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ENVIRONMENTAL ASSESSMENT AND MONITORING FOR THE SOUTHERN UTAH FUEL COMPANY MINE NEAR SALINA UTAH
-1978-

FOR:

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ENVIRONMENTAL ASSESSMENT AND MONITORING FOR THE SOUTHERN UTAH FUEL COMPANY MINE NEAR SALINA, UTAH -1978-

I. INTRODUCTION

As requested by Mr. Loren Williams of Coastal States Energy Company of Houston, Texas an environmental assessment and monitoring was completed on an underground coal mine operated by the Southern Utah Fuel Company near Salina, Utah. Hydrology, vegetation and wildlife were examined to further evaluate baseline conditions and to assess impacts of underground coal mining. A previous technical report (Botz, 1977) described the Southern Utah Fuel Company operation and described the environment, including hydrology, vegetation and wildlife. This report and accompanying maps provided a background for a continuing assessment and monitoring program in the area.

In 1978 detailed hydrological studies were conducted on the site and additional wildlife and vegetation assessments were made. This report describes the results of these 1978 environmental investigations and is a supplement to the 1977 baseline report.

II. SUMMARY AND CONCLUSIONS

The following summary and conclusions are based on the 1978 work at the Southern Utah Fuel Company Mine area near Salina, Utah. Monitoring and continued environmental assessments were made on hydrology, wildlife and vegetation in June to November, 1978. These investigations and data collection efforts are a supplement to the original baseline environmental survey of 1977. These efforts are designed to determine impacts of the SUFCo underground mine on the area's environmental resources.

1. Precipitation was slightly above normal in the mine permit area in 1978 and streamflow was higher than in 1977. Flows were measured at 8 stream sites and 4 springs. Springs flows were realtively constant from June to September, 1978 and in comparison with 1977 flows.

2. A Parshall flume was installed on the N. Fork Quitchupah Creek near its mouth and weirs were installed on the South Fork and upper end of the N. Fork of Quitchupah Creek. These measuring intallations will be used for flow measurements beginning in the summer of 1979.

3. A total of sixteen sites were sampled in June 1978 and nine in September 1978 to determine water quality in streams and springs. Eleven of the June samples and nine of the September samples were submitted for complete laboratory analysis.

4. Water quality in the area is generally fair to good and is a calcium-magnesium-bicarbonate type with low concentrations of metal and nutrients. Three samples had iron, 4 had manganese and 4 had total dissolved solids which somewhat exceeded recommended standards for drinking water. All other parameters and samples met all mandatory and recommended drinking water standards.

5. Water from springs had a relatively constant water quality and exhibited little seasonal fluctuations. Most streams had poorer quality water in the fall than in the spring.

6. There are several ephemeral streams, one perennial stream (N.Fk. Quitchupah Creek) and a few springs in the mining permit area. No subsidence impacts were observed on any springs or streams either in or peripheral to the mining permit area.

7. Examination was made for plant mortality, invasion of grasses and forbs and damage from rock falls in the subsidence area. Subsidence areas observed in 1977 were invensively covered in 1978 and known subsidence cracks revisited. Most subsidence cracks observed in 1977 were almost impossible to relocate in 1978 due to filling of the cracks. To date there are virtually no impacts of subsidence on vegetation.

8. The U.S. Forest Service has established several vegetation transects in and adjacent to the mining permit area.

9. No subsidence impacts on wildlife were observed in 1978. Big game use probably is more directly related to cover and browse than to water availability. Since subsidence impacts to hydrology and vegetation were minimal or absent there have been no impacts to wildlife.

III. HYDROLOGY

Hydrological investigations during 1978 included evaluation of groundwater, surface water and water quality, and examination of the subsidence area. Precipitation during the 1977-78 winter was slightly above average and was greater than the 1976-77 season. On June 3, 1978 approximately 30 percent of the mountainous area was covered by snow. Leaves were just beginning to appear on aspen trees along canyon rims but trees were still barren at higher elevations. Specific hydrological tasks completed during 1978 were:

1. Examination of the area from June 3-5, 1978 to determine hydrological conditions during spring runoff. Flows at all springs and streams examined in 1977 were measured in 1978. Sixteen sites were sampled and tested for water quality in the field and eleven were submitted for complete analysis. Examination of the subsidence area also conducted to assess hydrological impacts.

2. Examination of hydrological conditions during late summer/early fall low flow season (Sept. 26-27, 1978) to measure flows and obtain water samples. Nine sites were sampled and tested and nine were submitted for complete chemical analyses. Meet with U.S. Forest Service to coordinate location and installation of flume and weirs. Develop specifications and fabricate flume, weirs and crest gages.

3. Installation of one Parshall flume, two weirs and five crest gages in early November 1978.

Results of these activities are described in this annual monitoring and environmental assessment report.

A. Surface Water

Flows were measured at 8 stream sites, 4 springs and at the SUFCo mine in 1978 (Table 1). Flows generally were higher in all streams in 1978 than in 1977 probably reflecting the greater overall precipitation in 1978. Springs showed little change in flow probably reflecting the large storage in the groundwater system. All streams were accurately measured using either a small portable Parshall flume, a pigmy flow meter or stopwatch and a container of known volume. In the North Fork of Quitchupah Creek there was evidence of water flows slightly to moderately higher than measured in June 1978. The measured June flows were considered normal spring runoff. The channel shows geomorphic evidence of occasional very high flows which is typical of this part of the southern Wasatch Mountains.

The following sites were dry in September 1977, June and September 1978.

Site	Description
032	Mud Spring Hollow 2 mi. above mouth
-	Mud Spring Hollow at SUFCo Mine
-	East Spring Canyon at SUFCo Mine
-	Jolly Mud Hollow
-	Broad Hollow
-	Duncan Draw at Road (T22S,R45E,Sec.36CA)*
-	Mud Spring Hollow at Road (T22S,R4E,Sec.35CD)

Flow measuring sites are shown on Figure 1.

*See Appendix B

Table 1. Summary of Flows from Streams and Springs in the Vicinity of the SUFCo No. 1 Mine near Salina Utah.

Site No.	Site Description*	Date Sampled	Flow	Method Measured	Sept. 1977 Flow**
001	Spring in Duncan Draw	6-04-78	2 gpm	TIME/VOLUME	
001	Spring in Duncan Draw	9-26-78	2.2 gpm	TIME/VOLUME	1.7 gpm
005	Seep in tributary of E. Spring Canyon	6-04-78	1 gpm	Estimate	1 gpm (Est.)
006	S. Fork Quitchupah Cr.	6-04-78	.887 cfs	Flow Meter	
006	S. Fork Quitchupah Cr.	9-26-78	2 gpm	TIME/VOLUME	34.3 gpm
007	N. Fork Quitchupah Cr. above canyon	6-04-78	6.53 cfs	Flow Meter	
007	N. Fork Quitchupah Cr. above canyon	9-26-78	100 gpm	Flume	22.3 gpm
007B	Tributary to N. Fork Quitchupah above canyon	6-04-78	.179 cfs	Flume	Not Meas.
009	Tributary to N. Fork Quitchupah Cr. approx. 6 miles above mouth	6-04-78	11.8 gpm	TIME/VOLUME	16.5 gpm
013	N. Fork Quitchupah Cr. 5½ miles above mouth	6-04-78	-	Not Meas.	<1 gpm
017	N. Fork Quitchupah Cr. 3½ miles above mouth	6-04-78	-	Not Meas.	54.9 gpm
019	N. Fork Quitchupah approx. 2 miles above mouth	6-04-78	-	Not Meas.	32.6 gpm

* Locations shown on map

** See previous report by Botz (1977) for detailed 1977 data

Table 1
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Site No.	Site Description*	Sampled	1978 Flow	1978 Method Measured	Sept. 1977 Flow**
021	SUFCo No. 1 mine effluent	6-05-78	280± gpm	VOLUME/TIME	Not Meas.
021	SUFCo No. 1 mine effluent	9-26-78	315± gpm	VOLUME/TIME	Not Meas.
033	Seep in tributary of E. Spring Canyon	6-04-78	.8± gpm	Estimate	Dry
041	Quitchupah Cr. above N. Fork	6-05-78	292 gpm	Flow Meter	
041	Quitchupah Cr. above N. Fork	9-25-78	525 gpm	Flow Meter	245 gpm
042	N. Fork Quitchupah Cr. near mouth	6-05-78	6.7 cfs	Flow Meter	
042	N. Fk. Quitchupah Cr. near mouth	9-25-78	88 gpm	VOLUME/TIME	2.5 gpm
045A	Quitchupah Cr. downstream from drainfield	6-03-78	-	Not Meas.	Not Meas.
046	Convulsion Canyon (above pumphouse)	9-26-78	8.4 gpm	VOLUME/TIME	3.8 gpm
047	Pump House Effluent	6-03-78	60 gpm	VOLUME/TIME	
047	Pump House Effluent	9-26-78	49.4 gpm	VOLUME/TIME	52.2 gpm
047A	E. Spring Canyon above Convulsion Canyon	6-05-78	-	Not Meas.	
047A	E. Spring Canyon above Convulsion Canyon	9-26-78	358 gpm	Flow Meter	Not Meas.

* Locations shown on map

** See previous report by Botz (1977) for detailed 1977 data

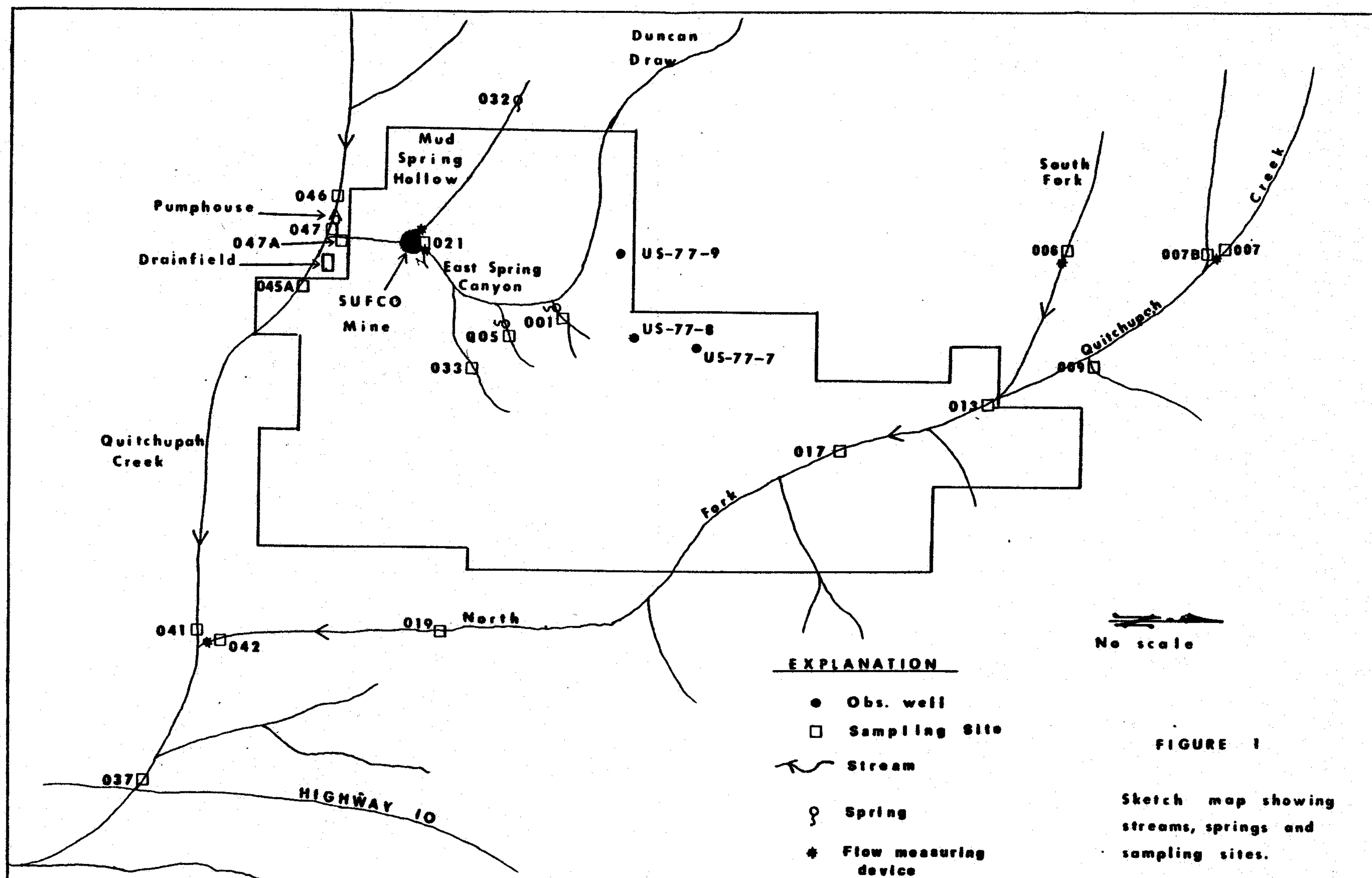

FIGURE 1

Sketch map showing streams, springs and sampling sites.

Flow Measurement Devices

In coordination with the U.S. Forest Service, Fishlake National Forest, two weirs and one Parshall flume were installed to provide a continuous flow record for the 1979 low flow period (July to Nov.). Installation sites are as follows:

1. Site 042, Parshall Flume. Located on the North Fork of Quitchupah Creek near the mouth.
2. Site 006. Weir located on South Fork Quitchupah Creek upstream from deep canyon.
3. Site 007. Weir located on North Fork of Quitchupah Creek upstream from deep canyon.

Installation sites are shown on Figure 1. At all three sites a crest gage was installed to measure stream flows that exceed the flume or weir capacity.

Streamflow measurement presented an unusual and difficult problem of accurate measurement of low flows and also accurate measurement of medium to high flows. Installation also should be cost effective. Flows in these drainages occasionally are very high and virtually any flow measuring device would be washed out. It was decided to use normal flow measuring devices with broad overflow areas adjacent to the devices. Such installations may wash out during extreme runoff events but could be replaced without undue cost. Large concrete flow measuring structures would last longer but would be much more expensive to install and probably would eventually fail during high flow events.

Measuring devices were sized and designed to handle expected normal flow ranges yet still accurately measure low flows.

Parshall Flume (Site 042)

A prefabricated Parshall flume was installed in North Fork of Quitchupah Creek approximately 300 feet upstream from its confluence with Quitchupah Creek. The flume is about 30 feet above the jeep trail crossing the stream (Site 042,T22S,R5E,Sec. 16DDA). The flume was installed using a backhoe to dig a diversion ditch in the terrace on the west bank and damming the stream to divert the flow. The flume was then installed with the bottom approximately level with the existing stream bed at the upstream end. Excavation in the terrace for installation revealed about 4 to 6 inches of silt overlying a coarse gravel. The backfill was hand tamped around the flume to provide a sound bed. The east upstream wing of the flume was anchored into the bank which rises very sharply to over 10 feet above the stream bed. The west wing is anchored into the stream bank with the top of the wing approximately 6 inches above the terrace elevation leaving a 10' wide overflow path. This allows flows in excess of the flume capacity without washing out the flume. The ends and wings were rip-rapped to prevent erosion. A crest gage was attached to a post set in the west bank of the stream approximately 20 feet upstream from the flume.

The flume has a 24 inch throat, is two feet in depth and has a maximum design capacity of about 25 cfs. Minimum flow that can be measured by this flume is about 0.1 cfs. Installation details are shown in Appendix A.

V-Notch Weir (Site 006)

A 90° V-notch weir was installed on the South Fork Quitchupah Creek about 100 feet upstream from the road and sampling Site 006 (T21S,R4E,Sec.24CAB). Metal weir plates were bolted to a piece of 3/4 inch plywood which had been waterproofed with water seal and epoxy resin. The plywood was reinforced with 2 x 4's to achieve necessary rididity. The north end is anchored into a nearly vertical bank 8 feet high. The south end is anchored into the bank but was installed such that the top of the structure is about 6 inches above the terrace level on this side. Very little water was flowing so a temporary dam was installed above the site and the water held back during construction. The backfill was hand tamped and local rock was used to riprap the stream bank downstream from the weir. A 15-inch by 5 foot long section of aluminum culvert was set vertically in the south bank and connected to the stream by 2 pieces of 2 inch PVC pipe. One pipe is installed level with the stream bottom and the other is 6 inches higher. The culvert was capped with a metal plate. This culvert will be a stilling well for measurement of head on the weir. This weir has a depth of 1 foot, a width of 2 feet and maximumdesign capacity of 2.5 cfs and a minimum flow .004 cfs can be measured. Installation details are shown in Appendix A.

A crest gage was attached to a post set in the bank of the stream about 20 feet upstream from the weir.

Combination V-notch and Cippoletti Weir (Site 007)

A combination V-notch and Cippoletti weir was installed in the North Fork Quitchupah Creek about 250 feet downstream from the road crossing (Site 007, T21S,R4E,13ADC). Weir construction was similar to the first weir. The south end was anchored into a nearly vertical bank about 10 feet high. The north end was anchored into the bank of the stream with the top of the weir maintained about 6 inches above the adjacent terrace level. Local rock was used to riprap the bank on the north side. A 15-inch diameter by 5 ft. long section of aluminum culvert was used to construct a stilling well. This culvert was set vertically into the bank on the south side of the stream. Two pieces of 2-inch PVC pipe were extended into the stream to transmit the water level in the pool to the stilling well. One piece of pipe was placed level with the stream bottom, and the other about 6 inches high. A metal cap was placed over the culvert top. A crest gage was installed about 20 feet upstream from the weir.

The Cippoletti weir has a 3.0 foot width, a depth of 1.0 feet and a maximum design capacity of about 11 cfs. The 6-inch deep by one foot wide 90^{0} V-notch will accurately measure a minimum low of about .004 cfs. Installation details are shown in Appendix A. The 90^{0} V-notch weirs have a standard calibration curve as does the Parshall flume. A 3-foot Cippoletti weir also has a standard calibration curve. The compound weir as installed, however will need calibration in the transition zone between the V-notch and shallow flows in the Cippoletti portion. At higher heads a good estimate of flow through the Cippoletti weir can be obtained from standard tables. This unusual installation will, after calibration, provide accurate measurements of both high and low flows.

Crest gages were installed upstream from the two weirs and the flume and also were installed in East Spring Canyon and Mud Spring Hollow where these streams enter metal culverts to be conveyed under the work area in front of the mine entrance (T22S,R4E,12BD). The crest gages at the metal culverts are attached to the metal debris catchers at the culvert inlets. Water from the mine is pumped into the East Spring Canyon therefore the gage was set so this water would not be measured.

Crest gages provide a measurement of stage and flow can be calculated by use of indirect techniques.

B. Groundwater

Springs and seeps are areas of groundwater discharge. There are few springs in the area and flow from these springs is small. The hydrogeological system apparently consists of very low to low permeability sandstone units containing substantial water storage but having small groundwater flows. Flow from springs (Table 1) in the mining permit area is small but tends to be steady and does not reflect short-term variations in precipitation. This suggests a large aquifer system with a small but consistent groundwater flow due to long-term recharge. There is little if any groundwater baseflow in streams in the mining permit area. Small seeps and springs generally are dry a short distance downstream from their appearance.

