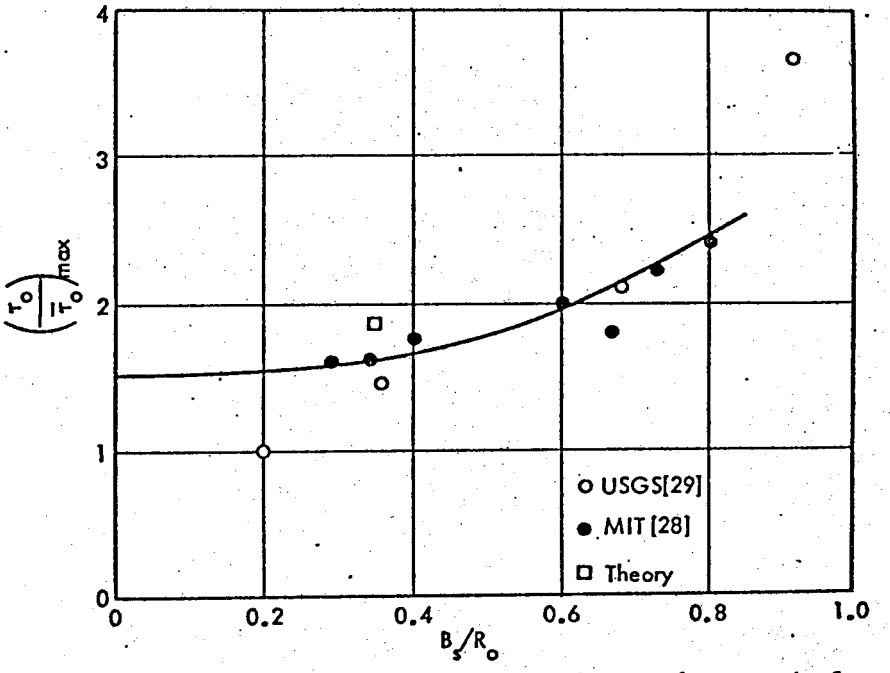


Figure 17. Ratio of maximum boundary shear stress to the mean shear stress for flow in bends.

Source: Anderson et al. (1970)

$$\tau_o = \gamma R S_b$$

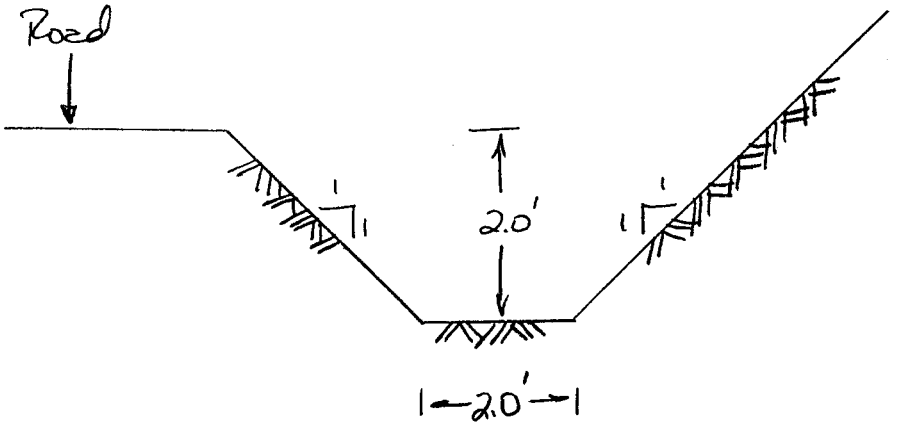
where τ_o = mean boundary shear (lb/ft^2)

γ = unit weight of water = 62.4 lb/ft^3

R = hydraulic radius of flow (ft)

S_b = channel slope (ft/ft)

Typical channel cross section above proposed slotted cross drain:



Flow into slotted cross drain:

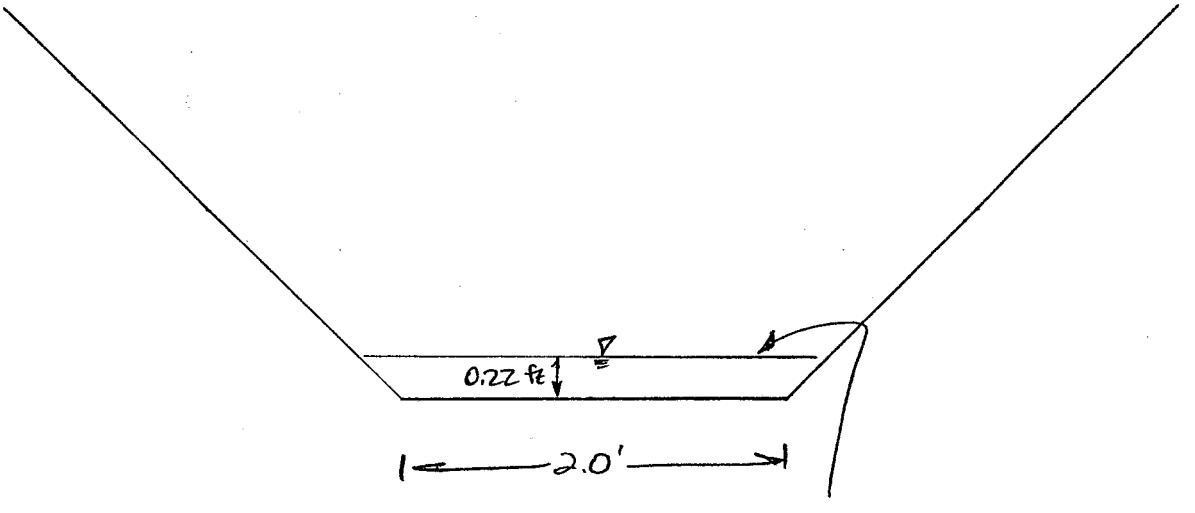
10-yr, 24-hr runoff = 2.4 cfs (see 17 Aug 1984 submittal)

Using the OSM trapezoidal channel design program TRAP1 (see Weider et al., 1983) and the following inputs:

- $n = 0.033$ (see 17 Aug 84 submittal, NOV No. 8 of 8)
- $S = 0.111$ ft/ft
- Channel side slopes = 1.00 (1:1)
- Channel bottom width = 2.0 ft

→ RESULTS: Flow depth = 0.22 ft
Hydraulic radius = 0.19 ft
Velocity = 4.9 ft/s ✓

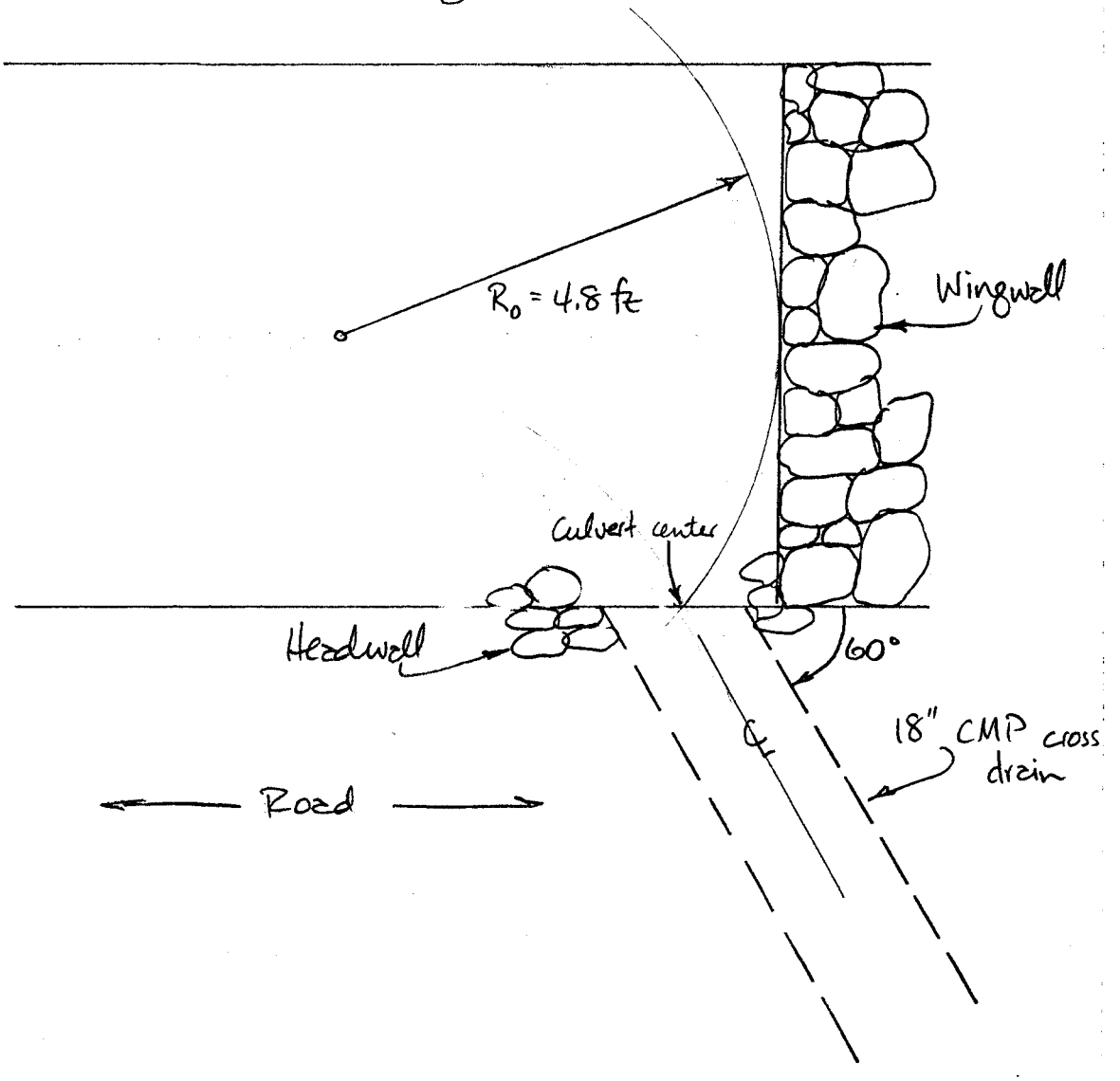
To use figure on page 2 of this calc., determine surface width of the flow upstream from the bend:



Surface width = 2.0 + (2)(0.22)

= 2.44 ft

Radius of bend at wingwall: PLAN VIEW (Scale: 1" = 2')



$$\frac{B_s}{R_o} = \frac{2.44\ ft}{4.80} = 0.51$$

From the figure on page 2 of this calc. (for $B_s/R_o = 0.81$)

$$\left(\frac{\tau_o}{\bar{\tau}_o}\right)_{max} = 1.8 \Rightarrow \tau_{o(max)} = 1.8\,\bar{\tau}_o$$

$\bar{\tau}_o = \gamma R S_b$ (see page 2 of this calc.)

$= (62.4\ lb/ft^3)(0.19\ ft)(0.11\ ft/ft)$

$= 1.30\ lb/ft^2$

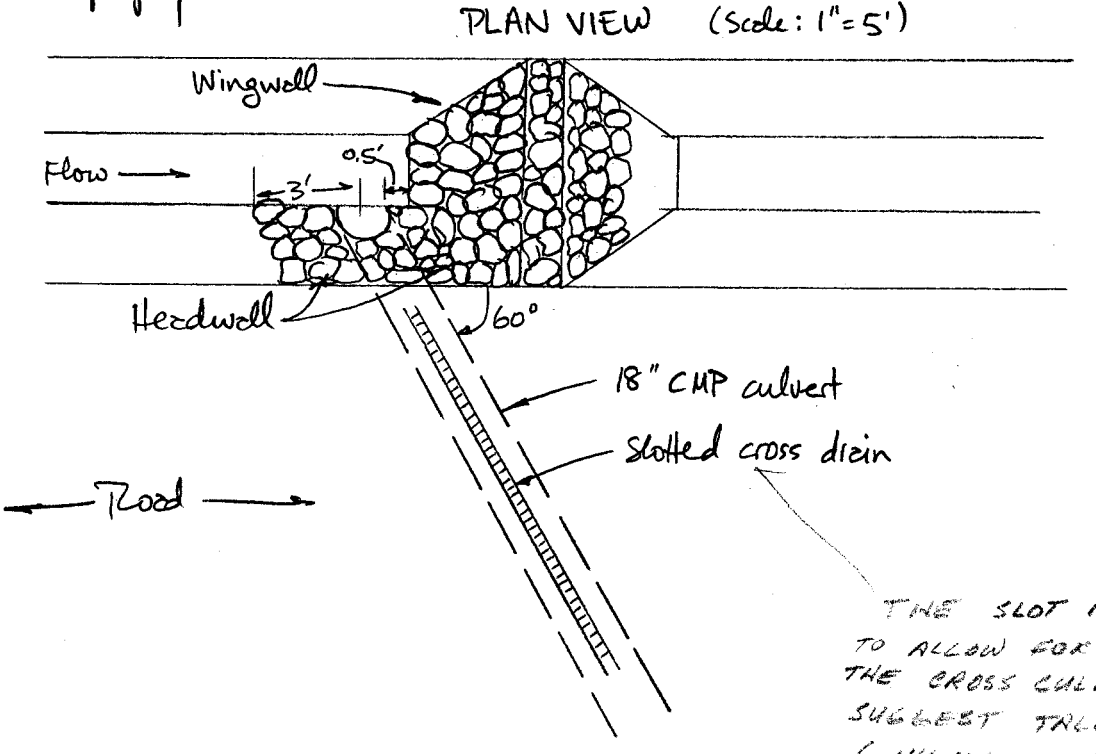
$$\tau_{o\,(max)} = (1.8)(1.30\ lb/ft^2)$$
$$= 2.34\ lb/ft^2$$

For the riprap proposed for used in the wingwall and headwall, $d_{50} = 8.2$ in (0.68 ft). Hence, the critical boundary shear on the bend is

$$\tau_c = 4\, d_{50} = (4)(0.68) = 2.73\ lb/ft^2$$

Because the maximum boundary shear on the bend is less than the critical shear, the riprap will be stable, and the proposed riprap can be used. The filter blanket designed for this riprap gradation will, therefore, also be adequate.

Riprap placement:



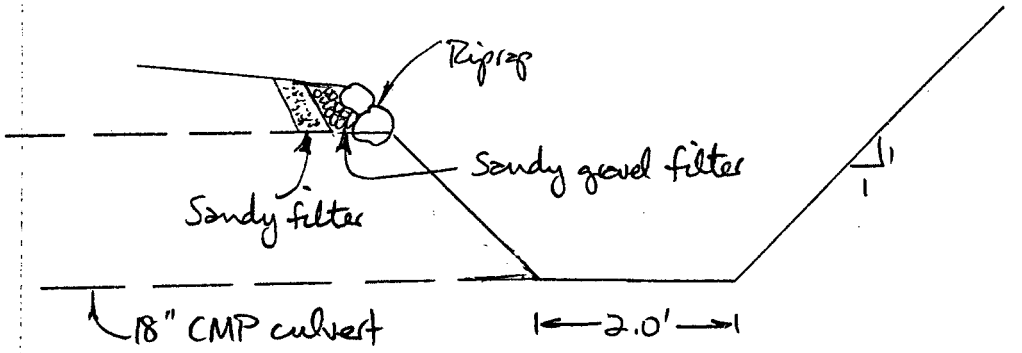
TINE SLOT IS TOO NARROW TO ALLOW FOR CLEANING OF THE CROSS CULVERT. WOULD SUGGEST TALKING TO LARRY GUYMON OF EMC TO FIND OUT PARTICULARITIES OF INSTALLING & MAINTAINING SLOTTED CROSS DRAINS. WOULD ALSO SUGGEST INSTALLATION OF CATTLE GUARD INSTEAD - THIS WOULD BE EASIER TO MAINTAIN

USFS + BLM ALSO

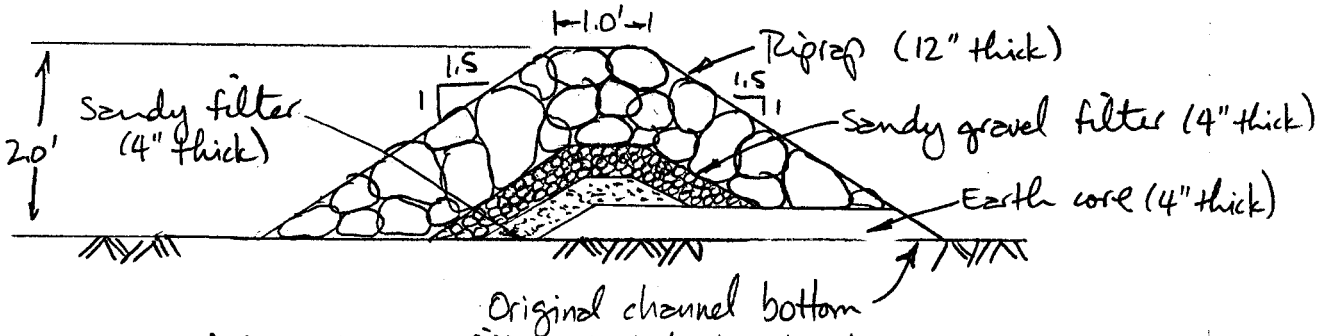
UDOT HAS INSTALLED & MAINTAINED HUNDREDS OF THEM SO THEY WOULD BE A GOOD SOURCE OF INFO.

DR

CHANNEL SIDE VIEW (Scale: 1"=2')



WINGWALL SIDE VIEW (Scale: 1"=2')



See sed. trap calcs. for filter blanket characteristics.

Velocity Calculations

Channel above culvert inlet → V = 4.9 ft/s (see page 3 of this calc.)

At culvert inlet:

Flow depth = (0.55)(1.5 ft)
= 0.83 ft

(see nomograph on page 7 of this calc.)

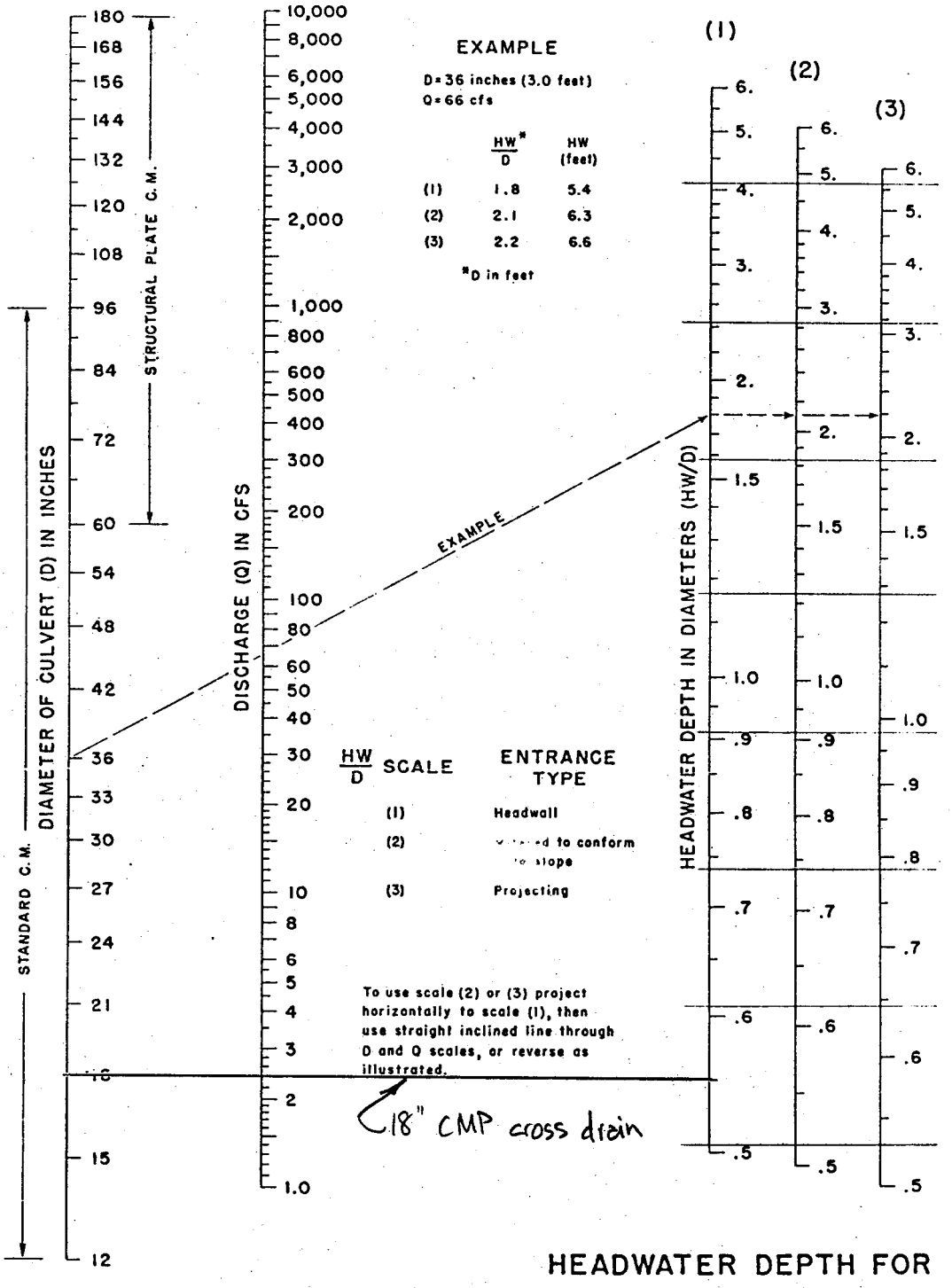
At a depth of 0.83 ft, A = 2.35 ft²

Hence,

$$V = \frac{Q}{A}$$

$$= \frac{2.4 \text{ ft}^3/\text{s}}{2.35 \text{ ft}^2} = \underline{\underline{1.0 \text{ ft/s}}}$$

CHART 5



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Source: Herr and Bossy (1965)

At culvert outlet:

Use the nomograph provided on page 9 of this calc. for $n = 0.024$ (see American Iron and Steel Institute, 1983).

Assume slope = 0.01 ft/ft

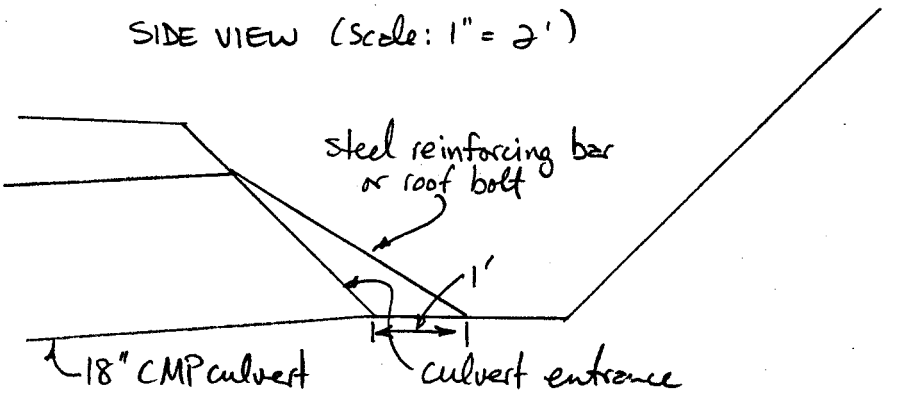
$d_n = 0.7$ ft
$V = 3.2$ ft/s

} $d_c = 0.6$ ft. Since $d_n > d_c \Rightarrow$ flow is subcritical.

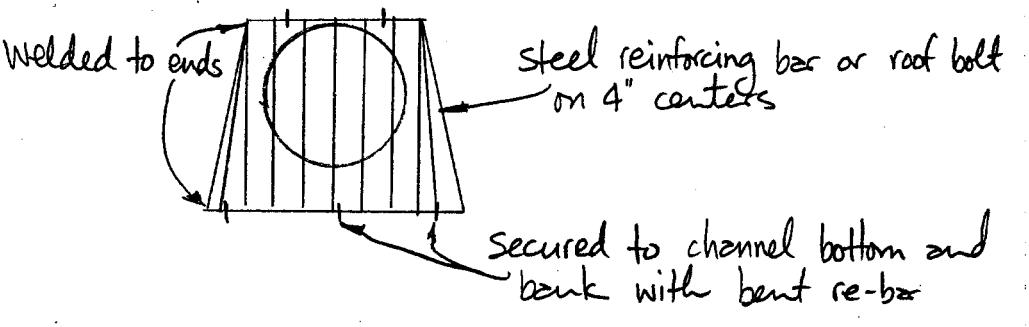
For location of cross drain, see page 10 of this calc.

