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

FOR:

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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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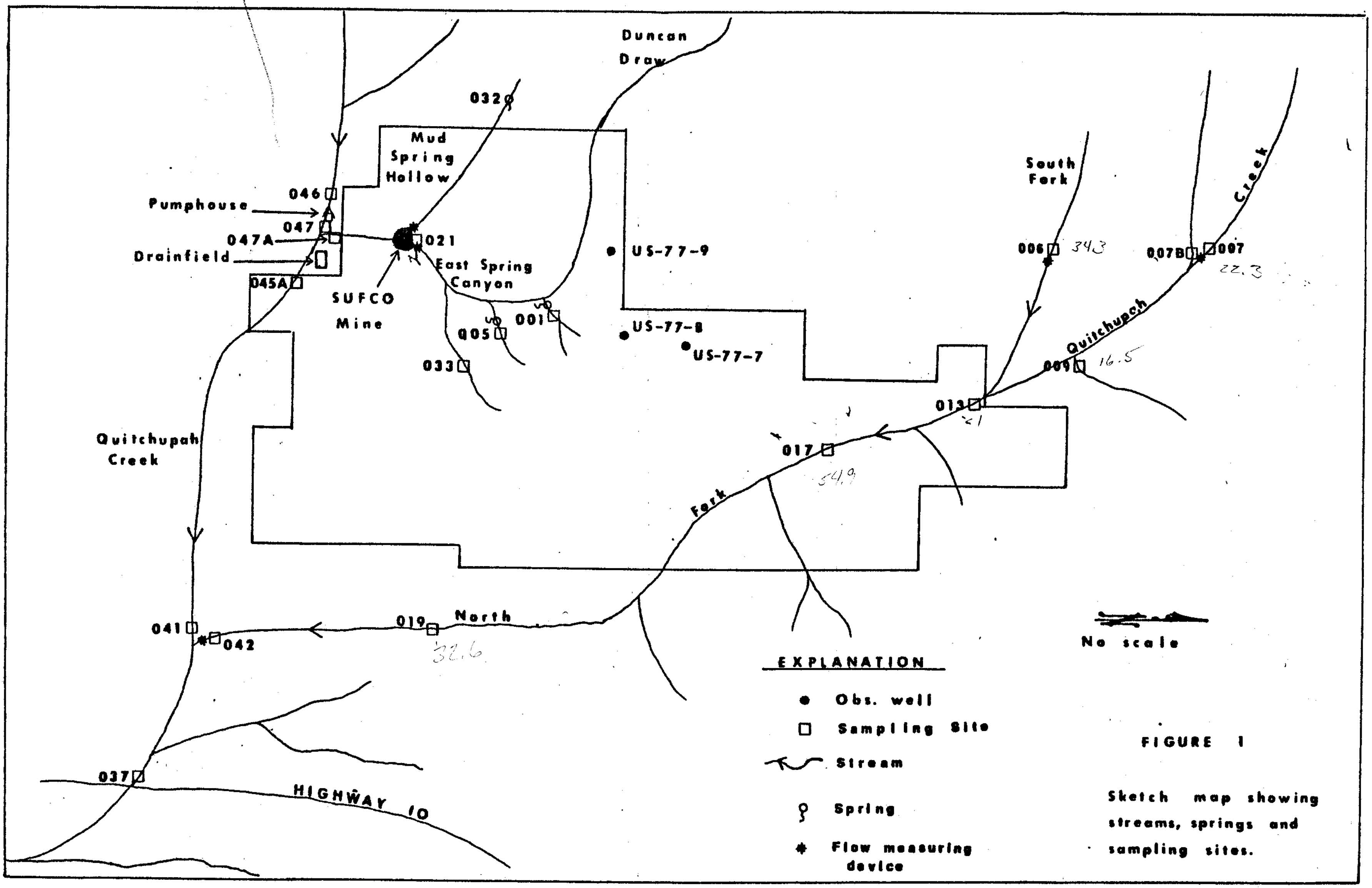
Site No.	Site Description*	Sampled	1978 Flow	1978 Method Measured	Sept. 1977 Flow**
021	SUFCo No. 1 mine effluent	6-05-78	280±gpm	VOLUME/TIME	Not Meas.
021	SUFCo No. 1 mine effluent	9-26-78	315±gpm	VOLUME/TIME	Not Meas.
033	Seep in tributary of E. Spring Canyon	6-04-78	.8±gpm	Estimate	Dry
041	Quitchupah 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



Duncan Draw
032
Mud Spring Hollow
046
Pumphouse
047
047A
021
Drainfield
045A
SUFCO Mine
East Spring Canyon
005
001
033
US-77-9
US-77-8
US-77-7
South Fork
006
343
007B
007
22.3
Creek
Quitchupah
009
16.5
013
<1
017
54.9
Fork
Quitchupah Creek
041
042
019
32.6
North
037
HIGHWAY 10
No scale
EXPLANATION
Obs. well
Sampling Site
Stream
Spring
Flow measuring device
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^{o} V-notch will accurately measure a minimum low of about .004 cfs. Installation details are shown in Appendix A. The 90^{o} 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

Table 3

Site No.	Site Description*	Date Sampled	Flow	Spec. Cond. (umhos/cm)	pH	Temp. oC
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	385 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.