The infiltration system in Convulsion Canyon that supplies water to the SUFCo pumphouse is intercepting groundwater in Convulsion Canyon alluvium, however, the warm temperature of this water (24^{o}C) suggests its origin is probably from a deep aquifer. Flow to the pumphouse is relatively steady (Table 1).

Three groundwater observation wells constructed by Coastal States Energy Company in late 1977 and static water levels were measured in June, 1978 and are shown in Table 2.

Water is discharged from the SUFCo mine workings at about 250 to 325 gpm. This flow is intermittent due to pump cycling but the total volume pumped has been relatively constant for the past year.

Table 2. Groundwater Observation Well Data

STATION	PARAMETER	MONITORING DATES
		6-3-78
Drill hole US-77-7	Elevation of drill hole	8555 (From Map)
	Depth to water table	261 ft.
	Height of well casing	~1.5 ft.
	Elevation of water table	
	Method of measurement	M-Scope
Drill hole US-77-8	Elevation of drill hole	8540 (From Map)
	Depth to water table	145.6 ft.
	Height of well casing	2.5 ft.
	Elevation of water table	
	Method of measurement	M-Scope
Drill hole US-77-9	Elevation of drill hole	8395 (From Map)
	Depth to water table	>300 ft.
	Height of well casing	
	Elevation of water table	
	Method of measurement	M-Scope

C. Water Quality

A total of sixteen sites were sampled in the field in June, 1978 including measurement of flow, pH, specific electrical conductivity and temperature. Results are shown in Table 3. At eleven of the sites, samples were collected for complete laboratory analysis (Table 4). In September, 1978 nine sites were sampled in the field (Table 3) and 9 samples were submitted for complete laboratory analysis (Table 4).

Water in the area generally is of fair to good quality and is an alkaline, calcium-magnesium-bicarbonate type with low concentrations of nutrients and metals. A total of 4 samples exceed recommended US Public Health Service Drinking Water Standards for total dissolved solids; three samples exceed the recommended iron standard and 4 exceed the recommended manganese standard. All other parameters meet mandatory and recommended drinking water standards.

Water quality had little seasonal fluctuation in springs and effluent from the SUFCo mine, but was poorer in the fall in streams except Quitchupah Creek above the North Fork. This stream, for reasons unknown, had poorer quality in the spring than in the fall. Water quality declined slightly downstream in the North Fork of Quitchupah Creek in June, 1978. No data were available for downstream quality trends in other streams.

Table 3. Results of field measurements of water quality from waters in the vicinity of the SUFCO No. 1 mine near Salina, Utah.

Site No.	Site Description*	Date Sampled	Flow	Spec. Cond. (umhos/cm)	pH	Temp. °C
001	Spring in Duncan Draw	6-04-78	2 gpm	-	-	7.5
001	Spring in Duncan Draw	9-26-78	2.2 gpm	456	7.3	12.8
005	Seep in tributary of E. Spring Canyon	6-04-78	1 gpm	-	7.3	9.0
006	S. Fork Quitchupah Cr.	6-04-78	.887 cfs	564	8.4	15
006	S. Fork Quitchupah Cr.	9-26-78	2 gpm	939	8.3	15
007	N. Fork Quitchupah Cr. above canyon	6-04-78	6.53 cfs	353	8.3	6.5
007	N. Fork Quitchupah Cr. above canyon	9-26-78	100 gpm	540	8.2	18
007B	Tributary to N. Fork Quitchupah above canyon	6-04-78	.179 cfs	506	8.6	12
009	Tributary to N. Fork Quitchupah Cr. approx. 6 miles above mouth	6-04-78	11.8 gpm	509	8.3	8
013	N. Fork Quitchupah Cr. 5½ miles above mouth	6-04-78	-	407	8.5	8
017	N. Fork Quitchupah Cr. 3½ miles above mouth	6-04-78	-	463	8.6	-
019	N. Fork Quitchupah approx. 2 miles above mouth	6-04-78	-	466	8.6	11

Site No.	Site Description*	Date Sampled	Flow	Spec. Cond. (umhos/cm)	pH	Temp. °C
021	SUFCO No. 1 mine effluent	6-05-78	280 ± gpm	615	8.1	13.5
021	SUFCO No. 1 mine effluent	9-26-78	315 gpm	568	7.8	16.8
033	Seep in tributary of E. Spring Canyon	6-04-78	.8 ± gpm	-	6.2	-
041	Quitchupah Cr. above N. Fork	6-05-78	0.65 cfs	1086	8.7	17
041	Quitchupah Cr. above N. Fork	9-25-78	525 gpm	811	8.5	17.5
042	N. Fork Quitchupah Cr. near mouth	6-05-78	6.7 cfs	498	8.6	14
042	N. Fk. Quitchupah Cr. near mouth	9-25-78	88 gpm	642	8.6	17.5
045A	Quitchupah Cr. downstream from drainfield	6-03-78	-	896	8.2	15
046	Convulsion Canyon (above pumphouse)	9-26-78	8.4 gpm	945	8.2	8.5
047	Pump House Effluent	6-03-78	60 gpm	811	6.9	24
047	Pump House Effluent	9-26-78	49.4 gpm	830	7.0	24
047A	E. Spring Canyon above Convulsion Canyon	6-05-78	-	759	7.7	15
047A	E. Spring Canyon above Convulsion Canyon	9-26-78	.885 gpm	664	7.8	10.5

* Locations shown on map

Table 4. Results of Laboratory Determinations of Water Quality from Waters in the Vicinity of the SUFCo No. 1 Mine near Salina, Utah

Note: All Quantities in mg/l unless otherwise noted

* location shown on map

Site No.	Site Description*	Date Sampled	Flow	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Total Dissolved Solids (meas.)	Conductivity (μmhos/cm) at 25°C	Total Suspended Solids	pH (Lab)	Temp. °C
001	Spring in Duncan Draw	6/04/78	2 gpm	60.0	19.2	16.7	1.40	<0.01	244	20	30	263	410	<1		7.5
001	" " "	9/26/78	2.2 gpm	56.8	21.6	16.1	1.42	<0.01	244	36	20	278	420		7.93	7.5
005	Seep in Trib. of E. Spring Can.	6/04/78	1 gpm	76.0	43.2	22.5	1.60	<0.01	410	42	30	406	620	5		9.0
006	S. Fk. Quitchupah	6/04/78	0.887cfs	56.0	24.5	38.6	1.86	<0.01	290	68	18	353	540	162		15
006	" "	9/26/78	2.0 gpm	68.0	38.9	73.4	2.72	<0.01	402	120	26	525	810		7.59	15
007	Quitchupah Ck.	6/04/78	6.5 cfs	56.0	19.7	15.7	1.01	<0.01	253	22	12	256	390	86		6.5
007	" "	9/26/78	100 gpm	55.2	19.2	30.3	1.36	<0.01	288	17	19	284	435		7.88	18
009	Trib. to N. Fk. Quitchupah	6/04/78	11.8 gpm	51.0	21.1	20.2	2.02	<0.01	188	62	26	274	410	5		8.0
021	Mine Effluent	6/05/78	280± gpm	56.8	35.5	16.7	2.00	<0.01	278	80	16	339	510	14		14.5
021	" "	9/26/78	315 gpm	55.2	38.9	21.6	2.08	<0.01	259	110	12	368	560		7.92	16.8
033	Seep in Trib. of E. Spring Can.	6/04/78	1.8± gpm	15.2	0.48	7.0	0.48	<0.01	41	8	12	60	100	<1		-
041	Quitchupah Ck. Above N. Fk.	6/05/78	.65 cfs	36.0	38.9	189.3	3.32	<0.01	329	238	42	712	1090	47		17
041	" " "	9/25/78	525 gpm	28.0	35.5	91.1	2.78	<0.01	271	150	28	470	770		7.57	17.5
042	N. Fork Quitchupah	6/05/78	6.7 cfs	52.0	21.6	23.6	1.37	<0.01	254	44	12	280	420	143		14
042	" "	9/25/78	88 gpm	48.8	34.5	42.0	2.05	<0.01	232	119	34	398	610			17.5
045A	Quitchupah ds from drain field	6/03/78	-	76.8	60.9	47.0	3.34	<0.01	376	172	40	580	900	5		8.0
046	Convulsion Can. above Pumphouse	9/26/78	8.4 gpm	75.2	60.5	40.0	5.03	<0.01	456	110	26	549	845			8.5
047	Pumphouse Effluent	6/03/78	60 gpm	88.0	42.7	37.6	3.45	<0.01	432	82	22	493	760	1		24
047	" "	9/26/78	49.4 gpm	85.6	90.7	25.1	3.14	<0.01	422	70	14	440	670			24.2
047A	E. Spring Can. above Convulsion Can.	9/26/78	385 gpm	72.8	31.2	18.7	2.31	<0.01	290	90	12	370	568			10.5

Table 4
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Note: All quantities in mg/l unless otherwise noted.

* Location shown on map

Site No.	Site Description*	Date Sampled	Fluoride (F)	Nitrate Plus Nitrate as (NO_3-N)	Total Kjeldahl Nitrogen	Total Phosphate (PO_4-P)	Silica (SiO_2)	Total Iron (Fe)	Total Manganese (Mn)	Total Zinc (Zn)	Total Arsenic (As)	Total Cadmium (Cd)	Total Selenium (Se)
001	Spring in Duncan Draw	6/04/78	0.20	0.27	0.10	0.025	10.5	0.006	<0.001		<0.001	<0.001	<0.001
001	" " "	9/26/78	0.19	0.30	<0.10	0.024		0.683	0.004	0.019	<0.001	<0.001	<0.001
005	Seep in Trib. of E. Spring Can.	6/04/78	0.26	0.02	0.12	0.022	9.4	0.011	0.015		<0.001	<0.001	<0.001
006	S. Fork Quitchupah	6/06/78	0.45	0.02	0.40	0.024	5.9	0.393	0.074		<0.001	<0.001	<0.001
006	" "	9/26/78	0.30	0.07	0.20	0.026		0.206	0.043	0.009	<0.001	<0.001	<0.001
007	Quitchupah Ck.	6/04/78	0.26	0.05	0.20	0.035	5.4	0.168	0.036		<0.001	<0.001	<0.001
007	" "	9/26/78	0.25	0.02	<0.10	0.022		<0.001	0.015	0.012	<0.001	<0.001	<0.001
009	Trib. to N. Fk. Quitchupah	6/04/78	0.17	0.02	0.10	0.020	10.0	0.012	0.002		<0.001	<0.001	<0.001
021	Mine Effluent	6/05/78	0.20	0.02	0.13	0.022	9.3	0.008	0.005		<0.001	<0.001	<0.001
021	" "	9/26/78	0.25	0.06	<0.10	0.023		0.141	0.008	0.010	<0.001	<0.001	<0.001
033	Seep in Trib. of E. Spring Can.	6/04/78	0.04	0.02	0.10	0.020	7.0	0.068	0.009		<0.001	<0.001	<0.001
041	Quitchupah Ck. Above N. Fk.	6/05/78	0.32	0.03	0.14	0.035	9.9	0.121	0.010		<0.001	<0.001	<0.001
041	" " "	9/25/78	0.30	0.03	<0.10	0.020		0.035	0.011	0.004	<0.001	<0.001	<0.001
042	N. Fork Quitchupah	6/05/78	0.26	0.02	0.18	0.038	5.2	0.326	0.061		<0.001	<0.001	<0.001
042	" "	9/25/78	0.36	0.02	<0.10	0.023		<0.001	0.006	0.004	<0.001	<0.001	<0.001
045A	Quitchupah ds from drain field	6/3/78	0.19	0.03	0.14	0.026	10.5	0.121	0.033		<0.001	<0.001	<0.001
046	Convulsion Can above Pumphouse	9/26/78	0.23	0.03	<0.10	0.024		0.111	0.101	0.017	<0.001	<0.001	<0.001
047	Pumphouse Effluent	6/03/78	0.20	0.04	0.15	0.020	13.5	0.045	0.105		<0.001	<0.001	<0.001
047	" "	9/26/78	0.24	0.02	<0.10	0.020		0.201	0.069	0.007	<0.001	<0.001	<0.001
047A	E. Spring Can. Above Convulsion Can.	9/26/78	0.25	0.02	<0.10	0.045		0.234	0.027	0.014	<0.001	<0.001	<0.001

D. Subsidence Impacts

There is one ephemeral stream (E. Spring Canyon) but no known springs in or adjacent to present subsidence areas. Detailed on-the-ground examination of subsidence panels showed few if any additional rock fractures in sandstone outcrops. Open cracks at the ground surface in 1977 were difficult or impossible to find in 1978. Precipitation, micro-erosion and sedimentation processes had effectively filled the cracks. No hydrological impacts of any type were observed in the subsidence area.

IV. VEGETATION

A. Introduction

A vegetation reconnaissance of the SUFCO lease area was conducted during September, 1977 and major vegetation communities in the area were described (Botz, 1977). Communities identified in the area were:

Pinyon/juniper woodland	Mountain shrub
Sagebrush/grassland	Mixed conifer
Ponderosa pine	Aspen

Potential impacts of subsidence on vegetation were also discussed. These included:

1) Plant mortality along subsidence crevices
2) Invasion of annual grasses and forbs
3) Damage resulting from displacement of rocks along canyon walls and rims
4) Changes related to topographic modifications, especially depressions
5) Changes in vegetation related to alterations of the hydrologic system, i.e. springs and seeps and resulting changes in grazing pressure

B. Methods

The SUFCO lease area was revisited August 29-31, 1978. The purpose of this visit was to qualitatively evaluate impacts of subsidence on vegetation. Subsidence panels dropped in 1977 were intensively covered to ascertain whether impacts were evident. Areas walked in 1977 were also walked in 1978 with known subsidence crevices revisited. An effort was made to determine whether potential impacts listed above were occurring.

Additional baseline data on the vegetative resources of the area was obtained from the U.S. Forest Service in Richfield, Utah.

C. Results

Most subsidence cracks from 1977 were almost impossible to relocate during 1978. The sandy nature of the soils in the area of the first subsidence panel together with winter and spring precipitation events effectively filled in cracks created in 1977. There was no apparent mortality of plants along the cracks and no significant increase in annual grasses and forbs.

The rim of East Spring Canyon was inspected to determine extent of rock displacement and vegetation damage due to rocks rolling down the canyon wall. Damage was minimal although a small number of rocks had recently been dislodged resulting in trunk scars to trees. It was not possible to distinguish between natural displacement and displacement caused by subsidence.

There were no apparent changes related to topographic modifications (depressions). Dunrud (1976) in his study of subsidence at the Geneva mine in east-central Utah found that surface topography takes about three years to reach a final profile. Changes in vegetation related to topographic modification may occur after surface conditions had stabilized.

There were no changes in water sources that would affect livestock or wildlife distribution patterns. Inspection of vegetation at the spring in East Fork Canyon showed showed substantial livestock use.

The Fishlake National Forest has mapped range condition and suitability for most of the lease area. Range condition varies from 97% of climax on non-suitable, non-used grassland to 39% on suitable sagebrush areas. The majority of the area was rated in good range condition (50-75% of climax). Flatter sagebrush and grassland areas generally rated lower than tall shrub and tree dominated areas which occurred on steeper slopes. The area around the East Fork Spring Creek water development was rated at 61% of climax with no apparent trend (stable). The range condition and suitability map was prepared in October, 1971 and changes have probably occurred since then.

The Forest Service has established several vegetation transects both within and adjacent to the lease area. These transect locations are shown on Figure 2. Transects 1, 2 and 3 are part of the grazing impact analysis. Dominant grasses on the transects were Letterman's needlegrass (Stipa lettermanii), western wheatgrass (Agropyron smithii), and mutton grass (Poa fendleriana). Green rabbitbrush (Chrysothamnus viscidiflorus) and bitterbrush (Purshia tridentata) were common shrubs. Other species listed for the transects were blue grama (Bouteloua gracilis), sedge (Carex spp.), needle-and-thread (Stipa comata), squirreltail (Sitanion hystrix), big sagebrush (Artemisia tridentata), and several forbs. Vegetation and litter coverage was 82% with 18% bare ground. Average utilization of grasses was 70%. Total average production for the three transects was 1099 lbs/acre of which 937 lbs/acre was grasses, 120 lbs/acre shrubs and 42 lbs/acre forbs.

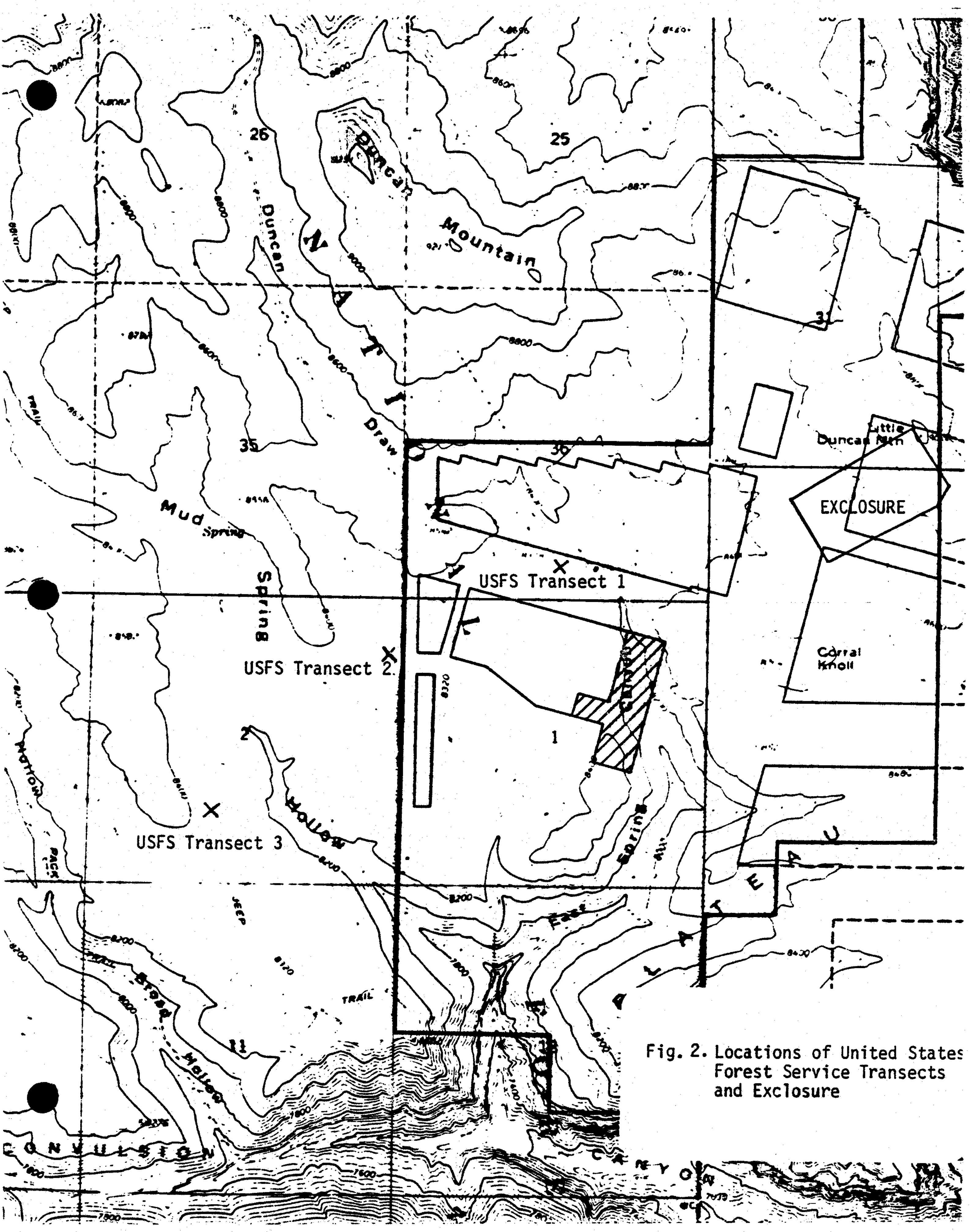


Fig. 2. Locations of United States Forest Service Transects and Exclosure

Table 5 lists the results for transects F 433 and F434 (Little Duncan). This area was dominated by shrubs, mainly big sagebrush, black sagebrush, and green rabbitbrush. Dominant grasses were western wheatgrass, desert needlegrass, and mutton grass. Common forbs were pussytoes, aster, Indian paintbrush, and Eriogonum. Plant cover and litter accounted for 79% while bareground and erosion pavement was 21%.