Trash Rack Configuration

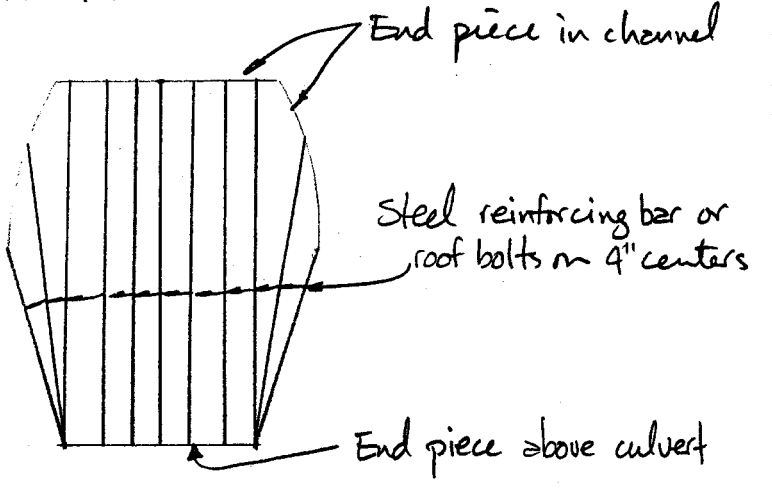
SIDE VIEW (Scale: 1" = 2')

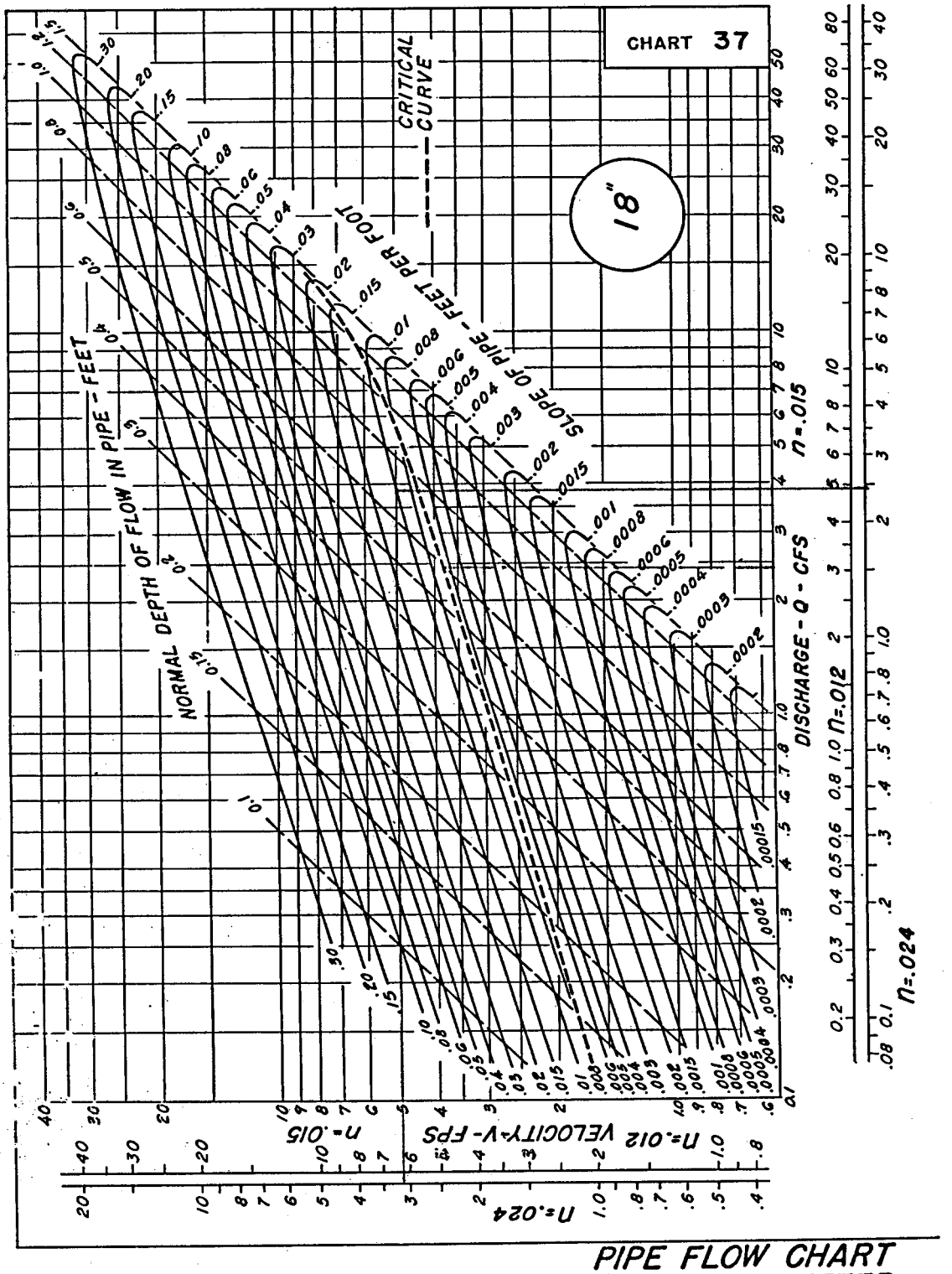


END VIEW (Scale: 1"=2')



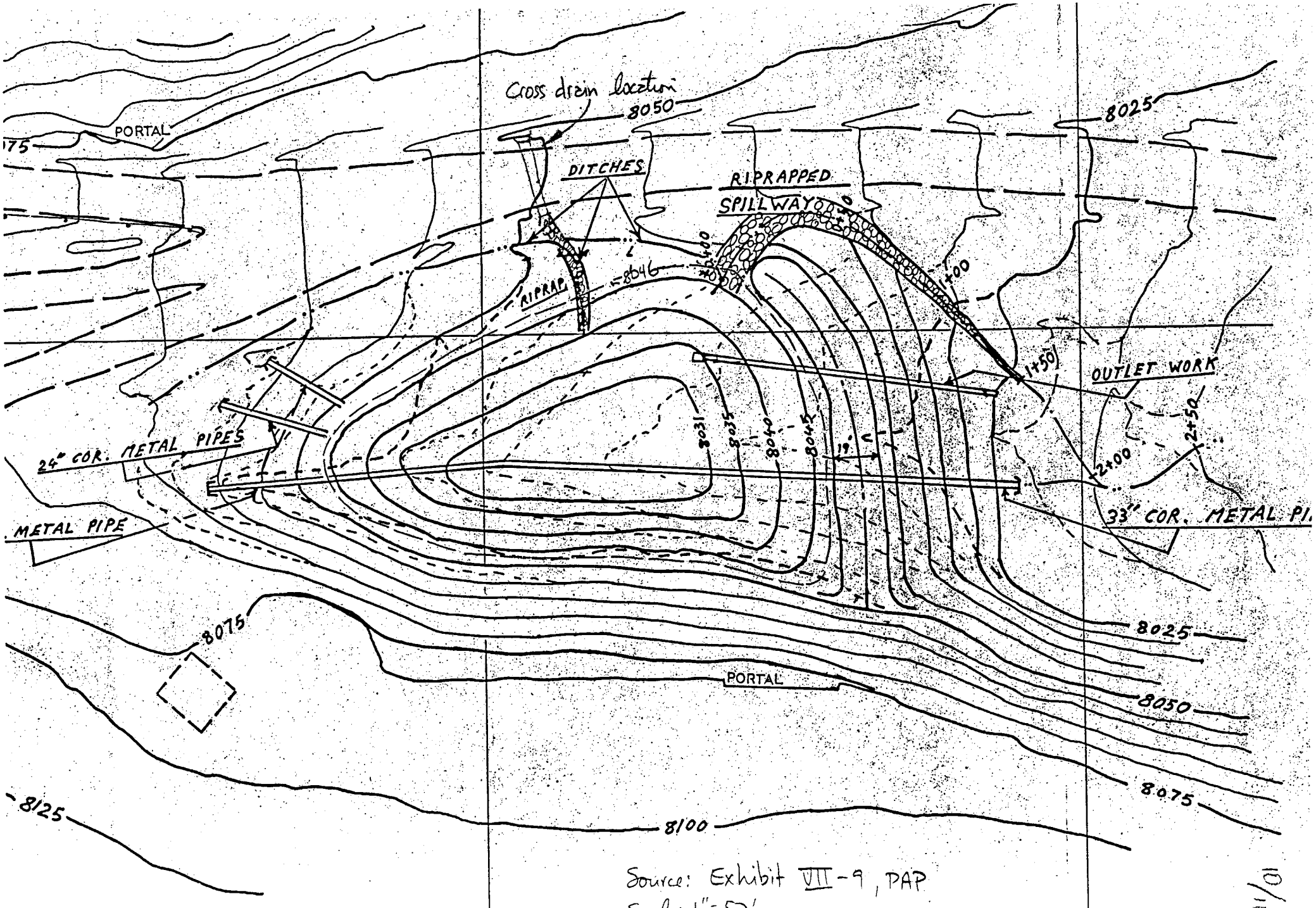
PLAN VIEW (Scale: 1"=2')





PIPE FLOW CHART
18-INCH DIAMETER

Source: U.S. Federal Hwy. Admin. 1961



Source: Exhibit VII-9, PAP
Scale: 1" = 50'

1/01

References

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Anderson, A.G., A.S. Paintal, and J.T. Davenport. 1970. Tentative Design Procedure for Riprap-Lined channels, National Cooperative Highway Research Program Report 108. Highway Research Board, National Academy of Sciences. Washington, D.C.

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U.S. Federal Highway Administration. 1961. Design Charts for Open-Channel Flow. Hydraulic Design Series No.3. U.S. Department of Transportation. Washington, D.C.

Weider, M.F., K.G. Kirk, and L.E. Welborn. 1983. Simplified Analysis Routines for Surface and Groundwater Hydrology Applications in Surface Mining. pp. 299-304 in Proceedings of the 1983 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation. University of Kentucky. Lexington, Kentucky.

APPENDIX B

Sedimentation Pond Capacity Calculations

EXAMINATION OF MIDDLE FORK SEDIMENTATION POND DESIGN

Drainage Area

Disturbed area = 9.9 ac (see page 2 of this calc.)

Undisturbed area = 50.5 ac ← SHOULD BE ~ 70 AC.
− 9.9 ac
40.6 ac (see page 3 of this calc.)

10-yr, 24-hr Runoff Volume

P = 2.25 in (see Richardson, 1971)

For the disturbed area, CN = 90

$$Q = \frac{(P-0.2s)^2}{P+0.8s} \qquad s = \frac{1000}{CN} - 10 = 1.11$$

Q = 1.31 in

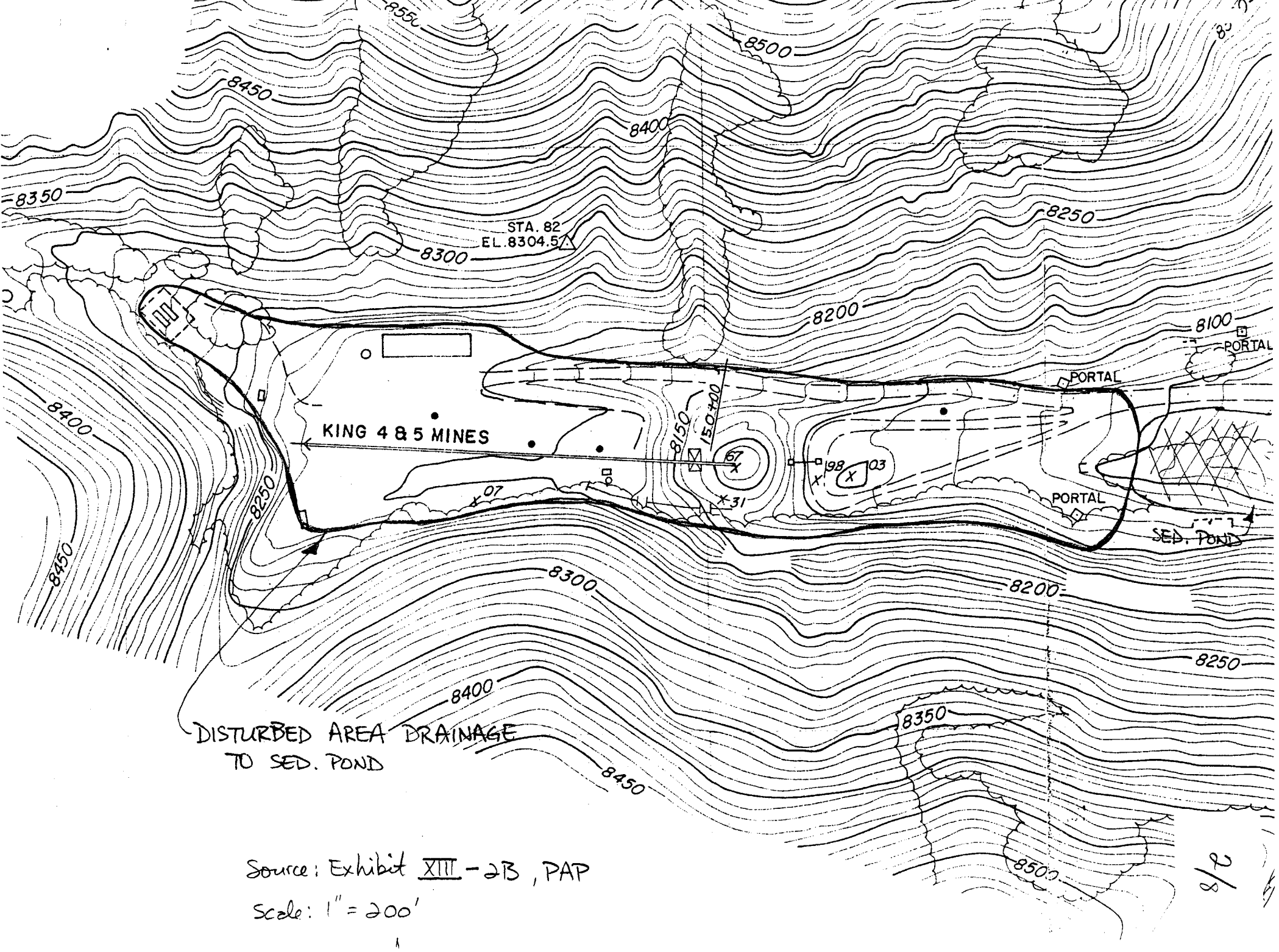
Over the entire disturbed area,

$$Q = \left(\frac{1.31 \text{ in}}{12 \text{ in/ft}}\right)(9.9 \text{ ac}) = \underline{1.08 \text{ AF}}$$

For the undisturbed area, determine CN from figure and table on page 4 of this calc. For south-facing slopes, predominant veg. type is Mountain Brush (see Chapter IX of July 1983 ACR response). The reference area for this type has a cover of 76%, consisting mainly of juniper, sagebrush, mountain mahogany, and grasses. The north-facing slopes are in the Mixed Conifer veg. type (see Chapter IX of July 1983 ACR response) with a cover of 84% in the reference area. Species consist primarily of fir, aspen, serviceberry, and grasses.

For mountain brush → CN = 64 (18.4 ac)
For mixed conifer → CN = 62 (32.1 ac)

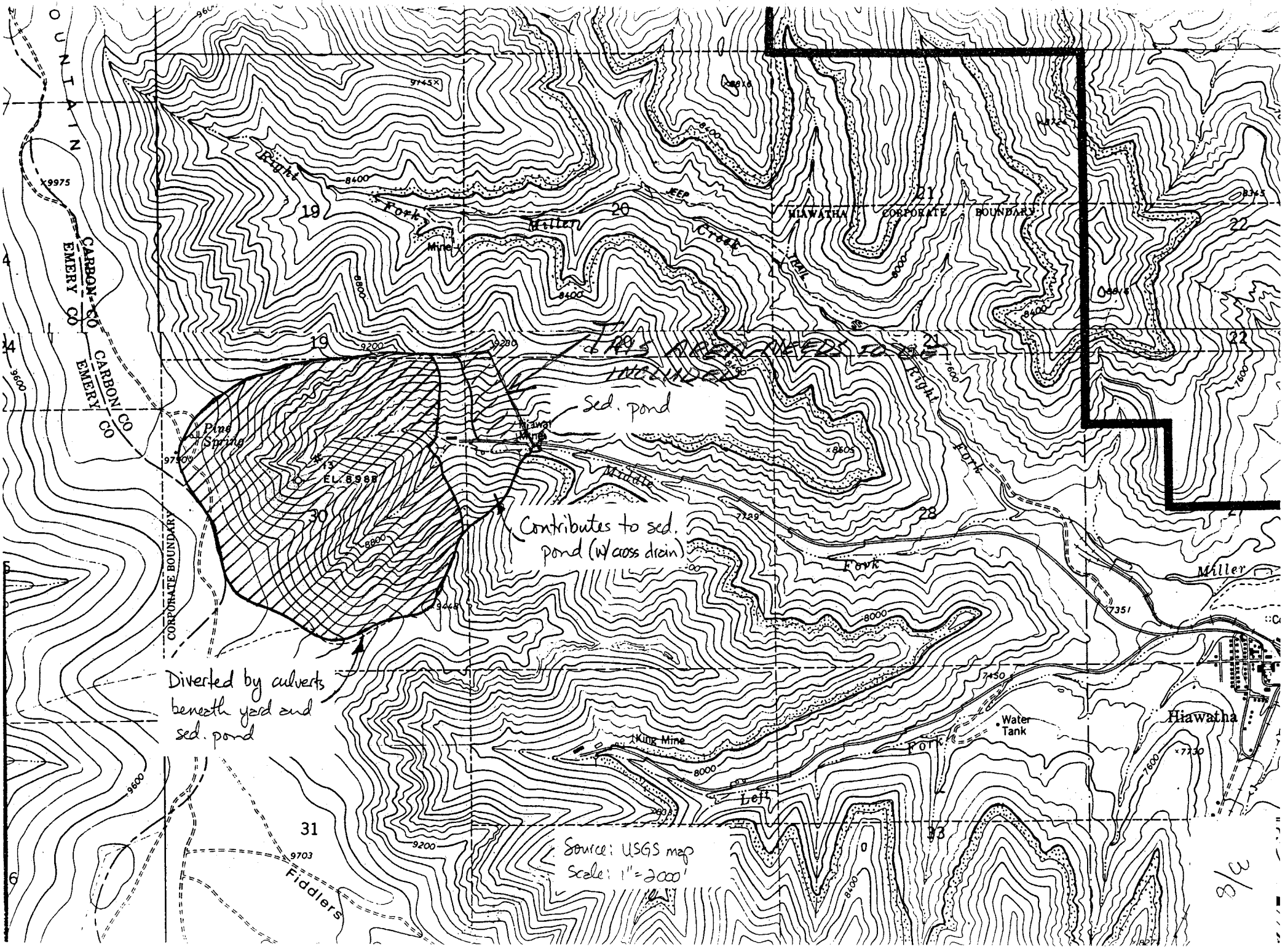
$$\text{Avg. CN} = \frac{(64)(18.4) + (62)(32.1)}{50.5} = \underline{63}$$

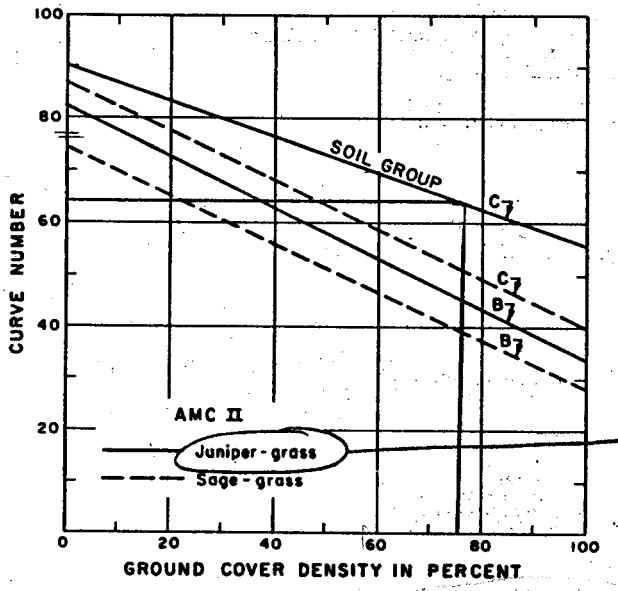


Source: Exhibit XIII-2B, PAP

Scale: 1" = 200'

2/2


Sed. pond
Contributes to sed. pond (w/ cross drain)
Diverted by culverts beneath yard and sed. pond
Source: USGS map
Scale: 1" = 2000'
Hiawatha
CORPORATE BOUNDARY
CARBON CO
EMERY CO
Pine Spring
Right Fork
Miller Creek
Middle Fork
Left Fork
King Mine
Water Tank
Fiddlers
EL. 8988
9/6



Typical of Mtn. Brush. Assume Soil Group C

Source: U.S. SCS (1972)

NEH 4 P 9.11 SOURCE OF CN's

I. COMMERCIAL OR NATIONAL FOREST, FOR WATERSHED CONDITION AMC-II AND $I_a = 0.2S$

Hydrologic condition class	Hydrologic soil group			
	A	B	C	D
I. Poorest	56	75	86	91
II. Poor	46	68	78	84
III. Medium	36	60	70	76
IV. Good	26	52	62	69
V. Best	15	44	54	61

Mixed Conifer veg. type.

Source: U.S. BOR (1977)

possibly this

$$Q = \frac{(P - 0.2s)^2}{P + 0.8s}$$

$$S = \frac{1000}{63} - 10 = 5.87$$

$= 0.17$ in

SHOULD BE ~ 70 AC.

P.L.

Over the entire undisturbed drainage area,

$$Q = \left(\frac{0.17 \text{ in}}{12 \text{ in/ft}}\right)\left(\frac{\cancel{50.5 \text{ ac}}}{70 \text{ AC}}\right) = \cancel{0.72 \text{ AF}} \quad = 1.0 \text{ AF}$$

Total runoff volume = 1.08 AF + 0.72 AF
= 1.80 AF

Sediment Storage Volume

Required storage → 0.1 AF/ac of disturbed area

Total sed. storage = (0.1 AF/ac)(9.9 ac) = 0.99 AF

Pond Characteristics (see page 6 of this calc.)