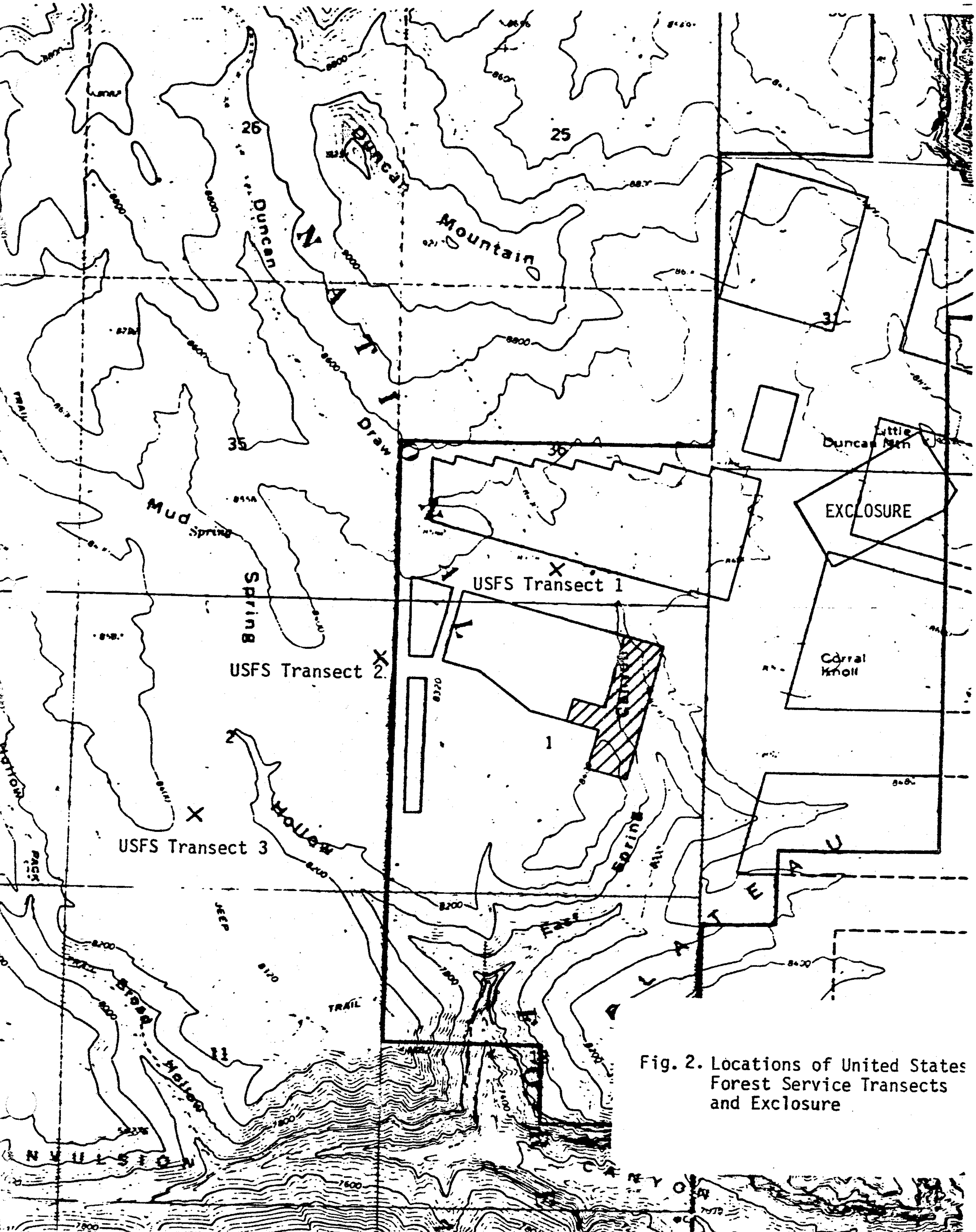


Fig. 2. Locations of United States Forest Service Transects and Exclosure

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	Percent Composition: Outside (F 409)	Percent Composition: Inside (F410)	Percent Composition: Average (Weighted)
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:

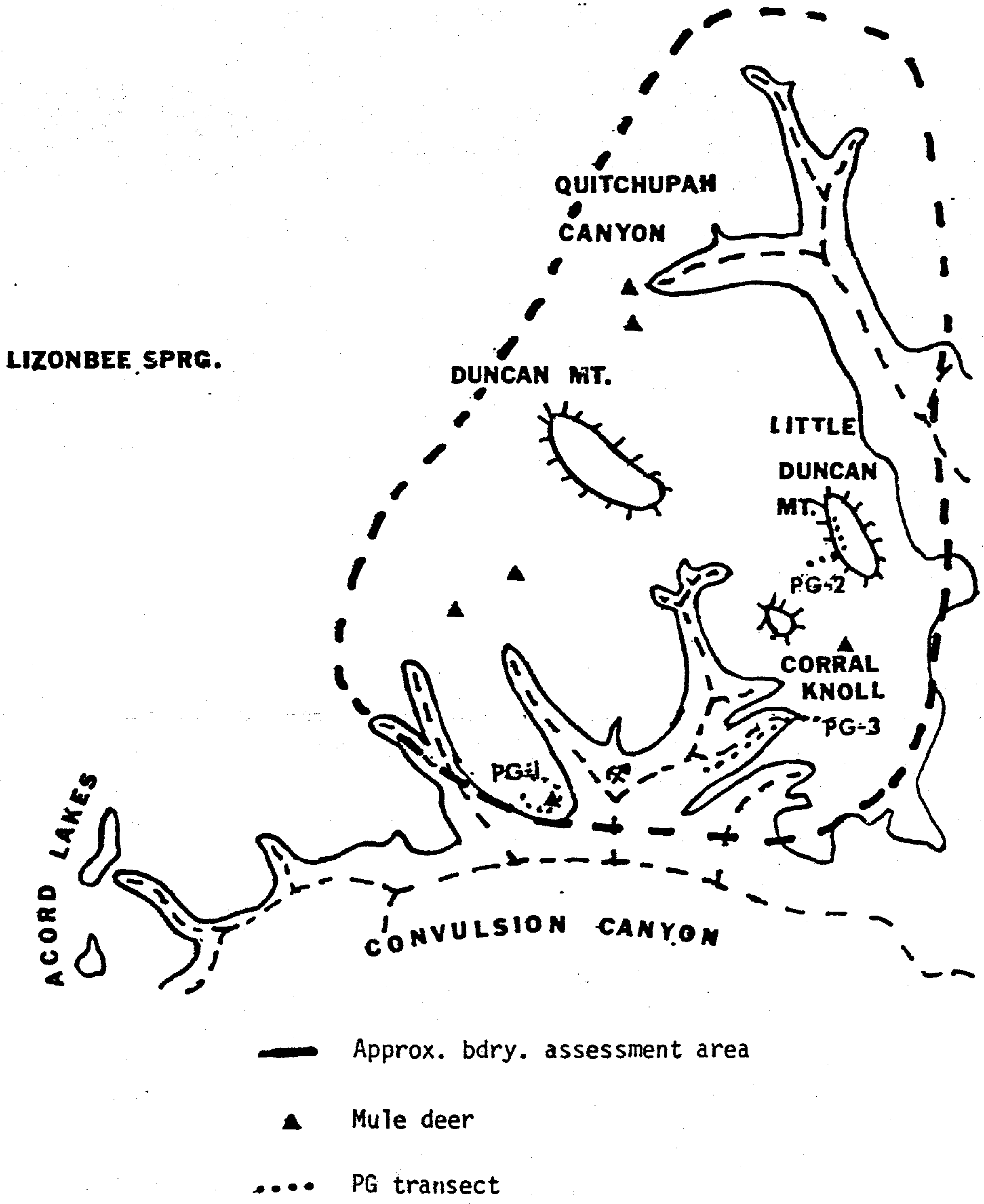


Fig. 3. SUFCo mine wildlife assessment area, August 29-30, 1978.

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 (<u>Artemesia tridentata</u>) and low sagebrush (<u>Artemesia arbuscula</u>), with bitterbrush (<u>Prushia tridentata</u>) and rabbitbrush (<u>Chrysothamnus spp</u>.) often abundant. Common grasses and grass-like plants in this type include slender wheatgrass (<u>Agropyron trachycaulum</u>), western wheatgrass (<u>A. smithii</u>), 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).

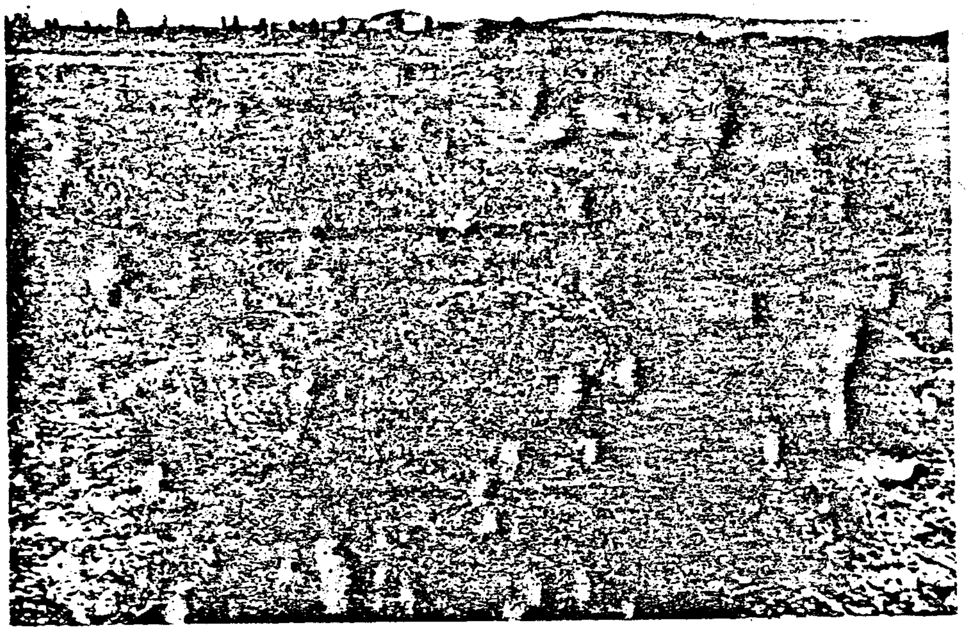


Fig. 4. Sagebrush/grassland community in the Sagebrush/grass and Ponderosa pine landform.