Table 5. Percent Composition of Vegetation, Little Duncan Transects

Species	Percent Composition
Grasses	
Agropyron smithii	8
Poa fendleriana	7
Stipa speciosa	8
	23
Shrubs	
Artemisia nora	17
Artemisia tridentata	24
Chrysothamnus viscidiflorus	27
Symphoricarpos spp.	1
	69
Forbs	
Antennaria spp.	3
Aster spp.	1
Castilleja spp.	2
Eriogonum spp.	2
	8
TOTAL	100%

Source: U.S. Forest Service, Fishlake National Forest unpublished data

Table 6 lists percent composition of species inside and outside of the Duncan Mountain exclosure. This exclosure was built in 1962 to examine the effects of trenching, pitting, sagebrush eradication and seeding of crested wheatgrass on the range (Laycock, 1969). Dominant shrubs in this area are big sagebrush and bitterbrush. Dominant grasses include mutton grass and Letterman's needlegrass.

Table 6. Percent Composition of Species, Duncan Mountain Exclosure (Transects F 409, F 410), 1978

Species	Outside (F 409)	Inside (F410)	Average (Weighted)
		Percent Composition	
Grasses			
Agropyron cristatum	-	3.8	2.4
Agropyron smithii	3.2	-	1.2
Poa fendleriana	22.5	22.6	23.2
Sifanion hystrix	6.5	5.7	6.0
Stipa lettermanii	29.0	2.8	12.5
	61.2	35.9	45.3
Shrubs			
Artemisia tridentata	6.5	28.3	20.2
Chrysothamnus viscidiflorus	6.5	5.7	5.9
Purshia tridentata	19.4	11.3	14.3
	32.4	45.3	40.4
Forbs			
Aster spp.	3.2	-	1.2
Astragalus spp.	-	3.8	2.4
Eriogonum spp.	-	15.0	9.5
Taraxacum officinale	3.2	-	1.2
	6.4	18.8	14.3
TOTAL	100.0	100.0	100.0

Source: U.S. Forest Service, Fishlake National Forest, unpublished data.

V. WILDLIFE

A. Introduction

Impacts of subsidence to wildlife in the SUFCo mine area were first investigated on September 13-14, 1977 and reported to the Coastal States Energy Company in a report by WESTECH in late 1977. The mine area was visited again on August 29-30, 1978 and impressions on wildlife use and impacts to wildlife from subsidence were updated.

B. Methods

Methods were identical to those used in 1977 (WESTECH, 1977). The assessment area was first examined by vehicle along access roads. The area was then divided into thirds and examined on foot. Weather conditions (temperature, wind speed and direction, cloud cover) were recorded approximately hourly during pedestrian surveys. Wildlife species actually observed or recorded by evidence were listed. Sightings of big-game species were mapped on U.S. Geological Survey 7½-minute topographic sheets. Sightings were recorded by species, time of day, vegetation type, number, sex, age and activity, when applicable.

General impressions of season and degree of habitat use by big game species also were recorded. To quantify these impressions somewhat, pellet group counts were run at three locations (Figure 3) using a method adopted from Lonner (1975). The observer followed a general route, counting numbers of paces walked and pellet groups within three feet of his route. Pellet groups of three species (elk, mule deer, cattle) were counted; when elk and deer pellet groups could not be differentiated, they were lumped as ungulate pellets. Pellet groups were subjectively separated into three age classes:

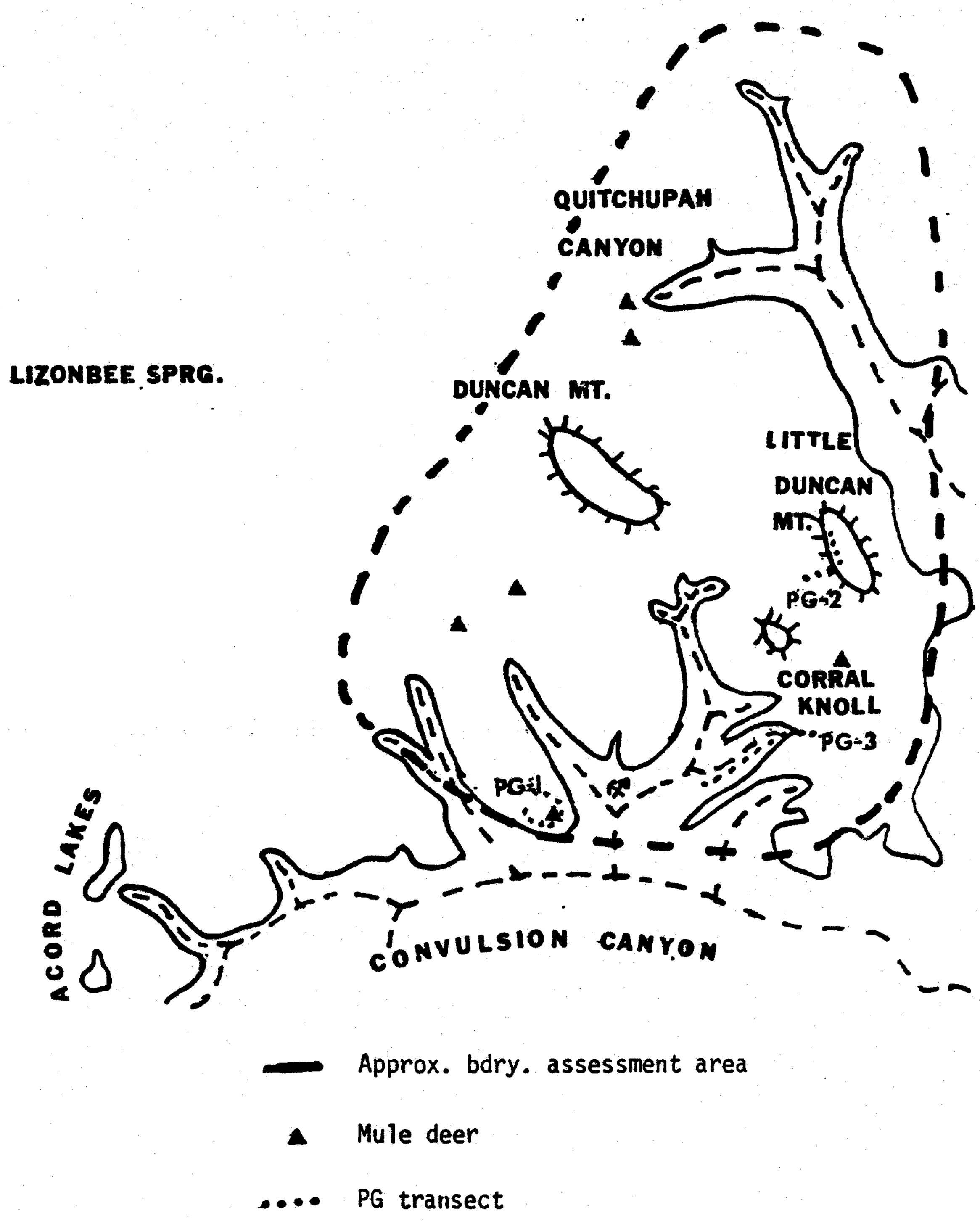


Fig. 3. SUFCo mine wildlife assessment area, August 29-30, 1978.

fresh (less than 48 hours), recent (probably deposited in summer), and old (the previous winter or older). Number of pellet groups was divided by number of paces to create a PG/pace/vegetation type of each age class.

Springs and seeps located during the pedestrian surveys also were examined for general use by the three species. Tracks, pellet groups, actual sightings, etc. were used as indicators.

C. Results and discussion

1. Habitat

The mine assessment area lies within the Old Mesas and Canyons Management Unit of the Old Woman Management Area. There are four major landforms (U.S. Forest Service, 1976), or habitats, within the Unit. All landforms provide habitat for a variety of wildlife; however the following discussion primarily concerns big game.

a. Sagebrush/grass and Ponderosa pine benches. This major landform includes several vegetation community types reported by WESTECH (1977). They are:

i. Sagebrush/grassland (Figure 4).

Found on plateaus and slopes above the canyons, this community is dominated by big sagebrush (Artemesia tridentata) and low sagebrush (Artemesia arbuscula), with bitterbrush (Prushia tridentata) and rabbitbrush (Chrysothamnus spp.) often abundant. Common grasses and grass-like plants in this type include slender wheatgrass (Agropyron trachycaulum), western wheatgrass (A. smithii), prairie junegrass (Koeleria macrantha), needle-and-thread grass (Stipa comata), Letterman needlegrass (S. lettermanii) and sedges (Carex spp.). This type produces more forage for livestock and big game than most other types.

Except in years with deep snow accumulations, it is an important component of big game winter range. Winter range condition in the Old Woman Management Area is fair to poor (U.S. Forest Service, 1976). Browse condition determined by the Forest Service from permanent line transects near the assessment area is fair. Browsing of bitterbrush is apparent in most stands. Bitterbrush is highly palatable to most grazing animals (Plummer, Christenson and Monson, 1978), and generally responds well to grazing pressures (Ferguson and Basile, 1966; Ferguson, 1972). It is a preferred mule deer winter browse in some Utah winter ranges (Robinette et al., 1977; Smith, 1952; Smith and Hubbard, 1954), and may be a preferred browse in the mine assessment area.

Sagebrush is often considered an important browse on big game winter ranges (Smith, 1952; Plummer, Christenson and Monson, 1968), but its high amount of aromatic oils reduces its palatability and therefore its preference (Smith and Hubbard, 1954; Dietz and Yeager 1959; Dietz, Udall and Yeager, 1959; Dietz and Nagy, 1976). It seems to be most valuable on those ranges where other browse species provide a diet mix (Dietz and Yeager, 1959).

Rabbitbrush is sometimes considered poor browse (Smith and Hubbard, 1954), but other authors consider it valuable, particularly for elk (Plummer, Christenson and Monson, 1968).

Fig. 4. Sagebrush/grassland community in the Sagebrush/grass and Ponderosa pine landform.

ii. Ponderosa pine

This community is found on benches and at the heads of several draws and canyons. Shrubs associated with this type are curlleaf mountain mahogany (Cercocarpus ledifolius) and manzanita (Arctostaphylos patula). Mountain mahogany is a valuable browse (Plummer, Christenson and Monson, 1968) but at many sites in the assessment area has grown above the reach of big game animals. Manzanita receives light to moderate use by mule deer (Kufeld, Wallmo and Feddema, 1973). In severe winters, much of the manzanita in the assessment area will likely be below snow level.

Selective harvest of old growth Ponderosa pine was underway during the assessment. Pine regeneration is sparse and openings created by harvesting are being invaded by mountain mahogany, manzanita and other shrubs (WESTECH, 1977). This practice should improve browse quantity and quality for some time, but these gains will be difficult to sustain as tree canopy increases (Robinette et al., 1977).

b. Steep slopes and scarp-faced canyon walls

This major landform included three community types: pinyon/juniper woodland, mixed conifer, and mountain shrub.

i. Pinyon/juniper woodland (Figure 5)

The pinyon/juniper woodland community is found in lower elevations of Quitchupah, East Spring and Convulsion Canyons. Pinyon (*Pinus edulis*) and juniper (*Juniperus osteosperma*) vary in coverage; at some sites there are almost pure stands of juniper. Understory is generally sparse. Common grasses are bluebunch wheatgrass (*Agropyron spicatum*) and Indian ricegrass (*Oryzopsis hymenoides*), while yarrow (*Achillea millefolium*), Indian paintbrush (*Castilleja linariaefolia*), comandra (*Comandra pallida*) and daisies (*Erigeron spp.*) were forbs observed during the assessment period (WESTECH, 1977).

This community type is used year round by mule deer and appeared to be used seasonally by elk. The steep slopes probably have less snow cover during severe winters than more gentle areas, but the absence of preferred forage probably reduces its attractiveness as a feeding site to both species. It appears to be important escape/security cover for mule deer.

Fig. 5. Steep slope/canyon wall landform, with pinyon/juniper community type on opposite slope.

ii. Mixed conifer (Figure 6)

This community type was found along steep north and east aspects of the canyons, and on the north side of Little Duncan Mountain. White fir (Abies concolor), Douglas fir (Pseudotsuga menziesii) and Ponderosa pine dominated the overstory.

At wetter sites and along stream bottoms, Engelman spruce (Picea engelmanii) occurred (WESTECH, 1977).

This type provides good escape/security cover during spring, summer and fall for big game, and some forage. Snow depths probably preclude extensive use in severe winters.

Fig. 6. Steep slope/canyon landform showing mixed conifer community on opposite slope, and mountain shrub community on near slope.

iii.Mountain shrub (Figure 6)

The mountain shrub community type is dominated by scrub oak and curlleaf mountain mahogany. These two species may occur as separate stands, or together. Other shrubs are present, in varying degrees (WESTECH, 1977).

This type appeared to be used year-round by mule deer, but there were very few elk tracks or pellet groups observed in this type where it occurred in the steep slope/canyon landform. This type was also found in the rolling hills landform, where it showed considerably more use by both species.

c. Narrow stringers in canyon bottoms (Figure 7).

This landform featured small grassy meadows, sometimes with stands of sage-brush/grassland. Other community types from the steep slope/canyon landform also occurred in the bottoms. There was very little understory around developed springs, where cattle use was heavy.

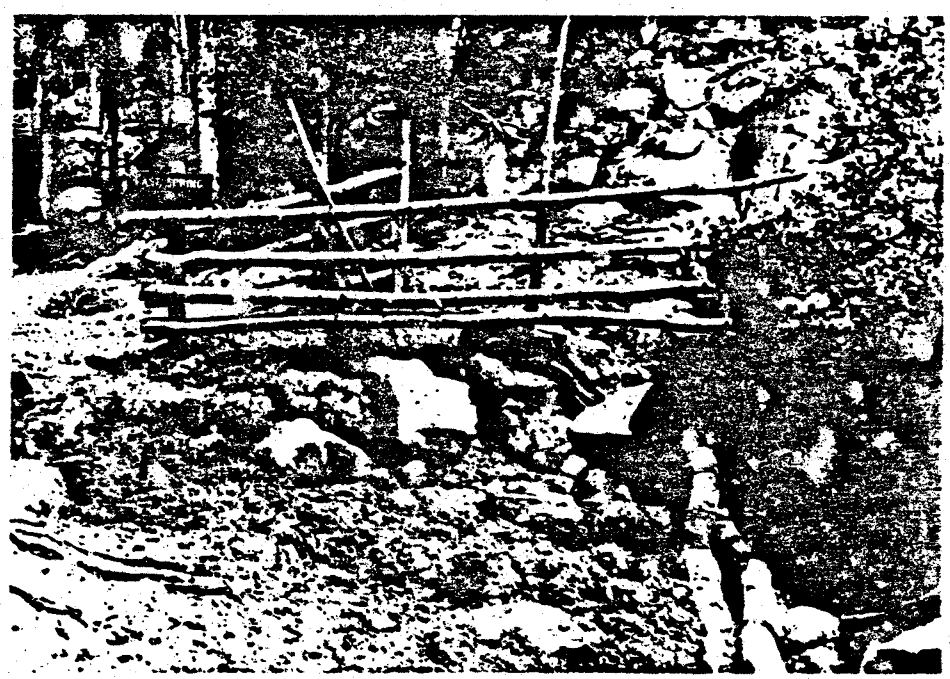


Fig. 7. Developed spring in canyon bottom showing absence of understory.

d. Rolling hills (Figure 8)

The rolling hills landform consists of four community types: mountain shrub (usually dominated by oak), mixed conifer, sagebrush/grassland and aspen. Aspen stands also occur in the other major landforms, but are most prominent in the rolling hills landform.

Due to its interspersion of communities and resulting "edge effect", this landform is valuable to big game in all seasons. Depending on aspect and slope, part of it may be unavailable in winter.

Fig. 8. Rolling hills landform, showing mixed conifer, aspen and sagebrush/grassland community types.

2. Birds

Seventeen avian species were identified in 1977 (WESTECH, 1977); 11 more were added in 1978, for a total of 28 (Table 7). The U.S. Forest Service (1976) listed 102 species of birds in the Salina Planning Unit, which includes the SUFCo mine assessment area. The assessment area list is con-

Table 7. Birds Observed in the SUFCo Mine Assessment Area.[a]

Falconiformes	
Cooper's Hawk	Accipiter cooperii
Golden eagle	Aquila chrysaetos
American kestrel	Falco sparverius
Falliformes	
Blue grouse	Dendragapus obserus
Columbiformes	
Mourning dove	Zenaida macroura
Strigiformes	
Great horned owl	Bubo virginianus
Piciformes	
Yellow-bellied sapsucker	Sphyrapicus varius
Common flicker	Coloptes auritus
Hairy Woodpecker	Dendrocopos villosus
Passeriformes	
Horned lark	Eremophial alpestris
Steller's jay	Cyanocitta stelleri
Scrub jay	Aphelocoma coerulescens
Black-billed magpie	Pica pica
Clark's nutcracker	Nucifraga columbiana
Mountain chickadee	Parus gambeli
White-breasted nuthatch	Sitta carolinensis
American robin	Turdus migratorius
Swainson's thrush	Hylocichla ustulata
Mountain bluebird	Sailia currucoides
Solitary vireo	Vireo solitarius
Pine siskin	Spinus pinus
Green-tailed towhee	Chlorura chlorura
Rufous-sided towhee	Pipilo naculatus
Vesper sparrow	Pooecetes gramineus
Lark Sparrow	Chondestes grammacus
Gray-headed junco	Junco caniceps
Chipping sparrow	Spizella passerina
Brewer's sparrow	Spizella breweri

[a] Nomenclature from A.O.U. (1957) and Skaar (1975).

siderably smaller due to the small amount of field time (four days in two years), influenced by the autumn season (few singing males, difficulty in identifying immature passerines, and possibly some migration out of the area).