Elev. 8031 ft (bottom)
A = 0.091 ac

Elev. 8035 ft
A = 0.161 ac

$V = \left(\frac{0.091 + 0.161}{2}\right)(4) = 0.504$ AF

Elev. 8040 ft
A = 0.269 ac

$V = \left(\frac{0.161 + 0.269}{2}\right)(5) = 1.075$ AF

Elev. 8045 ft
A = 0.386 ac

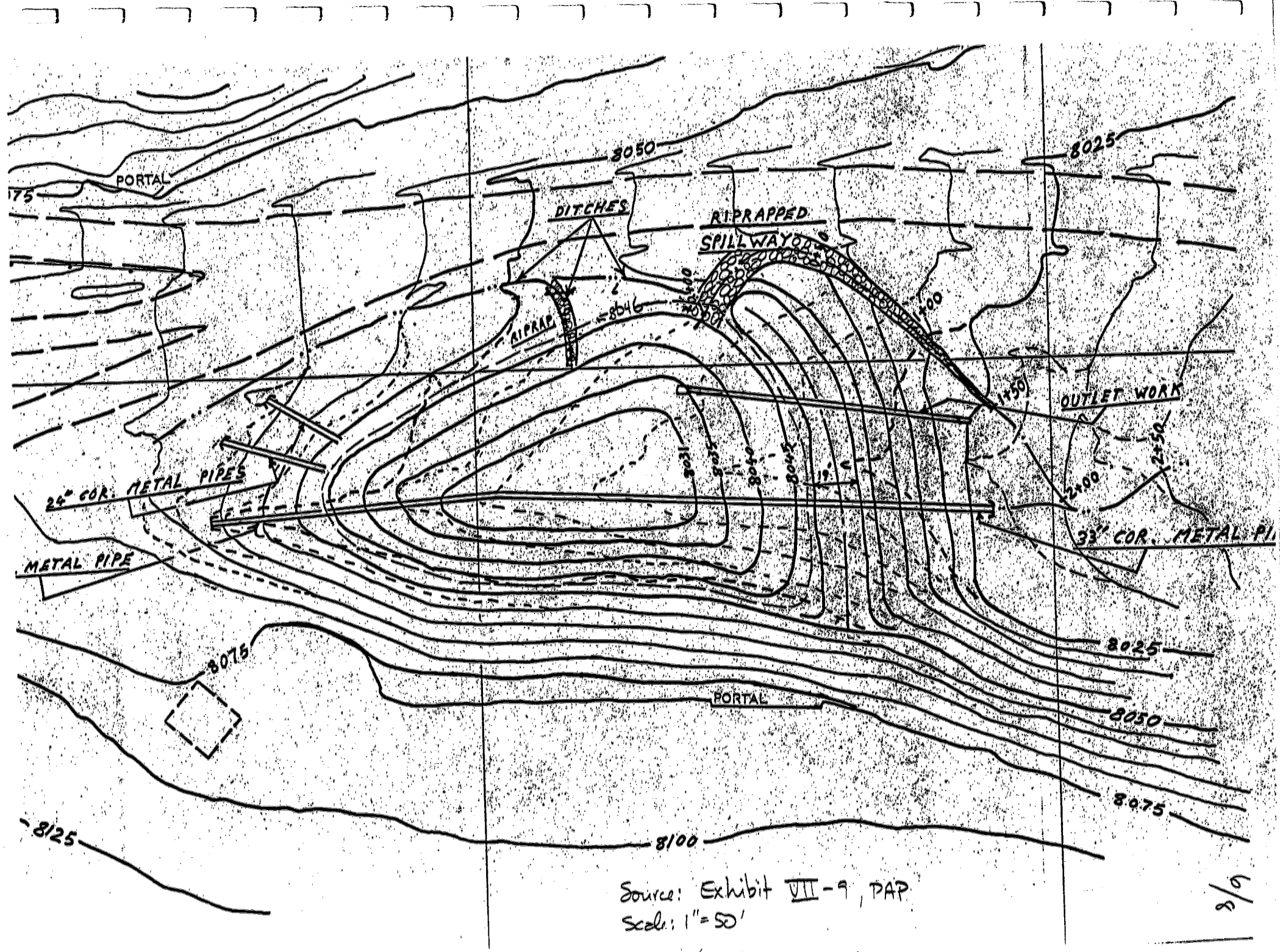
$V = \left(\frac{0.269 + 0.386}{2}\right)(5) = 1.638$ AF

Elev. 8046 ft (crest of emergency spillway)
A = 0.420 ac

$V = \left(\frac{0.386 + 0.420}{2}\right)(2) = 0.403$ AF

Total storage volume below crest of emergency spillway = 3.620 AF

See page 7 of this calc. for stage capacity curve.



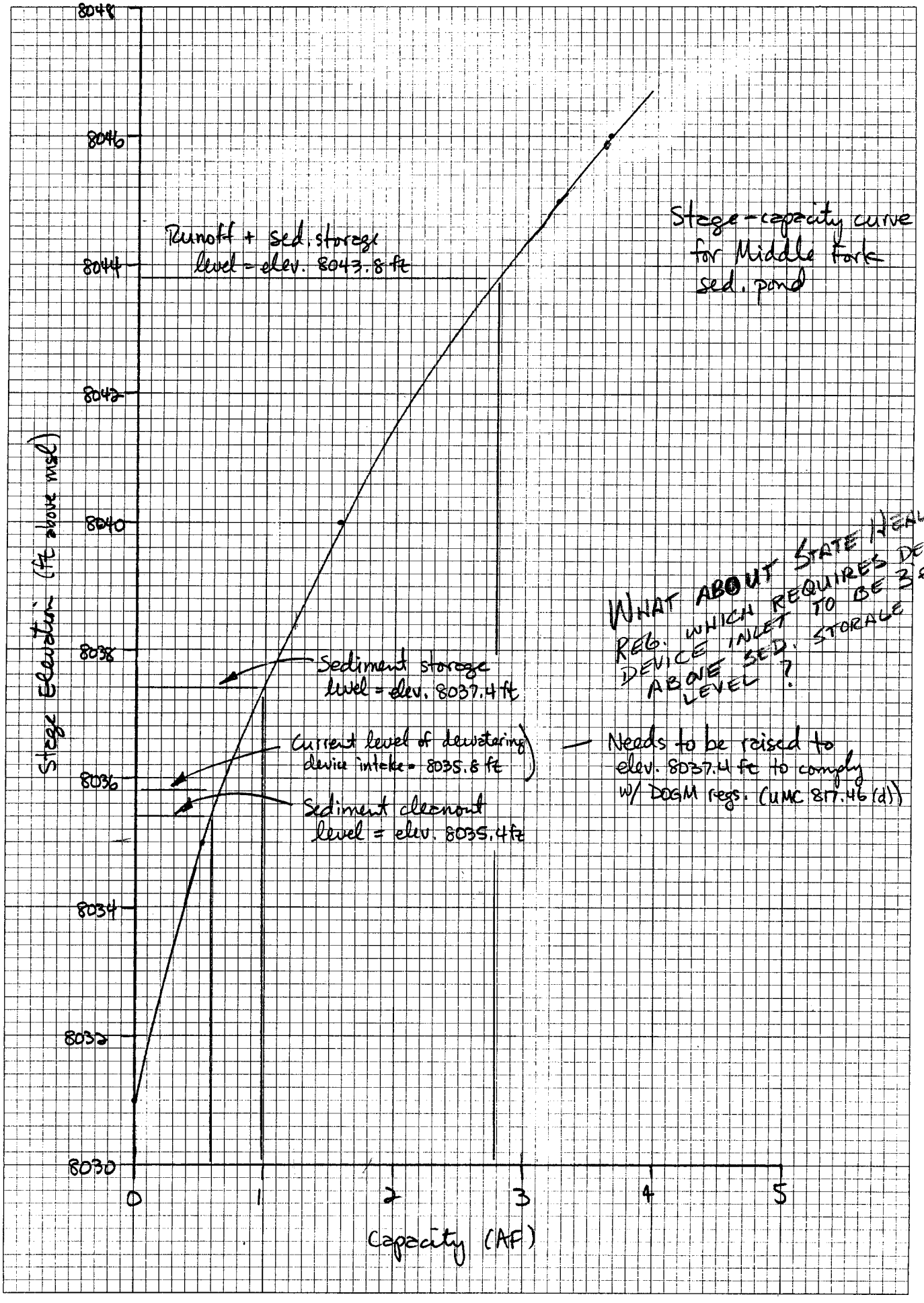
Source: Exhibit VII-9, PAP
Scale: 1"=50'

9/6

within last month
Rec 8-22-84 exhibit

turnaround

late Aug
early Sept



Conclusions

The pond is adequately sized to handle runoff due to increased area. The intake structure needs to be raised 1.6 ft to elev. 8037.4 ft.

References

Richardson, E.A. 1971. Estimated Return Periods for Short-Duration Precipitation in Utah. Dept. of Soils and Biomet. Bull. No. 1. Utah State University. Logan, UT.

U.S. Bureau of Reclamation. 1977. Design of Small Dams. U.S. Government Printing Office. Washington, D.C.

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CHAPTER IX

Vegetation Information (ACR Response)
UMC 783.19

UNITED STATES FUEL CO.
Hiawatha, Utah

July 1983

VEGETATION OF THE U.S. FUEL COMPANY PROPERTY, HIAWATHA, UTAH: A CONSOLIDATION OF DATA COLLECTED DURING THE 1980 AND 1981 FIELD SEASON

Submitted to

U.S. Fuel Company
P. O. Box A
Hiawatha, UT 84527

Prepared by

John A. Rice, Ph.D.

Submitted by

BIO/WEST, Inc.
P. O. Box 3226
Logan, UT 84321

July 12, 1983

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Scope

On July 23, 1980, BIO/WEST, Inc., was contracted by U.S. Fuel Company to perform a vegetation survey of U.S. Fuel Company property near Hiawatha, Utah. Preliminary data were collected between August 21 and 27, 1980, and supplementary data were collected October 7, 1980. The following persons (all employed by BIO/WEST, Inc.) were involved in the collection of data: Chris Call, Jerry Barker, Jim Albee, Alan Taye, Mike Madany, and Haile Tamrat. The data were analyzed by Chris Call and Jerry Barker. The following were consulted regarding the vegetation survey:

Larry Dalton
Wildlife Biologist
Division of Wildlife Resources
Price, UT 84501

Ron Dickemore
Range Conservationist
U.S. Forest Service
Manti LaSal National Forest District
Price, UT 84501

Bob Eccli
Mining Engineer
U.S. Fuel Company
Hiawatha, UT 84527

Bob Grover
Range Wildlife Specialist
U.S. Forest Service
Manti LaSal National Forest District
Price, UT 84501

Steve Spencer
Range Conservationist
U.S. Forest Service
Manti LaSal National Forest District
Price, UT 84501

Gary Sey
District Forest Ranger
U.S. Forest Service
Manti LaSal National Forest District
Price, UT 84501

INTRODUCTION

Ten vegetation types were identified (and mapped) within the permit area: 1) Barren land, 2) pinyon-juniper woodland, 3) riparian, 4) sagebrush, 5) mountain brush, 6) grassland, 7) mixed conifer, 8) mixed conifer-aspen, 9) aspen, and 10) high elevation sagebrush-grass. Eleven reference areas were established in five vegetation types, and the vegetation sampled for cover, productivity, tree density, distribution of tree size-classes (diameter at breast height), and species composition. The reference areas were chosen to be representative of the area disturbed or proposed to be disturbed with respect to vegetation, soils, aspect, climate, and elevation. Within the areas of proposed disturbance, "sample sites" were established and sampled in the same manner as the reference areas. The results of this survey were reported in "Vegetation Survey of U.S. Fuel Company Property, Hiawatha, Utah" (PR-41-1). This report was submitted to U.S. Fuel Company, and included as an appendix to the Vegetation Information section of the mining and reclamation plan.

Following Apparent Completeness Review of the mining and reclamation plan and Technical Environmental Assessment of the proposed conveyor belt in the Left Fork of Miller Creek, additional baseline vegetation data was requested.

In a telephone conversation, July 6, 1981, Mr. James Rutzloft, Office of Surface Mining, outlined the data requirements. Written confirmation of data requirements from the Division of Oil, Gas, and Mining was received August 4, 1981 (Appendix A). Subsequent to the conversation with Mr. Rutzloft, the additional data were collected between

July 28 and 30, 1981, and analyzed by Mr. Christopher Call and Mr. Jerry Barker. The results of cover and woody plant density sampling in reference area 4 (PJR4) and "affected area" 4 (PJA4), and a new reference area (SBR12) and "affected area" (SBA12) were reported in PR-41-2, "Vegetation Survey for the South Fork Area, Sharon Steel Company Property, Hiawatha, Utah." This report was submitted to U.S. Fuel Company who subsequently submitted the report to the Division of Oil, Gas, and Mining.

The objective of this report is to consolidate report PR-41-1, report PR-41-2, and heretofore unreported data (collected between July 28 and 30, 1981) into a single, organized report of all vegetation information collected by BIO/WEST, Inc.

METHODOLOGY

1980 Field Season

Vegetation types of the permit area and adjacent areas were identified and mapped (Figures 1-6) by field reconnaissance and the use of aerial photography. The acreages of the vegetation types and their percentages of the total permit area (Table 1) were determined from Figure 1. The acreages of the vegetation types found in previously disturbed areas and areas of proposed disturbance, and their percentages of the total acreage of each vegetation type in the permit area (Table 2) were determined from Figures 2-6. Vegetation types within previously disturbed areas were inferred from vegetation on adjacent, undisturbed areas.

Reference areas and sampling sites within areas of proposed disturbance were sampled for aerial cover, species composition, productivity, tree density, and distribution of tree size-classes (diameter at breast height). Each 45,000 ft^2 (4200 m^2) sampling site and reference area was marked with four metal T-posts. Percent aerial cover of vegetation, litter, rock, and bare ground were estimated by the step-point method (Evans and Love 1957). The starting point and direction of each 20-point transect were randomly selected. Species composition was determined by listing the species along the transects. Productivity was determined by clipping grasses, forbs, and current year's shrub growth within a 1 m^2 frame randomly placed along the step-point transects. Clipped plant material was oven-dried at 120 F (49 C) for 48 hours and

weighed on a Metler top-loading balance. Tree density was measured by the point-centered quarter method (Mueller-Dombois and Ellenberg 1974). Quarters were established by using the four corners of the 1 m^2 productivity frame. Tree size classes were determined by measuring the circumference at breast height of the nearest tree in each quarter. Due to the branching habit of Rocky Mountain juniper, Utah juniper, and pinyon pine, it was necessary to take basal circumference readings. For trees smaller than 4 feet (1.2 m) in height, circumference was also measured at the base of the tree. All circumference measurements were converted to diameter measurements.

Sample adequacy for the representative cover and productivity parameters was determined by using the following equation:

$$m = \frac{t^2 s^2}{D^2}$$ (Snedecor and Cochran 1967)

where: m = the minimum number of observations needed,

t = t distribution value for a given level of confidence,

s^2 = the variance estimate from preliminary vegetation sampling, and

D = the level of accuracy desired for the estimate of the mean.

Sample adequacy for aerial cover estimates was determined after completing 10 step-point transects at each area. Sample adequacy for productivity measurements was determined after clipping and weighing

plant material from 25 plots at each area. A 90 percent confidence level with a 10 percent error of the meas was used to calculate the proper sample size for aerial cover estimates. An 85 percent confidence level with a 15 percent error of the mean was used to calculate the proper sample size for productivity measurements. Additional sampling was performed at those areas where preliminary sample sizes were inadequate.

*Note: Since an improper confidence level and error of the mean were used to calculate sample adequacy for productivity data it was suggested (Appendix A) that productivity be developed from Soil Conservation Service descriptions. Therefore, productivity data will not be reported in this document.

1981 Field Season

Reference areas and sampling sites within areas of proposed disturbance were sampled for plant cover, woody plant density, and species composition. Each 45,000 ft^2 (4,200 m^2) reference area was marked with four metal T-posts. Percent cover of vegetation, litter, rock and bare ground were estimated using a 0.5 m^2 (0.5 x 1.0 m) quadrat. Percent cover was estimated only for individual plants that were rooted within the limits of the quadrat. Plant density was determined for woody species only. A 2.0 m^2 (1 x 2 m) quadrat was used for this purpose. Only woody plants that were rooted within the quadrat were counted. Species composition for reference areas and sampling sites was based on observations during cover sampling.

An estimate of plant productivity was developed from the Soil Conservation Service descriptions of range sites (see Chapter VII of the mining and reclamation plan).

The Jaccard Community Coefficient Equation was used to quantify community similarity between the reference areas and sampling sites. The coefficient is:

$$cc_j = \frac{c}{S_1+S_2-c}$$

where: cc_j = community coefficient,

S_1, S_2 = number of species in each community, and

c = number of species in common between the two communities.

The value of cc_j can vary from 0 to 1.0 (or 0 to 100 percent) with 0 showing the most dissimilarity and 1.0 showing the greatest similarity.

Statistical analyses included adequate sample size and student t-tests. All data plots were randomly selected using a random number table. Plots were located in the reference areas and sampling sites using a grid system.

Sampling adequacy for percent plant cover and plant density was determined by the same equation used in 1980. Sample adequacy for plant cover and density was determined after completing 20 sampling plots. An 80 percent confidence level with a 10 percent error of the mean was used to calculate the proper sample size. Additional sampling was performed in those areas where preliminary sample sizes were inadequate.

Student t-tests were performed to test for differences in plant cover and density between the reference and affected sites for each vegetation type. Significance was determined at the 90 percent level.

EXISTING RESOURCES

A diversity of vegetation types occurs within the boundaries of the U.S. Fuel Company permit area. This diversity is due primarily to differences in elevation, moisture, temperature, topography, aspect, and soils. During the 1980 field season, ten vegetation types (distinguished by the visually dominant species) were identified and mapped (Figures 1 through 7) within the permit area: 1) aspen, 2) barren land, 3) grassland, 4) mixed conifer, 5) mixed conifer-aspen, 6) mountain brush, 7) pinyon-juniper woodland, 8) riparian, 9) sagebrush, and 10) high elevation sagebrush-grass.

During 1980, the Soil Conservation Service (SCS) conducted a vegetation survey of the U.S. Fuel Company property in conjunction with a soil survey. This survey is included in Chapter VII. Table 3 correlates the ecological sites of the SCS survey to the vegetation types of BIO/WEST's survey.

Disturbed Areas

Four vegetation types (mixed conifer, mountain brush, pinyon-juniper woodland, and riparian) were disturbed by past mining activities. More than one of these vegetation types was disturbed at several of the existing mines. Table 4 lists the disturbed areas and their respective vegetation types and reference areas. Even with variations in slope, exposure, and elevation, the visually dominant overstory and understory species remained fairly constant.

Mixed Conifer Vegetation Type

The portal area in the Right Fork of Miller Creek elevation (8,400 feet), the portions of the King 4 and King 5 mines in the Middle Fork of Miller Creek (elevation 8,300 feet), the King 6 Mine in the Left Fork of Miller Creek (elevation 8,200 feet), the Blackhawk Mine southwest of the town of Hiawatha (elevation 8,200 feet), and the Mohrland Mine in Mohrland Canyon (elevation 7,800 feet) are in this mixed conifer type (Figure 1). Table 5 lists the major plant species assumed to have been present prior to disturbance at these sites. The dominant tree species were Douglas fir, white fir, quaking aspen, and Rocky Mountain maple. The dominant understory species were Saskatoon serviceberry, mallow ninebark, mountain snowberry, creeping barberry, myrtle pachistima, common juniper, mountain mahogany, aster, salina wildrye, and fringed brome.

Mountain Brush Vegetation Type

Portions of the King 4 and King 5 mines (Hiawatha Mine) and the Blackhawk Mine are in this mountain brush type (Figure 1). Table 6 lists the major plant species assumed to have been present prior to disturbance at these sites. The dominant overstory species were Saskatoon serviceberry, Gambel oak, mountain mahogany, mountain snowberry, and big sagebrush. Dominant understory species were green ephedra, eriogonum, salina wildrye, and Indian ricegrass.

Pinyon-Juniper Woodland Vegetation Type

Portions of the King 6 Mine (King Mine), the Mohrland Mine, and the coal preparation plant-waste disposal complex next to the town of Hiawatha are in this pinyon-juniper woodland type (Figure 1). Table 7 lists the major plant species assumed to have been present prior to disturbances at these sites. The dominant trees were Utah juniper and pinyon pine. The dominant understory species were big sagebrush, black sagebrush, pricklypear cactus, Saskatoon serviceberry, mountain mahognay, mountain snowberry, hoary aster, Salina wildrye, and Indian ricegrass.

Riparian Vegetation Type

Small portions of the King 4 and King 5 mines (Hiawatha Mine), the King 6 Mine (King Mine), and the Mohrland Mine are in this riparian type

(Figure 1). Table 8 lists the major plant species assumed to have been present prior to disturbances at these sites. The dominant tree species were narrowleaf cottonwood, sandbar willow, Douglas fir, and quaking aspen. The dominant understory species were big sagebrush, rubber rabbitbrush, Wood's rose, mountain snowberry, western virginsbower, horsetail, sweetclover, sedge, and American bullrush.

Areas of Proposed Disturbance

Four vegetation types (mixed conifer, pinyon-juniper woodland, riparian, and sagebrush) will be disturbed by proposed mining activities. As with previously disturbed areas, more than one vegetation type will be disturbed at the proposed mines and associated facilities. Table 4 lists the areas of proposed disturbance and their respective vegetation types and reference areas.

Mixed Conifer Vegetation Type

The King 7 and King 8 mines and associated yard areas in Mohrland Canyon (MCA6 and MCA7: elevation 7,300 to 8,100 feet) will be in this mixed conifer type (Figures 1-7). Tables 9, 10, 11, and 12 summarize the species composition, cover, woody plant density, and tree size-class distribution data, respectively. Sampling adequacy is demonstrated in Appendix B. The dominant trees are white fir, Douglas fir, Rocky Mountain maple, and quaking aspen. Dominant shrubs include Saskatoon serviceberry, creeping barberry, mountain mahogany, mallow ninebark,

myrtle pachistima, and mountain snowberry. Dominant forbs and grasses include blueleaf aster, Wyoming painted-cup, goldenrod, Salina wildrye, needle-and-thread grass, and Indian ricegrass. All of the mixed conifer areas are in good condition. Weedy species are low in frequency and cover, open areas have good stands of desirable forbs and perennial grasses, and trees are not showing signs of widespread insect and disease damage. However, due to fire suppression, the fuel load (fallen trees and branches) has built up significantly in several areas. Relatively young stands of conifers occur in the areas of proposed disturbance. White fir is the only tree species with individuals distributed in larger size classes.

Pinyon-Juniper Woodland Vegetation Type

The conveyor system, coal storage area and load-out area below the King 6 Mine (King Mine) in the Left Fork of Miller Creek (PJA4: elevation 7,800 to 8,100 feet); a portion of the conveyor system (elevation 7,400 to 7,600 feet) from the King 4 and King 5 mines (Hiawatha Mine) to the coal preparation plant in Hiawatha (PJA14); and a portion of the conveyor system (PJA8) and King 7 and King 8 mine facilities in Mohrland Canyon (PJA11: elevation 7,100 to 7,800 feet) will be in this pinyon-juniper woodland type (Figures 1-7). Tables 13, 14, 15, and 16 summarize the species composition, cover, woody plant density, and tree size-class distribution data, respectively. Sample adequacy is demonstrated in Appendix B. The dominant tree species are Utah juniper and pinyon pine. The dominant understory species are Saskatoon serviceberry, big sagebrush, mountain mahogany, low rabbitbrush, yucca,

goldenrod, Salina wildrye, western wheatgrass, and Indian ricegrass. Several of the sampling sites had cliffs and outcrops with very little plant cover. Understory cover is also limited directly beneath the juniper and pinyon trees. Pinyon pine was more evenly distributed among the size classes compared to Utah juniper whose population was comprised mainly of seedlings and young trees.

Riparian Vegetation Type

A portion of the conveyor system (elevation 7,200 to 7,400 feet) from the King 4 and King 5 mines (Hiawatha Mine) to the coal preparation plant in Hiawatha (RA13), and a portion of the King 7 and King 8 mine facilities in Mohrland Canyon (RA9: elevation 7,300 to 7,400 feet) will be in this riparian type (Figures 1-7). Tables 17, 18, 19, and 20 summarize the species composition, cover, woody plant density, and tree size-class distribution data, respectively. Sample adequacy is demonstrated in Appendix B. The dominant tree species are narrowleaf cottonwood, sandbar willow, river birch and quaking aspen. Dominant understory species include Saskatoon serviceberry, rabbitbrush, silver buffaloberry, Wood's rose, mountain snowberry, aster, western virgins-bower, horsetail, yellow sweetclover, sedge, Indian ricegrass, and needle-and-thread grass. Shrubs such as low and rubber rabbitbrush are spreading into the streambank areas from disturbed areas along roadsides, and these root-sprouting shrubs are crowding out desirable forbs and perennial grasses. Narrowleaf cottonwood has some individuals in larger size-classes, but the remaining tree species are mainly comprised of seedlings and young trees (Table 20).

Sagebrush Vegetation Type

Portions of the conveyor system (elevation 7,150 to 7,300 feet) from the King 4 and King 5 mines (Hiawatha Mine) to the coal preparation plant in Hiawatha (SBA3); portions of the King 7 and King 8 mine facilities in Mohrland Canyon (SBA10: elevation 7,000 to 7,150 feet); and the topsoil stockpile and borrow areas below the King 6 Mine (King Mine) in the Left Fork of Miller Creek (SBA12) will be in this sagebrush type (Figures 1-7). Tables 21, 22, and 23 summarize the species composition, cover, and woody plant density data, respectively. Sample adequacy is demonstrated in Appendix B. The dominant overstory is comprised almost exclusively of big sagebrush. Dominant understory species include rubber rabbitbrush, pricklypear cactus, rose, broom snakeweed, hoary aster, western virginsbower and Indian ricegrass. Most areas of proposed disturbance are old townsites (circa 1900 to 1915), and many still have building foundations remaining. This prior disturbance has led to the development of overgrown sagebrush stands with relatively little understory cover.

