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HYDROLOGIC INVENTORY OF
THE SOLDIER CANYON MINE LEASE AND ADJACENT AREAS,
CARBON COUNTY, UTAH

Prepared for
SOLDIER CREEK COAL COMPANY
Price, Utah

JANUARY, 1980



CONSULTANTS/ENGINEERS
**VAUGHN
HANSEN
ASSOCIATES**
SALT LAKE CITY, UTAH

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INTRODUCTION

Regulations, established by the U.S. Office of Surface Mining Reclamation and Enforcement (OSM) (Volume 44, Number 50 of the Federal Register, dated Tuesday, March 13, 1979), require that water monitoring programs be established to monitor the hydrologic impacts to areas affected by underground coal mining activities and to protect the hydrologic balance of such areas. As a result, a hydrologic investigation has been conducted on the 1707 acre lease area owned by Soldier Creek Coal Company. The lease area is located north and east of Price, Utah in the Book Cliffs (see Figure 1). The purpose of this report is to describe the existing hydrologic conditions of the lease area and to propose a program to predict and monitor the impacts from mining.

This report contains a description of the hydrologic environment; a description of the surface water hydrologic system of the Soldier Canyon Mine lease and adjacent areas, with the during and the post-mining monitoring program; and a description of the groundwater hydrologic system and associated monitoring program.

Vaughn Hansen Associates of Salt Lake City has been responsible for the collection and interpretation of hydrologic data. Water quality

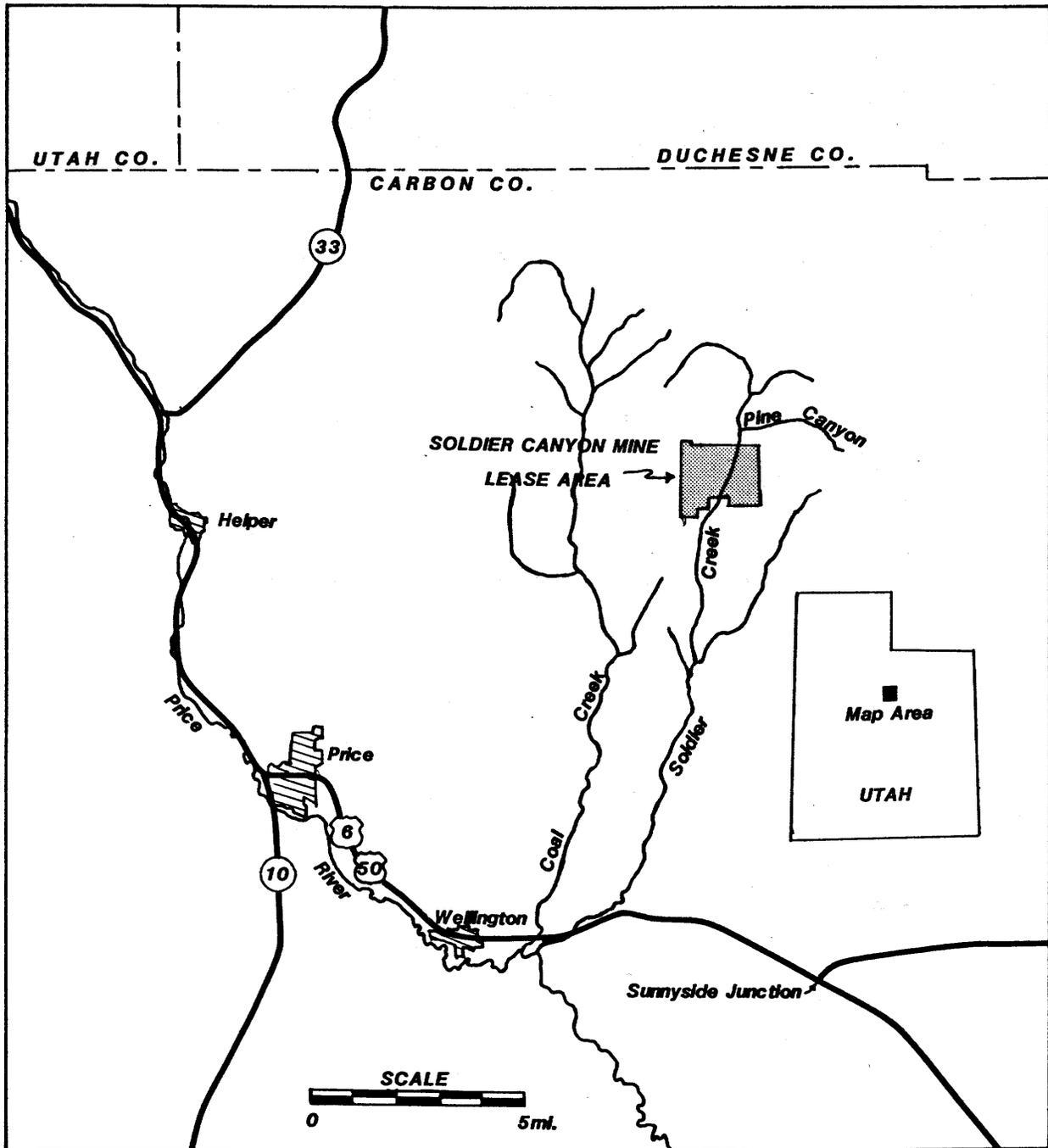


Figure 1. Location of the Soldier Canyon Mine lease area.

samples have been analyzed by Ford Chemical Laboratory, Inc. of Salt Lake City, Utah. Hydrologic data were gathered from September to October of 1979, and the methodologies used to collect and analyze the data are described in the appropriate sections of this report.