Birds were observed in all habitats. No raptor eyries were located, but many potential nest sites are present along canyon rims, in Ponderosa pine snags and in living trees. The U.S. Forest Service has deleted many Ponderosa pine snags from timber harvest in the assessment area for the purpose of providing habitat for cavity-nesting birds and other species which utilize snags.

3. Mammals

Eleven mammalian genera were recorded from actual sightings or observations of evidence (Table 8). Several could not be identified to species.

Of 49 mammals potentially found in the Salina Planning Unit (U.S. Forest Service, 1976), 45 were included in Armstrong's (1977) list of distributional patterns of Utah mammals. These 45 species appeared to fit the SUFCo mine assessment area into the Northern High Plateaus Province, of the Central Highlands Faunal Area. This zoogeographic classification is based upon areographic patterns of mammalian distribution.

Elk were not observed in the assessment area in 1978, although they had been recorded in 1977 (WESTECH, 1977). The elk herd in the Salina Planning Unit has been increasing for several years. The area receives considerable hunting pressure for elk and deer, with the number of hunters increasing 122 percent from 1969-1972 (U.S. Forest Service, 1976).

Table 8. Mammals Recorded in the SUFCo Mine Assessment Area. [a]

Lagomorpha	
Black-tailed jackrabbit	_Lepus californicus_
Cottontail	_Sylvilagus_ spp.
Rodentia	
Red squirrel	_Tamiasciurus hudsonicus_
Chipmunk	_Eutamias_ Spp.
Pocket gopher	_Thomomys talpoides_
Wood rat	_Neotoma_ spp.
Carnivora	
Coyote	_Canis latrans_
Badger	_Taxidea taxis_
Bobcat	_Felis rufus_
Artiodactyla	
Elk	_Cervus elephus_
Mule deer	_Odocoileus hemionus_

[a] Nomenclature from Jones et. al., 1975.

The U.S. Forest Service (1976) reported that part of the assessment area is considered an elk calving ground, most of the area is an elk winter concentration site, and the remainder is "normal" big game winter range (Figure 9). Winter range condition in the area, as determined from permanent line transects conducted by Fishlake National Forest personnel, is considered fair.

During severe winters, parts of the "normal" winter range and elk concentration site may not be used. There was 3-4 feet of snow on the plateau above the mine for part of the 1977-1978 winter; at this time, no deer or elk were sighted on the plateau (Dall Dumick, personal communication to M.K. Botz).

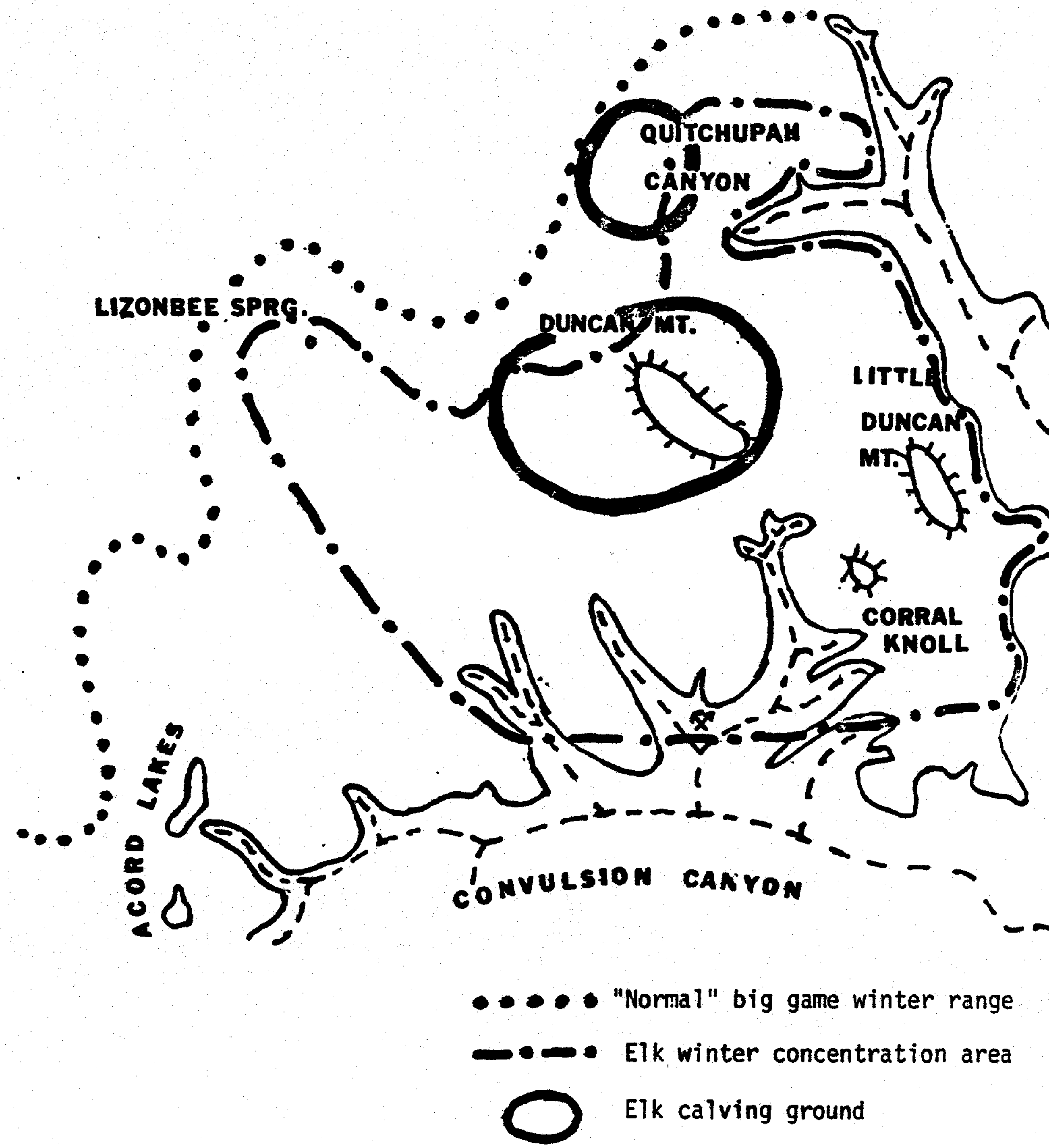


Fig. 9. Big game use areas in the mine assessment area (adapted from U.S. Forest Service, 1976).

By late winter-early spring, elk and mule deer were again observed on the plateau.

Numbers of mule deer in Utah have declined in recent years. The wintering population declined 34 percent between 1971-1972 and 1975-1976. The decline was attributed to a debilitating cycle of severe drought summers and high snowfall winter/springs, high percentage of doe kill in some hunting units, loss of winter range, and possibly predation (John, 1976). Within the Salina Planning Unit, the severe 1972-1973 winter contributed to the decline (U.S. Forest Service, 1976).

Mule deer sightings are shown in Figure 3. Six groups were observed: one doe in sagebrush/grassland, one doe and two fawns in mixed conifer, one buck in an aspen-sagebrush ecotone, two does and two fawns in mountain shrub, two bucks and one doe in Ponderosa pine, and one buck in Ponderosa pine. Three sightings were within one hour of sunrise, one within one hour of sunset, and two were of deer flushed from mid-day beds.

In addition, skulls of three mule deer (one buck, two does) were found during pedestrian surveys. These skulls were quite weathered; these animals had been dead for several years. Leg remains of three more deer were found at a hunting camp site. One dead mule deer was found along the paved haul road leading from the mine to I-70, and there were remains of three deer which were caught in the I-70 boundary fence, where it paralleled the haul road.

Pellet group count results are shown in Table 9. Only PG's estimated to be old in age were considered, since small sample size precluded PG/pace/type values for more recent age groups. No fresh elk PG's were observed on any transect, and only a few were judged recent. These results support the conclusion drawn in the previous year (WESTECH, 1977) that the area is more important to elk in late autumn, winter, and early spring than in late spring, summer and early autumn. However, a number of factors including precipitation and solar exposure affect the rate at which PG's dissipate; in addition, observer error in judging age may have also affected the results. Nevertheless, the age conclusion supports the U.S. Forest Service (1976) statement that the assessment area is important big game winter range.

As in 1977 (WESTECH, 1977), the highest elk values were from PG-2. This transect was located both inside and outside the Duncan Mountain Experimental Plot (Figure 1). The Duncan Mountain plot comprises 70 acres on a southwest slope of Little Duncan Mountain; it was created in 1962, was seeded to crested wheatgrass after trenching, pitting and sagebrush eradication (Laycock, 1969). Cattle were excluded, but in recent years the fence has not been maintained and gates have been opened, allowing cattle to enter the exclosure.

In 1977 PG/pace/type values for PG-2 were considered only for inside and outside the exclosure. Low cattle values outside the exclosure were attributed to steep slopes, since the "outside" portion of the transect was run along the upper slope of Little Duncan Mountain (WESTECH, 1977). To verify this hypothesis, the "inside" values were divided by slope in 1978 (Table 9). Values for all three species were highest on the lower, relatively gentle slope where grasses predominated. Cattle and elk values were the same. However cattle PG's declined dramatically as slope increased, suggesting that steeper slopes were not as attractive to cattle as to big game species. In general,

Table 9. Pellet group count results (PG's considered old in age), SUFCo mine assessment area, August 29-30, 1978.

Transect	Vegetation Type	PG/pace Values Deer	Elk	Cattle
PG-1	Ponderosa pine-mountain mahogany-manzanita	0.019	0.000	0.000
PG-2	Sagebrush/grass (outside exclosure)	0.021	0.034	0.011
	Sagebrush/grass (exclosure-lower slope)	0.021	0.104	0.104
	Sagebrush/grass (exclosure-upper slope)	0.018	0.053	trace
PG-3	Mixed conifer	0.015	0.000	trace
	Aspen-Sagebrush/grass	0.022	0.013	0.044

elk values declined with increasing slope more than did deer values. This may be attributed to difference in food habits between the two species (elk possibly preferring the grasses more abundant at lower slopes during late autumn and winter), and to the fact that deer seem to be relatively more abundant year-round in the area and would therefore be more likely to cover all available habitat.

Results on the other two transects generally paralleled 1977 (WESTECH, 1977). Cattle values were highest in the relatively flat aspen-sagebrush/grassland of PG-3. Deer values were lower than elk values in open habitats, and higher in wooded habitats. There were no elk and cattle values from PG-1, a dramatic change from 1977. The reason for this change is unknown. Deer values were highest of all three species in rough terrain (PG-1 and mixed conifer of PG-3).

Part of this difference may be the lack of water sources which influenced cattle distribution in this topography.

D. Impacts of subsidence to big game populations

In 1977, it was suggested that subsidence might alter vegetation in affected areas thereby influencing big game use (WESTECH, 1977). By the 1978 field period, the subsidence fissures observed in 1977 had closed, and there was no apparent difference in vegetation survival between the subsidence area and nearby unaffected sites. It appears that vegetation will not be significantly affected by the physical action of subsidence. Effects due to altered soil moisture conditions, if any, have not yet become apparent.

Effect of loss of springs and seeps due to subsidence remains speculative. Developed springs observed in 1977 were still flowing in 1978, so that there was no water loss at these sources. Water was also available at small developed impoundments on intermittent drainages, and in natural "slick-rock" catchments.

Several factors may influence big game use of springs and seeps in the assessment area:

(1) Water use characteristics of local big game populations. Wood et al. (1970) showed that permanent sources of water affected mule deer distribution in a pinyon-juniper ecosystem in New Mexico. In their study, range use by mule deer decreased as distance from water increased. They also found deer densities fluctuating in response to the number of water sources available, suggesting that water location influences deer density as well as distribution.

Other authors have stated that water sources are important to big game. For example, ideal spacing of water for deer is reported to be at intervals of one mile or less (U.S. Forest Service, 1969). But some authors do not discuss water requirements (Robinette et al., 1977) while others (Grenston and Ryerson, 1973; Ogle and Ross, 1970) emphasize its importance in forage production rather than direct intake.

In contrast, Mackie (1970) also found that range use by mule deer and elk in the Missouri River Breaks of Montana decreased as distance from water increased, but concluded that this change was related more to seasonal changes in food habits than to water locations. Cattle distribution, however, was markedly influenced by water distribution.

In the SUFCo assessment area, most springs and seeps are located in canyons. General impressions and pellet group counts (Table 9) suggested very little elk use of canyons and considerable elk use of dry hillsides, implying that elk distribution is not significantly influenced by water sources.

While deer use of canyons was relatively high (Table 9), it was also high in other habitats. Although sample size was small, this result suggests that cover and browse availability may be more influential than water in determining deer distribution.

A developed spring (East Spring) near the head of East Spring Hollow, and an unmaintained spring and an undeveloped seep in the same drainage near the mine, were inspected for wildlife use. Cattle tracts and pellet groups were predominant at all three locations.

(2) Season of use. The SWFCo assessment area is a wintering ground for elk and mule deer (U.S. Forest Service, 1977). There were no springs in that portion of the area considered an elk calving ground. With most use occurring in winter, snow or runoff may decrease the importance of springs to game species. Wood et al. (1970) implied that water sources were less important on winter ranges than summer ranges.

(3) Runoff collection sites. Natural ponds or man-made reservoirs which hold water in dry periods may also decrease the importance of springs. There were several small reservoirs located in or near the assessment area, most of which were dry during the field period. There was rainfall collected in depressions on large flat rocks in several draws, another possible short-term water source.

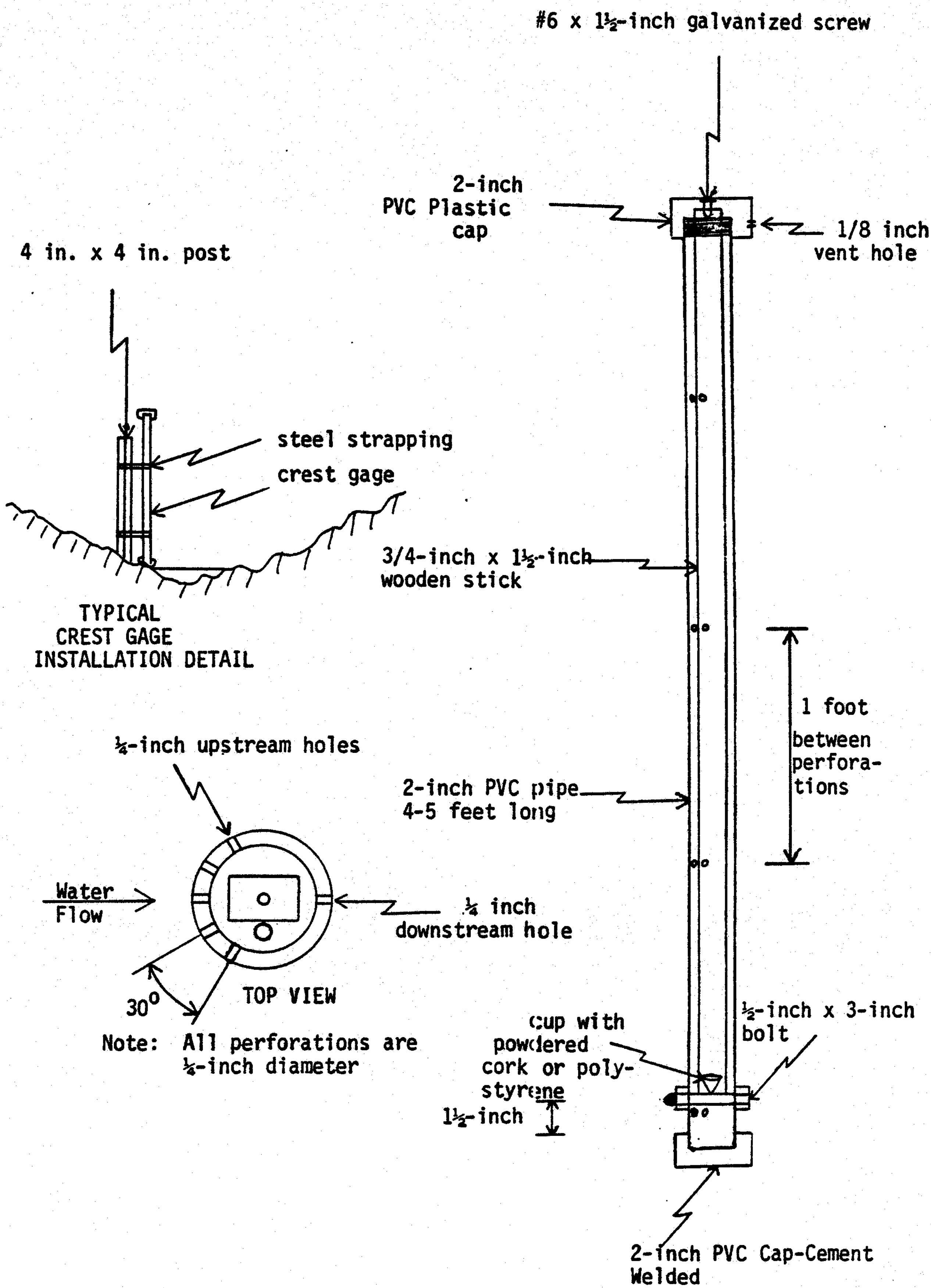
(4) Competition with cattle. Several studies (Lonner, 1975) have suggested that elk and cattle are socially incompatible. Others (Bickford and Reed, 1943; Stevens, 1966) have indicated that elk, deer and cattle may compete for food items. If cattle are the predominant users of water at springs and seeps, they will probably also dominate use of nearby plants, further reducing value of springs for big game species.

E. Mitigations

Suggested mitigations are identical to those recommended in 1977 (WESTECH, 1977) for combined impacts to hydrology, vegetation and wildlife.