Other perturbations such as fire, grazing, plowing, spraying, and seeding have occurred primarily on high elevation Forest Service land near the western boundary of the permit area. This Forest Service land comprises less than 5 percent of the Gentry Allotment which supports 4,800 AUM's (cattle) during the grazing season. All areas of new disturbance will be below this Forest Service land.

Reference Areas

Nine reference areas were selected in the five vegetation types which had existing disturbed areas and areas of proposed disturbance. All reference areas were located as close as possible to disturbed areas and areas of proposed disturbance without interfering with present and future mining activities (Figure 1). Table 4 lists the disturbed areas and areas of proposed disturbance, with their respective reference area. Species lists were developed for each reference area within the various vegetation types. Tables 24 through 50 summarize species composition, cover, woody plant density, and tree composition by size class data. The similarity between disturbed areas and areas of proposed disturbance, and reference areas is demonstrated in Tables 51 through 61. Sample adequacy is demonstrated in Appendix B.

Range Condition of Reference Areas

The Vegetation Survey conducted by the Soil Conservation Services in 1981 (see Chapter VIII of the Mining and Reclamation Plan) indicated that all ecological sites were in poor to fair range condition with the exception of the following sites in good condition: Upland Loam (P-J), Mountain Shallow Loam (Shrub), Mountain Shallow Loam (Curl-leaf mountain mahogany), and Wet Meadow. Since none of the reference areas are in the good condition ecological sites, it is assumed that they are in poor to fair condition. Though it would appear that fencing of reference areas is in order, since the area is presently used only for short periods during the sping and fall for trailing cattle to and from summer and winter ranges, fencing should not be necessary.

Table 1. Acreages of each vegetation type and their percentages of the total permit area acreage.

Vegetation Type	Acreage	% of Permit Area
Aspen	2,386	12.4
Barren Land	52	0.2
Grassland	582	3.0
High Elevation Sagebrush-Grass	1,122	6.0
Mixed Conifer	7,743	40.3
Mixed Conifer-Aspen	2,516	13.1
Mountain Brush	1,862	9.7
Pinyon-Juniper Woodland	2,465	12.8
Riparian	212	1.1
Sagebrush	266	6.0
	19,206	100.0

Table 2. Acreages of each vegetation type found in previously disturbed areas and areas of proposed disturbance, and their percentages of the total acreage of each type in the permit area.

Vegetation Type	Acreage Previously Disturbed (Proposed Disturbance)	% of Vegetation Type Previously Disturbed (Proposed Disturbance)
Mixed Conifer	8.5 (53.1)	0.1 (0.7)
Mountain Brush	4.0 (3.8)	0.2 (0.2)
Pinyon-Juniper	260.0 (17.5)	10.5 (0.7)
Riparian	1.0 (1.7)	0.5 (0.8)
Sagebrush	(24.3)	(9.1)

Total Disturbance = 373.9 acres.

Table 3. Correlation of SCS ecological sites to vegetation types of the permit area.

Vegetation Type	SCS Ecological Site[a]
Aspen	Woodland
Barren Land	Badland Soil (not placed in an ecological site)
Grassland	Mountain Loam Mountain Stony Loam Upland Stony Loam
Mixed Conifer	Disturbed Site Semi-wet Stream Bottom Woodland
Mixed Conifer-Aspen	Semi-wet Stream Bottom Woodland
Mountain Brush	Disturbed Site Mountain Shallow Loam Mountain Shallow Loam (Curl-leaf Mountain Mahogany Mountain Stony Loam
Pinyon-Juniper Woodland	Disturbed Site Mountain Shallow Loam Upland Loam (P-J) Upland Shallow Loam Upland Stony Loam
Riparian	Disturbed Site Semiwet Streambottom
Sagebrush	Disturbed Site Mountain Loam Upland Loam
High Elevation Sagebrush-Grass	Intermixed with Woodland

[a]Source: Vegetation Survey, Soil Survey and Interpretations for U.S. Fuel Co. Mine Area, Soil Conservation Service, February, 1981.

Table 4. Disturbed areas and areas of proposed disturbance in each vegetation type, and their respective reference area.

Vegetation Type	Disturbed Area or Area of Proposed Disturbance	Reference Area
Mountain Brush	Disturbed area at the King 4 & 5 Mines, and the Blackhawk Mine.	MBR1
Mixed Conifer	Disturbed area at the portal in the Right Fork of Miller Creek, the King 4 & 5 Mines, the King 6 Mine, and the Blackhawk Mine.	MCR2
	Proposed disturbance for the alternative upper seam portal site above the Mohrland Mine (MCA6), and King 7 & 8 alternative seam portal site and yard areas near the Mohrland Mine (MCA7).	MCR7
Sagebrush	Proposed disturbance for the conveyor system from King 4 & 5 Mines to the coal preparation plant near Hiawatha (SBA3); and King 7 & 8 Mine facilities, load-out, and transportation areas (SBA10).	SBR3
	Proposed disturbance for the topsoil stockpile and borrow area below the King 6 Mine (SBA12)	SBR12
Pinyon-Juniper Woodland	Disturbed area at the King 6 Mine. Proposed distrubance for the conveyer system from King 4 & 5 Mines to the coal preparation plant near Hiawatha (SBA14), the load-out area below the King 6 Mine (PJA4), and the conveyor system and load-out area at the King 7 & 8 Mines (PJA8).	PJR4
	Disturbed area at the coal preparation plant-waste disposal complex area near Hiawatha.	PJR5
	Proposed disturbance for the King 7 and 8 Mine facilities, load-out, and transportation areas (PJA11)	PJR11
Riparian	Proposed disturbance for the mine yard and transportation areas at the King 7 & 8 Mines (RA9), and the conveyor system from King 4 & 5 Mines to the coal preparation plant near Hiawatha (RA13).	RR9

Table 5. Major plant species assumed to have been present in the mixed conifer vegetation type prior to disturbance.

Life Form	Botanical Name	Common Name
Portal Site in the Right Fork of Miller Creek		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Picea pungens	Colorado blue spruce
	Populus tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Berberis repens	Creeping barberry
	Holodiscus dumosus	Bush ocean-spray
	Juniperus communis	Common juniper
	Physocarpus malvaceus	Mallow ninebark
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Arnica cordifolia	Heartleaf arnica
	Lupinus sp.	Lupine
	Swertia perennis	Alpinebog swertia
Grass	Elymus salina	Salina wildrye
	Bromus ciliatus	Fringed brome
King 4 and King 5 Mines		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Juniperus scopulorum	Rocky Mountain juniper
	Picea pungens	Colorado blue spruce
	Populus tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Berberis repens	Creeping barberry
	Holodiscus dumosus	Bush ocean-spray
	Juniperus communis	Common juniper
	Physocarpus malvaceus	Mallow ninebark
	Ribes cereum	Wax currant
	Shepherdia canadensis	Russet buffaloberry
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Astragalus sp.	Locoweed
	Lupinus sp.	Lupine
	Osmorhiza sp.	Sweetroot
	Swertia perennis	Alpinebog swertia
	Viola sp.	Violet
Grass	Elymus salina	Salina wildrye
	Bromus ciliatus	Fringed brome

Table 5. Continued

Life Form	Botanical Name	Common Name
King 6 Mine		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Juniperus scopulorum	Rocky Mountain juniper
	Picea pungens	Colorado blue spruce
	Pinus edulis	Pinyon pine
	Populus tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Cercocarpus montanus	True mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Pachistima myrsinites	Myrtle pachistima
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Aster glaucodes	Blueleaf aster
	Castilleja linariaefolia	Wyoming painted-cup
	Eriogonum sp.	Eriogonum
	Lupinus sp.	Lupine
	Machaeranthera canescens	Hoary aster
Grass	Agropyron smithii	Western wheatgrass
	Bromus ciliatus	Fringed brome
	Elymus salina	Salina wildrye
	Koeleria cristata	Prairie junegrass
Blackhawk Mine		
Tree	Abies concolor	White fir
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Cercocarpus montanus	True mountain mahogany
	Packistima myrsinites	Myrtle pachistima
	Physocarpus malvaceus	Mallow ninebark
	Symphoricarpos oreophilus	Mountain snowberry

Table 5. Continued

Life Form	Botanical Name	Common Name
Blackhawk Mine - Continued		
Forb	Aster glaucodes	Blueleaf aster
	Castilleja linariaefolia	Wyoming painted-cup
	Eriogonum sp.	Eriogonum
	Machaeranthera canescens	Hoary aster
	Salidago sp.	Goldenrod
Grass	Agropyron smithii	Western wheatgrass
	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
Mohrland Mine		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Juniperus scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	P. ponderosa	Ponderosa pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia nova	Black sagebrush
	Artemisia tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Juniperus communis	Common juniper
	Packistima myrsinites	Myrtle pachistima
	Physocarpus malvaceus	Mallow ninebark
	Sambucus cerulea	Blueberry elder
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Artemisia ludoviciana	Louisiana sagebrush
	Aster glaucodes	Blueleaf aster
	Castilleja linariaefolia	Wyoming painted-cup
	Clematis ligustifolia	Western Virginsbower
	Eriogonum sp.	Eriogonum
	Machaeranthera canescens	Hoary aster
	Solidago canadensis	Canada goldenrod
Grass	Agropyron smithii	Western wheatgrass
	Bromus ciliatus	Fringed brome
	Elymus salina	Salina wildrye
	Koeleria cristata	Prairie junegrass
	Oryzopsis hymenoides	Indian ricegrass

Table 6. Major plant species assumed to have been present in the mountain brush vegetation type prior to disturbance.

Life Form	Botanical Name	Common Name
King 5 and King 6 Mines		
Tree	Juniperus osteosperma	Utah juniper
	J. scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Cercocarpus montanus	True mountain mahogany
	Ephedra viridis	Green ephedra
	Holodiscus dumosus	Bush ocean-spray
	Quercus gambellii	Gambel oak
	Symphoricarpos oreophilus	Mountain snowberry
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Cirsium sp.	Thistle
	Eriogonum corymbosum	Corymbed eriogonum
	Machaeranthera canescens	Hoary aster
	Solidago sp.	Goldenrod
Grass	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
	Poa pratensis	Kentucky bluegrass
Blackhawk Mine		
Tree	Juniperus osteosperma	Utah juniper
	Pinus edulis	Pinyon pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Cercocarpus montanus	True mountain mahogany
	Holodiscus dumosus	Bush ocean-spray
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Eriogonum sp.	Eriogonum
	Machaeranthera canescens	Hoary aster
	Solidago sp.	Goldenrod
Grass	Agropyron smithii	Western wheatgrass
	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian Ricegrass

Table 7. Major plant species assumed to have been present in the pinyon-juniper woodland vegetation type prior to disturbance.

Life Form	Botanical Name	Common Name
King 6 Mine		
Tree	Abies concolor	White fir
	Juniperus osteosperma	Utah fir
	Juniperus scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia nova	Black sagebrush
	Artemisia tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Cercocarpus montanus	True mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Ephedra viridis	Green ephedra
	Symphoricarpos oreophilus	Mountain snowberry
	Tetrademia canescens	Gray horsebrush
	Xanthocephalum sarothrae	Broom snakeweed
	Yucca harrimaniae	Harriman yucca
Forb	Arabis sp.	Rockcress
	Artemisia ludoviciana	Louisiana sagebrush
	Eriogonum sp.	Eriogonum
	Hymenoxys acaulis	Stemless hymenoxys
	Machaeranthera canescens	Hoary aster
	Solidago sp.	Goldenrod
Grass	Agropyron smithii	Western wheatgrass
	Bouteloua gracilis	Blue grama
	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
	Stipa comata	Needle-and-thread grass
Mohrland Mine		
Tree	Abies concolor	White fir
	Juniperus osteosperma	Utah juniper
	J. scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	C. montanus	True mountain mahogany

Table 7. Continued

Life Form	Botanical Name	Common Name
Mohrland Mine - Continued		
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Ephedra viridis	Green ephedra
	Opuntia sp.	Pricklypear
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Astragalus sp.	Locoweed
	Clematis ligusticifolia	Western virginsbower
	Eriogonum sp.	Eriogonum
	Machaeranthera canescens	Hoary aster
Grass	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
Coal Preparation Plant-Waste Disposal Complex		
Tree	Pinus edulis	Pinyon pine
	Juniperus osteosperma	Utah juniper
Shrub	Artemisia nova	Black sagebrush
	Artemisia tridentata	Big sagebrush
	C. montanus	True mountain mahogany
	Opuntia sp.	Pricklypear cactus
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Talinum parviflorum	Fameflower
Grass	Agropyron smithii	Western wheatgrass
	Bouteloua gracilis	Blue grama
	Sporobolus aeroides	Alkali sacaton
	Stipa comata	Needle-and-thread grass

Table 8. Major plant species assumed to have been present in the riparian vegetation type prior to disturbance.

Life Form	Botanical Name	Common Name
King 4 and King 5 Mines		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Juniperus scopulorum	Rocky Mountain juniper
	Populus angustifolia	Narrowleaf cottonwood
	P. tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
	Salix exigua	Sandbar willow
Shrub	Artemisia tridentata	Big sagebrush
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Ribes aureum	Wax currant
	Rosa woodsii	Wood's rose
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Artemisia ludoviciana	Louisiana sagebrush
	Aster glaucodes	Blueleaf aster
	Clematis ligusticifolia	Western virginsbower
	Equisetum arvense	Field horsetail
	E. hyemale	Western scouring rush
	Lupinus sp.	Lupine
	Melilotus officinalis	Yellow sweetclover
	Solidago sp.	Goldenrod
Grass	Bromus ciliatus	Fringed brome
	Carex sp.	Sedge
	Juncus sp.	Rush
	Oryzopsis hymenoides	Indian ricegrass
	Scirpus americanus	American bullrush
	Stipa comata	Needle-and-thread grass
King 6 Mine		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Juniperus scopulorum	Rocky Mountain juniper
	P. tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
Shrub	Artemisia tridentata	Big sagebrush
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Rhus trilobata	Skunk bush sumac

Table 8. Continued

Life Form	Botanical Name	Common Name
King 6 Mine - Continued		
	Rosa woodsii	Wood's rose
	Symphoricarpos oreophilus	Mountain snowberry
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Artemisia ludoviciana	Louisiana sagebrush
	Aster glaucodes	Blueleaf aster
	Cirsium vulgare	Bull thistle
	Clematis ligusticifolia	Western virginsbower
	Equisetum sp.	Horsetail
	Isomopsis aggregata	Wyoming painted-cup
	Melilotus officinalis	Yellow sweetclover
Grass	Bromus ciliatus	Fringed brome
	Carex sp.	Sedge
	Oryzopsis hymenoides	Indian ricegrass
	Stipa comata	Needle-and-thread grass
Mohrland Mine		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Betula occidentalis	River birch
	Juniperus scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	Populus angustifolia	Narrowleaf cottonwood
	P. tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
Shrub	Artemisia tridentata	Big sagebrush
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Ribes aureum	Wax currant
	Rosa woodsii	Wood's rose
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Artemisia ludoviciana	Louisiana sagebrush
	Aster glaucodes	Blueleaf aster
	Cirsium vulgare	Bull thistle
	Clematis ligusticifolia	Western virginsbower
	Equisetum arvense	Field horsetail
	Grindelia squarrosa	Curlycup gumweed

Table 8. Continued

Life Form	Botanical Name	Common Name
Mohrland Mine - Continued		
	Ipomopsis aggregata	Scarlet gilia
	Lupinus sp.	Lupine
	Melilotus officinalis	Yellow sweetclover
Grass	*Agropyron* sp.	Wheatgrass
	Bromus ciliatus	Fringed brome
	Carex sp.	Sedge
	Juncus sp.	Rush
	Scirpus americanus	American bullrush

Table 9. Major plant species in the mixed conifer vegetation type within proposed distrubance areas (1980 field season)

Life Form	Botanical Name	Common Name
Sampling Site MCA6: Alternative Site for Upper Seam Portal		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Picea pungens	Colorado blue spruce
	Pinus flexilis	Limber pine
	Populus angustifolia	Narrowleaf cottonwood
	P. tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
	Salix sp.	Willow
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Juniperus communis	Common juniper
	Physocarpus malvaceus	Mallow ninebark
	Ribes aureum	Wax currant
	Rosa woodsii	Wood's rose
	Sambucus cerulea	Blueberry elder
	Shepherdia canadensis	Russet buffaloberry
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Aster glaucodes	Blueleaf aster
	Astragalus sp.	Locoweed
	Fragaria sp.	Strawberry
	Solidago canadensis	Canada goldenrod
	Viola sp.	Violet
Grass	Agropyron trachycaulum	Slender wheatgrass
	Bromus ciliatus	Fringed brome
	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
Sampling Site MCA7: Alternative Seam Portal Site and Yard Areas		
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Juniperus scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	P. ponderosa	Ponderosa pine
	Pseudotsuga menziesii	Douglas fir

Table 9. Continued

Life Form	Botanical Name	Common Name
Sampling Site MCA7: Alternative Seam Portal Site and Yard Areas - Continued		
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	C. montanus	True mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Ephedra viridis	Green ephedra
	Pachistima myrsinites	Myrtle pachistima
	Sambucus cerulea	Blueberry elder
	Symphoricarpos oreophilus	Mountain snowberry
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Aster glaucodes	Blueleaf aster
	Castelleja linariaefolia	Wyoming painted-cup
	Eriogonum sp.	Eriogonum
	Linum lewisii	Lewis flax
	Machaeranthera canescens	Hoary aster
	Solidago canescens	Canada goldenrod
Grass	Agropyron sp.	Wheatgrass
	Bromus ciliatus	Fringed brome
	Carex sp.	Sedge
	Elymus salina	Salina wildrye
	Koeleria cristata	Prairie june grass

Table 10. Summary of cover data for the combined mixed-conifer sampling sites MCA6 and MCA7 (1981 field season).

Life form	Species	Common name	% relative cover	% relative cover by life form
Grasses	*Elymus salina*	Salina wildrye	51.8	53.6
	Poa sp.	Bluegrass	1.8	
Forbs	*Aster foliaceus*	Leafy aster	3.2	11.2
	Hymenoxys acaulis	Stemless hymenoxys	2.7	
	Solidago sp.	Goldenrod	2.2	
	Artemisia ludoviciana	Louisiana sagebrush	1.5	
	Cryptantha sp.	Cryptantha	1.0	
	Castelleja sp.	Indian paintbrush	0.4	
	Ipomopsis aggregata	Scarlet gilia	0.2	
Shrubs	*Symphoricarpos oreophilus*	Mountain snowberry	17.2	32.9
	Amelanchier alnifolia	Saskatoon serviceberry	9.2	
	Pachistima myrsinites	Myrtle pachistima	5.0	
	Berberis repens	Creeping barberry	1.5	
Trees	*Pinus edulis*	Pinyon pine	1.3	2.3
	Abies concolor	White fir	0.5	
	Juniperis scopulorum	Rocky Mountain juniper	0.5	
	Plant		13.4	
	Litter		26.1	
	Rock		15.1	
	Bare ground		45.4	

Table 11. Average woody plant density (number of plants per 2.0 m^2) for the combined mixed-conifer sampling sites MCA6 and MCA7 (1981 field season).

Life form	Species	Common name	Density
Shrubs	Symphoricarpos oreophilus	Mountain snowberry	0.83
	Amelanchier alnifolia	Saskatoon serviceberry	0.42
	Pachistima myrsinites	Myrtle pachistima	0.20
	Artemisia tridentata	Big sagebrush	0.18
	Berberis repens	Creeping barberry	0.17
	Sambucus cerulea	Blueberry elder	0.02
	Cercocarpus ledifolius	Curl-leaf mountain mahogany	0.02
Total			1.84
Trees	Abies concolor	White fir	0.08
	Juniperus osteosperma	Utah juniper	0.08
	Pseudotsuga menziesii	Douglas fir	0.08
	Pinus edulis	Pinyon pine	0.07
Total			0.31

Table 12. Tree composition by size class for the mixed conifer sampling sites MCA6 and MCA 7 (1980 field season).

	Diameter breast height (in.)					
	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of Total
A. Sampling site MCA6 (alternative site for upper seam portal above old Mohrland Mine)						
Abies concolor	20	22	10	10	15	84
Pseudotsuga menziesii	3	7	1	0	1	15
Populus tremuloides	0	1	0	0	0	1
% of total	29	38	14	8	11	100
Absolute Density = 538 trees/acre						
B. Sampling site MCA7 (alternative seam portals and possible yard areas near old Mohrland Mine)						
Abies concolor	27	9	1	2	1	54
Pinus edulis	3	4	3	4	3	22
Pseudotsuga menziesii	7	5	2	1	1	21
Juniperus scopulorum	2	0	0	0	0	2
J. osteosperma	1	0	0	0	0	1
% of total	53	24	8	9	6	100
Absolute Density = 483 trees/acre						

Table 13. Major plant species in the pinyon-juniper woodland present within proposed disturbance areas (1980 field season).

Life Form	Botanical Name	Common Name
King 6 Mine Conveyor System, Coal Storage, and Load-Out Areas (PJA4)		
Tree	Abies concolor	White fir
	Acer grandidentatum	Big-tooth maple
	Juniperus osteosperma	Utah juniper
	J. scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	P. ponderosa	Ponderosa pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia nova	Black sagebrush
	A. tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	C. montanus	True mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Ephedra viridis	Green ephedra
	Juniperus communis	Common juniper
	Pachistima myrsinites	Myrtle pachistima
	Symphoricarpos oreophilus	Mountain snowberry
	Tetrademia canescens	Gray horsebrush
	Xanthocephalum sarothrae	Broom snakeweed
	Yucca harrimaniae	Harriman yucca
Forb	Arabis sp.	Rockcress
	Artemisia ludoviciana	Louisiana sagebrush
	Eriogonum corymbosum	Corymbed eriogonum
	Hymenoxys acaulis	Stemless hymenoxys
	Solidago sp.	Goldenrod
Grass	Agropyron smithii	Western wheatgrass
	Bouteloua gracilis	Blue grama
	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
	Sitanion hysterix	Bottlebrush squirreltail
	Stipa comata	Needle-and-thread grass

Table 13. Continued

Life Form	Botanical Name	Common Name
King 7 and 8 Mines, Conveyor System, and Load-Out Areas (PJA8)		
Tree	Juniperus osteosperma	Utah juniper
	J. scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
Shrub	Artemisia tridentata	Big sagebrush
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	C. montanus	True mountain mahogany
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Echinocereus triglochidiatus	Echinocereus
	Ephedra viridis	Green ephedra
	Opuntia sp.	Pricklypear
	Sclerocactus whipplei	Sclerocactus
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Arenaria sp.	Sandwort
	Astragalus sp.	Locoweed
	Clematis ligusticifolia	Western virginsbower
	Eriogonum sp.	Eriogonum
	Machaeranthera canescens	Hoary aster
Grass	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
King 7 and 8 Mine Facilities, Load-Out and Transportation Areas (PJA 11)		
Tree	Juniperus osteosperma	Utah juniper
	Pinus edulis	Pinyon pine
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia nova	Black sagebrush
	A. tridentata	Big sagebrush
	C. montanus	True mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Ephedra viridis	Green ephedra
	Opuntia barkleyana	Pricklypear
	Symphoricarpos oreophilus	Mountain snowberry
	Yucca harrimaniae	Harriman yucca
Forb	Eriogeron sp.	Fleabane
	Machaeranthera linearis	Hoary aster
	Penstemon sp.	Penstemon
Grass	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
	Poa pratensis	Kentucky bluegrass

Table 14. Summary of cover data for the pinyon-juniper sampling sites (1981 field season).