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 sagebrush/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.

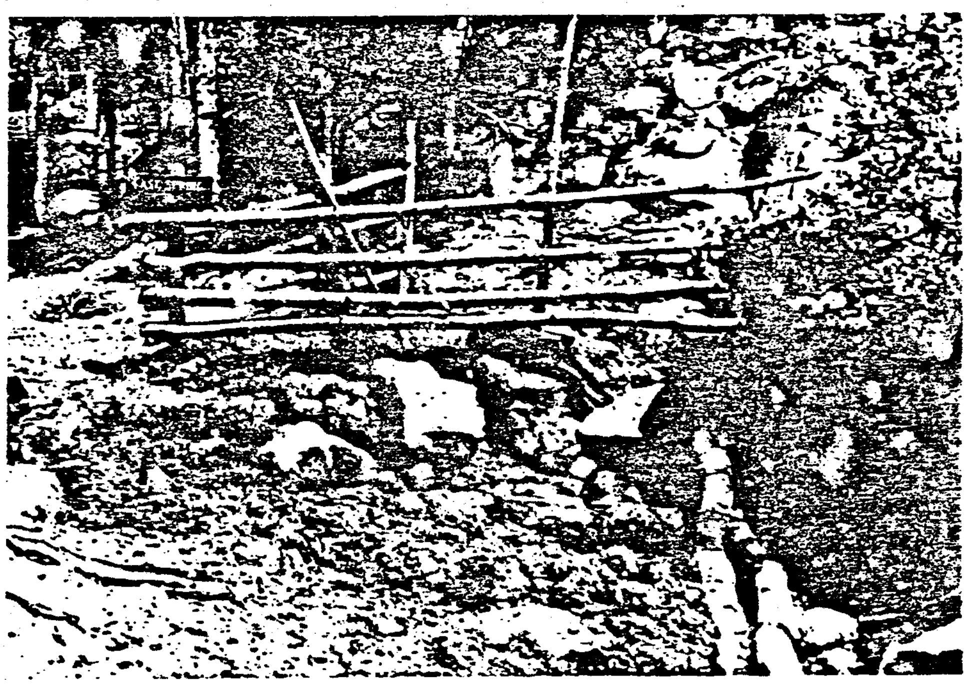


Fig. 7. Developed spring in canyon bottom showing absence of understory.

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).