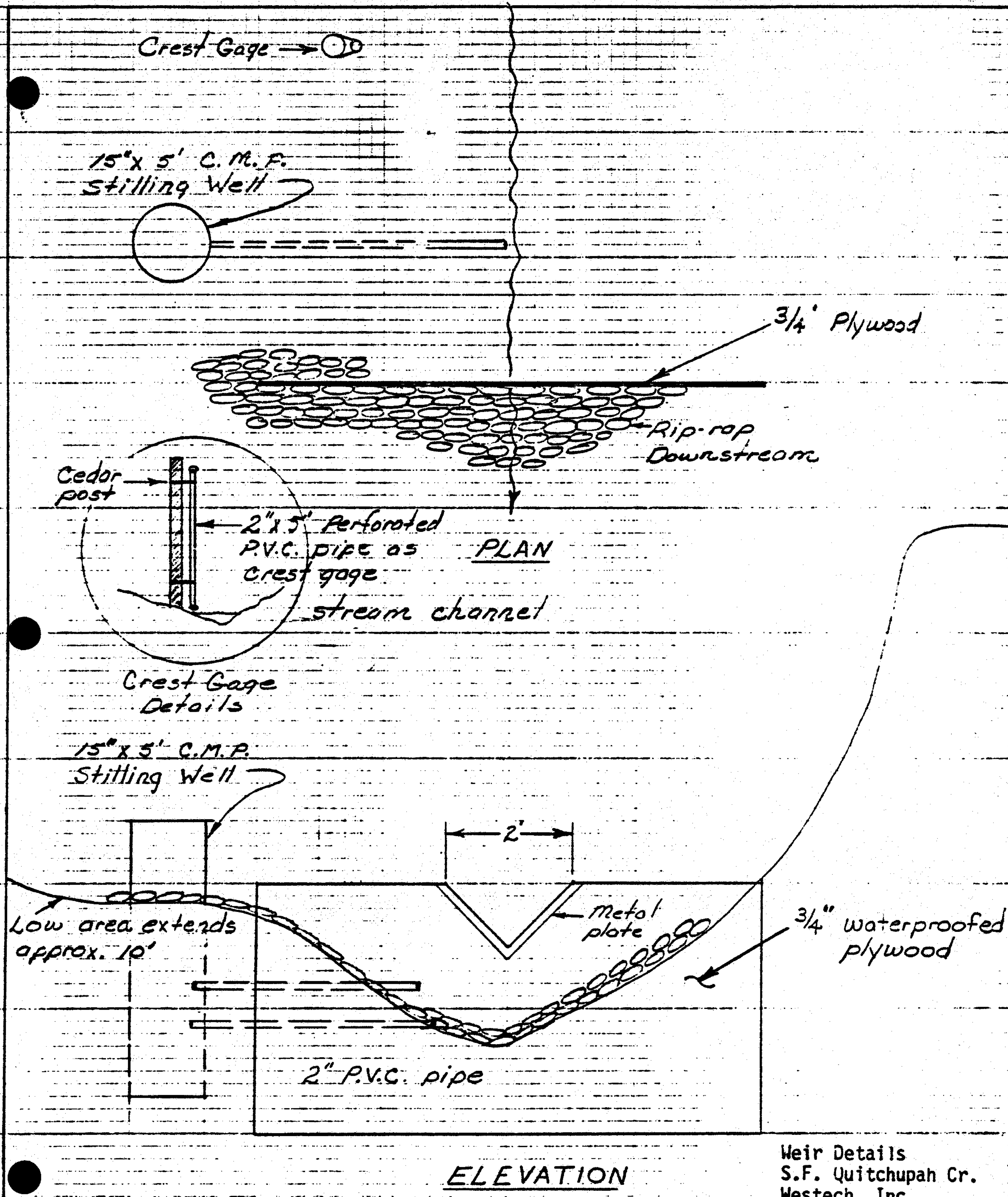
VI. APPENDICES

Appendix A. Construction and Installation Details of Crest Gages, Weirs and Flume.

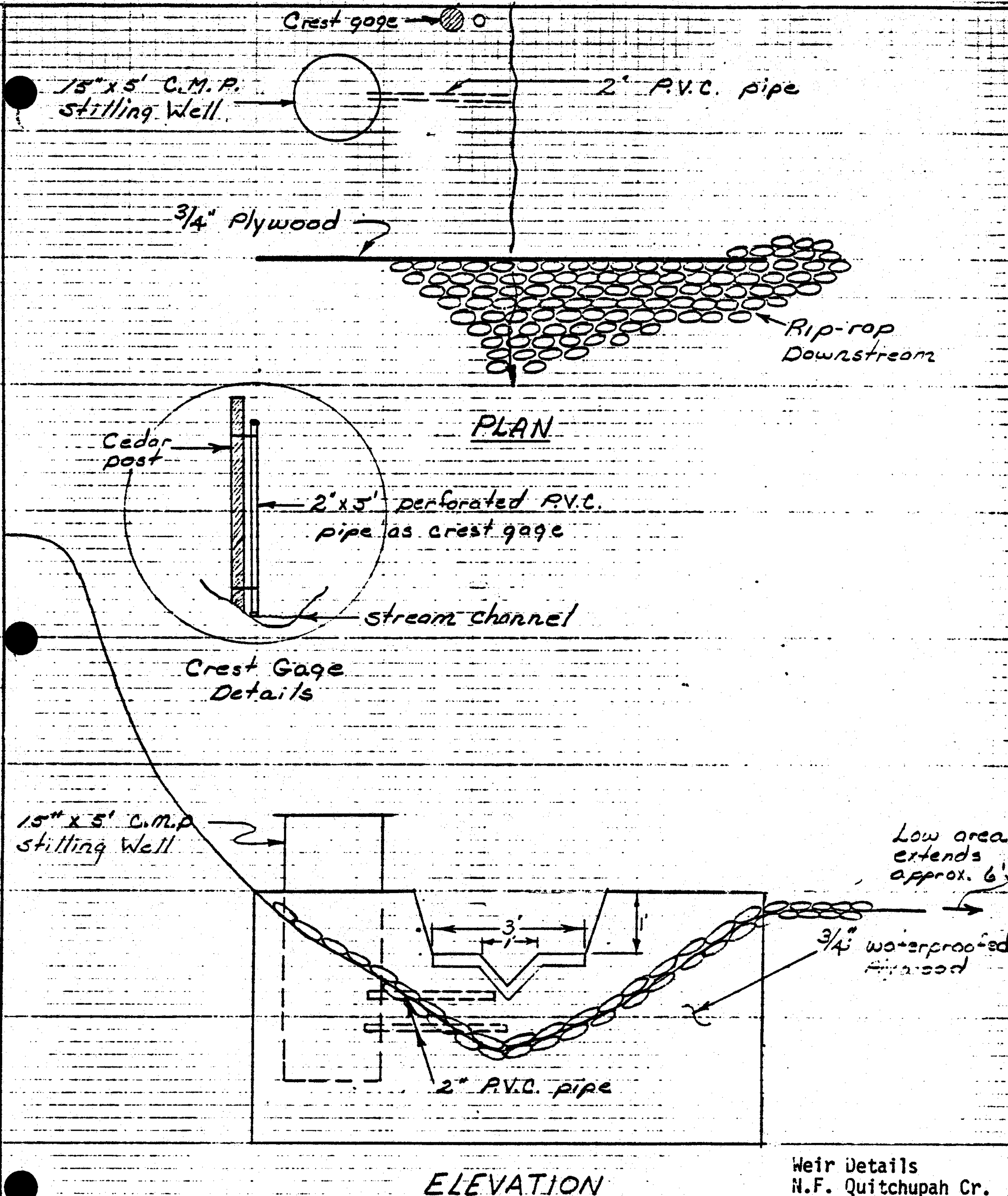


Crest Gage Construction Detail

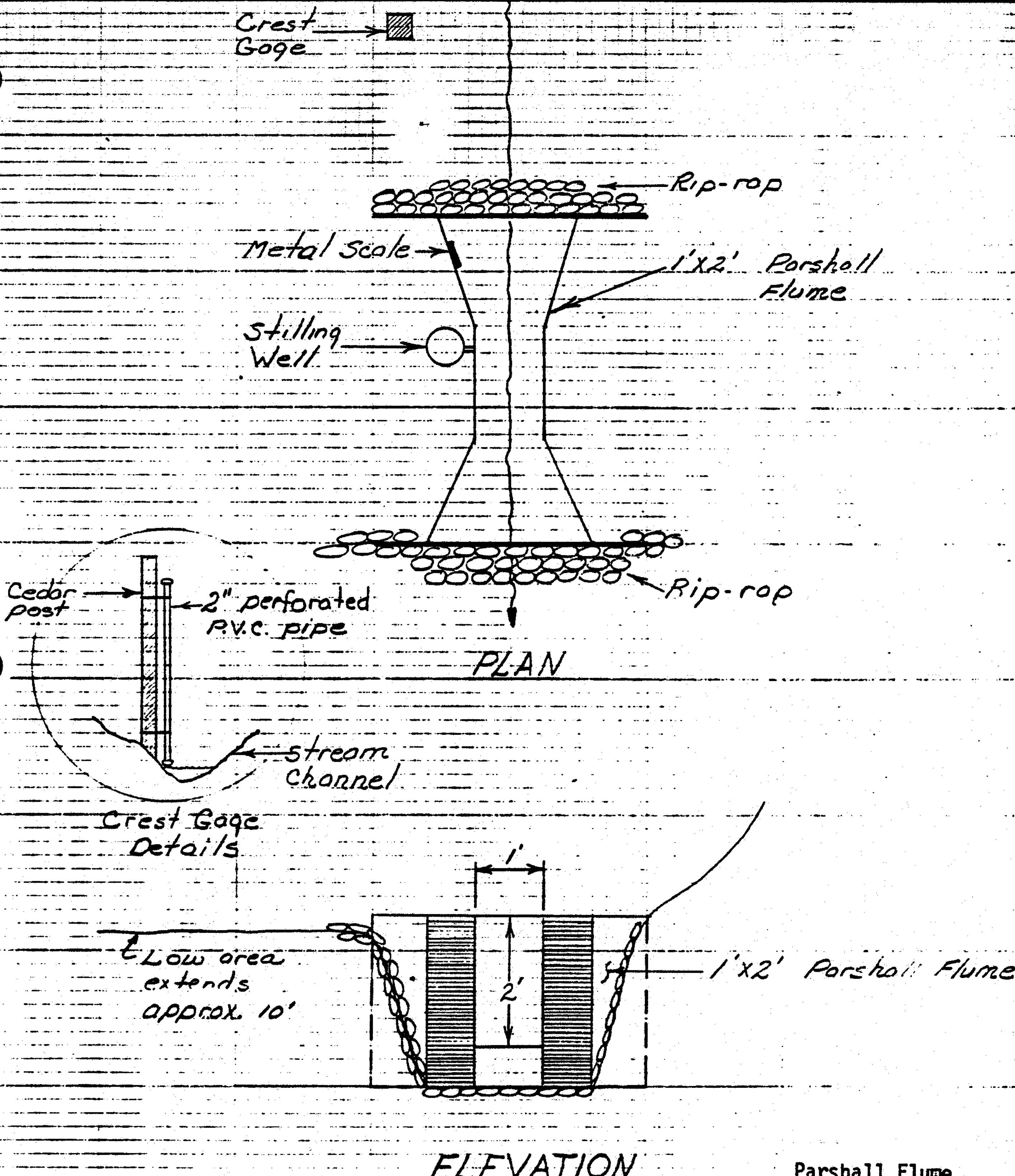
CROSS-SECTION



Weir Details
S.F. Quitchupah Cr.
Westech, Inc.
Feb. 1979



Weir Details
N.F. Quitchupah Cr.
Westech, Inc.
Feb. 1979

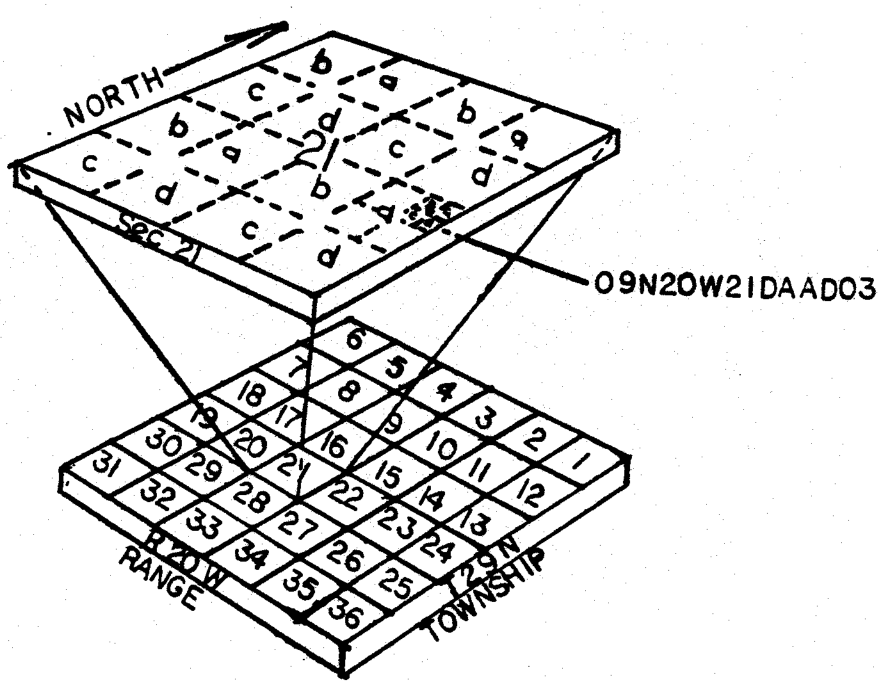


Parshall Flume
N.F. Quitchupah Cr.
Westech, Inc.
Feb. 1979

Appendix B. System for Geographical Location of Features.

SYSTEM FOR GEOGRAPHICAL LOCATION OF FEATURES

Features such as water sampling sites, wells, and springs are assigned a location number that is based on the system of land subdivision used by the U. S. Bureau of Land Management. The number consists of fifteen characters and describes the location by township, range, section and position within the section. The figure below illustrates this numbering method. The first three characters of the number give the township, the next three the range. The next two numbers give the section number within the township, and the next four letters describe the location within the quarter section (160-acre tract), and quarter-quarter section (40-acre tract), and a quarter-quarter-quarter section (10-acre tract), and the quarter-quarter-quarter-quarter (2 1/2-acre tract). These subdivisions of the 640-acre section are designated as A, B, C, and D in a counterclockwise direction, beginning in the northeast quadrant. If there is more than one feature in a 2 1/2-acre tract, consecutive digits beginning with the number 02 are added to the number. For example, if a water quality sample was collected in Section 21, T29N, R20W it would be numbered 29N20W21DAAD02. The letters DAAD indicate that the well is in the southeast 1/4 of the northeast 1/4 of the northeast 1/4 of the southeast 1/4, and the number 02 following the letters DAAD indicates that there is more than one site location in this 2 1/2-acre tract.



VII. BIBLIOGRAPHY

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ENVIRONMENTAL MONITORING PROGRAM
FOR 1979
SUFCo MINE - SALINA, UTAH

For

LOREN A. WILLIAMS
COASTAL STATES ENERGY CORP.
COASTAL TOWER
NINE GREENWAY PLAZA
HOUSTON, TEXAS 77046

By

MAXWELL K. BOTZ
HYDROMETRICS
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Helena, Montana 59601

and

WESTECH
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MAY 18, 1979

ENVIRONMENTAL MONITORING PROGRAM
FOR 1979
SUFCo MINE - SALINA, UTAH

It is planned to conduct water resources, wildlife, vegetation and other environmental monitoring in the vicinity of the SUFCo #1 mine near Salina, Utah. This provides the third year of baseline environmental assessment and impact evaluation from the SUFCo #1 mine area. The 1979 program is designed to meet environmental requirements of the new OSM Permanent Regulatory Program for underground coal mines. The State of Utah currently is developing the required regulatory authority to administer this mining program. This 1979 monitoring program also will satisfy the U.S. Forest Service environmental requirements for underground coal mines.

WATER RESOURCES

The 1979 monitoring plan will include evaluation of surface water, groundwater and water quality. The snowpack is about 125% of normal and peak run-off should occur in June. To meet the water resources requirements of regulatory agencies, the following will be completed in 1979.

1. Instrument and activate streamflow recording stations installed in 1978. This will include calibration of the combination weir on the N. Fork of Quitchupah Creek.
2. Conduct a well and spring survey to determine baseline conditions and assess subsidence impacts. In addition to flow measurement, a photo record will be started for each station.
3. Measure groundwater levels in all monitoring wells and coordinate with Coastal States Energy Company geologist in development of additional monitoring sites. This will be in conjunction with the summer exploration drilling program.

4. Conduct examination of subsidence areas to determine possible hydrological impacts.
5. Evaluate mine water inflow information and pumping records.
6. Obtain water quality samples in July and early fall. The July samples will be for a few selected constituents and the fall samples will be tested for a complete set of parameters. This will allow comparison with 1978 water quality data. As required by OSM, results of water quality analysis will be submitted to OSM within 60 days of sampling. This will include a description of analytical quality control used in the field and laboratory.
7. Assessment of surface water drainage facilities and treatment of run-off from disturbed areas.

VEGETATION

Since vegetation monitoring in 1977 and 1978, the Office of Surface Mining has promulgated rules pertaining to underground coal mining. These rules contain specific references to vegetation monitoring. This 1979 program attempts to incorporate provisions of the new Permanent Regulatory Program in addition to requirements of the U.S. Forest Service. Monitoring for the 1979 field season has been separated into tasks to identify important components of vegetation monitoring.

Task 1. Establish quantitative transects to identify pre-disturbance conditions over proposed subsidence panels

Transect locations will be cooperatively selected by SUFCo, U.S. Forest Service and Westech. Specific methods to be used should also be agreed upon by the three parties. Several locations should be selected and sampled to provide analysis of different vegetative community types.

Task 2. Establish reference areas or obtain USDA or USDI data for eventual analysis of reclamation success

Federal rules require the collection of data to be used as a comparison of revegetation success prior to bond release. A company may use data from reference areas or data from USDA or USDI agencies, if it is available. If existing information on ground cover and productivity is available from the federal agencies it should be assembled and summarized for later use. If this information is not available, reference areas should be selected and sampled for various vegetation types that are to be disturbed. A detailed study plan should be prepared to show how and when the reference areas will be sampled. Existing Forest Service transects (off-site) could fulfill part of this requirement.

Task 3. Long range study plan design for assessment of subsidence impacts

After the baseline data for Task 1 has been summarized a long range study plan should be developed to detail methodology and timing for analysis of impacts due to subsidence. Responsibilities for data collection should be worked out between SUFCo and the Forest Service.

WILDLIFE

The wildlife survey will be a continuation of the wildlife surveys performed in 1977. It will include vehicle traverses and pedestrian surveys. The objective will be to expand the species list and to map wildlife sitings. For a more quantitative estimate, a continuation of the pellet group counts will be made including separation by age class, and vegetation type. These data will provide a trend in wildlife in the area. Methods used will be those listed in WESTECH's previous assessments.

AIR AND SOILS

To answer OSM concerns on air quality, a dust control plan will be developed for the mine area and the air quality monitoring program will be described.

A soils map will be prepared for the disturbed mine area (exclusive of subsidence areas). This will include a program to reclaim the final tipple site.

940 River Heights Blvd.
Logan, UT 84321

May 19, 1979

Mr. Wes Sorensen, Mining Engineer
Southern Utah Fuel Co.
PO Box P
Salina, UT 84654

Dear Mr. Sorensen:

Re: Water and Soil Data Report from SUFCO Mine

Enclosed are data and interpretations from samples collected on May 4, 1979.

The data show the water quality to be good, with no evidence of toxicity of heavy metals from spoils. There is evidence of some increase in amount of suspended sediment in the stream.

I have also included a revegetation plan for the cut bank east of the office complex.

If I can be of further service, please call me.

Yours very truly,

Alvin R Southard

Alvin R. Southard
Certified Professional
Soil Scientist
ARCPACS #528.