Life form	Species	Common name	% relative cover	% relative cover by life form
King 6 Mine Conveyor System, Coal Storage, and Load-Out Areas (PJA4)				
Grasses	Elymus salina	Salina wildrye	6.4	55.4
	Agropyron smithii	Bluebunch wheatgrass	8.1	
	Oryzopsis hymenoides	Indian ricegrass	18.8	
	Bouteloua gracilis	Blue grama	7.7	
	Stipa camata	Needle-and-thread grass	13.6	
	Poa pratensis	Kentucky bluegrass	0.8	
Forbs	Ipomopsis aggregata	Scarlet gilia	0.8	4.7
	Grindelia squarrosa	Curlycup gumweed	0.6	
	Eriogonum sp.	Eriogonum	0.9	
	Hymenoxys acaulis	Stemless hymenoxys	0.5	
	Cryptantha sp.	Cryptantha	1.0	
	Machaeranthera linearis	Hoary aster	0.9	
Shrub	Ephedra viridis	Green ephedra	1.9	35.1
	Xanthocephalum sarothrae	Broom snakeweed	1.5	
	Chrysothamnus nauseosus	Rubber rabbitbrush	1.7	
	Cercocarpus montanus	True mountain mahogany	5.2	
	Berberis repens	Creeping barberry	6.1	
	Artemisia nova	Black sagebrush	6.8	
	Sambucus cerulea	Blueberry elder	1.2	
	Symphoricarpos oreophilus	Mountain snowberry	1.5	
	Yucca harrimaniae	Harriman yucca	2.0	
	Opuntia sp.	Prickly pear	0.8	

Table 14. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
King 6 Mine Conveyor System, Coal Storage, and Load-Out Areas (PJA4) - Continued				
Shrub - Continued				
	Tetrademia canescens	Gray horsebrush	0.8	
	Artemisia tridentata	Big sagebrush	5.6	
	Juniperus osteosperma	Utah juniper	1.5	4.8
	Juniperus scopulorum	Rocky Mountain juniper	1.2	
	Pinus edulis	Pinyon pine	2.1	
	Plant		10.7	
	Litter		23.6	
	Rock		18.2	
	Bare ground		47.5	
King 7 and 8 Mines Conveyor System and Load-Out Areas (PJA8)				
Grasses	Agropyron smithii	Western wheatgrass	20.2	40.0
	Oryzopsis hymenoides	Indian ricegrass	15.7	
	Bouteloua gracilis	Blue grama	1.7	
	Stipa comata	Needle-and-thread grass	1.4	

Table 14. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
King 7 and 8 Mines Conveyor System and Load-Out Areas (PJA8) - Continued				
Forbs	Eriogonum sp.	Eriogonum	2.7	8.7
	Cryptantha sp.	Cryptantha	2.2	
	Hedysarum boreale	Sweetvetch	1.8	
	Ipomopsis aggregata	Scarlet gilia	1.3	
	Machaeranthera linearis	Hoary aster	0.3	
	Artemisia ludoviciana	Louisiana sagebrush	0.4	
Shrub	Cercocarpus montanus	True mountain mahogany	9.4	
	Artemisia tridentata	Big sagebrush	9.1	
	Artemisia nova	Black sagebrush	7.6	
	Ephedra viridis	Green ephedra	7.0	
	Amelanchier alnifolia	Saskatoon serviceberry	1.8	
	Symphoricarpos oreophilus	Mountain snowberry	1.4	
	Yucca harrimaniae	Harriman yucca	1.3	
	Xanthocephalum sarothrae	Broom snakeweed	1.2	
	Opuntia sp.	Pricklypear	1.0	
	Chrysothamnus viscidiflorus	Low rabbitbrush	0.6	
Trees	Juniperus osteosperma	Utah juniper	8.5	11.9
	Pinus edulis	Pinyon pine	3.4	7.7
	Plant		10.4	
	Litter		14.2	
	Rock		17.6	
	Bare ground		57.5	

Table 14. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
King 7 and 8 Mine Facilities, Load-Out and Transportation Areas (PJA11)				
Grasses	Oryzopsis hymenoides	Indian ricegrass	9.7	14.5
	Elymus salina	Salina wildrye	2.3	
	Bouteloua gracilis	Blue grama	2.1	
	Poa pratensis	Kentucky bluegrass	0.4	
Forbs	Eriogonum sp.	Eriogonum	6.2	12.3
	Cryptantha sp.	Cryptantha	4.0	
	Machaeranthera linearis	Hoary aster	1.1	
	Ipomopsis aggregata	Scarlet gilia	1.0	
Shrub	Amelanchier alnifolia	Saskatoon serviceberry	23.2	59.2
	Yucca harrimaniae	Harriman yucca	11.0	
	Cercocarpus montanus	True mountain mahogany	7.2	
	Opuntia sp.	Pricklypear	6.1	
	Symphoricarpos oreophilus	Mountain snowberry	5.1	
	Artemisia tridentata	Big sagebrush	2.8	
	Ephedra viridis	Green ephedra	2.3	
	Xanthocephalum sarothrae	Broom snakeweed	1.5	
Trees	Pinus edulis	Pinyon pine	11.4	14.0
	Juniperus osteosperma	Utah juniper	2.6	
	Plant		7.4	
	Litter		18.0	
	Rock		16.4	
	Bare ground		58.1	

Table 14. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (PJA14)				
Grasses	Oryzopsis hymenoides	Indian ricegrass	19.7	29.2
	Stipa comata	Needle-and-thread grass	6.6	
	Bouteloua gracilis	Blue grama	1.8	
	Agropyron smithii	Western wheatgrass	1.1	
Forbs	Cryptantha sp.	Cryptantha	2.9	11.9
	Cirsium vulgare	Common thistle	2.0	
	Eriogonum sp.	Eriogonum	1.8	
	Sphaeralcea sp.	Globemallow	1.3	
	Artemisia ludoviciana	Louisiana sagebrush	1.1	
	Machaeranthera linearis	Hoary aster	1.1	
	Aster foliaceus	Leafy aster	0.9	
	Hedysarum boreale	Sweetvetch	0.6	
	Ipomopsis aggregata	Scarlet gilia	0.2	
Shrub	Cercocarpus montanus	True mountain mahogany	15.4	51.2
	Artemisia tridentata	Big sagebrush	8.0	
	Symphoricarpos oreophilus	Mountain snowberry	6.0	
	Amelanchier alnifolia	Saskatoon serviceberry	4.7	
	Ephedra viridis	Green ephedra	3.4	
	Artemisia nova	Black sagebrush	2.7	
	Chrysothamnus viscidiflorus	Low rabbitbrush	2.0	
	Xanthocephalum sarothrae	Broom snakeweed	2.0	
	Opuntia sp.	Pricklypear	1.8	

Table 14. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (PJA14) - Continued				
Shrub - Continued				
	Sambucus cerulea	Blueberry elder	1.8	
	Berberis repens	Creeping barberry	1.4	
	Tetrademia canescens	Gray horsebrush	1.3	
	Yucca harrimaniae	Harriman yucca	0.7	
Trees	Pinus edulis	Pinyon pine	7.3	7.7
	Juniperus osteosperma	Utah juniper	0.4	
	Plant		10.5	
	Litter		8.3	
	Rock		15.3	
	Bare ground		66.0	

Table 15. Average woody plant density (number of plants per 2.0 m^2) for the pinyon-juniper sampling sites (1981 field season).

Life form	Species	Common name	Density
King 6 Mine Conveyor System, Coal Storage, and Load-Out Areas (PJA4)			
Shrubs	Berberis repens	Creeping barberry	0.93
	Cercocarpus montanus	True mountain mahogany	0.44
	Artemisia tridentata	Big sagebrush	0.23
	Amelanchier alnifolia	Saskatoon serviceberry	0.16
	Artemisia nova	Black sagebrush	0.13
	Cercocarpus ledifolius	Curl-leaf mountain mahogany	0.10
	Ephedra viridus	Mormon tea	0.08
	Symphoricarpos oreophilus	Mountain snowberry	0.07
	Xanthocephalum sarothrae	Broom snakeweed	0.03
	Chrysthamnus nauseosus	Rubber rabbitbrush	0.02
	Total		2.19
Trees	Pinus edulis	Pinyon pine	0.05
	Juniperus osteosperma	Utah juniper	0.08
	J. scopulorum	Rocky Mountain juniper	0.01
	Abies concolor	White fir	0.01
	Pseudotsuga menziesii	Douglas-fir	0.01
	Total		0.19
King 7 and 8 Mines Conveyor System and Load-Out Areas (PJA8)			
Shrubs	Cercocarpus ledifolius	Curl-leaf mountain mahogany	0.26
	Ephedra viridus	Mormon tea	0.23
	Artemisia nova	Black sagebrush	0.16
	Symphoricarpos oreophilus	Mountain snowberry	0.13
	Berberis repens	Creeping barberry	0.12
	Cercocarpus montanus	True mountain mahogany	0.09
	Amelanchier alnifolia	Saskatoon serviceberry	0.08
	Artemisia tridentata	Big sagebrush	0.07
	Xanthocephalum sarothrae	Broom snakeweed	0.01
	Total		1.15
Trees	Pinus edulis	Pinyon pine	0.19
	Juniperus osteosperma	Utah juniper	0.10
	Total		0.29

Table 15. Continued

Life form	Species	Common name	Density
King 7 and 8 Mine Facilities, Load-Out and Transportation Areas (PJA11)			
Shrubs	Amelanchier alnifolia	Saskatoon serviceberry	0.46
	Symphoricarpos oreophilus	Mountain snowberry	0.17
	Artemisia tridentata	Big sagebrush	0.12
	Berberis repens	Creeping barberry	0.11
	Cercocarpus montanus	True mountain mahogany	0.09
	Cercocarpus ledifolius	Curl-leaf mountain mahogany	0.08
	Ephedra viridus	Mormon tea	0.05
	Xanthocephalum sarothrae	Broom snakeweed	0.03
	Total		1.11
Trees	Pinus edulis	Pinyon pine	0.28
	Juniperus osteosperma	Utah juniper	0.11
	Total		0.39
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (PJA14)			
Shrubs	Artemisia tridentata	Big sagebrush	0.37
	Cercocarpus ledifolius	Curl-leaf mountain mahogany	0.10
	C. montanus	True mountain mahogany	0.10
	Symphoricarpos oreophilus	Mountain snowberry	0.10
	Xanthocephalum sarothrae	Broom snakeweed	0.08
	Amelanchier alnifolia	Saskatoon serviceberry	0.07
	Ephedra viridus	Mormon tea	0.07
	Berberis repens	Creeping barberry	0.07
	Artemisia nova	Black sagebrush	0.06
	Tetrademia canescens	Gray horsebrush	0.04
	Chrysothanmus viscidiflorus	Little rabbitbrush	0.01
	C. nauseosus	Rubber rabbitbrush	0.01
	Total		1.08
Trees	Pinus edulis	Pinyon pine	0.30
	Juniperus osteosperma	Utah juniper	0.05
	Total		0.35

Table 16. Tree composition by size class for the pinyon-juniper woodland type within proposed disturbance areas (1980 field season).

Life Form	Diameter breast height (in.) 0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of Total
A. Sampling site PJA4 (conveyor system, coal storage and load-out areas below King 6 ming (King Mine) in the Left Fork of Miller Creek)						
Pinus edulis	24	13	6	7	5	68
Juniperus osteosperma	6	1	1	2	1	18
Abies concolor	3	1	1	0	0	6
Juniperus scopulorum	1	3	0	0	1	6
Pseudotsuga menziesii	0	1	0	0	1	2
% of total	42	24	10	14	10	100
Absolute Density = 199 trees/acre						
B. Sampling site PJA8 (conveyor system and load-out area in King 7 and King 8 mine area in Mohrland Canyon)						
Pinus edulis	30	10	7	5	1	66
Juniperus scopulorum	12	6	3	1	5	34
% of total	54	20	12	7	7	100
Absolute Density = 302 trees/acre						
C. Sampling site PJA11 (mine facilities, load-out and transportation areas in Kine 7 and King 8 mine area in Mohrland Canyon)						
Pinus edulis	36	11	9	11	7	95
Juniperus osteosperma	1	1	2	0	0	5
% of total	46	15	14	14	11	100
Absolute Density = 318 trees/acre						

Table 17. Major plant species in the riparian vegetation type within the proposed disturbance area in Mohrland Canyon, sampling site RA9 (possible yard area, transportation area). (1980 Field season)

Life Form	Botanical Name	Common Name
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Betula occidentalis	River birch
	Juniperus osteosperma	Utah juniper
	J. scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	Populus angustifolia	Narrowleaf cottonwood
	P. fremontii	Fremont cottonwood
	Pseudotsuga menziesii	Douglas fir
	Salix exigua	Sandbar willow
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Chrysothamnus nauseosus	Rubber rabbitbrush
	C. viscidiflorus	Low rabbitbrush
	Holodiscus dumosus	Bush ocean-spray
	Juniperus communis	Common juniper
	Opuntia sp.	Pricklypear
	Rhus trilobata	Skunkbush sumac
	Rosa woodsii	Wood's rose
	Sherpherdia argenta	Silver buffaloberry
	Symphoricarpos oreophilus	Mountain snowberry
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Arabis sp.	Rockcress
	Cirsium vulgare	Bull thistle
	Clematis ligusticifolia	Western virginsbower
	Equisetum arvense	Field horsetail
	E. hyemale	Western scouring-rush
	Habeneria sp.	Rain orchid
	Hedysarum boreale	Utah sweetvetch
	Lupinus sp.	Lupine
	Melilotus alba	White sweetclover
	M. officinales	Yellow sweetclover
	Solidago canadensis	Canada goldenrod
Grass	Agrostis sp.	Bentgrass
	Bromus ciliatus	Fringed brome
	B. tectorum	Cheatgrass brome
	Calamagrostis sp.	Reedgrass
	Carex aurea	Golden sedge
	C. nebraskensis	Nebraska sedge
	Juncus sp.	Rush
	Oryzopsis hymenoides	Indian ricegrass
	Stipa comata	Needle-and-thread grass

Table 18. Summary of cover data for the riparian sampling sites (1981 field season).

Life form	Species	Common name	% relative cover	% relative cover by life form
King 7 and 8 Mines Yard and Transportation Areas (RA9)				
Grasses	Poa pratensis	Kentucky bluegrass	6.6	13.4
	Panicum spp.	Switchgrass	3.8	
	Bromus tectorum	Cheatgrass	2.6	
	Agropyron smithii	Western wheatgrass	0.4	
Forbs	Clematis ligusticifolia	White clematis	40.0	59.8
	Aster foliaceus	Leafy aster	9.5	
	Cirsium vulgare	Common thistle	6.6	
	Machaeranthera linearis	Hoary aster	0.9	
	Melilotus officianales	Sweetclover	0.9	
	Solidago sp.	Goldenrod	0.9	
	Arnica cordifolia	Heartleaf arnica	0.6	
	Hedysarum boreale	Sweetvetch	0.4	
Shrub	Rosa woodsii	Wild rose	11.2	12.1
	Artemisia tridentata	Big sagebrush	0.6	
	Ribes aureum	Wax currant	0.3	
Trees	Salix exigua	Sandbar willow	5.8	15.7
	Populus angustifolia	Narrowleaf cottonwood	3.8	
	Pseudotsuga menziesii	Douglas fir	2.9	
	Abies concolor	White fir	1.2	
	Juniperus scopulorum	Rocky Mountain juniper	2.0	
	Plant		19.8	
	Litter		51.3	
	Rock		3.2	
	Bare ground		25.8	

Table 18. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (RA13)				
Grasses	Carex sp.	Sedge	41.3	72.8
	Poa sp.	Bluegrass	26.4	
	Scirpus americanus	American bullrush	3.1	
	Hordeum jubatum	Foxtail barley	2.0	
Forbs	Equisetum arvense	Field horsetail	5.6	16.9
	Equisetum laevigatum	Smooth horsetail	5.5	
	Cirsium vulgare	Common thistle	2.6	
	Agoseris glauca	False dandelion	1.8	
	Cynoglossum officinale	Houndstongue	0.8	
	Aster foliaceus	Leafy aster	0.5	
	Rumex crispus	Curlydock	0.1	
Shrub	Rosa woodsii	Wild rose	2.7	6.7
	Symphoricarpos oreophilus	Mountain snowberry	2.2	
	Chrysothamnus nauseosus	Rubber rabbitbrush	1.2	
	Artemisia tridentata	Big sagebrush	0.6	
Trees	Salix exigua	Sandbar willow	3.6	3.6
	Plant		32.6	
	Litter		45.6	
	Rock		1.2	
	Bare ground		21.8	

Table 19. Average woody plant density (number of plants per 2.0 m^2) for the riparian sampling sites (1981 field season).

Life form	Species	Common name	Density
King 7 and 8 Mines Yard and Transportation Areas (RA9)			
Shrubs	Rosa woodsii	Wood's rose	0.90
	Shepherderdia argentia	Buffaloberry	0.12
	Ribes aureum	Wax currant	0.10
	Amelanchier alnifolia	Saskatoon serviceberry	0.04
	Artemisia tridentata	Big sagebrush	0.04
	Rhus trilobata	Skunk bush	0.02
Total			1.22
Trees	Salix exigua	Sandbar willow	0.32
	Populus angustifolia	Narrowleaf cottonwood	0.20
	Abies concolor	White fir	0.10
	Juniperus osteosperma	Utah juniper	0.08
	Pseudotsuga menziesii	Douglas fir	0.02
Total			0.72
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (RA13)			
Shrubs	Rosa woodsii	Wood's rose	0.27
	Artemisia tridentata	Big sagebrush	0.14
	Symphoricarpos oreophilus	Mountain snowberry	0.12
	Chrysothanmus nauseosus	Rubber rabbitbrush	0.07
Total			0.60
Trees	Salix exigua	Sandbar willow	0.55
	Pseudotsuga menziesii	Douglas fir	0.04
	Populus tremuloides	Quaking aspen	0.02
Total			0.61

Table 20. Tree composition by size class for the riparian vegetation type within the proposed disturbance area in Mohrland Canyon, sampling site RA9 (possible yard area, transportation area) (1980 field season).

	Diameter breast height (in.)					
Life Form	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of Total
Populus angustifolia	22	9	7	6	5	62
Acer glabrum	9	1	0	0	0	13
Juniperus osteosperma	2	3	1	1	0	9
Abies concolor	3	3	0	0	0	8
Juniperus scopulorum	1	2	0	0	0	3
Betula occidentalis	2	0	0	0	0	2
Pinus edulis	2	0	0	0	0	2
Pseudotsuga menziesii	0	0	0	0	1	1
% of total	51	22	10	9	8	100

Absolute Density = 617 trees/acre

Table 21. Major plant species in the sagebrush vegetation type within the proposed disturbance areas (1980 field season).

Life Form	Botanical Name	Common Name
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (SBA3)		
Tree	Juniperus osteosperma	Utah juniper
	Pinus edulis	Pinyon pine
Shrub	Artemisia nova	Black sagebrush
	A. tridentata	Big sagebrush
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Opuntia sp.	Pricklypear
	Rosa sp.	Rose
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Clematis ligusticifolia	Western virginsbower
	Machaeranthera canescens	Hoary aster
	Salsola kali	Russian thistle
Grass	Oryzopsis hymenoides	Indian ricegrass
	Stipa comata	Needle-and-thread grass
King 7 and 8 Mine Facilities, Load-Out and Transportation Areas (SBA10)		
Tree	Juniperus osteosperma	Utah juniper
	Pinus edulis	Pinyon pine
Shrub	Artemisia tridentata	Big sagebrush
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Opuntia sp.	Pricklypear
	Rhus trilobata	Skunkbush sumac
	Rosa sp.	Rose
	Sambucus cerulea	Blueberry elder
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Clematis ligusticifolia	Western virginsbower
	Lappula sp.	Stickweed
	Machaeranthera canescens	Hoary aster
	Sphaeralcea grossulariaefolia	Gooseberryleaf globemallow
Grass	Oryzopsis hymenoides	Indian ricegrass

Table 22. Summary of cover data for the sagebrush sampling sites (1981 field season).

Life form	Species	Common name	% relative cover	% relative cover by life form
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (SBA3)				
Grasses	Oryzopsis hymenoides	Indian ricegrass	5.8	8.3
	Bromus tectorum	Cheatgrass	2.1	
	Sitanion hystrix	Squirrel-tail grass	0.4	
Forbs	Grindelia squarrosa	Gumweed	0.4	0.8
	Astragalus sp.	Locoweed	0.3	
	Salsola kali	Russian thistle	0.1	
Shrub	Artemesia tridentata	Big sagebrush	85.4	90.9
	Chrysothamnus nauseosus	Rubber rabbitbrush	3.8	
	Yucca harrimaniae	Harriman yucca	0.8	
	Xanthocephalum sarothrae	Broom snakeweed	0.6	
	Ceratoides lanata	Winterfat	0.2	
	Amelanchier alnifolia	Saskatoon serviceberry	0.1	
Trees			0	0
	Plant		27.1	
	Litter		18.1	
	Rock		0.2	
	Bare ground		54.6	

Table 22. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
King 7 and 8 Mine Facilities, Load-Out and Transportation Areas (SBA10)				
Grasses			0	0
Forbs			0	0
Shrub	Artemisia tridentata	Big sagebrush	93.5	100
	Chrysothamnus nauseosus	Rubber rabbitbrush	6.5	
Trees			0	0
	Plant		24.5	
	Litter		35.6	
	Rock		1.7	
	Bare ground		38.2	
King 6 Mine Topsoil Stockpile and Borrow Areas (SBA12)				
Grasses	Stipa comata	Needle-and-thread grass	41.0	42.8
	Bouteloua gracilis	Blue grama	1.0	
	Agropyron smithii	Western wheatgrass	0.4	

Table 23. Average woody plant density (number of plants per 2.0 m^2) for the sagebrush sampling sites (1981 field season).

Life form	Species	Common name	Density
King 4 and 5 Mines Conveyor System to Coal Preparation Plant (SBA3)			
Shrubs	*Artemisia tridentata*	Big sagebrush	2.60
	Chrysothamnus nauseosus	Rubber rabbitbrush	0.20
	Xanthocephalum sarothrae	Broom snakeweed	0.03
	Total		2.83
Trees			0
King 7 and 8 Mine Facilities, Load-Out and Transportation Areas (SBA10)			
Shrubs	*Artemisia tridentata*	Big sagebrush	2.55
	Chrysothanmus nauseosus	Rubber rabbitbrush	0.33
	Total		2.88
Trees			0
King 6 Mine Topsoil Stockpile and Borrow Areas (SBA12)			
Shrubs	*Artemisia tridentata*	Big sagebrush	1.21
	Artemisia nova	Black sagebrush	0.44
	Berberis repens	Creeping barberry	0.18
	Chrysothamnus nauseosus	Rubber rabbitbrush	0.11
	Xanthocephalum sarothrae	Broom snakeweed	0.09
	Tetrademia canescens	Gray horsebrush	0.07
	Ceratoides lanata	Winterfat	0.04
	Symphoricarpos oreophilus	Mountain snowberry	0.02
	Total		2.16
Trees	*Juniperus scopulorum*	Rocky Mountain juniper	0.09
	Pinus edulis	Pinyon pine	0.02
	Total		0.11

Table 24. Major species present within reference area MBR1 (above King 4 and King 5 mines, Hiawatha Mine, in the Middle Fork of Miller Creek).

Life form	Botanical name	Common name
Tree	Juniperus osteosperma	Utah juniper
	J. scopulorum	Rocky Mountain Juniper
	Pinus edulis	Pinyon pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	A. utahensis	Utah serviceberry
	Artemisia tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus montanus	True mountain mahogany
	Ephedra viridis	Green ephedra
	Holodiscus dumosus	Bush ocean-spray
	Quercus gambellii	Gambel oak
	Symphoricarpos oreophilus	Mountain snowberry
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Cirsium sp.	Thistle
	Eriogonum corymbosum	Corymbed eriogonum
	Eriogonum sp.	Eriogonum
	Machaeranthera linearis	Hoary aster
	Solidago sp	Goldenrod
	Viguiera multiflora	Goldeneye

Table 24. continued

Life form	Botanical name	Common name
Grass	Agropyron smithii	Western wheatgrass
	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass
	Poa pratensis	Kentucky bluegrass

Table 25. Major species present within reference area MCR2 (above King 4 and King 5 mines, Hiawatha Mines, in the Middle Fork of Miller Creek).