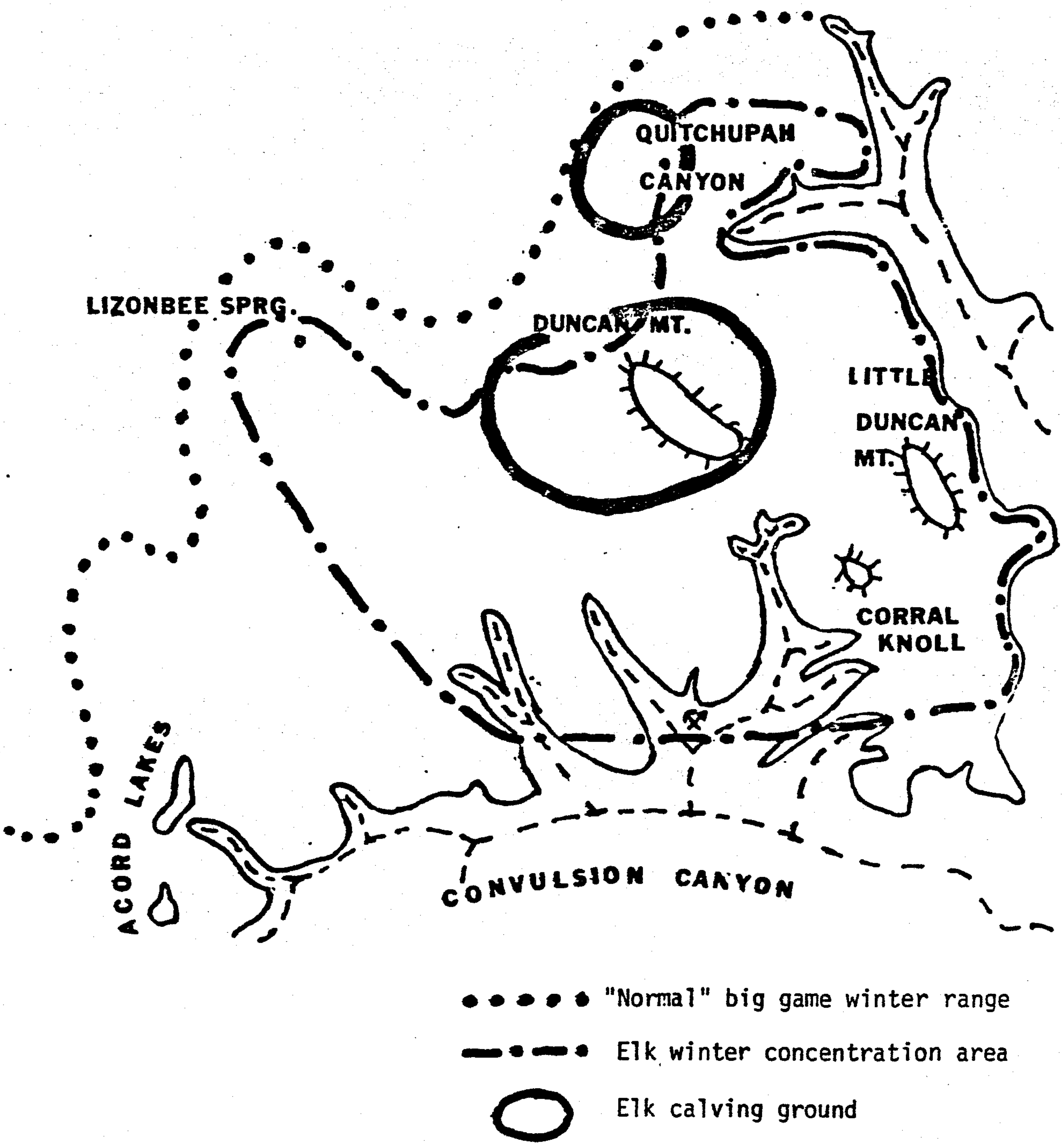


Fig. 9. Big game use areas in the mine assessment area (adapted from U.S. Forest Service, 1976).

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.

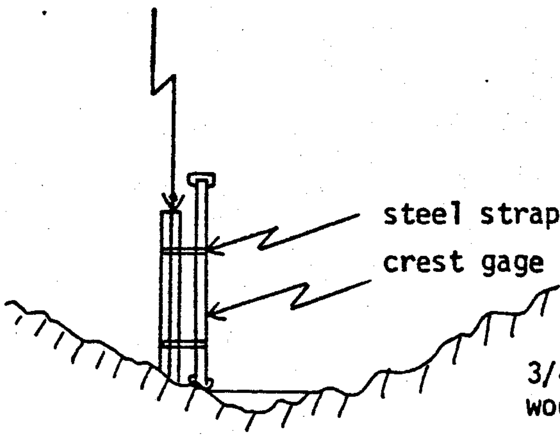
(4) Competition with cattle. Several studies (Lonner, 1975) have suggested that elk and cattle are socially incompatible. Others (Bickford and Reed, 1943; Stevens, 1966) have indicated that elk, deer and cattle may compete for food items. If cattle are the predominant users of water at springs and seeps,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

E. Mitigations

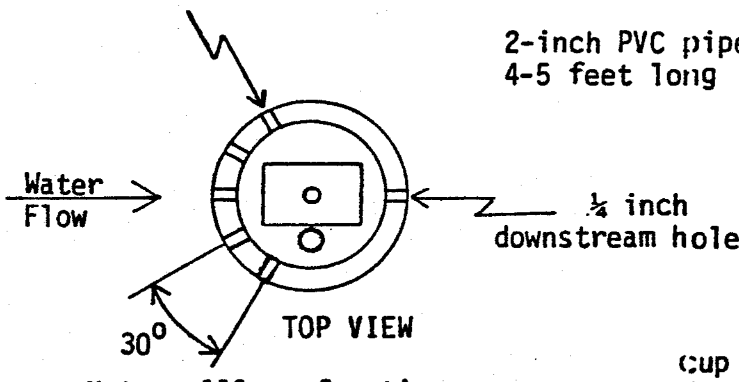
Suggested mitigations are identical to those recommended in 1977 (WESTECH, 1977) for combined impacts to hydrology, vegetation and wildlife.