Enclosure
ARS/mh

RECEIVED
OCT 23 1979
STATE OF UTAH
Division of Oil, Gas & Mining

WATER AND SOIL DATA REPORT FROM SUFCO MINE

SAMPLING STRATEGY.

Water. Water samples were collected as follows:

#1 - above the mine operation.

#2 - at the culvert exit from under the spoil.

#3 - above the culvert on the trail south of the power line.

Spoil. Spoil samples were collected as follows:

Starting at a point near the culvert exit under the spoil, and working in a west-southwest direction, samples #1, #2, and #2A were collected about 30 feet below the top of the spoil bank; sample #3 was from the yellow "gob" about 35 feet below the top of the spoil bank; sample #4, high in fine coal, was collected 15 feet above the stream. That is evidently the place of most recent dumping of coal waste. Sample #5 was collected downstream at the site where slumping had created a blockage of the stream. The sample was taken about 10 feet above the stream. This sample contained coal and small pieces of shale.

Soil. Soil samples were collected as follows:

#6 - east of the office complex on the cut bank just above the coal seam.

#7 and #8 - These represent the A and B horizons, respectively, of the soil under the conifers east and above the office complex.

INTERPRETATIONS.

Water Quality. (Table 1.)

Sample #1 was taken above the mine operation. It is class C-1. It shows 46 ppm suspended sediment. Samples from the culvert as it emerges from the spoil bank show an increase in sodium and rate as class C-2, with 66 ppm sediment. Sample #3, collected below the mine operations, shows an increase in salinity and sediment, but is still in class C-2. The sodium is low at all sample points. The water is of good quality, even at the most salty site, and is adequate for most agronomic crops.

It is important to note that water quality is not adequately assessed from one sampling, and that daily monitoring for substantial periods is required to determine the exact quality of the water, especially in streams where volume of flow fluctuates widely during a season as well as annually.

Spoil. Chemical Properties of the Spoil. (Table 2.)

Samples #1, #2, and #2A are only mildly saline (EC_e), the pH is moderately alkaline, and they have low SAR values (SAR = 15 is considered the threshold of concern). These samples show a reaction with hydrochloric acid indicated as ++ under Lime in Table 2. Water-soluble cations are low. Extractable heavy metals are low. With additions of nitrogen and phosphorus, and with irrigation, these materials should support grass and legumes. Spoil sample #3, from the yellowish "gob", is moderately saline and moderately alkaline. The SAR approaches the threshold of concern, but is below. This material, with fertilization and irrigation, should support plant species tolerant of moderately saline and sodic conditions. Spoil samples #4 and #5 are mildly saline and alkaline, and show no problem with sodium (SAR). These materials, if mixed and covered with spoils from samples #1, #2, and #2A, should support vegetation if fertilized and irrigated.

Soil. Chemical Properties of the Soil. (Table 2.)

Soil sample #6, just above the coal seam, is moderately saline and alkaline, and shows no more than moderate SAR values. This material, if fertilized and irrigated, should support grasses and legumes. Soil samples #7 and #8 were collected under the trees east of the office complex, and are nonsaline and moderately alkaline (pH). There is no indication of sodic problem. These soils are low in nitrogen and phosphorus. The A horizon, 0-6 cm, is thin, and has a wide C:N (17:1) ratio. This surface soil needs fertilization to support vigorous growth of grass and legumes. The B horizon, 6-20 cm, has a narrow C:N ratio (~11:1), considered to be about normal in soil-biological systems.

None of the soil or spoil samples contains heavy metals at concentrations which would cause toxicity concerns. The soils and spoils are calcareous, and in such systems most heavy metals are insoluble.

If SUFCO's operations preclude entry of sediment from the spoil and cut banks into the stream, the sediment load would be reduced and the quality of water sample #2 can be maintained.

REVEGETATION STRATEGY.

Seeding of the cut bank east of the office complex can be accomplished as follows:

Construct 6-inch-wide row-terraces along the contour (across the slope). Terrace rows should be about 1 foot apart vertically. Apply nitrogen fertilizer at the rate of 100 lbs. N per acre, and phosphorus at the rate of 50 lbs. P per acre. Seed yellow sweet clover, crested wheat-grass, and Russian wild rye, at the rate of 2 lbs. each per 1,000 square feet. Cover the seeds with a thin covering of soil and irrigate (sprinkle) lightly and often until seedlings emerge and the plants reach a height of about 2 inches. Then irrigate to maintain the plants in an actively growing condition.

It is important to inoculate the clover seed before planting to insure adequate N for the grasses in future years.

(Note: A "thin covering of soil" as mentioned above should be not more than 1/2 inch thick.)

#

UTAH STATE UNIVERSITY LOGAN UTAH 84322

SOIL, PLANT and WATER
ANALYSIS LABORATORY
UMC 48

May 18, 1979

Name A.R. Southard/Sufco

Street

City

State Zip

TABLE 1. WATER ANALYSIS REPORT

USU No.	Collector's Description	Salinity µmhos/cm	Sodium meq/1	SAR	Class	Ca + Mg meq/1	SAR_{adj}	Residual Carbonate meq/1	Chloride meq/1	Boron ppm	pH	ppm Sedim
1555	above mine	148	.1	.2	C1-S1	1.3	<.1	0	.13	.05	8.1	46
1556	below culvert	425	.6	.4	C2-S1	3.8	.8	0	.33	.17	8.2	66
1557	culvert bottom	488	.7	.5	C2-S1	4.7	.9	0	.39	.17	8.2	342

The end effect of using a particular water for irrigation depends upon several factors besides the water quality: *type of soil*, its *salt content* and *drainage; crops* to be grown; *climatic factors;* and *management practices*. The user must make the final evaluation of water quality test results with these factors in mind, according to his situation.

Research has yielded useful guidelines, which are summarized on the enclosed sheet. Two systems of water quality evaluation are given: The USDA Handbook 60 (1954), and a more recent system that places more emphasis on the sodium hazard. The principal value of each is in alerting the water user so that he can make appropriate adjustments in his water management before serious problems develop.

If possible problems are indicated by either of these evaluation methods, we suggest you consult a qualified adviser.

Reuel E. Lamborn
Director

(See Key to Abbreviations, page 7.)

Dr. A.R. Southard
UMC 48

UTAH STATE UNIVERSITY · LOGAN, UTAH 84322

SOIL, PLANT and WATER
ANALYSIS LABORATORY
UMC 48

Data report on So. Utah Fuel Co. soil samples received 5/7/79.

TABLE 2.

Log #	Ident		ECe mmhos/cm	pH	ppm NaHCO3-P	ppm NaHCO3-K	%O.C.	%N	meq/1 Na	meq/1 Ca+Mg	SAR
79-											
1558	sufco	1 of 9	3.4	7.8	1.5	43	7.1	.18	10.4	28.5	2.8
1559		2 of 9	2.0	7.7	.3	62	16.7	.43	4.0	18.6	1.3
1560		2A	5.5	7.9	.8	90	1.6	.08	15.2	54.2	2.9
1561	Gob	3	9.1	7.7	.1	82	7.4	.33	59.1	47.0	12
1562	mostly coal	4	3.6	8.0	.1	54	9.5	.12	16.1	21.3	4.9
1563	sediment Dam	5	2.6	7.9	.1	81	10.9	.37	2.2	25.7	.6
1564	rk above c.str	6	6.0	8.3	<.1	32	.3	.02	33.0	35.0	7.9
1565	0-6cm	7	.7	8.1	2.0	353	3.9	.22	1.0	9.8	.6
1566	6-20	8	.6	8.3	.3	382	1.4	.12	1.4	7.7	.6

Log #	meq/100g water-soluble Na	meq/100g water-soluble K	meq/100g water-soluble Ca	meq/100g water-soluble Mg	Lime	ppm Fe	ppm Zn	ppm Cu	ppm Mn
1558	.5	<.1	.7	.9	++	21	1.7	.4	2.2
1559	.2	<.1	.7	.6	++	46	1.3	.6	2.2
1560	.5	<.1	1.0	1.3	++	6.0	2.0	.6	4.4
1561	2.5	<.1	1.2	1.2	++	8.6	2.8	1.0	11
1562	.7	<.1	.7	.6	++	7.6	2.6	1.0	8.0
1563	.1	<.1	.7	.5	++	16	2.3	1.0	10
1564	1.2	<.1	.3	1.2	++	2.0	.8	.6	2.0
1565	<.1	.1	.3	.1	++	4.0	1.6	.6	4.2
1566	.1	<.1	.2	<.1	++	2.0	.6	.6	2.2

R. L. Lamborn [signature]

(See Key to Abbreviations, page 7.)

KEY TO ABBREVIATIONS

Atm.	Atmosphere
CEC	Cation Exchange Capacity
CO_3	Carbonate
EC	Electrical Conductivity (water) (millimhos/cm or micromhos/cm)
ECe	Electrical Conductivity of Saturation Extract
ESP	Exchangeable Sodium percentage
Exch.	Exchangeable
Ext.	Extractable
HCO_3	Bicarbonate
H2O-Sol	Solubility in saturation extract
Lime	$CaCO_3$
MAh	Mechanical Analysis (hydrometer)
VCS	Very Coarse Sand
CS	Coarse Sand
MS	Medium Sand
FS	Fine Sand
VFS	Very Fine Sand
MAp	Mechani 1 Analysis (pipet
meq/1	milliequivalents per liter
meq/100g	milliequivalents per 100g of soil
NO_3-N	Nitrogen (Nitrate)
%N	Nitrogen (Total-Kjeldahl)
O.C.	Organic Carbon
O.M.	Organic Matter
%P	Total Phosphorus
ppm	Parts per million
pH	Acidity-Alkalinity
SAR	Sodium Adsorption Ratio
Sat. Ext.	Saturation extract
SP	Saturation Percent (%H_2O)
SO_4	Sulfate

ELEMENTS

Al	Aluminum
B	Boron
Ca	Calcium
Cd	Cadmium
Cl	Chloride
Cu	Copper
Fe	Iron
K	Potassium
Mg	Magnesium
Mn	Manganese
Na	Sodium
P	Phosphorus
Pb	Lead
Zn	Zinc
S	Sulfur

L.L.	Liquid Limit
P.L.	Plastic Limit
P.I.	Plasticity Index

WATER QUALITY ANALYSIS
(For Irrigation)

Total Salt (Salinity)

Plants remove much water from the soil but only a small amount of soluble salt. Evaporation also removes water, but no salt. Salts contained in irrigation water can therefore be removed effectively only by applying enough excess water to leach them downward, out of the root zone and into the underground drainage system. Indicated "leaching requirements" give the amount of water (%), in *excess* of crop requirements, which must be applied and drained down through the root zone in order to control salt accumulation. Crops vary widely in their salt tolerance, as indicated in the table on the reverse side of this sheet.

Sodium Hazard

Soils high in adsorbed sodium (sodic soils) are hard to wet when irrigated, tend to run together when wet, have low permeability and are difficult to drain. When dry, they form hard clods and large cracks. A good soil can be converted to a sodic soil by irrigation with water that is high in sodium relative to calcium and magnesium (a high sodium adsorption ratio or SAR). Also, bicarbonate in the water can convert the calcium and magnesium to insoluble forms in the soil and thus increase the sodium hazard. If the amount of bicarbonate is greater than the Ca + Mg, the difference is called "Residual Sodium Carbonate."

USDA Handbook 60 Evaluation

Electrical Conductivity (Salinity)

Class C1 (Conductivity 0-250). This LOW SALINITY water can be used to irrigate all crops on all soils with little likelihood that soil salinity will develop. Some leaching is required, but this usually occurs under normal irrigation practices. Application of this water to new land high in sodium salts may cause a sodic condition to develop.

Class C2 (Conductivity 250-750). This MEDIUM SALINITY water can be used on most soils. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control. Leaching requirement 5-15%.

Class C3 (Conductivity 750-2250). HIGH SALINITY water should not be used on soils with restricted drainage. It can be used with crops having medium to high salt tolerance on light soils having good drainage and with irrigation practices which provide appreciable leaching. Leaching requirement 15-25%.

Class C4 (Conductivity 2250-5000). VERY HIGH SALINITY water is not suitable for irrigation under ordinary conditions. It may be used successfully with crops of high salt tolerance, on light and well-drained soils, and with very carefully conducted soil and water management practices. Leaching requirement 25-65%. Winter or early spring leaching should be practiced on most soils to insure removal of salts remaining from the previous season.

Class C5 (Conductivity over 5000). This water is generally unsuitable except in an emergency to prevent loss of a crop on soils with good drainage. Any such use should be followed by leaching with better water.

Sodium (Alkalinity)

Class S1. LOW SODIUM water can be used on all soils with little sodium hazard.

Class S2. MEDIUM SODIUM water will present an appreciable sodium hazard in fine-textured soils, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils having good permeability.

Class S3. HIGH SODIUM water may produce harmful levels of sodium in most soils and will require special soil management—good drainage, high leaching, and addition of organic matter. Soils high in gypsum may not develop harmful effects from such water, and the effects may be less in soils high in lime. Chemical amendments may be of benefit if the water is not too high in salinity (C3 or better).

Class S4. VERY HIGH SODIUM water is generally unsatisfactory for irrigation purposes except at salinity levels C1 and perhaps C2, where addition of amendments or dissolving of calcium from the soil may reduce the proportion of sodium in the soil solution.

Residual Sodium Carbonate

0 to 1.25 meq/1: probably safe
1.25 to 2.5 meq/1: marginal
More than 2.5 meq/1: not suitable for irrigation

SUPPLEMENTAL EVALUATION

Sodium Hazard

The term "Adjusted Sodium Adsorption Ratio" (SAR_{adj}) is calculated to take into account the total salinity and the concentration of sodium relative to calcium + magnesium, and the bicarbonate.

Root absorption of sodium can also cause specific toxicity problems, primarily for trees, vines, and woody ornamentals. Annual crops are usually not affected by sodium except for its contribution to total salt content. Water with SAR_{adj} below 3: no problem; from 3 to 9: problems increase; above 9: problems are severe.

Leaf absorption of sodium (from sprinklers) can cause toxicity symptoms under some conditions if the sodium exceeds 3 meq/1.

Chloride Hazard

Chlorides are found in all natural waters, and normally cause no problems. In high concentrations, however, chlorides can inhibit plant growth and they are specifically toxic to some plants.

Chlorides (meq/1)	
0-2	Generally safe for all plants.
2-4	Sensitive plants may show slight to moderate injury.
4-10	Moderately tolerant plants usually show slight to substantial injury.
10+	Severe problems.

3 or more (sprinklers) may cause problems under adverse conditions.

Sprinkler Irrigation

When the rate of evaporation is high (low humidity, high temperature, high wind), leaf burn may occur at levels of salinity, sodium and chloride that would be safe under less severe conditions. Usually there is no problem if salinity is less than 1200 umhos/cm and sodium and chloride are less than 3 meq/1. At higher levels, it may be advisable to increase rate of rotation or to sprinkle only at night during periods of hot, dry weather.

SOIL PROBLEM	DEGREE OF PROBLEM		
	None	Increasing	Severe
Salinity (μmhos/cm)	0-750	750-3000	3000+
Sodium (SAR_{adj})	0-6	6-9	9+
Residual carbonate (meq/1)	0-1.2	1.2-2.5	2.5+

TOXICITY TO CROPS	DEGREE OF PROBLEM		
	None	Increasing	Severe
Furrow or flood:			
Sodium (SAR_{adj})	0-3	3-9	9+
Chloride (meq/1)	0-4	4-10	10+
Boron (ppm)	0-.5	.5-2	2+
Sprinklers:			
Sodium (meq/1)	0-3	3+	--
Chloride (meq/1)	0-3	3+	--

CROP TOLERANCE TO SALINITY* and LEACHING REQUIREMENT

Crop	EC water μmhos/cm	ECe Soil mmho/cm	Leach. Req. %	Crop	EC water μmhos/cm	ECe Soil mmho/cm	Leach. Req. %
FIELD CROPS							
Barley	5300	8.0	12	Soybean	2500	3.7	10
Sugar beet	4500	6.7	11	Corn	2200	3.3	12
Wheat	3100	4.7	8	Beans	700	1.0	6
VEGETABLE CROPS							
Beets	3500	5.3	11	Onion	900	1.3	8
Tomato	1800	2.7	8	Carrot	700	1.0	6
Potato	1100	1.7	6	Beans	700	1.0	7
Sweet Corn	1100	1.7	6				
FRUIT CROPS							
Apple/pear	1100	1.7	7	Raspberry	800	1.8	8
Apricot/peach	1100	1.7	7	Strawberry	700	1.0	7
FORAGE CROPS							
Tall wheatgrass	4900	7.3	11	Alfalfa	1300	2.0	5
Barley (hay)	3500	5.3	10	Orchard grass	1300	1.7	4
Tall fescue	--	3.9	--	Alsike, Ladino, Red, Strawberry	900	1.5	4-6
Reed canary grass	--	--	--	Sweet clover	--	--	--
Brome grass	--	--	--				

*Values shown are maximum for no appreciable loss in yield. For approximately 10% yield reduction, multiply each value by 1.5.

BORON HAZARD

A small amount of boron is necessary for plant growth. Most Utah soils have adequate boron for crops, and most surface waters carry it. Some wells and saline waters contain toxic levels, and should be avoided.

Boron (ppm)	Toxicity
0.0-0.5	Safe for all crops
0.5-1.0	Sensitive crops show slight to moderate injury
1.0-2.0	Semitolerant crops show slight to moderate injury
2.0-4.0	Tolerant crops show slight to moderate injury
4.0+	Unsatisfactory for all crops

Relative Tolerance of Plants to Boron

(In each group the plants first named are considered as being more sensitive and the last named more tolerant)

Sensitive 0.5 ppm	Semi-Tolerant 1 ppm	Tolerant 2 ppm
Apricot	Tomato	Carrot
Peach	Oat	Lettuce
Cherry	Corn	Cabbage
Grape	Wheat	Onion
Apple	Barley	Alfalfa
Pear	Field Pea	Sugar Beet
Plum	Potato	
1 ppm	2 ppm	10 ppm

Adapted from USDA Tech. Bul. No. 448.

Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis

40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

RECEIVED
OCT 23 1979
STATE OF UTAH
Division of Oil, Gas & Mining

DATE: 08/15/79

CERTIFICATE OF ANALYSIS

HYDROMETRICS, INC.
1300 CEDAR STREET
HELENA, MT
59601

79-005384

SAMPLE: WATER RECEIVED 7/10/79.