Life form	Botanical name	Common name
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Picea pungens	Colorado blue spruce
	Populus tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Berberis repens	Creeping barberry
	Holodiscus dumosus	Bush ocean-spray
	Juniperus communis	Common juniper
	Pachistima myrsinites	Myrtle pachistima
	Physocarpus malvoceus	Mallow ninebark
	Prunus virginiana	Common chokecherry
	Shepherdia canadensis	Russet buffaloberry
	Symphoricarpos oreophilus	Mountain snowberry
Forb	Arnica sp.	Arnica
	Astragalus sp.	Locoweed
	Lupinus sp.	Lupine
	Osmorhiza sp.	Osmorhiza
	Swertia perennis	Alpinebog swertia
	Viola sp.	Violet
Grass	Elymus salina	Salina wildrye

Table 26. Tree composition by size-class for reference area MCR2 mixed confier vegetation type (above King 4 and 5 Mines, Hiawathia Mine, in the Middle Fork of Miller Creek). (1980 field season)

	Diameter breast height (in.)					
Species	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of total
Abies concolor	45	3	1	0	1	62
Pseudotsuga menziesii	10	0	1	0	1	15
Populus tremuloides	10	1	0	0	0	14
Acer glabrum	5	1	0	0	0	8
Picea pungens	0	1	0	0	0	1
% of total	88	8	0	0	0	100

Absolute Density = 3,556 trees/acre

Table 27. Major species present within reference area SBR3 (along lower portion of proposed conveyor system from King 4 and King 5 mines, Hiawatha Mine, to the coal preparation plant in Hiawatha).

Life form	Botanical name	Common name
Tree	Juniperus osteosperma	Utah juniper
	Pinus edulis	Pinyon pine
Shrub	Artemisia nova	Black sagebrush
	A. tridentata	Big sagebrush
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Opuntia sp.	Pricklypear
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Clematis ligusticifolia	Western virginsbower
	Machaeranthera canescens	Hoary aster
	Salsola kali	Russian thistle
Grass	Oryzopsis hymenoides	Indian ricegrass

Table 28. Relative percent plant cover for sagebrush reference area SBR3.

Life form	Species	Common name	% relative cover	% relaive cover by life form
Grasses	Oryzopsis hymenoides	Indian ricegrass	8.8	9.6
	Sitanion hystrix	Squirrel-tail grass	0.8	
Forbs	Astragalus sp.	Locoweed	1.3	1.3
Shrub	Artemesia tridentata	Big sagebrush	86.2	89.1
	Ceratoides lanata	Winterfat	1.2	
	Chrysothamnus nauseosus	Rubber rabbitbrush	0.5	
Trees			0	0
	Plant		30.6	
	Litter		17.1	
	Rock		0.4	
	Bare ground		51.9	

Table 29. Average woody plant density (number of plants per 2.0 m^2) for sagebrush reference area SBR3.

Life form	Species	Common name	Density
Shrubs	Artemisia tridentata	Big sagebrush	2.22
	Ceratoides lanata	Winterfat	0.11
	Chrysothamnus nauseosus	Rubber rabbitbrush	0.04
Total			2.37
Trees			0

Table 30. Major species present within reference area PJR4 (near proposed conveyor system and coal storage and load-out area below King 6 Mine, King Mine, in the Left Fork of Miller Creek).

Life form	Botanical name	Common name
Tree	Abies concolor	White fir
	Juniperus osteosperma	Utah juniper
	Juniperus scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	C. montanus	True mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Ephedra viridis	Green ephedra
	Juniperus communis	Common juniper
	Pachistima myrsinites	Myrtle pachistima
	Symphoricarpos oreophilus	Mountain snowberry
	Tetrademia canescens	Gray horsebrush
	Yucca harrimaniae	Harriman yucca
Forb	Artemisia ludoviciana	Louisiana sagebrush
	Eriogonum corymbosum	Corymbed eriogonum
	Hymenoxys acaulis	Stemless hymenoxys
	Machaeranthera linearis	Hoary aster
	Solidago sp.	Goldenrod

Table 30. Continued

Life form	Botanical name	Common name
Grass	Agropyron smithii	Western wheatgrass
	Bouteloua gracilis	Blue grama
	Oryzopsis hymenoides	Indian ricegrass
	Stipa comata	Needle-and-thread grass

Table 31. Relative percent cover for plants, litter and rock for pinyon-juniper reference area PJR4.

Life form	Species	Common name	% relative cover	% relative cover by life form
Grasses	*Stipa comata*	Needle-and-thread grass	33.9	54.3
	Bouteloua gracilis	Blue grama	11.0	
	Oryzopsis hymenoides	Indian ricegrass	6.8	
	Bromus tectorum	Cheatgrass	1.1	
	Elymus salina	Salina wildrye	0.6	
	Agropyron smithii	Bluebunch wheatgrass	0.9	
Forbs	*Eriogonum* sp.	Eriogonum	1.5	8.6
	Cryptantha sp.	Cryptantha	1.9	
	Ipomopsis aggregata	Scarlet gilia	2.0	
	Grindelia squarrosa	Curlycup gumweed	0.8	
	Machaeranthera linearis	Hoary aster	0.6	
	Shaeralcea sp.	Globemallow	0.2	
	Artemisia ludoviciana	Louisiana sagebrush	1.6	
Shrub	*Cerococarpus montanus*	True mountain mahogany	6.8	30.7
	Xanthocephalum sarothrae	Broom snakeweed	3.9	

Table 31. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
Shrub (Continued)				
	Amelanchier alnifolia	Saskatoon serviceberry	2.1	
	Opuntia sp.	Pricklypear	0.5	
	Artemesia tridentata	Big sagebrush	9.7	
	Tetrademia canescens	Gray horsebrush	1.4	
	Symphoricarpos oreophilus	Mountain snowberry	2.7	
	Fero sp.	Fero cactus	0.9	
	Berberis repens	Creeping barberry	1.5	
	Artemisia nova	Black sagebrush	1.2	
Trees	*Pinus edulis*	Pinyon pine	5.0	6.4
	Juniperus osteosperma	Utah juniper	1.4	
	Plant		15.4	
	Litter		19.4	
	Rock		16.8	
	Bare ground		48.6	

Table 32. Average woody plant density (number of plants per 2.0 m^2) for pinyon-juniper reference area PJR4.

Life form	Species	Common name	Density
Shrubs	Cercocarpus montanus	True mountain mahogany	0.37
	Artemisia tridentata	Big sagebrush	0.28
	Berberis repens	Creeping barberry	0.19
	Amelanchier alnifolia	Saskatoon serviceberry	0.16
	Cercocarpus ledifolius	Curl-leaf mountain mahogany	0.12
	Ephedra viridus	Mormon tea	0.05
	Chrysothamnus nauseosus	Rubber rabbitbrush	0.04
	Symphoricarpos oreophilus	Mountain snowberry	0.04
	Xanthocephalum sarothrae	Broom snakeweed	0.03
	Total		1.28
Trees	Pinus edulis	Pinyon pine	0.15
	Juniperus osteosperma	Utah juniper	0.11
	Abies concolor	White fir	0.01
	Total		0.27

Table 33. Tree composition by size-class for reference area PJR4, pinyon-juniper woodland vegetation type (near proposed conveyor system and coal storage and load-out area below King 6 Mine, King Mine, in the Left Fork of Miller Creek) (1980 field season).

	Diameter breast height (in.)					
Species	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of total
Pinus edulis	25	10	5	4	11	55
Juniperus osteosperma	23	9	7	0	5	44
Pseudotsuga menziesii	1	0	0	0	0	1
% of total	49	19	12	4	16	100

Absolute Density = 185 trees/acre

Table 34. Major species present within reference area PJR 5 (near perimeter of waste disposal area near town of Hiawatha).

Life form	Botanical name	Common name
Tree	Juniperus osteosperma	Utah juniper
	Pinus edulis	Pinyon pine
	Artemisia nova	Black sagebrush
	A. tridentata	Big sagebrush
	Cercocarpus montanus	True mountain mahogany
	Opuntia sp.	Pricklypear
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Talinum parviflorum	Prairie flameflower
Grass	Agropyron smithii	Western wheatgrass
	Bouteloua gracilis	Blue grama
	Sporobolus aeroides	Alkali sacaton
	Stipa comata	Needle-and-thread grass

Table 35. Tree composition by size-class for reference area PJR5, pinyon-juniper woodland vegetation type (near perimeter of waste disposal area near town of Hiawatha) (1980 field season).

	Diameter breast height (in.)					
Species	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of total
Pinus edulis	12	1	2	3	0	32
Juniperus osteosperma	26	8	3	0	1	68
% of total	68	16	9	5	2	100

Absolute Density = 73 trees/acre

Table 36. Major species present within mixed confier reference area MCR7 (near proposed alternative seam portal sites and yard areas near old Mohrland Mine in Mohrland Canyon).

Life form	Botanical name	Common name
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Juniperus scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	Pseudotsuga menziesii	Douglas fir
Shrub	Amelanchier alnifolia	Saskatoon serviceberry
	Artemisia nova	Black sagebrush
	Berberis repens	Creeping barberry
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Chrysothamnus viscidiflorus	Low rabbitbrush
	Holdiscus dumosus	Bush ocean-spray
	Juniperus communis	Common juniper
	Pachistima myrsinites	Myrtle pachistima
	Physocarpus malvaceus	Mallow ninebark
	Prunus virginiana	Common chokecherry
	Ribes aureum	Wax currant
	Rosa woodsii	Wood's rose
	Sambucus cerulea	Blueberry elder
	Symphoricarpos oreophiuls	Mountain snowberry

Table 36. Continued

Life form	Botanical name	Common name
Forb	Aster glaucodes	Blueleaf aster
	Artemisia ludoviciana	Louisiana sagebrush
	Castelleja linariaefolia	Wyoming painted-cup
	Chenopodium fremontii	Fremont goosefoot
	Clematis ligusticifolia	Western virginsbower
	Eriogonum sp.	Eriogonum
	Machaeranthera canescens	Hoary aster
	Penstemon sp.	Penstemon
	Solidago canadensis	Canada goldenrod
Grass	Bromus ciliatus	Fringed brome
	Elymus salina	Salina wildrye
	Koeleria cristata	Prairie junegrass
	Oryzopsis hymenoides	Indian ricegrass
	Poa fendleriana	Mutton bluegrass

Table 37. Relative percent plant cover the mixed-conifer reference area MCR7 (1981 field season)

Life form	Species	Common name	% relative cover	% relative cover by life form
Grasses	Elymus salina	Salina wildrye	39.8	46.8
	Bouteloua gracilis	Blue grama	2.6	
	Poa sp.	Bluegrass	2.6	13.4
	Oryzopsis hymenoides	Indian ricegrass	1.8	
Forbs	Solidago sp.	Goldenrod	4.4	11.8
	Aster foliaceus	Leafy aster	4.1	
	Artemisia ludoviciana	Louisiana sagebrush	2.1	
	Arnica cordifolia	Heartleaf arnica	0.5	
	Machaeranthera lineris	Hoary aster	0.5	
	Castillej sp.	Indian paintbrush	0.2	
Shrubs	Symphoricarpos oreophilus	Mountain snowberry	15.7	34.8
	Physocarpus malvaceus	Mallow ninebark	6.5	
	Pachistima myrsinites	Mountain lover	3.5	
	Sambucus cerulea	Blueberry elder	3.5	
	Berberis repens	Creeping barberry	2.6	

Table 37. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
Shrubs (continued)				
	Juniperus communis	Common juniper	1.8	
	Artemesia tridentata	Big sagebrush	1.2	
Trees	Juniperus scopulorum	Rocky Mountain juniper	2.8	6.6
	Abies concolor	White fir	2.0	
	Pseudotsuga menziesii	Douglas fir	1.0	
	Pinus edulis	Pinyon pine	0.8	
	Plant		15.6	
	Litter		33.3	
	Rock		12.8	
	Bare ground		38.3	

Table 38. Average woody plant density (number of plants per 2.0 m^2) for mixed-conifer reference area MCR7. (1981 field season)

Life Form	Species	Common name	Density
Shrubs	Symphoricarpos oreophilus	Mountain snowberry	0.73
	Berberis repens	Creeping barberry	0.31
	Artemisia tridentata	Big sagebrush	0.20
	Pachistima myrsinites	Myrtle pachistima	0.20
	Physocarpus malvaceus	Mallow ninebark	0.13
	Sambucus cerulea	Blueberry elder	0.08
	Cercocarpus ledifolius	Curl-leaf mountain mahogany	0.01
Total			1.66
Trees	Abies concolor	White fir	0.15
	Pinus edulis	Pinyon pine	0.05
	Juniperus osteosperma	Utah juniper	0.05
	Pseudotsuga menziesii	Douglas fir	0.03
Total			0.28

Table 39. Tree composition by size class for reference area MCR7, mixed conifer vegetation type (near proposed alternative seam portal sites and yard areas near old Mohrland Mine in Mohrland Canyon). (1980 field season)

	Diameter breast height (in.)					
Species	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of total
Abies concolor	30	5	3	2	2	41
Pseudotsuga menziesii	9	6	2	0	7	24
Pinus edulis	3	1	3	1	11	
Juniperus scopulorum	4	0	1	0	6	
J. osteosperma	1	0	0	0	1	
% of total	48	2	3	3	28	100

Absolute Density = 380 trees/acre

Table 40. Major species present within riparian reference area RR9 (near proposed yard and transportation areas for King 7 and King 8 Mines in Mohrland Canyon) (1980 field season).

Life form	Botanical name	Common name
Tree	Abies concolor	White fir
	Acer glabrum	Rocky Mountain maple
	Betula occidentalis	River birch
	Juniperus osteosperma	Utah juniper
	J. scopulorum	Rocky Mountain juniper
	Pinus edulis	Pinyon pine
	Populus angustifolia	Narrowleaf cottonwood
	P. tremuloides	Quaking aspen
	Pseudotsuga menziesii	Douglas fir
	Salix exigua	Sandbar willow
Shrub	Artemisia tridentata	Big sagebrush
	Cercocarpus ledifolius	Curl-leaf mountain mahogany
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Rhus trilobata	Skunkbush sumac
	Ribes aureum	Wax currant
	Rosa woodsii	Wood's rose
	Symphoricarpos oreophilus	Mountain snowberry
	Xanthocephalum sarothrae	Broom snakeweed
Forb	Artemisia ludoviciana	Lousisiana sagebrush
	Aster glaucodes	Blueleaf aster
	Cirsium vulgare	Bull thistle

Table 40. Continued

Life form	Botanical name	Common name
Forb (continued)	*Clematis ligusticifolia*	Western virginsbower
	Conyza canadensis	Canadian horseweed
	Eqiusetum arvense	Field horsetail
	E. laevigatum	Smooth horsetail
	Erigeron sp.	Fleabane
	Grindelia squarrosa	Curlycup gumweed
	Impomopsis aggregata	Scarlet gilia
	Lupinus sp.	Lupine
	Melilotus alba	White sweetclover
	M. officinalis	Yellow sweetclover
	Solidago sparsiflora	Goldenrod
Grass (Grasslike)	*Agropyron albicans*	Mountain wheatgrass
	Carex sp.	Sedge
	Hordeum jubatum	Foxtail barley
	Juncus balticus	Baltic rush
	Muhlenbergia asperifolia	Alkali muhly
	Scirpus americanus	American bullrush

Table 41. Relative percent plant cover for the riparian reference area RR9. (1981 field season)

Life form	Species	Common name	% relative cover	% relative cover by life form
Grasses	*Carex* sp.	Sedge	22.6	38.7
	Poa sp.	Bluegrass	6.8	
	Panicum sp.	Switchgrass	4.1	
	Bromus tectorum	Cheatgrass	2.5	
	Agropyron smithii	Western wheatgrass	1.0	
	Oryzopsis hymenoides	Indian ricegrass	0.9	
	Scirpus americanus	American bullrush	0.6	
	Agropyron albicans	Montana wheatgrass	0.2	
Forbs	*Clematis ligusticifolia*	White clematis	11.3	25.4
	Melilotus officianales	Sweetclover	3.1	
	Melilotus alba	White sweetclover	2.2	
	Cirsium vulgare	Common thistle	1.6	
	Grindelia squarrosa	Gumweed	1.5	
	Arnica cordifolia	Heartleaf arnica	1.3	
	Equisetum laevigatum	Smooth horsetail	1.3	

Table 41. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
Forbs (Continued)				
	Aster foliaceus	Leafy aster	1.2	
	Equisetum arvense	Field horsetail	1.2	
	Verbascum thapsus	Mullein	0.4	
	Tragopogon dubious	Goatsbeard	0.3	
Shrub	Artemisia tridentata	Big sagebrush	5.6	14.3
	Shepherdia argentea	Silver buffaloberry	5.2	
	Rosa woodsii	Wild rose	1.9	
	Chrysothamnus nauseosus	Rubber rabbitbrush	1.6	
Trees	Salix exigua	Sandbar willow	20.7	21.6
	Abies concolor	White fir	0.9	
	Plant		28.8	
	Litter		25.6	
	Rock		1.7	
	Bare ground		43.9	

Table 42. Average woody plant density (number of plants per 2.0 m^2) for the riparian reference area RR9 (1981 field season).

Life form	Species	Common name	Density
Shrubs	Shepherderdia argentia	Buffaloberry	0.25
	Chrysothamnus nauseosus	Rubber rabbitbrush	0.24
	Artemisia tridentata	Big sagebrush	0.20
	Symphoricarpos oreophilus	Mountain snowberry	0.09
	Ribes aurem	Wax currant	0.05
	Chrysothamnus linifolius	Spreading rabbitbrush	0.04
Total			0.87
Trees	Salix exigua	Sandbar willow	1.20
	Populus angustifolia	Narrowleaf cottonwood	0.20
	Juniperus osteosperma	Utah juniper	0.05
	Abies concolor	White fir	0.04
	Pseudotsuga menziesii	Douglas fir	0.04
	Pinus edulis	Pinyon pine	0.02
Total			1.55

Table 43. Tree composition by size-class for reference area RR9, riparian vegetation type (near proposed yard transportation areas of King 7 and 8 Mines area in Mohrland Canyon). (1980 field season).

	Diameter breast height (in.)					
Species	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of total
Populus angustifolia	43	3	3	0	3	67
Abies concolor	4	2	2	0	0	10
Juniperus scopulorum	3	2	1	0	0	9
Betula occidentalis	4	0	0	0	0	5
Pinus edulis	3	1	0	0	0	5
Acer glabrum	2	0	0	0	0	4
% of total	74	10	9	0	7	100

Absolute Density = 204 trees/acre

Table 44. Major species present within pinyon-juniper reference area PJR11 (near proposed mine facilities, load-out, and transporation areas for King 7 and King 8 Mines in Mohrland Canyon) (1980 field season).

Life form	Botanical name	Common name
Tree	Juniperus osteosperma	Utah juniper
	Pinus edulis	Pinyon pine
Shrub	Amerlanchier alnifolia	Saskatoon serviceberry
	Artemisia tridentata	Big sagebrush
	Cercocarpus montanus	True mountain mahogany
	Ephedra viridis	Green ephedra
	Opuntia sp.	Pricklypear
	Yucca harrimaniae	Harriman yucca
Forb	Ipomopsis aggregata	Scarlet gilia
	Senecio sp.	Groundsel
Grass	Elymus salina	Salina wildrye
	Oryzopsis hymenoides	Indian ricegrass

Table 45. Relative percent cover of plants, litter and rock pinyon-juniper reference area PJR11 (1981 field season)

Life form	Species	Common name	% relative cover	% relative cover by life form
Grasses	Elymus salina	Salina wildrye	6.4	55.4
	Agropyron smithii	Bluebunch wheatgrass	8.1	
	Oryzopsis hymenoides	Indian ricegrass	18.8	
	Bouteloua gracilis	Blue grama	7.7	
	Stipa comata	Needle-and-thread grass	13.6	
	Poa pratensis	Kentucky bluegrass	0.8	
Forbs	Ipomopsis aggregata	Scarlet gilia	0.8	4.7
	Grindelia squarrosa	Curlycup gumweed	0.6	
	Eriogonum sp.	Eriogonum	0.9	
	Hymenoxys acaulis	Stemless hymenoxys	0.5	
	Cryptantha sp.	Cryptantha	1.0	
	Machaeranthera linearis	Hoary aster	0.9	
Shrub	Ephedra viridis	Green ephedra	1.9	35.1
	Xanthocephalum sarothrae	Broom snakeweed	1.5	

Table 45. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
Shrub continued				
	Chrysothamnus nauseosus	Rubber rabbitbrush	1.7	
	Cercocarpus montanus	True mountain mahogany	5.2	
Trees	Pinus edulis	Pinyon pine	5.5	10.3
	Juniperus osteosperma	Utah juniper	4.8	
	Plant		6.9	
	Litter		16.2	
	Rock		26.9	
	Bare ground		50.0	

Table 46. Average woody plant density (number of plants per 2.0 m^2) for pinyon-juniper reference area PJR11 (1981 field season).

Life form	Species	Common name	Density
Shrubs	Amelanchier alnifolia	Saskatoon serviceberry	0.34
	Symphoricarpos oreophilus	Mountain snowberry	0.21
	Ephedra viridis	Green ephedra	0.17
	Cercocarpus montanus	True mountain mahogany	0.13
	Artemisia tridentata	Big sagebrush	0.11
	Berberis repens	Creeping barberry	0.10
	Xanthocephalum sarothrae	Broom snakeweed	0.04
Total			1.10
Trees	Juniperus osteosperma	Utah juniper	0.15
	Pinus edulis	Pinyon pine	0.15
Total			0.30

Table 47. Tree composition by size-class for reference area PJR11, pinyon-juniper woodland vegetation type (near proposed mine facilities, and load-out and transportation areas of King 7 and King 8 Mines in Mohrland Canyon). (1980 field season).

	Diameter breast height (in.)					
Species	0-2.99	3.0-5.99	6.0-8.99	9.0-12.0	>12.0	% of total
Pinus edulis	39	6	10	6	1	77
Juniperus osteosperma	15	2	1	0	0	23
% of total	68	10	14	7	1	100

Absolute Density = 563 trees/acre

Table 48. Major species present within sagebrush reference area SBR12 (King 6 Mine top soil stockpile and borrow area in the Left Fork of Miller Creek) (1981 field season).

Life form	Botanical name	Common name
Trees	Juniperus scopulorum	Rocky Mountain Juniper
	Juniperus osteosperma	Utah juniper
Shrub	Artemisia nova	Black sagebrush
	Artemisia tridentata	Big sagebrush
	Chrysothamnus nauseosus	Rubber rabbitbrush
	Xanthocephalum sarothrae	Broom snakeweed
	Ceratoides lanata	Winterfat
Forb	Eriogonum sp.	Eriogonum
	Melilotus alba	White sweetclover
Grasses	Oryzopsis hymenoides	Indian ricegrass
	Stipa comata	Needle-and-thread grass
	Bouteloua gracilis	Blue grama
	Sitanion hystrix	Squirrel-tail grass

Table 49. Relative percent cover of plants, litter and rock for sagebrush reference area SBR12 (1981 field season)

Life form	Species	Common name	% relative cover	% relative cover by life form
Grasses	*Oryzopsis hymenoides*	Indian ricegrass	25.8	41.1
	Stipa comata	Needle-and-thread grass	7.2	
	Bouteloua gracilis	Blue grama	4.6	
	Sitanion hysterix	Squirrel-tail grass	3.5	
Forbs	*Eriogonum* sp.	Eriogonum	5.7	7.5
	Melilotus alba	White sweetclover	1.8	
Shrub	*Artemisia nova*	Black sagebrush	19.2	51.0
	Artemisia tridentata	Big sagebrush	17.3	
	Chrysothamnus nauseosus	Rubber rabbitbrush	6.4	
	Xanthocephalum sarathrae	Broom snakeweed	3.7	
	Ceratoides lanata	Winterfat	1.2	

Table 49. Continued

Life form	Species	Common name	% relative cover	% relative cover by life form
Trees	Juniperus scopulorum	Rocky Mountain juniper	3.0	3.6
	Juniperus osteosperma	Utah juniper	0.6	
	Plant		16.4	
	Litter		21.0	
	Rock		11.1	
	Bare ground		71.4	

Table 50. Average woody plant density (number of plants per 2.0 m^2) for sagebrush reference area SBR12.

Life form	Species	Common name	Density
Shrubs	Artemisia tridentata	Big sagebrush	0.91
	Artemisia nova	Black sagebrush	0.66
	Chrysthamnus nauseosus	Rubber rabbitbrush	0.23
	Ceratoides lanata	Winterfat	0.14
	Xanthocephalum sarothrae	Broom snakeweed	0.09
	Symphoricarpus oreophilus	Mountain snowberry	0.03
	Total		2.06
Trees	Juniperus scopulorum	Rocky Mountain juniper	0.03
	Total		0.03

Table 51. Similarities between mountain brush reference area MBR1 and disturbed areas at the King 4 and King 5 Mines and the Blackhawk Mine (1980 field season).