VI. APPENDICES

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

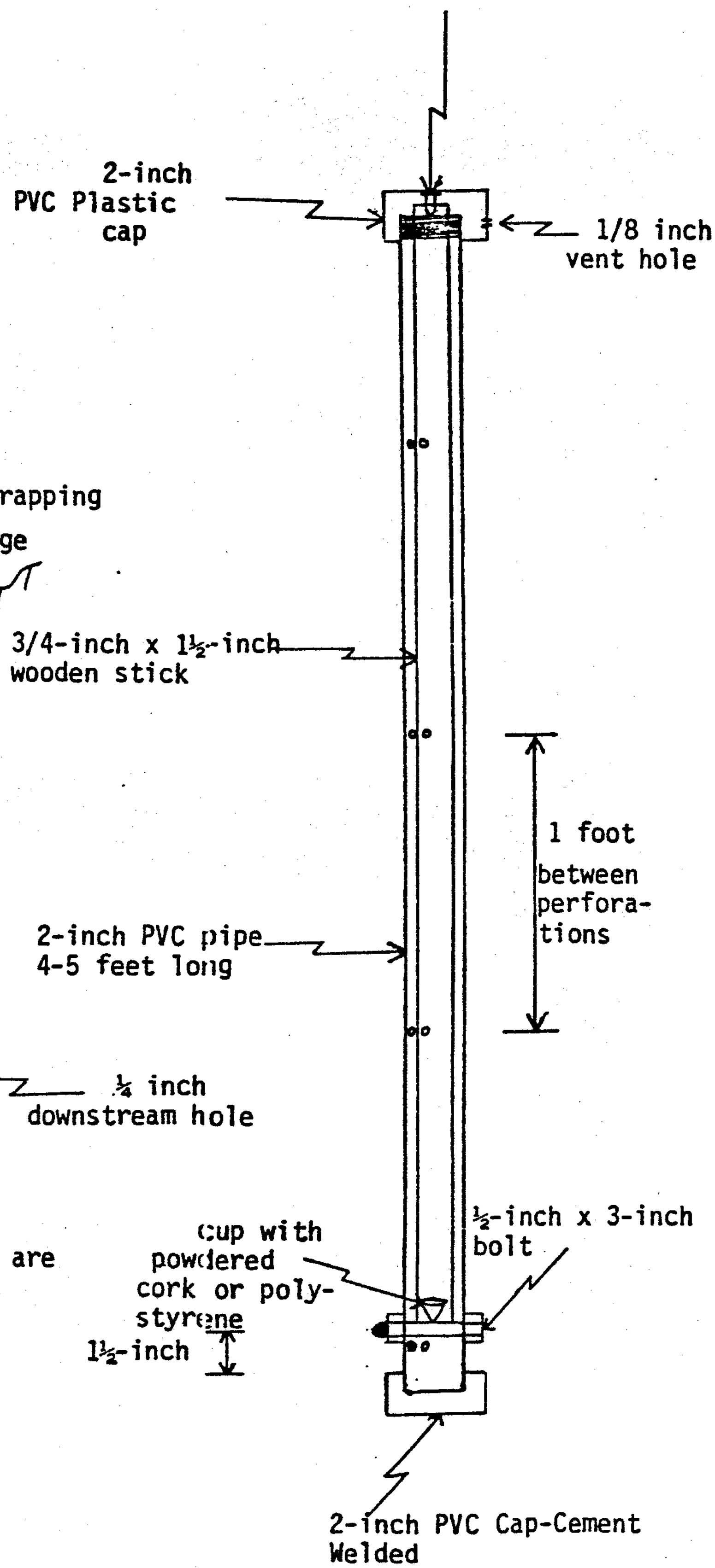


TYPICAL
CREST GAGE
INSTALLATION DETAIL



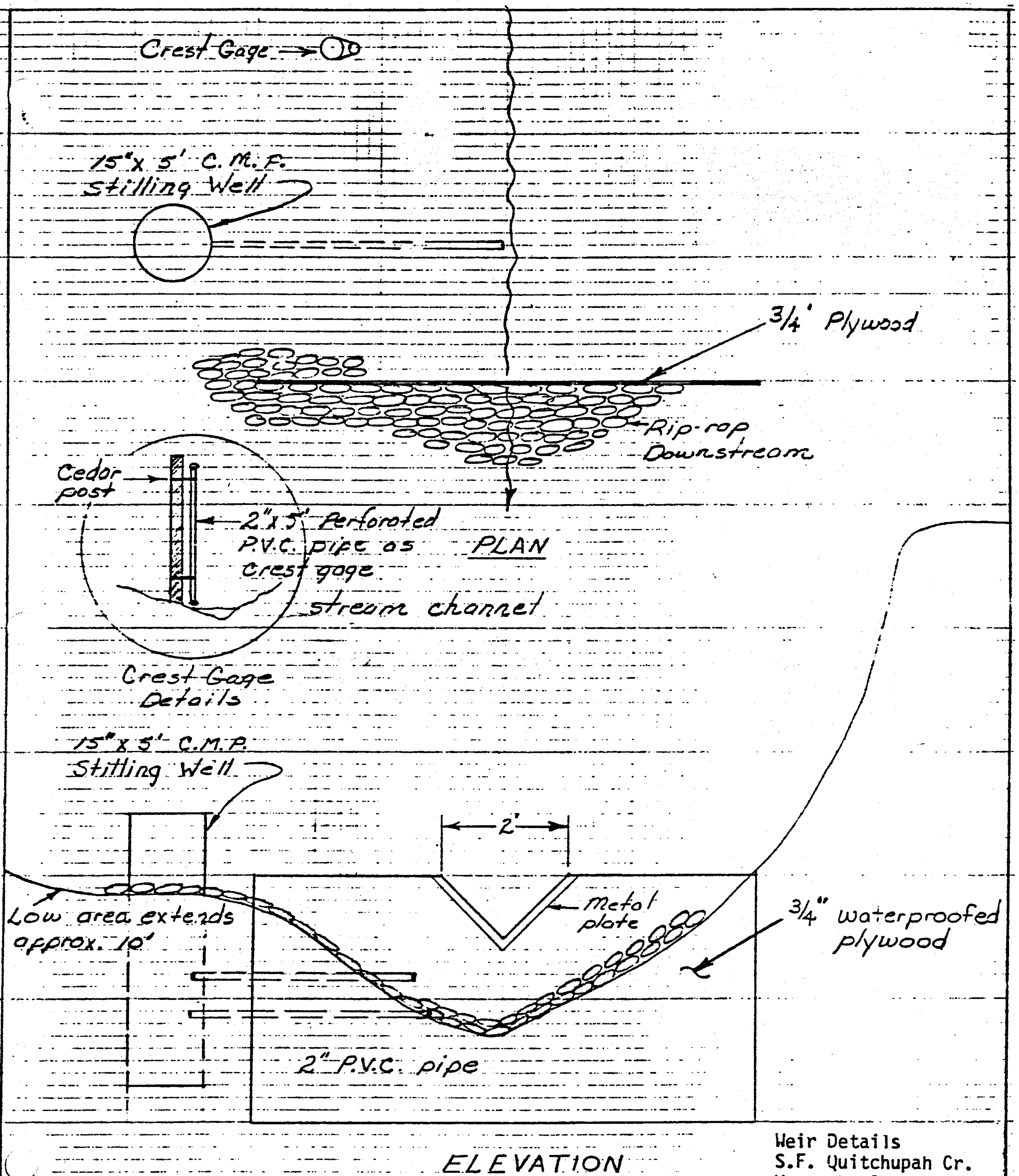
TOP VIEW

Note: All perforations are ¼-inch diameter