	#100 (021) MINE DISCHARGE 7/3/79	046 CONV. CANYON ABOVE #101 046 PUMP HOUSE ~~EFF~~ 7/3/79	#102 047 A E SPRNG C. ABV CONV CAN. 7/3	#103 007 NORTH FRK QUITC HUPAH ABV CAN. 7/3	#104 006 SOUTH FRK QUITC HUPAH. 7/3/79
senic as As mg/l	<.001	<.001	<.001	<.001	.002
Bicarbonate as HCO3 mg/l	251.32	502.64	285.48	209.84	229.36
Cadmium as Cd mg/l	<.001	<.001	<.001	<.001	<.001
Calcium as Ca mg/l	61.60	96.00	64.80	45.60	55.20
Carbonate as CO3 mg/l	<.01	<.01	<.01	<.01	<.01
Chloride as Cl mg/l	12.0	34.0	14.0	2.0	6.0
Conductivity umhos/cm	580	1,000	610	670	500
Fluoride as F mg/l	.33	.26	.31	.23	.42
Iron as Fe mg/l	.110	1.230	.330	.170	.470
Magnesium as Mg mg/l	35.52	74.40	40.32	64.32	29.76
Manganese as Mn mg/l	.004	.181	.025	.020	.050
Nitrate as NO3-N mg/l	.25	.10	.05	.02	.04
Phosphate as PO4-P (Total) mg	.060	.100	.060	.100	.060

Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
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CERTIFICATE OF ANALYSIS

79-005384

	#100 (021) DISCHARGE 7/3/79	046 CONV. CANYON ABOVE #101 046 PUMP HOUSE 7/3/79	#102 047 A E SPRNG C. ABV CONV CAN. 7/3	#103 007 NORTH FRK QUITC HUPAH ABV CAN. 7/3	#104 006 SOUTH FRK QUITC HUPAH. 7/3/79
Potassium as K mg/l	2.163	4.310	2.420	.678	1.276
Selenium as Se mg/l	.001	<.001	<.001	<.001	<.001
Silica as SiO2 mg/l	3.50	5.10	2.90	1.50	6.30
Sodium as Na mg/l	20.90	34.37	21.47	12.73	17.90
Sulfate as SO4 mg/l	116	157	114	210	100
Suspended Solids mg/l	33.0	95.0	59.0	45.0	87.0
Total Dissolved Solids mg/l	380	652	400	438	328
Total Kjeldahl Nitrogen mg/l	.30	.25	.18	.20	.25

Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

CERTIFICATE OF ANALYSIS

79-005384

	#105 001 EAST SPRING 7/4/79	#106 041 QUITC HFAH CRK AB NO FK 7/4/79	#107 042 NO. FK.QUITCH PAH 7/4/79
Arsenic as As mg/l	<.001	<.001	.001
Bicarbonate as HCO3 mg/l	251.32	265.96	219.60
Cadmium as Cd mg/l	<.001	<.001	<.001
Calcium as Ca mg/l	58.40	45.60	46.40
Carbonate as CO3 mg/l	<.01	<.01	<.01
Chloride as Cl mg/l	20.0	30.0	10.0
Conductivity umhos/cm	400	970	460
Fluoride as F mg/l	.18	.31	.30
Iron as Fe mg/l	.010	.080	.290
Magnesium as Mg mg/l	19.68	48.00	27.36
Manganese as Mn mg/l	.008	.011	.027
Nitrate as NO3-N mg/l	.10	.12	.10
Phosphate as PO4-P (Total) mg	.030	<.010	<.010
Potassium as K mg/l	1.452	2.894	1.142
Selenium as Se mg/l	.001	.001	<.001
Silica as SiO2 mg/l	2.44	4.50	2.85
Sodium as Na mg/l	11.98	103.00	22.69

Ford Chemical
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Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

CERTIFICATE OF ANALYSIS

79-005384

	#105 001 EAST SPRING 7/4/79	#106 041 QUITC HPAH CRK AB NO FK 7/4/79	#107 042 NO. FK.QUITCH PAH 7/4/79
Sulfate as SO4 mg/l	21.0	260	78.0
Suspended Solids mg/l	9.0	5.0	45.0
Total Dissolved Solids mg/l	260	631	299
Total Kjeldahl Nitrogen mg/l	.22	.20	.30

FORD CHEMICAL LABORATORY, INC.

DRAINAGE FACILITIES
AND SEDIMENT CONTROL PLAN

SOUTHERN UTAH FUEL COMPANY
MINE NO. 1

September 17, 1979

Prepared for

Southern Utah Fuel Company
P. O. Box P
Salina, Utah 84654

Prepared by

MERRICK & COMPANY
Engineers and Architects
P. O. Box 22026
(10855 East Bethany Drive)
Denver, Colorado 80222

Reference: 197-2904

merrick and company
engineers and architects

10855 east bethany drive
p.o. box 22026
denver, colorado 80222
(303) 751-0741

meeker, colorado
(303) 878-5058

crested butte, colorado
(303) 349-5313

September 17, 1979

Mr. Kerry Frame
Chief Engineer
Southern Utah Fuel Company
P. O. Box P
Salina, Utah 84654

Subject: Drainage Facilities and Sediment Control Plan for the Southern Utah Fuel Company, Mine No. 1

Dear Kerry:

Submitted herewith is a report describing our recommendations for drainage facilities at the Southern Utah Fuel Company, Mine No. 1.

We suggest collecting runoff, from the disturbed area, at the toe of the slope and piping it to a sedimentation pond. This pipe will be transitioned to an open channel in two areas to collect runoff from the two coal dumping areas.

We feel that these measures will minimize any adverse impact on East Spring Canyon resulting from operations of the Southern Utah Fuel Company, Mine No. 1.

Very truly yours,

MERRICK & COMPANY

REGISTERED PROFESSIONAL ENGINEER
No. 5016
DUANE M. JOHNSON
STATE OF UTAH

Duane M. Johnson
Utah P.E. #5016

Mark W. Glidden

MWG/kar

Site Location

The Southern Utah Fuel Company Mine Number 1 is located in Sevier County, Utah about 24 miles east of Salina. The mine lies in Section 12 of Township 22 South, Range 4 East, Utah Meridian.

Hydrology

The total upstream drainage basin contributing flows to the mine site is approximately 8 square miles in area. This basin consists of two major drainageways, Mud Spring Hollow and East Spring Canyon.

Mud Spring Hollow contributes flows from the west of the site. This drainage basin is approximately 3 square miles in area and nearly rectangular with a length of 3.3 miles and a width of 1 mile. A 10 year - 24 hour storm event for this basin results in a rainfall of 1.88 inches and a peak runoff of 147 cfs.

East Spring Canyon contributes flows from the east part of the total drainage basin. This sub basin is highly irregular in shape and has an area of 5 square miles. A 10 year-24 hour storm event results in a peak runoff of 247 cfs.

Rainfall data for this report was obtained using the NOAA Atlas for Utah (Ref. 1). The runoff for the various storms was determined by SCS procedures using rainfall and runoff curve numbers. These methods are described in References 2 and 3. The curve numbers for the various soil types used in this method were determined by talking to the soil scientist and hydrologist for the Fishlake National Forest. The Soils Map shows the various soil types and their locations. A composite curve number was obtained by taking a weighted average of the individual soil types. Reference 4 gives soils information for the basin.

Drainage Plan

Flows from the two tributary streams are diverted under the fill area by two large corrugated metal pipes. Mud Spring Hollow flows into a 42" diameter CMP. This pipe will require paving on the bottom 25% of the pipe and an addition of 4 feet to the headwall in order to pass the flow. These conclusions were arrived at using Manning's equation and nomographs to find required headwater, found in Chow's book, Reference 5, and Bureau of Public Roads publications, Reference 6.

The flows in East Spring Canyon are carried by a 72" diameter CMP. This pipe can handle the flows as well as the combined flows after the two pipes combine. This pipe will be extended to avoid having water run down the slope of the fill area.

A small interception ditch will be constructed in the maintenance road to the transformer. This ditch will divert flows from undisturbed areas to the east of the site and prevent them from passing through the disturbed area. These flows will be collected in a pipe and flow under the road and into a drainage way that will guide it to East Spring Canyon downstream of the fill area.

A water surface profile, Reference 7, has been performed to insure that no adverse effects are caused by the sedimentation pond or other work near the stream.

Sedimentation Control Plan

Sediment volume from the disturbed area was determined using the 0.1 Acre Feet/Acre criteria described in 30CFR715 and 717 as published in Federal Register, Vol. 43, No. 220 - Tuesday, November 14, 1978 and Part 817 - Permanent Program Performance Standards-Underground Mining Activities. All other designs in this plan and the drainage plan are also in accordance with these regulations.

The 0.1 Acre Feet/Acre criteria was used because no method of estimating actual sediment volume can be applied to basins as steep or long as the basins at the Southern Utah Fuel Company Mine Number 1.

Runoff from the fill area (disturbed area) as well as the tributary basin to the west is collected by an inlet structure on the fill and piped down the slope to an impact stilling basin (Reference 8) where energy is dissipated. This flow is combined with flow that runs off the slope area directly. This combination of flows is concentrated by a concrete wall and is forced into a pipe that carries it along the side of the canyon to a sedimentation pond. This pipe will be transitioned to an open channel at two locations to allow sediment and runoff from two coal slide areas to be collected and routed to the sedimentation pond. This pipe will be laid slightly below grade in an approximately 10 foot wide R.O.W. along the colluvium.

The sedimentation pond was sized to store the entire 10 year - 24 hour storm runoff and 0.1 Acre Feet/Acre of sediment from the disturbed area. The embankment will be a zoned embankment with an impervious core and rip-rap outer shell. The upstream and downstream embankment slopes are both 3 horizontal to 1 vertical. A spillway was sized to pass the 25 year - 24 hour storm with a freeboard of 1 foot above the water surface. A principle spillway was designed above the maximum volume of sediment to be expected. This is a gated outlet that will insure no runoff receives less than the required 24 hour detention time. A similar gate has been installed at the bottom of the pond to facilitate dewatering the pond after the sediment has been removed.

A complete plan set showing details and designs of all structures associated with the plan has been prepared. Hydrologic and hydraulic calculations are included in this report and follow.

REFERENCES

1. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Precipitation - Frequency Atlas of the Western United States; Volume VI - Utah; National Weather Service, Silver Springs, Maryland; 1973.

2. U.S. Department of Agriculture, Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology; SCS, August, 1972.

3. U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release No. 55; SCS, January, 1975.

4. Fishlake National Forest, Land Systems Inventory, Salina Planning Unit, Fishlake National Forest, Richfield, Utah, A Basic Inventory for Planning and Management; Fishlake National Forest, Richfield, Utah, 1975.

5. Chow, Ven Te, Open-Channel Hydraulics; McGraw-Hill Book Company; 1959.

6. U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Engineering Circulars No.'s 5 and 10; Bureau of Public Roads; April, 1964.

7. U.S. Army, Corps of Engineers, HEC-2 Water Surface Profiles, Users Manual; Hydrologic Engineering Center; October, 1973.

8. U.S. Department of the Interior, Bureau of Reclamation, Design of Small Canal Structures; Bureau of Reclamation; 1974.

9. Environmental Protection Agency, Technology Transfer, Erosion and Sediment Control, Surface Mining in the Eastern U.S., Vol. 2; E.P.A.; October, 1976.

10. U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, Bureau of Reclamation, 1974.

APPENDIX

HYDROLOGIC AND HYDRAULIC CALCULATIONS

DESCRIPTION OF TABLES

TABLE 1: BASIN TOPOGRAPHIC CHARACTERISTICS

This table gives various quantifiable values for each of the drainage sub-basins.

These values are used to determine factors used in SCS Technical Release No. 55, Table 5-3, specifically T_t and Time of Concentration.

Time of Concentration (T_c) is defined as the time it takes for rainfall hitting the farthest point in the basin to reach the bottom point in the sub-basin. This value is based on length, slope and type of flow.

Time of Travel (T_t) is defined as the time it takes flow to reach the design point from the bottom of the sub-basin. The design point is the upstream end of the mine site.

TABLE 2: HYDROGRAPH AT A GIVEN TIME (CSM/IN)

This table gives the hydrographs for each basin in cfs/sq. mi/in. These values are interpolated from Table 5-3 of TR55.

These values are then used in the equation $q=q_pAQ$ where q is the discharge at a given time, q_p is the interpolated value given in this table, A is the area of the sub-basin in square miles and Q is the runoff in inches based on the curve number and the rainfall event.

TABLES 3, 4 & 5:

These tables give peak flow hydrographs for each sub-basin in cfs for the 10, 25 and 100-year storm respectively. They also total the flows at both the upstream end of the site and the junction with Convulsion Canyon. A conservative value of flow at the mine site plus DWN 1 is used for the hydrograph at the junction.

TABLE 6:

This table gives summaries of the peak flows in CFS and volumes of sediment and runoff in Acre Feet for the 10, 25 and 100-year - 24 hours storm events.

HYDROLOGIC CALCULATIONS

The SCS Runoff Curve Number Method was used to determine the runoff for the 10, 25, and 100-year 24 hours storm events. This method is outlined in the SCS publications, Section 4, Hydrology and Technical Release 55. The rainfall was determined using the NOAA Atlas 2, Vol. VI Utah. Curve Numbers were determined after conversations with the staff Hydrologist and Soil Scientist at the Fishlake National Forest. The values for different soils types (outlined on Soils Map) were averaged to determine the composite Curve Number.

The drainage basins are shown on the enclosed Drainage Basin Map. The sediment producing areas are outlined on the Plan Views included in the plan set. Because of the steepness of the sediment producing areas, the Universal Soil Loss Equation was deemed unsatisfactory, and .1 Acre Feet/Acre of sediment from the disturbed area was used to calculate the sediment storage required.

DATA DERIVED FROM	NOAA Atlas 2 Precipitation-Frequency Atlas of the Western United States Volume VI - Utah U. S. Department of Commerce NOAA 1973
AREA OF BASIN	8.1 square miles

POINT RAINFALL VALUES

2 yr. - 6 hr.	.875 in.
100 yr. - 6 hr.	1.94 in.
2 yr. - 24 hr.	1.18 in
100 yr. - 24 hr.	2.90 in.

CONVERSION FACTOR FOR AREAL CORRECTION FOR ENTIRE BASIN

.99

2 yr. - 24 hr.	1.17 in.
100 yr. - 24 hr.	2.87 in.

From Figure 6:

10 yr. - 24 hr.	1.88 in.
25 yr. - 24 hr.	2.25 in.
50 yr. - 24 hr.	2.60 in.

TABULAR RAINFALL - 24 HR. STORM

Event	Depth
2	1.17
10	1.88
25	2.25
50	2.60
100	2.87

LANDTYPE	AREA	1 PERCENTAGE	2 CN	1x2
11	1.00	.12	50	6.00
15	4.15	.51	75	38.25
20	1.75	.22	78	17.16
21	0.25	.03	70	2.10
22	0.86	.11	70	7.70
23	0.09	.01	85	0.85
CN				72.06

USE CN 72

TABLE 1

BASIN TOPOGRAPHIC CHARACTERISTICS

Basin	Area	Lolf	Solf	Volf	Tolf	Lch	Sch	Vch	Tch	T_c sec/hr	T_t Mine
MSH1	3.08	1600	.20	4.0	400	18900	.06	3.0	6300	6700/1.9	0
ESC1	1.39	4400	.07	2.4	1830	11400	.04	2.5	4750	6580/1.8	.68
ESC2	1.63	2200	.35	5.5	400	7300	.05	2.7	2700	3100/.86	.68
ESC3	0.30	2700	.25	4.5	600	4000	.07	3.3	1210	1810/.50	.34
ESC4	0.72	4200	.11	3.0	1400	6200	.09	3.7	1680	308/~~.86~~ .086	.34
ESC5	0.80	1600	.22	4.3	370	9200	.11	4.1	2240	2610/.72	0
DWN1	0.12	2500	.41	5.8	430	1900	.15	4.8	400	830/.23	-
TOTAL	8.04										

Basin

MSH	Mud Spring Hollow
ESC	East Spring Canyon
DWN	Downstream Basin

Area

Drainage Sub Basin Area in Square Miles

Lolf

Length of Overland Flow to Channel (Ft)

Solf

Slope of Overland Flow to Channel (Ft/Ft)

Volt

Velocity of Overland Flow Based on Slope and Land Cover from SCS TR55 (Ft/Sec)

Tolf

Time of Overland Flow Travel Lolf/Volf (Sec)

Lch

Length of Flow in Channel to Bottom of Basin (Ft)

Sch

Slope of Channel from Beginning to Bottom of Basin (Ft/Ft)

Vch

Velocity of Flow in Channel Based on Slope and Channel Form (Ft/Sec)

Tch

Time of Travel in Channel. Lch/Vch (Sec)

T_c

Time of Concentration for Sub Basin. Tolf + Tch. Time for Rainfall Striking Furthest Point in Basin to Reach Bottom of Sub Basin. (Sec and Hr)

T_t Mine

Time of Travel of the Flood Wave from Bottom of Sub Basin to Top of Mine Site (Hr)

RUNOFF INFORMATION

CN Information based upon information obtained from Fishlake National Forest's Hydrologist and Soil Scientist as well as Engineer's Field Inspection.

CN = 72 (CN = 80 for Disturbed Area)

Event	Rainfall	Runoff	Disturbed Runoff
2 yr.	1.17	0.03	0.14
10 yr.	1.88	0.24	0.49
25 yr.	2.25	0.40	0.72
50 yr.	2.60	0.58	0.96
100 yr.	2.87	0.74	1.16

Runoff Determined from NEH Section 4

TABLE 2

HYDROGRAPH AT A GIVEN TIME (CSM/IN)

BASIN	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0
MSH1	32	42	55	72	91	109	130	148	167	179	187	194	199	192	171	123	88	64
ESC1	12	14	17	22	28	38	49	63	80	98	117	135	151	175	194	169	123	86
ESC2	18	20	26	35	51	74	107	146	187	225	255	276	283	268	208	115	69	48
SEC3	44	74	131	214	299	363	389	380	347	305	260	219	183	129	84	53	41	34
ESC4	30	43	66	102	148	198	244	279	298	302	293	275	252	201	139	83	53	41
ESC5	103	174	263	342	383	388	364	318	269	226	190	161	138	104	74	50	39	33
DWN1	454	733	646	457	283	194	152	129	110	90	78	73	69	58	50	40	34	29

TABLE 3

10 YR. FLOW HYDROGRAPHS (CFS)

BASIN	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0
MSH1	24	31	41	53	68	81	96	109	124	132	139	143	147	142	126	91	65	47
ESC1	4	4	5	7	10	12	16	21	27	33	39	45	51	59	65	56	41	28
ESC2	7	8	10	13	20	29	42	57	73	88	100	108	111	105	82	45	27	19
ESC3	4	5	10	15	21	26	28	28	25	22	19	16	13	9	6	4	3	3
ESC4	5	7	12	18	26	34	42	48	53	53	51	47	44	35	24	14	9	7
ESC5	20	34	51	66	74	75	70	61	52	44	36	31	27	20	14	10	7	6
ESC Peak												247						
Total to Mine	64	89	129	172	219	257	294	324	353	371	384	390	393	350	317	220	152	110
DWN1	13	21	19	13	8	6	4	4	4	3	3	2	2	2	1	1	1	1
Total to Junction	77	110	148	185	227	263	298	328	357	374	387	392	395	352	318	221	153	111

TABLE 4

25 YR. FLOW HYDROGRAPH (CFS)

BASIN	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0
MSH1	39	52	68	89	112	135	169	183	205	221	230	239	<u>245</u>	236	211	152	108	79
ESC1	6	8	9	12	15	21	27	35	45	55	65	75	84	97	108	94	68	48
ESC2	12	13	17	23	34	48	70	95	122	146	166	180	185	175	135	75	45	31
ESC3	5	9	15	25	35	44	46	45	42	36	31	26	22	15	10	6	5	4
ESC4	9	13	19	29	43	57	70	73	85	87	85	79	73	58	40	24	15	12
ESC5	33	55	85	109	123	125	116	102	86	73	61	52	45	34	24	161	13	11
ESC Peak												<u>412</u>						
Total at Mine	104	150	213	287	362	430	489	533	585	618	638	651	654	615	528	367	254	185
DWN1	22	35	31	22	14	10	7	6	5	5	4	4	4	3	3	2	2	1
Total at Junction	126	185	244	309	376	440	496	539	590	623	642	655	658	618	531	369	256	186

TABLE 5

100 YR FLOW HYDROGRAPH (CFS)

BASIN	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0
MSH1	73	96	125	164	208	249	296	338	380	408	426	442	453	437	390	280	200	146
ESC1	12	14	17	23	28	39	50	65	83	101	120	139	156	180	199	174	126	88
ESC2	22	24	31	42	62	89	129	176	226	271	307	333	342	324	250	139	83	58
ESC3	9	16	29	47	66	81	86	84	77	67	58	48	41	28	19	11	9	8
ESC4	16	23	35	54	79	105	130	149	158	161	157	146	135	107	74	45	28	22
ESC5	61	103	156	202	227	230	215	188	159	134	113	95	82	62	44	29	23	20
ESC Peak												761						
Total at Mine	193	276	393	532	670	793	906	1000	1083	1142	1181	1203	1209	1138	976	678	469	342
DWN1	40	64	58	41	26	17	13	11	10	8	7	7	6	6	5	4	4	3
Total at Junction	233	340	451	573	696	810	919	1011	1093	1150	1188	1210	1215	1144	981	682	473	345

RUNOFF

Area Top of Fill (ATOF)

L = 1095

S = 15%

Vel = 4 FPS

T_c = .1 Hr.

q_p = 991

Area = 12.0 Acres = .019 Sq. Mi.