Item	Reference Area MBR1	King 4 and 5 mines (MBA1)	Blackhawk Mine
Species number	25	19	14
Total aerial cover (%)	76	70-80	60-70
Productivity (lbs/A[1])	1400	1400	1400
Geology	Blackhawk Formation	Blackhawk Formation	Blackhawk Formation
Soils[1]	Pachic Agriboroll	Pachic Agriboroll	Pachic Agriboroll
Slope (degrees)	32°	25-35°	20-25°
Aspect	SSE	SSE	NNE
Range Site[1]	Mountain Stony Loam	Mountain Stony Loam	Mountain Stony Loam

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conservation Service, February, 1981.

Table 52. Similarities between mixed confier reference area MCR2 and disturbed areas at the portal in the Right Fork of Miller Creek, King 4 and King 5 Mines, the King 6 Mine (King Mine), and the Blackhawk Mine (1980 field season).

Item	Reference Area MCR2	King 4 and 5 Mines	Portal Area	King 6 Mine	Blackhawk Mine
Species number	22	21	17	25	18
Total aerial cover (%)	84	75-90	75-90	75-90	70-80
Productivity (lbs/A)[1]	2000	2000	2000	2000	2000
Geology	Blackhawk Formation	Blackhawk Formation	Blackhawk Formation	Blackhawk Formation	Blackhawk Formation
Soils[1]	Mollic Cryoboralf	Mollic Cryoboralf	Mollic Cryoboralf	Mollic Cryoboralf	Mollic Cryoboralf
Slope (degrees)	31°	30-35°	20-25°	30-35°	20-25°
Aspect	NNW	NNW	NE	NNE	NNE
Range Site[1]	Woodland	Woodland	Woodland	Woodland	Woodland

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conservation Service, February, 1981.

Table 53. Similarities between sagebrush reference area SBR3 and proposed disturbance areas SBA3 and SBA10. (1981 field season).

Item	SBR3	SBA3	SBA10
Species number	6	12	2
Total cover (%)	30.6	27.12	24.5
Productivity (lbs/A)[1]	1500	1500	1500
Density (2.0 m^2)			
Shrub	2.37	2.83	2.88
Trees	0	0	0
Geology	Masuk Shale	Masuk Shale	Masuk Shale
Soils[1]	Ustic Torrifluvent	Ustic Torrifluvent	Usic Torrifluvent
Slope (degrees)	4°	5°	3°
Aspect	SSE	SSE	NE
Range Site[1]	Upland Loam	Upland Loam	Upland Loam
Jaccard's Community Coefficient	-	0.50	0.333

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area. Soil Conservation Service, February, 1981.

Table 54. Similarities between pinyon-juniper reference area PJR4 and proposed disturbance areas PJA4, PJA8, and PJA 14. (1981 field season).

Item	PJR4	PJA4	PJA8	PJA14
Species number	25	27	22	28
Total cover (%)	15.2	10.7	10.4	10.5
Productivity (lbs/A)	1200	1200	1200	1200
Density (2.0 m^2)				
Shrub	1.28	2.19	1.15	1.08
Trees	0.27	0.19	0.29	0.35
Geology	Masuk Shale	Masuk Shale	Masuk Shale	Masuk Sahle
Soils	Cumulic Haploboroll	Cumulic Haploboroll	Cumulic Haploboroll	Cumulic Haploboroll
Slope (degrees)	22°	20°	15°	23°
Aspect	SSE	SSE	SSE	SSE
Range Site	Upland Loam (P-J)	Upland Loam (P-J)	Upland Loam (P-J)	Upland Loam (P-J)
Jaccard's Community Coefficient	-	0.68	0.69	0.67

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conservation Service, February, 1981.

Table 55. Similarities between the pinyon-juniper woodland reference area PJR5 and the disturbed waste disposal area near the town of Hiawatha (PJA5). (1980 field season).

Item	PJR5	PJA5
Species number	12	12
Total aerial cover (%)	46	45-60
Productivity (lbs/A)[1]	300	300
Geology	Masuk Shale	Masuk Shale
Soils[1]	-	-
Slope (degrees)	3-4°	2-10°
Aspect	E	E
Range Site	Upland Shallow Shale	Upland Shallow Shale

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conservation Service, February 1981.

Table 56. Similarities between mixed-conifer reference area MCR7 and proposed disturbance areas MCA6 and MCA7 combined. (1981 field season).

Item	MCR7	MCA6/MCA7
Species number	21	16
Total cover (%)	15.6	13.4
Productivity (lbs/A)[1]	2000	2000
Density (2.0 m^2)		
Shrub	1.66	1.84
Trees	0.28	0.31
Geology	Blackhawk Formation	Blackhawk Formation
Soils[1]	Mollic Cryoboralf	Mollic Cryoboralf
Slope (degrees)	38°	38°
Aspect	NNE	NNE
Range Site[1]	Woodland Site	Woodland Site
Jaccard's Community Coefficient	0.682	

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conservation Services, Feb., 1981.

Table 57. Similarities between riparian reference area RR9 and proposed disturbance areas RA9 and RA13. (1981 field season)

Item	RR9	RA9	RA13
Species number	25	20	16
Total cover (%)	28.8	20.3	32.4
Productivity (lbs/A)[1]	3000	3000	3000
Density (2.0 m^2)			
Shrub	0.87	1.22	0.60
Trees	1.55	0.72	0.61
Geology	Masuk Shale	Masuk Shale	Masuk Shale
Soils[1]	Typic Ustorthent	Typic Ustorthent	Typic Ustorthent
Slope (degrees)	6-8°	6-8°	6-8°
Aspect	SW	SW	SW
Range Site[1]	Semi-wet Stream Bottom	Semi-wet Stream Bottom	Semi-wet Stream Bottom
Jaccard's Community Coefficient	-	0.364	0.414

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conservation Service, February 1981.

Table 58. Similarities between pinyon-juniper reference area PJR11 and proposed disturbance area PJA11 (1981 field season).

Item	PJR11	PJA11
Species number	16	18
Total cover (%)	6.9	7.4
Productivity (lbs/A)[1]	400	400
Density (2.0 m^2)		
Shrub	1.1	1.1
Trees	0.3	0.4
Geology	Masuk Shale	Masuk Shale
Soils[1]	Ustollic Calciorthid	Ustollic Calciorthid
Slope (degrees)	9°	7°
Aspect	NE	NE
Range Site[1]	Upland Stony Loam (P-J)	Upland Stony Loam (P-J)
Jaccard's Community Coefficient	0.888	

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conservation Service, February 1981.

Table 59. Similarities between sagebrush reference area SBR12 and proposed disturbance area SBA12 (1981 field season).

Item	SBR12	SBA12
Species number	13	15
Total cover (%)	16.4	24.0
Productivity (lbs/A)[1]	2000	2000
Density (2.0 m^2)		
Shrub	2.06	2.16
Trees	0.03	0.11
Geology	-	-
Soils	Cumulic Haploboroll	Cumulic Haploboroll
Slope (degrees)	6-8°	6-8°
Aspect	SW	SW
Range Site	Mountain loam	Mountain loam
Jaccard's Community Coefficient	0.56	

[1]Source: Vegetation Survey, Soil Survey and Interpretation for U.S. Fuel Co. Mine Area, Soil Conversation Service, February, 1981.

Table 60. t-test comparing plant cover for reference and proposed disturbance areas (1981 field season).

Areas		t-value	
Proposed Disturbance	Reference	Critical	Observed
SBA3	SBR3	1.28	3.98
PJA4	PJR4	1.28	3.20
MCA6/MCA7	MCR7	1.28	5.14
PJA8	PJR4	1.29	8.21
RA9	RR9	1.29	17.14
SBA10	SBR3	1.29	8.24
PJA11	PJR11	1.28	3.63
SBA12	SBR12	1.30	8.65
RA13	RR9	1.29	3.74
PJA14	PJR4	1.29	14.83

Table 61. t-test comparing woody plant density for reference and proposed disturbance areas (1981 field season).

Areas		t-value	
Proposed Disturbance	Reference	Critical	Observed
SBA3	SBR3	1.29	6.91
PJA4	PJR4	1.25	4.16
MCA6/MCA7	MCR7	1.28	4.37
PJA8	PJR4	1.29	2.19
RA9	RR9	1.28	10.84
SBA10	SBR3	1.29	7.30
PJA11	PJR11	1.29	1.74
SBA12	SBR12	1.29	3.02
RA13	RR9	1.28	12.60
PJA14	PJR4	1.29	2.11

Appendix A

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS, AND MINING
1588 West North Temple
Salt Lake City, Utah 84116
(801) 533-5771

August 4, 1981

Mr. Christapher A. Call
Reclamation Specialist
Bid/West Inc.
P.O. Box 3226
Logan, Utah 84321

RE: Baseline Vegetation Data
U.S. Fuel Company
King Mines Complex
ACT/007/011
Carbon County, Utah

Dear Mr. Call:

In response to your telephone call to James Ratzloff of Office of Surface Mining on July 6, 1981, below is a delineation of the baseline vegetation data requirements for the King Mines Complex. The data requirements are summarized from the Technical Environmental Assessment for the proposed conveyor belt in the left fork of Miller Creek and the Apparent Completeness Review for the entire King Mines Complex.

The following is needed for the affected vegetation communities and the corresponding reference areas:

-cover, by species and total aerial cover below the tree canopy (not to exceed 100%)

-woody plant density (both trees and shrubs)

-production, according to SCS Range Site Description

-a comparison of similiarity between affected area communities and reference areas, according to cover, shrub density, (by a t-test), slope, aspect, soils and species composition (by a similarity index)

Sampling adequacy should be met for woody plant cover and density at 80% confidence and 10% precision (d = .1) using a two tailed t value. The sampling plots should be layed-out at random in the affected area communities so that all vegetation has an equal chance of being sampled.

Cover should be sampled using the ocular estimation method or another approved method. Shrub density should be sampled using the point-centered quarter method or a quadrant method.

The reference areas chosen must be in fair or better range condition. Site specific production and species diversity data are not required until the bond-release period. A general indication of production for the affected communities and reference areas according to a Science Conservation Service range site description is necessary, however, range site data does not need to be statistically adequate.

If you have any questions, call me.

Sincerely,

LYNN M. KUNZLER
RECLAMATION BIOLOGIST

LMK/te

cc: James Ratzloff, OSM

Appendix B

Table 1B. Sample adequacy for plant cover (1981 field season).

Area	$\bar{x}$[a]	s^2[b]	Minimum Sample Size	Observed Sample Size
Proposed Disturbance				
SBA3	27.1	108.07	26	50
PJA4	10.7	53.08	74	75
MCA6/MCA7	13.4	34.30	33	30
PJA8	10.4	45.43	69	70
RA9	20.3	71.60	32	35
SBA10	24.5	88.67	25	35
PJA11	7.4	21.94	67	75
SBA12	24.0	35.31	11	20
RA13	32.4	121.33	21	25
PJA14	10.5	33.58	51	55
Reference				
SBR3	30.6	118.96	22	40
PJR4	15.2	63.58	48	50
MCR7	15.6	46.36	33	35
RR9	28.8	98.25	21	32
PJR11	6.9	17.98	62	70
SBR12	16.4	32.48	19	20

[a]Mean percent plant cover
[b]Sample variance

Table 2B. Sample adequacy for woody plant density (1981 field season).

Area	$\bar{x}$[a]	s^2[b]	Minimum Sample Size	Observed Sample Size
Proposed Disturbance				
SBA3	3.06	1.70	31	35
PJA4	2.38	1.94	89	90
MCA6/MCA7	2.15	1.24	44	60
PJA8	1.44	1.06	79	90
RA9	1.94	1.06	47	50
SBA10	2.88	1.00	21	40
PJA11	1.50	0.84	62	65
SBA12	2.27	1.42	43	45
RA13	1.21	0.86	83	85
PJA14	1.14	0.65	55	60
Reference				
SBR3	2.37	1.51	45	45
PJR4	1.55	1.22	75	75
MCR7	1.94	1.74	70	70
RR9	2.42	2.06	54	55
PJR11	1.46	0.66	51	70
SBR12	2.09	0.81	32	35

[a]Mean woody plant density
[b]Sample variance

Table 3B. Sample adequacy for tree density data (1980 field season).

Area	$\bar{x}$[a]	s^2[b]	Minimum Sample Size	Observed Sample Size
Proposed Disturbance				
PJA4	14.79	34.6	28	20
PJA8	12.00	18.4	22	20
RA9	8.48	9.48	29	20
Reference				
PJR4	15.60	18.8	13	20
PJR8	11.06	16.4	23	20
PR9	14.60	105.1	86	20

[a]Mean plant density
[b]Sample variance


PROPOSED CONVEYOR SYSTEM
PROPOSED CONVEYOR SYSTEM and LOADING AREA
PROPOSED KING 7 and 8 MINE FACILITIES
MC
MC-A
MB
PJ
SH
A
B
G
R
SB
UNITED STATES FUEL COMPANY
HIAWATHA, UTAH
U.S. FUEL CO. BOUNDARY
DISTURBED AREA
AREA OF PROPOSED DISTURBANCE
■ - Reference Area
● - Sampling Site in Area of Proposed Disturbance
VEGETATION TYPES
A - Aspen
B - Barren Land
G - Grassland
MC - Mixed Conifer
MC-A - Mixed Conifer-Aspen
MB - Mountain Brush
PJ - Pinyon-Juniper Woodland
R - Riparian
SB - Sagebrush
SH - High Elevation Sagebrush -Grass
SCALE 1:24 000
CONTOUR INTERVAL 80 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
HIAWATHA, UTAH
1978

Figure 1.

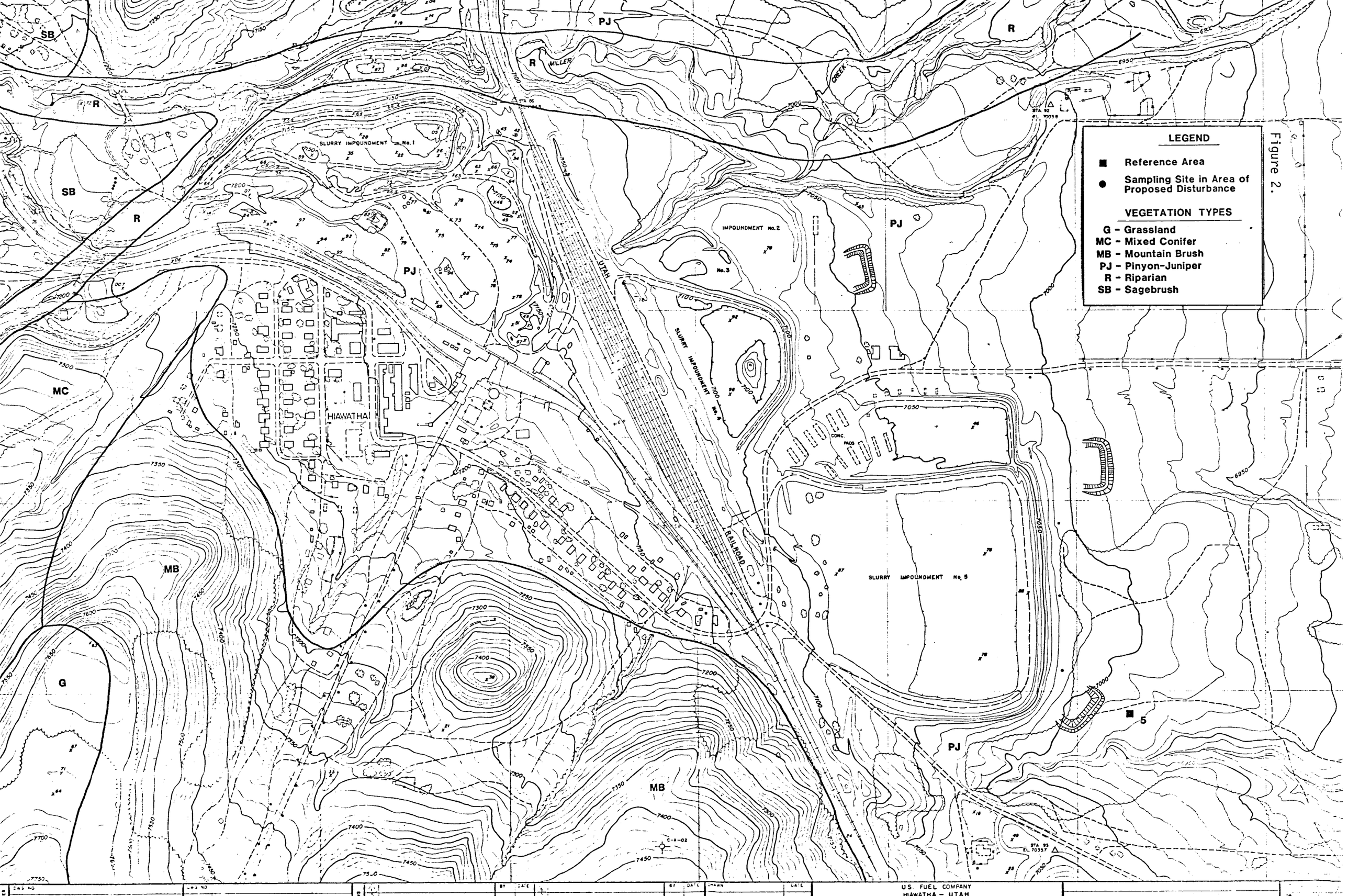

LEGEND
Reference Area
Sampling Site in Area of Proposed Disturbance
VEGETATION TYPES
G - Grassland
MC - Mixed Conifer
MB - Mountain Brush
PJ - Pinyon-Juniper
R - Riparian
SB - Sagebrush
SLURRY IMPOUNDMENT No. 1
IMPOUNDMENT No. 2
No. 3
SLURRY IMPOUNDMENT No. 4
SLURRY IMPOUNDMENT No. 5
HIAWATHA
UTAH
RAILROAD
MILLER
CREEK
CONC. PADS
STA 92 EL 7003.8
STA 93 EL 7033.7
C-A-02
5
U.S. FUEL COMPANY
HIAWATHA - UTAH

Figure 2.

LEGEND

- ■ Reference Area
- ● Sampling Site in Area of Proposed Disturbance

VEGETATION TYPES

- G - Grassland
- MC - Mixed Conifer
- MB - Mountain Brush
- PJ - Pinyon-Juniper
- R - Riparian
- SB - Sagebrush

FIGURE 3

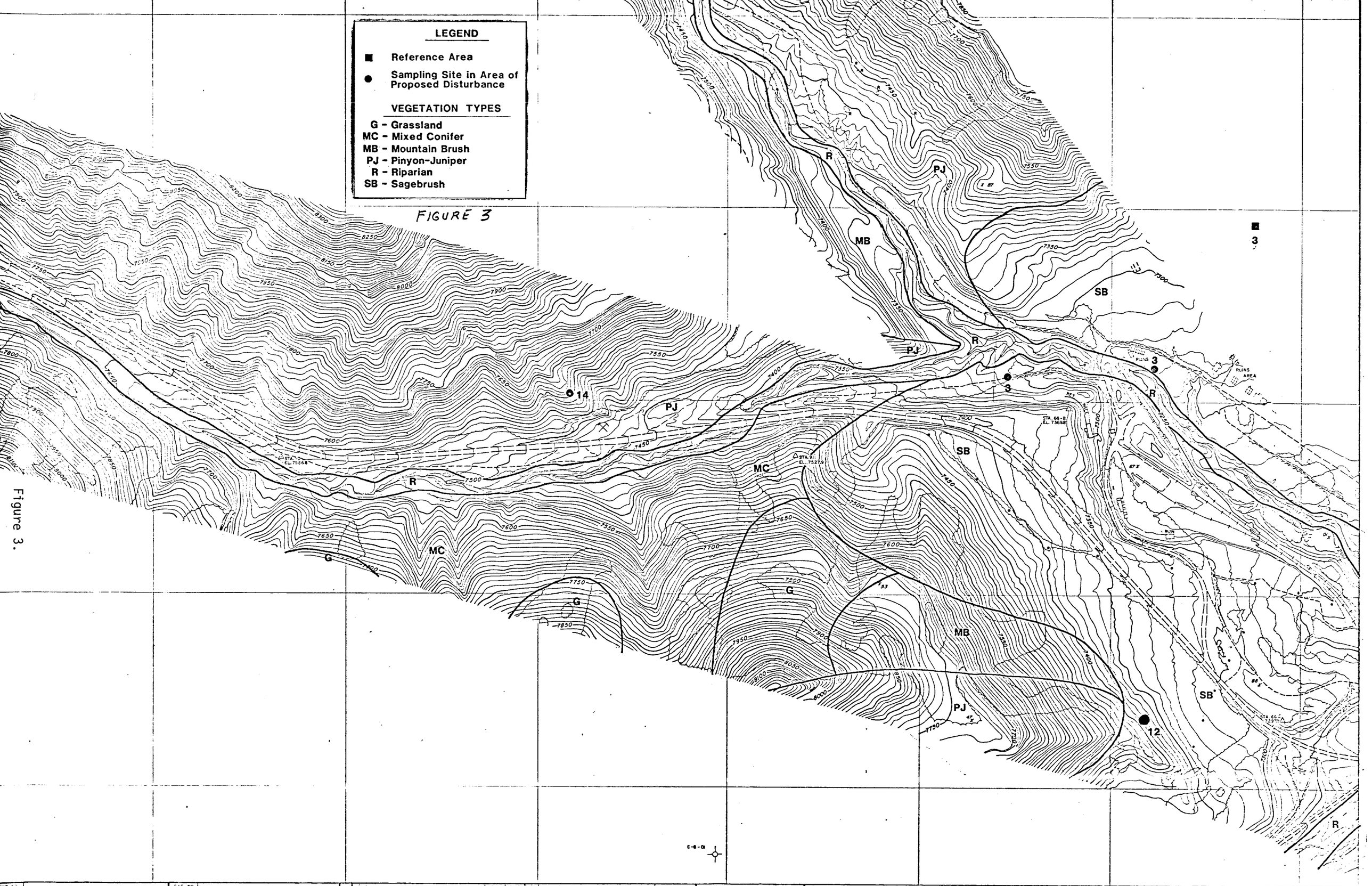


Figure 3.

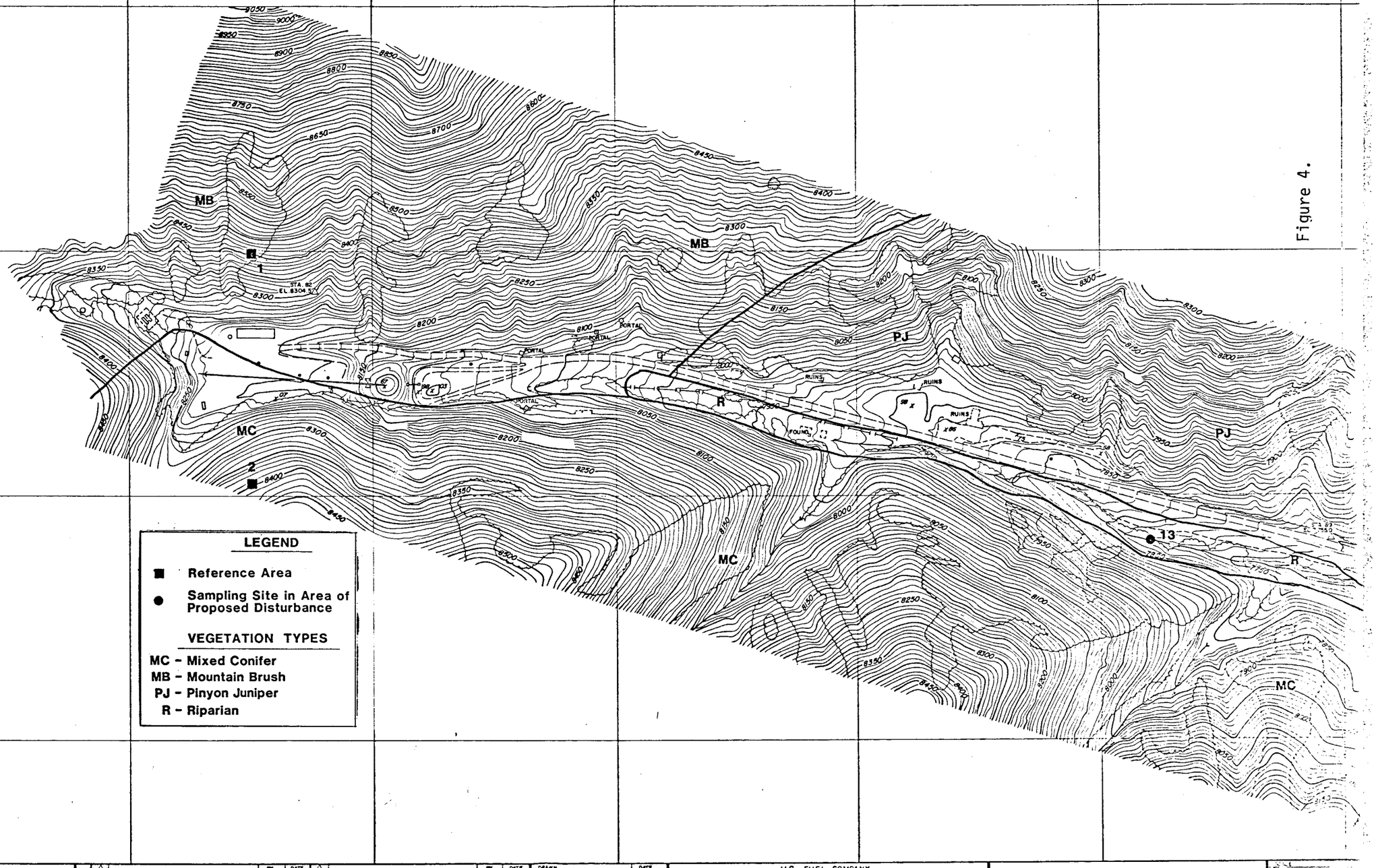


Figure 4.