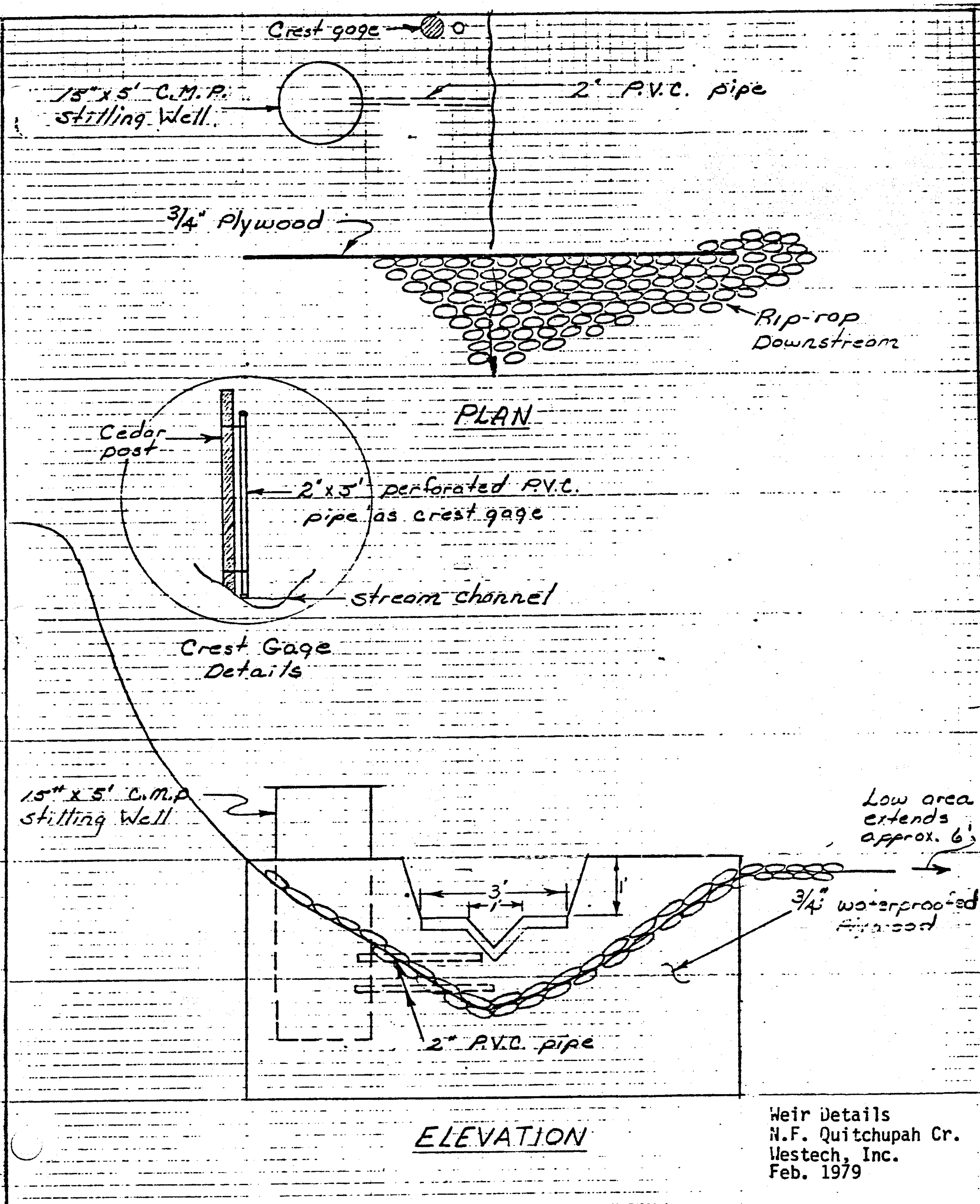


CROSS-SECTION

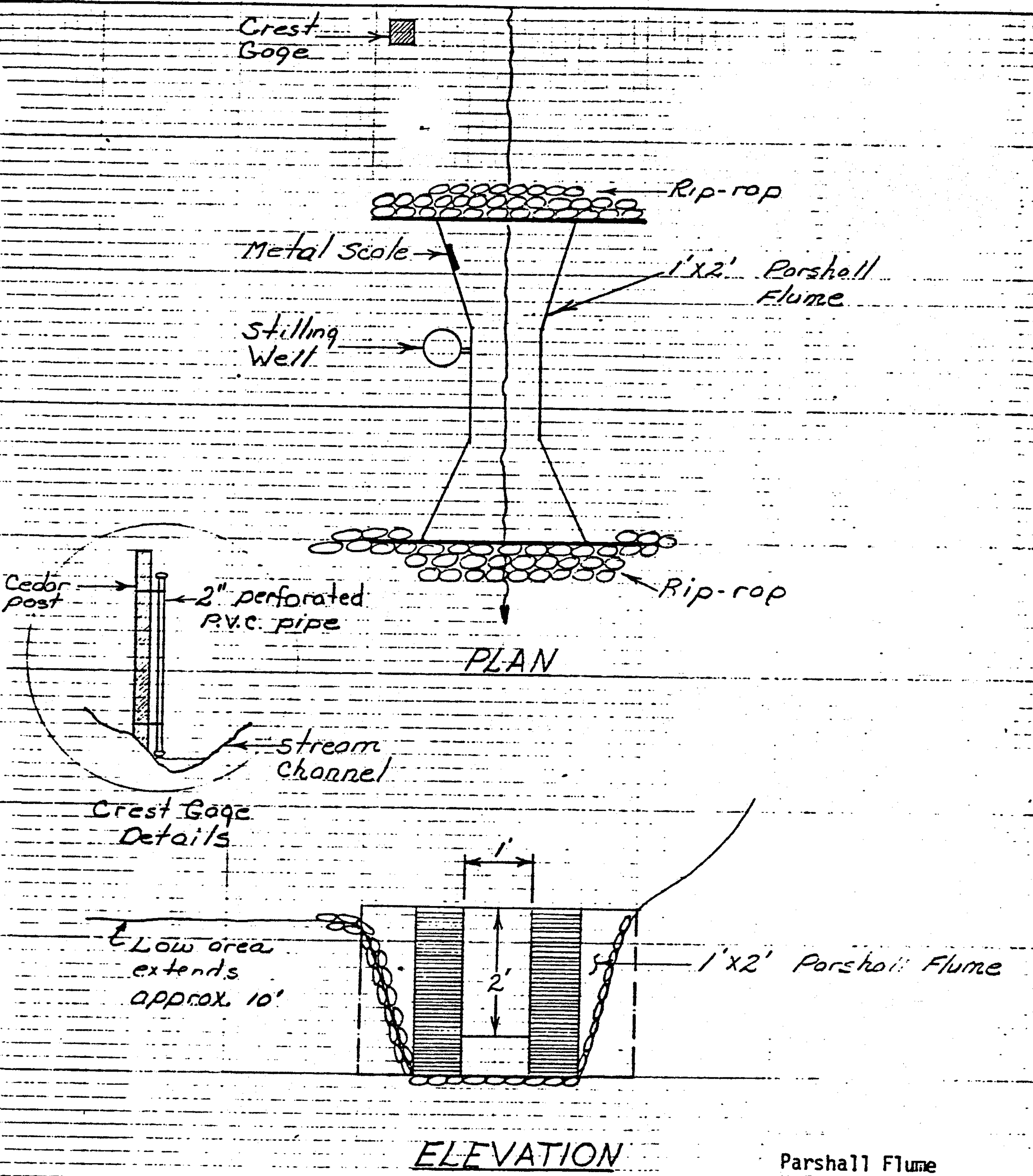
Crest Gage Construction Detail



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



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