Event	Volume Ac Ft	Peak Flow CFS
10	.49	9.2
25	.72	13.6
100	1.16	21.8

Area Slope of Fill (SOF)

L = 310

S = 60%

Vel = 6.2 FPS

T_c = .1 Hr.

q_p = 991

Area = 2.5 Acres = .004 Sq. Mi.

Event	Volume Ac Ft	Peak Flow CFS
10	.10	1.9
25	.15	2.8
100	.24	4.5

DIS = ATOF + SOF

Area Tributary to Disturbed Area

Contributing Basin East (CBE)

To be Diverted Around Site by Access Road - Ditch

No Contribution to Pond

L = 1300

S = 49%

Vel = 6.5 FPS

T_c = .1 Hr.

q_p = 991

Area = 14.9 AC = .023 Sq. Mi.

Event	Peak Flow (CFS)
10	5.5
25	9.3
100	17.1

Contributing Basin West (CBW)

L = 1200

S = 68%

Vel = 7.5 FPS

T_c = .1 Hr.

q_p = 991

Area = 25.4 AC = .04 Sq. Mi.

Event	Volume Ac Ft	Peak Flow CFS
10	.51	9.5
25	.85	15.8
100	1.57	29.3

Coal Slide Areas (CSA)

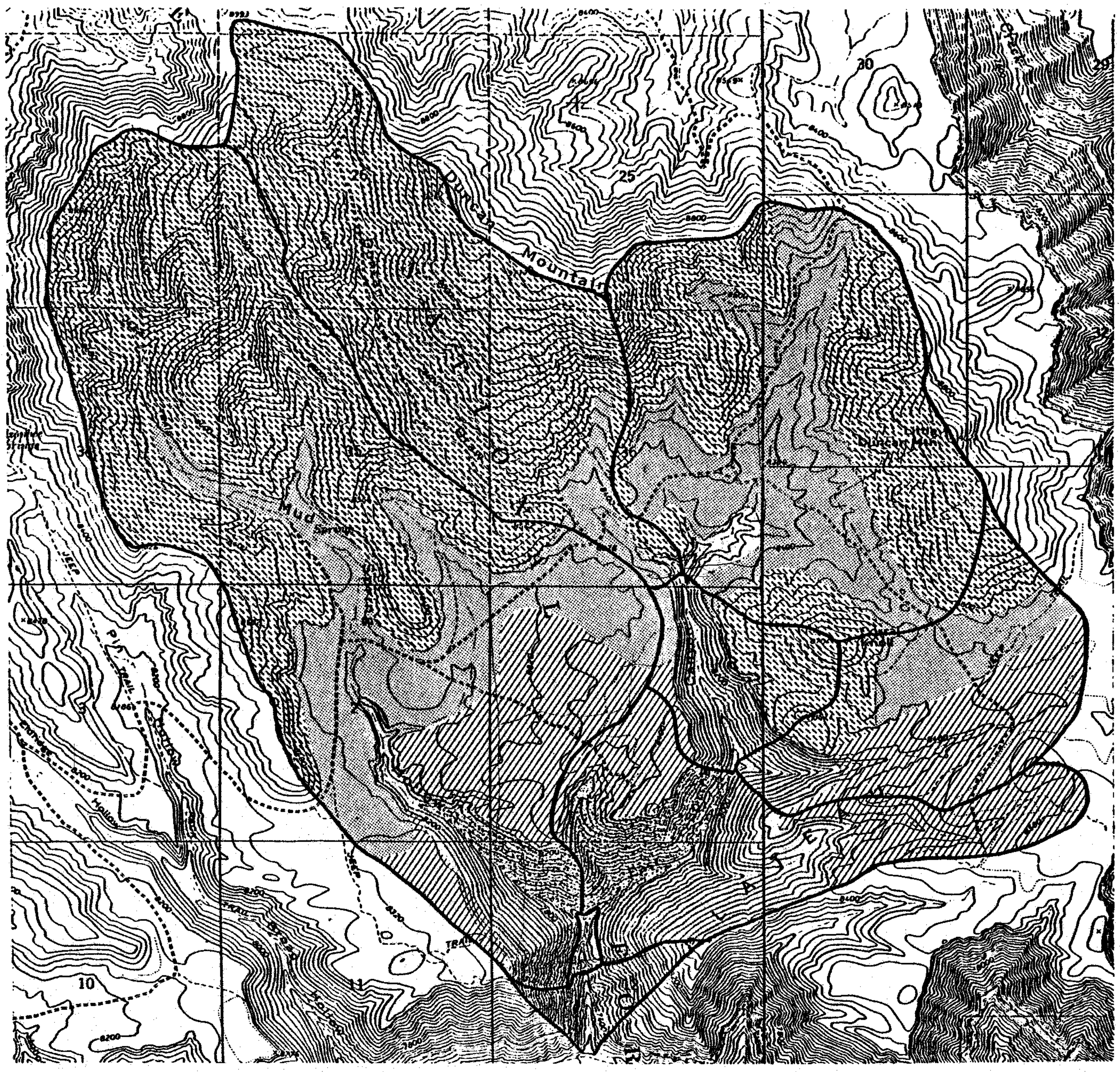
q_p = 991
Area = 2.57 AC = .004 Sq. Mi.

Event	Volume Ac Ft	Peak Flow CFS
10	.10	1.9
25	.15	2.9
100	.25	4.6

Area Tributary to Pond (ATTP)

q_p = 991
Area = 2.0 AC = .003 Sq. Mi.

Event	Volume Ac Ft	Peak Flow CFS
10	.04	.7
25	.07	1.2
100	.12	2.2



SOILS MAP

LEGEND

- (11) SANDY LOAM SURFACE; GRAVELLY LOAMY SAND SUBSTRATUM OVERLYING SANDSTONE BEDROCK
- (15) SURFACE LOAMS; SANDY LOAM SUBSURFACE
- (20) SURFACE SILT LOAMS; SUBSOILS GRAVELLY LOAMS & CLAY LOAMS
- (21) THIN LOAMY SURFACE W/STONES & COBBLES; SILTY CLAY LOAM SUBSTRATUM
- (22) LOAMY SAND TO SANDY LOAM SURFACE; LOAMY SAND SUBSTRATUM

REFERENCE: LAND SYSTEMS INVENTORY, SALINA PLANNING UNIT, FISHLAKE NATIONAL FOREST, RICHFIELD, UTAH. A Basic Inventory for Planning and Management, 1975

SEDIMENT VOLUME

Volume Sediment = .1 Ac Ft/Ac

ATOF = 12.0 x .1 = 1.20 Ac Ft

SOF = 2.5 x .1 = 0.25 Ac Ft

CSA = 2.57 x .1 = 0.26 Ac Ft

TOTAL SEDIMENT = 1.71 Ac Ft

TOTAL 10-YEAR POND VOLUME = 2.95 Ac Ft

Pond Sizing

El	Area	$\overline{Area}$	h	Vol	Total Vol	
7240	5025					
		6388	2	12775		
7242	7750				0.29	
		9125	2	18250		
7244	10500				0.71	
		12100	2	24200		
7246	13700				1.27	
		15650	2	31300		
7248	17600				1.99	
		19738	2	39475		Total Volume 2.95 Ac Ft
7250	21875				2.90	@ elevation 7250.09 ft.
		24325	2	48650		
7252	26775				4.02	

Spillway 30 Ft. Wide

$Q = CLH^{3/2}$ C = 3.0 L = 30 Q = 36.3

H = .55 ft

W.S. @ 25 Yr Flows = 7250.64 ft

Freeboard 1.36 ft

11' Crest Width

TABLE 6

PEAK FLOWS AND VOLUMES

Event	Basin	Peak Flow	Runoff Volume Ac Ft	Sediment Volume Ac Ft	Total Ac Ft
10	MSH	147			
	ESC	247			
	CBE	5.5			
	CBW	9.5	.51		
	ATOF	9.2	.49	1.20	
	SOF	1.9	.10	0.25	
	CSA	1.9	.10	0.26	
	ATTP	0.7	.04		
	Total to Pond	23.2	1.24	1.71	2.95
25	MSH	245			
	ESC	412			
	CBE	9.3			
	CBW	15.8	.85		
	ATOF	13.6	.72	1.20	
	SOF	2.8	.15	0.25	
	CSA	2.9	.15	0.26	
	ATTP	1.2	.07		
	Total to Pond	36.3	1.94	1.71	3.65
100	MSH	453			
	ESC	761			
	CBE	17.1			
	CBW	29.3	1.57		
	ATOF	21.8	1.16	1.20	
	SOF	4.5	.24	0.25	
	CSA	4.6	.25	0.26	
	ATTP	2.2	.12		
	Total to Pond	62.4	3.34	1.71	5.05

HYDRAULIC DESIGN

There are two large pipes located under the fill which carry the 10 year - 24 hour flow under the fill. The capacity of both the inlet and pipe were determined and some improvements are required.

An existing inlet from the fill area is in place and is currently connected to the large pipes. This pipe will be detached and plugged and a new 24" diameter pipe will replace it and will be extended down the slope to a stilling basin. These flows will combine with flows generated on the slope and be concentrated into a smaller pipe to carry it to the sedimentation pond.

A diversion ditch was sized to intercept flows from undisturbed areas on the west side of the disturbed area.

All hydraulic calculations were performed using Manning's equation, the Bureau of Public Roads Publications 5 and 10, and other commonly used hydraulic equations.

Q	=	Flow cubic feet per second
A	=	Area of flow feet squared
HW	=	Head water feet
D	=	Depth feet
R	=	Hydraulic radius feet
S	=	Slope feet per foot or percent
n	=	Manning's roughness coefficient
W	=	Width feet
H	=	Head over spillway
L	=	Length
Z	=	Slope feet horizontal per 1 foot verticle
L_s	=	Length of pipe within phreatic zone
V_b	=	Bottom velocity of channel
V	=	Average velocity
D_x	=	Stone size at which x% of sample by weight is less than

A 24 inch diameter corrugated steel pipe was sized to carry flows concentrated at the toe of the fill slope to the sedimentation pond. This pipe will be placed slightly below grade and covered. It was felt this would minimize any permanent damage to the environment.

In order to collect runoff from the two coal slide areas, the closed pipe will be transitioned into one half of a 36 inch diameter corrugated steel pipe. This pipe will be transitioned, back into the closed 24 inch pipe, with a small drop to maintain the energy grade line. All calculations for the design of these structures are included in the hydraulic calculations.

HYDRAULIC CALCULATIONS

Large Pipe Flows

72" Dia	Q = 247 cfs
42" Dia	Q = 147 cfs

72" Dia Inlet
CMP
Q = 247 cfs
HW/D Req = 1.18
HW = 7.1 Ft
Available HW = 12 Ft

Capacity

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

A = 28.3 Sq Ft R = 1.5 Ft S = 0.042 Ft/Ft n = 0.027
Q = 419 cfs
Q req. after Junction = 393 cfs Good

42" Dia Inlet
CMP
Q = 147 cfs
HW/D req = 3.2
HW = 11.2 Ft
Available HW = 7.2 Ft, No Good
Add 4 Ft to headwall, continue steel and concrete

Capacity

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

A = 9.62 Sq Ft R = 0.87 Ft S = 0.07 Ft/Ft n = 0.027
Q = 128 cfs, No Good
Pave bottom 25% n = 0.023
Q = 150 cfs, Good

Top of Slope Inlet

Existing inlet HW = 18" Pipe = 12" Dia
Q = 23.2 cfs, Not enough head available

Try new 24" Dia CMP

Orifice Control
HW req = 1.14 Ft = 14", Good
Inlet Control (at bend)
HW req = 2.8 Ft = 34", Good

Pipe Sizing Along Slope

Shallowest slope 0.05
Use unpaved CMP 2-2/3 x 1/2 Corrugations
n = .024
Q = 23.2 cfs

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Size	A	R	Q		
18	1.77	0.375	15.5	No Good	
24	3.14	0.50	27.5	Good	V = 8.75 fps
21	2.41	0.44	19.3	No Good	

Q/Q Full = .84 V = 9.8 fps D = 1.23 ft

S	Q Cap	V Cap	Q/Q Cap	V	d
0.215	52.3	16.6	0.44	9.4	0.92
0.135	41.4	13.2	0.56	13.5	1.06
0.120	39.1	12.4	0.59	12.9	1.10

Open Channel Part - Collection of Coal Slide Areas

Try 1/2 - 36 inch diameter CMP @ 0.05
Q Cap = 81.0 cfs V Cap = 11.5 fps
Q/Q Cap = .29 V = 10.0 fps y = 1.11 ft

Find Drop Required at Transition from Open Channel

$E_1 = E_2\, th_L - \triangle Z$ Sta 3+79.68 to Sta 5+19.47

h_L = head loss in transition

$\triangle Z$ = drop required through transition

$$h_L = .2\left(\frac{V_2^2}{2} - \frac{V_1^2}{2g}\right)$$

$y_1 = 1.11$ ft $y_2 = 1.23$ ft

$V_1 = 10.0$ fps $V_2 = 9.8$ fps

$E_1 = 2.66$ ft $E_2 = 2.721$

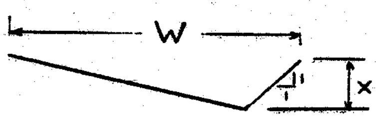
$h_L = 0.012$ ft

$\triangle Z = 0.07$ ft

Continue second pipe into pond with Class II rip-rap erosion layer

Interception Ditch (Access Road to Transformer)

Q = 6.2 cfs W = 12 ft
S = 1.1% Minimum
Design as triangular open channel



$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2} \qquad n = 0.035$$

what slope?
Back calc. to 1.1%

X	A	R	Q	
1	6	0.46	16	
0.7	4.2	0.34	9.2	
0.6	3.6	0.29	7.1	Good use this

Berm on Fill Area

Prevents flow from going down fill slope

Top Width = 4 ft
Side Slopes 3:1
Height = 1 ft

Spillway Sizing (Sedimentation pond)

Q = 36.3 cfs   25 yr - 24 hr flow

$Q = CLH^{3/2}$ C = 3.0   L = 30 ft

H = .55'

Anti-Seep Collars

L = 63 ft   outlet pipe
S = 5%
y = 5 ft   head above inlet to pipe
Z = 3   upstream embankment slope

$$L_s = y\,(Z + 4)\left[1 + \frac{S}{0.25 - S}\right] = 44'$$

Anti-Seep Collar size = 3'-4" x 3'-4" with 3 collars
space collars at 8'cc

Rip-Rap Sizing in East Spring Canyon

V_b = 9.81 (based on velocity and depth in natural stream)

D_{50} req = 15"   Class II Rip-Rap

Filter Sizing

Existing Soil

$d_{85} = 0.37$ mm

$d_{50} = 0.135$ mm

$d_{15} = 0.017$ mm

Filter Layer 1

$DF_{1\,15} \leq 5d_{85}$	$DF_{1\,15} \leq 1.85$ mm	$DF_{1\,15} = 0.50$ mm
$DF_{1\,15} \geq 5d_{15}$	$DF_{1\,15} \geq 0.085$ mm	$DF_{1\,50} = 1.50$ mm
$DF_{1\,50} \leq 25d_{50}$	$DF_{1\,50} \leq 3.38$ mm	$DF_{1\,85} = 3.50$ mm
$DF_{1\,15} \leq 40d_{15}$	$DF_{1\,15} \leq 0.68$ mm	

Filter Layer 2

$DF_{2\ 15} \leq 17.50$ mm	$DF_{2\ 15} = 7.0$ mm
$DF_{2\ 15} \geq 2.50$ mm	$DF_{2\ 50} = 23.0$ mm
$DF_{2\ 50} \leq 37.50$ mm	$DF_{2\ 85} = 55.0$ mm
$DF_{2\ 15} \leq 20.00$ mm	

Rip-Rap Limits

$RR_{15} \leq 275$ mm

$RR_{15} \geq 35$ mm

$RR_{50} \leq 575$ mm

$RR_{15} \leq 280$ mm

Stilling Basin for Pipe from top of fill

Q = 23.2 cfs in 24" Dia CMP
S = 51% Down Face of Slope
S = 15% Final 30' into stilling basin

$Q\ Cap = \frac{1.49}{n} AR^{2/3} S^{1/2}$ n = 0.027 A = 3.14 Ft^2 R = 0.5 Ft S = 0.15

Q Cap = 42.3 cfs V Cap = 13.5 fps
Q/Q Cap = .55 V = 13.9 fps y = 1.1 ft

Froude number = $V/\sqrt{gd}$

where $V = \sqrt{2gh}$

g = acceleration of gravity

h = head loss required

d = A

$V = \sqrt{2g\ (4.1)} = 16.2$

$\sqrt{gd} = \sqrt{g(1.77)} = 7.6$

F = 2.15

W/d = 4.4

W = 7.8 ft - use W = 8 ft

Use Type 5 baffled outlet 103-D-1344

SOUTHERN UTAH FUEL COMPANY

MINE PLAN ADDENDUM

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