U.S. FUEL COMPANY
MIAWATHA - UTAH
SCALE 1" = 200'
CONTOUR INTERVAL 50' PHOTOGRAPHY DATE AUG 20, 1975

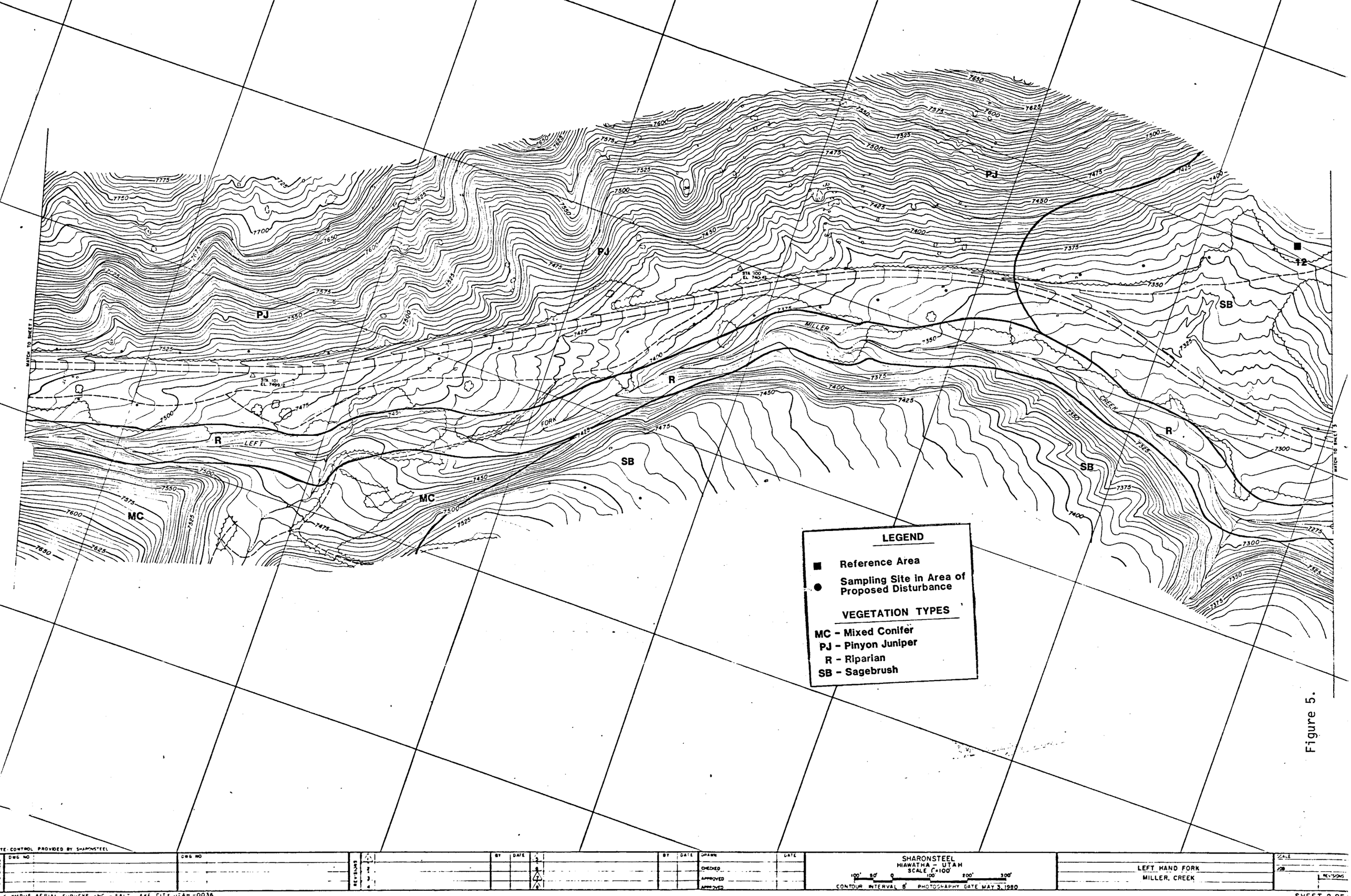

LEGEND
Reference Area
Sampling Site in Area of Proposed Disturbance
VEGETATION TYPES
MC - Mixed Conifer
PJ - Pinyon Juniper
R - Riparian
SB - Sagebrush
MILLER FORK
LEFT FORK
MILLER CREEK
STA 100 EL 7403.42
STA 101 EL 7499.12
MATCH TO SHEET 1
MATCH TO SHEET 3
SHARONSTEEL
HIAWATHA - UTAH
SCALE 1"=100'
CONTOUR INTERVAL 5' PHOTOGRAPHY DATE MAY 3, 1980
LEFT HAND FORK
MILLER, CREEK
OLYMPUS AERIAL SURVEYS, INC - SALT LAKE CITY, UTAH - 0036

Figure 5.

Figure 6.

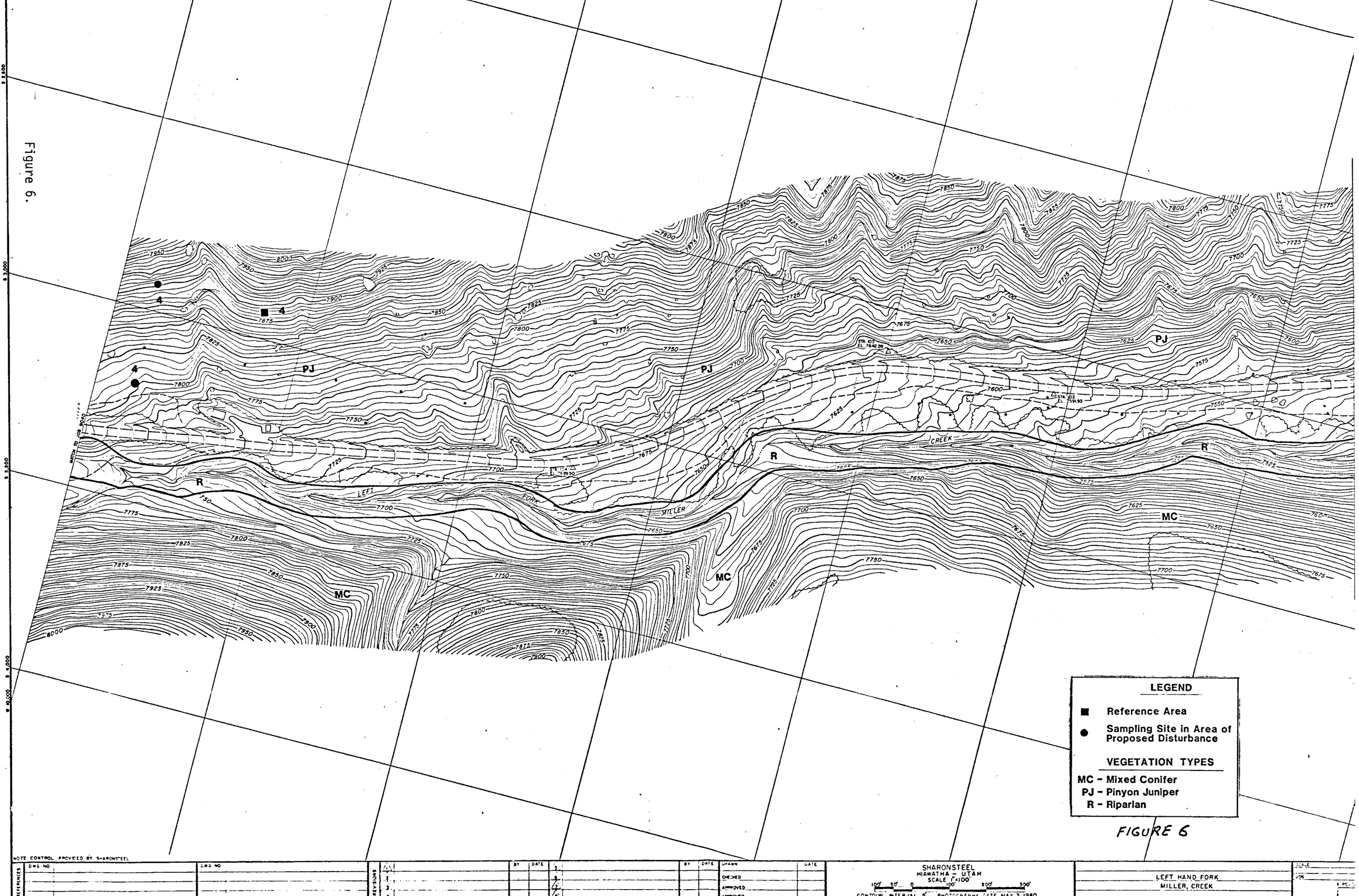


FIGURE 6

NOTE CONTROL PROVIDED BY SHARONSTEEL

REFERENCES DWG NO | DWG NO

REVISIONS | BY | DATE

DRAWN | CHECKED | APPROVED | APPROVED | DATE

SHARONSTEEL
HIAWATHA - UTAH
SCALE 1"=100'
CONTOUR INTERVAL 5' PHOTOGRAPHY DATE MAY 3, 1980

LEFT HAND FORK
MILLER CREEK

SCALE | JOB

LEGEND

■ Reference Area

● Sampling Site in Area of Proposed Disturbance

VEGETATION TYPES

MC - Mixed Conifer
MB - Mountain Brush
PJ - Pinyon Juniper
R - Riparian

FIGURE 7

Figure 4

LEFT FORK

TANK

WALL

62-A EL 8056.22

62-B EL 8016.32

62-C EL 8023.91

PJ

MC

MB

R

4

U.S. FUEL COMPANY
LEFT FORK AREA
SCALE 1"=100'
CONTOUR INTERVAL 10' PHOTOGRAPHY DATE APRIL 30,1979

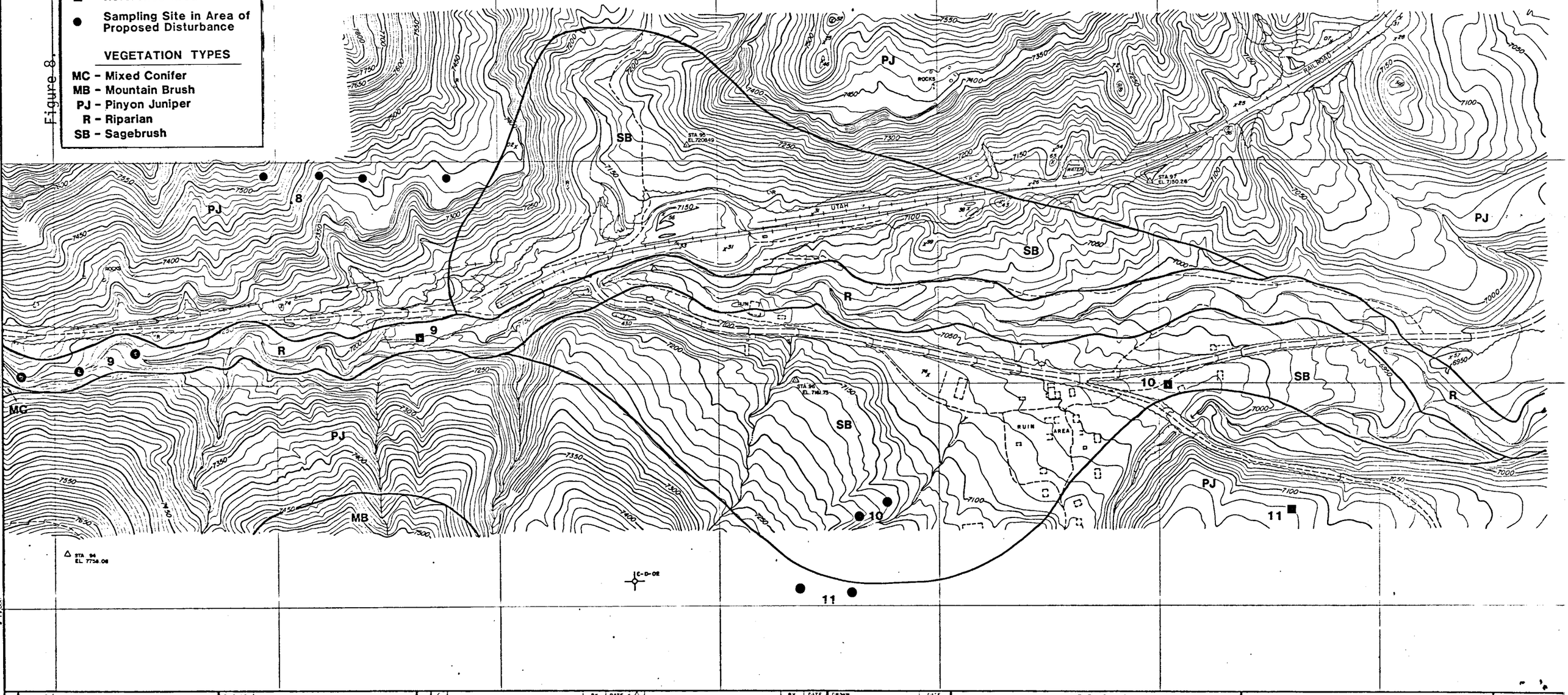
Figure 8.

LEGEND

- ■ Reference Area
- ● Sampling Site in Area of Proposed Disturbance

VEGETATION TYPES

- MC - Mixed Conifer
- MB - Mountain Brush
- PJ - Pinyon Juniper
- R - Riparian
- SB - Sagebrush



DWG. NO.	DWG NO	REVISIONS	BY	DATE	BY	DATE	DRAWN	DATE
							CHECKED	
							APPROVED	
							ADDROVED	

U.S. FUEL COMPANY
MOHRLAND MINE
SCALE 1" = 200'
200' 0 200' 400' 600'
CONTOUR INTERVAL 10' PHOTOGRAPHY FLOWN JULY 30, 1976

SCALE
JOB
REV

OLYMPUS AERIAL SURVEYS, INC. - SALT LAKE CITY, UTAH - 6069

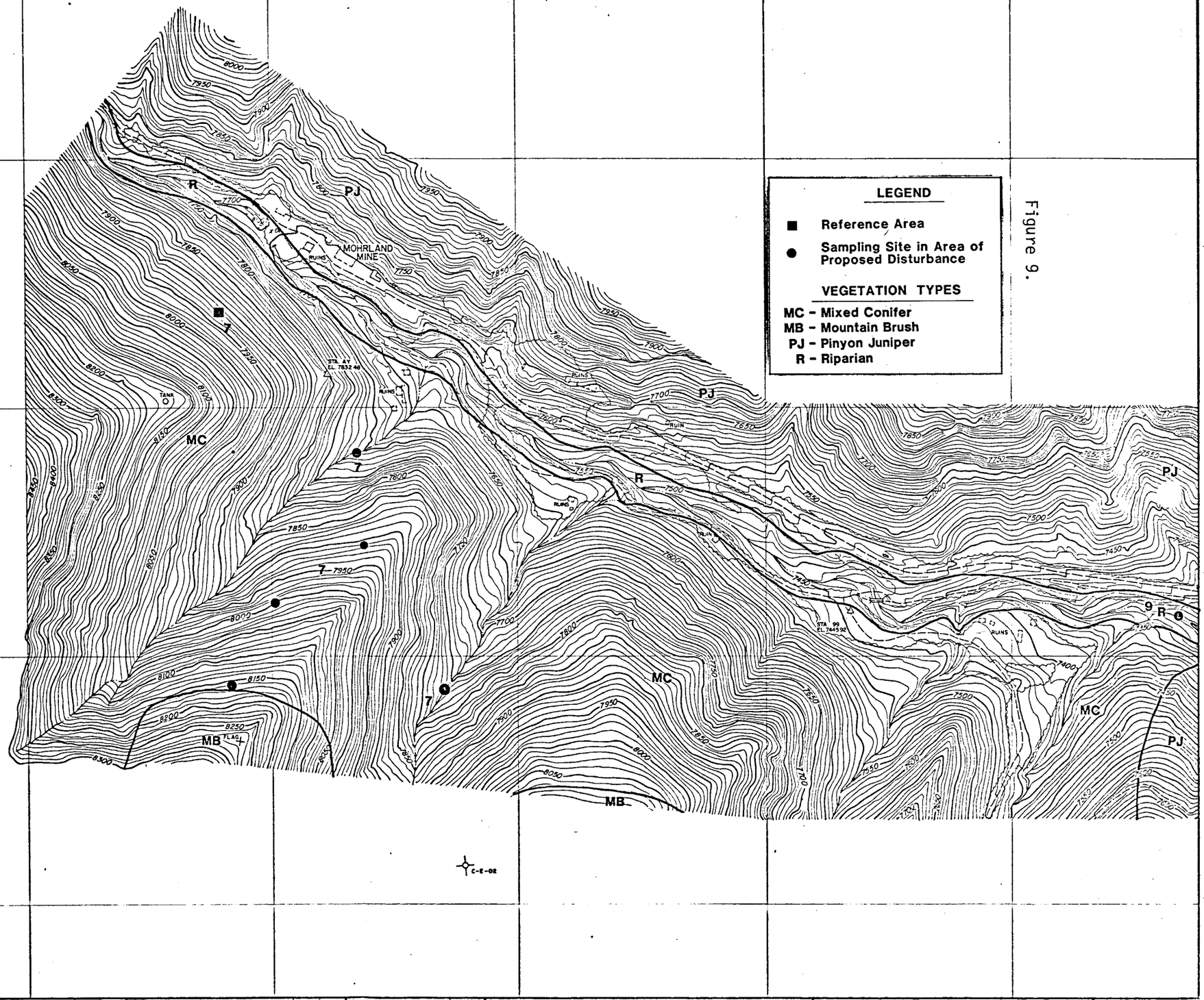


Figure 9.

W.O. NO.		DWG NO.		REVISIONS	BY	DATE		BY	DATE	DRAWN	DATE
				1			5			CHECKED	
				2			6			APPROVED	
				3			7			APPROVED	
				4			8				

U.S. FUEL COMPANY
MOHRLAND MINE
SCALE 1" = 200'
200' 0 200' 400' 600'
CONTOUR INTERVAL 5' PHOTOGRAPHY DATE AUG. 29, 1976

SCALE
VSB

US AERIAL SURVEYS, INC - SALT LAKE CITY, UTAH - 6069

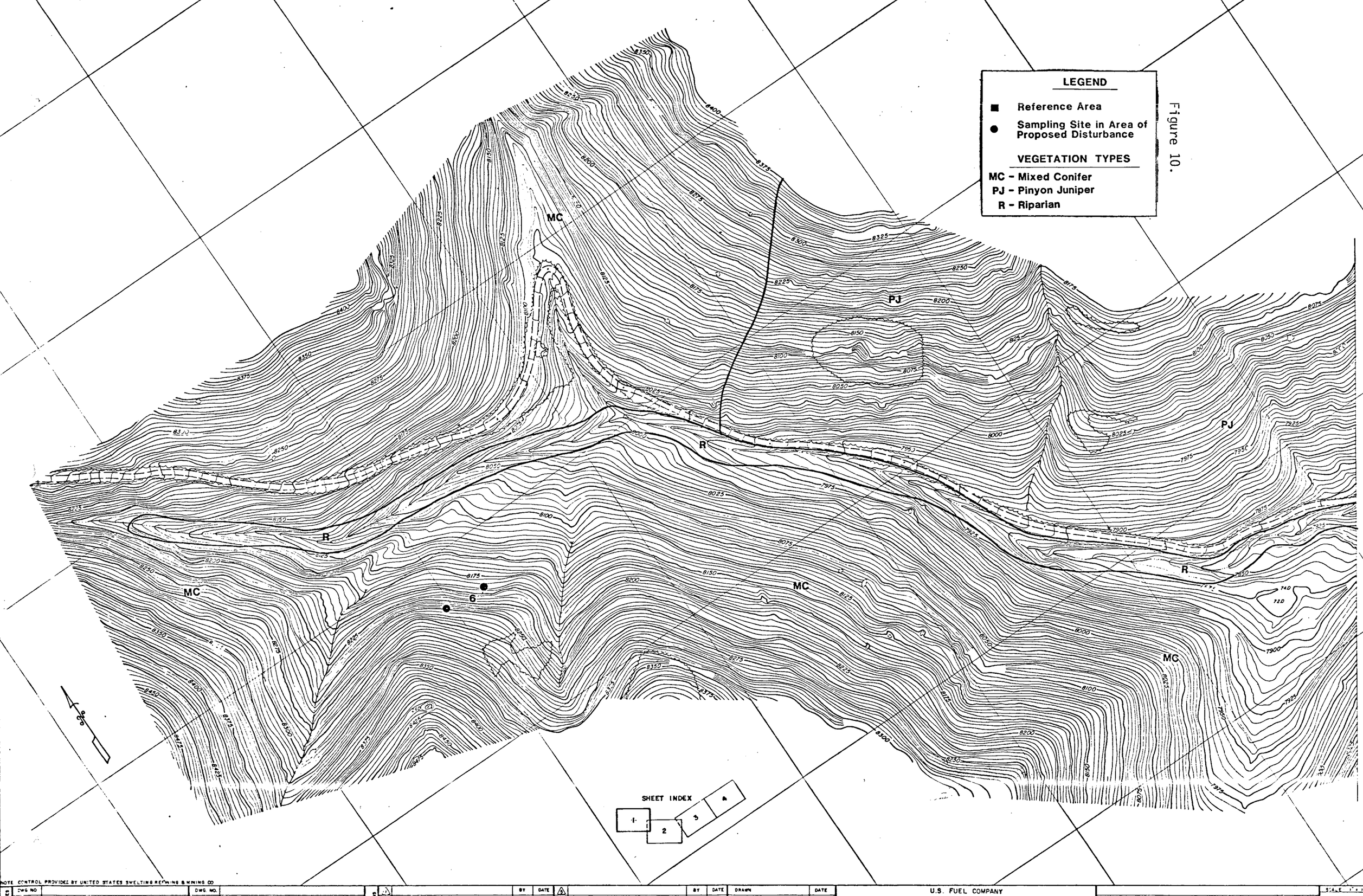


Figure 10.

NOTE CONTROL PROVIDED BY UNITED STATES SMELTING REFINING & MINING CO

REFERENCES

DWG NO		DWG NO.	

REVISIONS

		BY	DATE			BY	DATE
1				3			
2				4			

DRAWN	DATE
CHECKED	
APPROVED	
APPROVED	

U.S. FUEL COMPANY
MOHRLAND VICINITY
SCALE 1" = 100'
CONTOUR INTERVAL 5' PHOTOGRAPHY DATE AUG 20, 1976

SCALE 1" = 100'
JOB

MEMPHIS AERIAL SURVEYS INC - SALT LAKE CITY UTAH - 8221