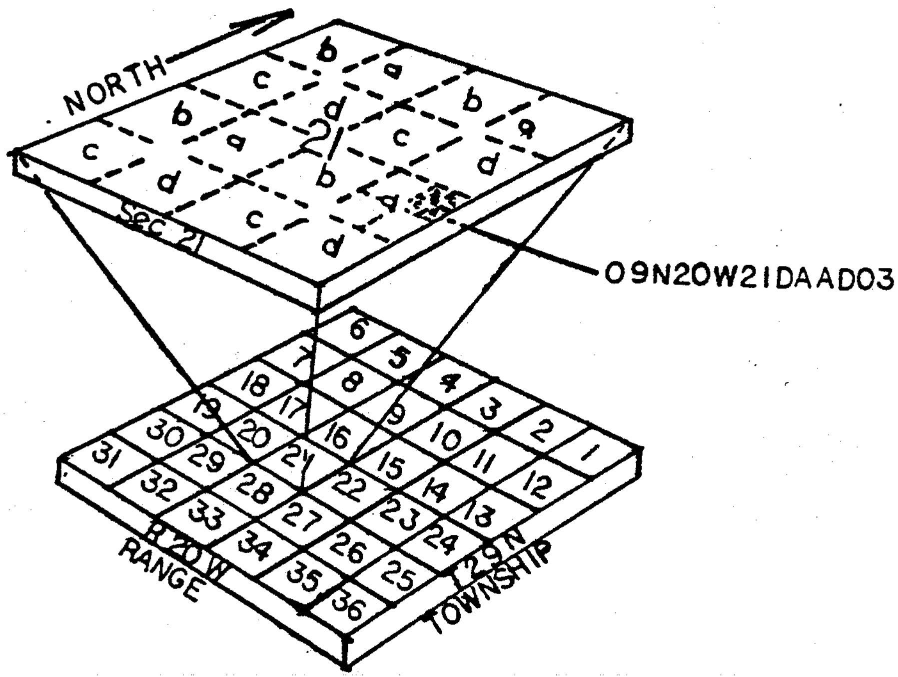


Parshall Flume
N.F. Quitchupah Cr.
Westech, Inc.
Feb. 1979

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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