HYDROLOGIC ENVIRONMENT

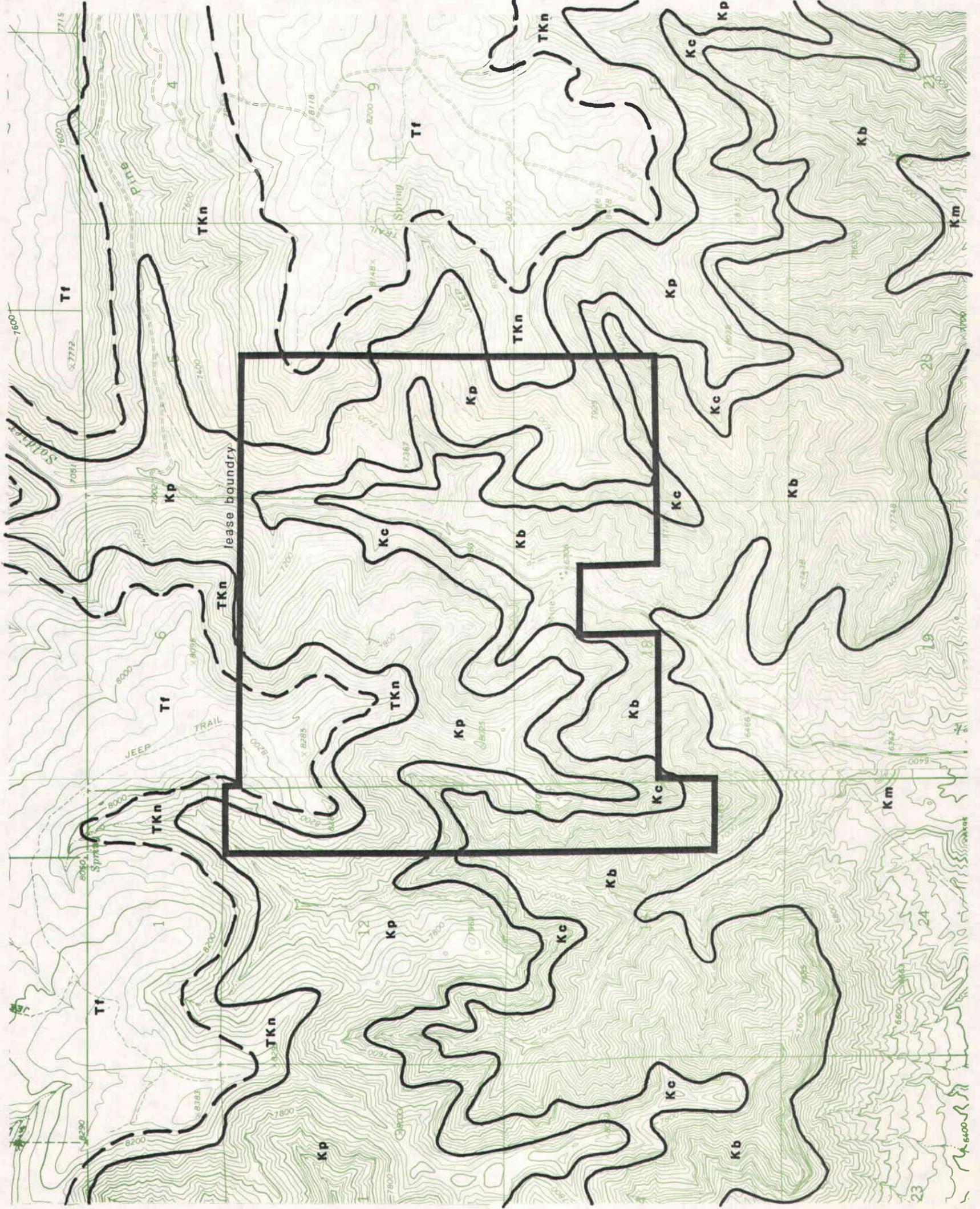
Geology, soils, climate and vegetation are variables that influence the hydrologic response of an area. These variables, as they pertain to the hydrologic environment of the Soldier Canyon Mine lease area, are described in the following sections of this report.

Geology

The Soldier Canyon Mine lease area is located within the Book Cliffs coal field, which extends from the Utah-Colorado state line to Castle-gate, Utah. The general dip of the strata in the vicinity of the lease area is to the north and east at approximately 11 percent (6 degrees) (Doelling, 1972). The strike of the strata coincides in general with the trend of the cliffs (Spieker, 1925).

Geologic formations exposed within the lease area are the Blackhawk and Price River formations of the Mesaverde Group and the North Horn and Flagstaff formations of the Wasatch Formation (see Figures 2 and 3).

Blackhawk Formation. The Blackhawk Formation, which directly overlies the Mancos Shale in the vicinity of the Soldier Canyon Mine (Doelling, 1972), is the middle and coal bearing unit of the Mesaverde Group. The Blackhawk consists of a basal sandstone (the Aberdeen Sandstone), overlain by massive beds of gray to buff sandstone with alternating beds of sandy shale, shale, and coal (Clark, 1928). In the vicinity of the Soldier Canyon Mine lease area, the Blackhawk Formation ranges in thickness from



LEGEND

- Km** Mancos Shale
- Kb** Blackhawk Formation
- Kc** Castlegate Sandstone
- Kp** Price River Formation
- TKn** North Horn Formation
- Tf** Flagstaff Limestone

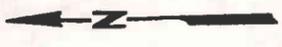


Figure 2. Surface geology of the Soldier Canyon Mine lease area.

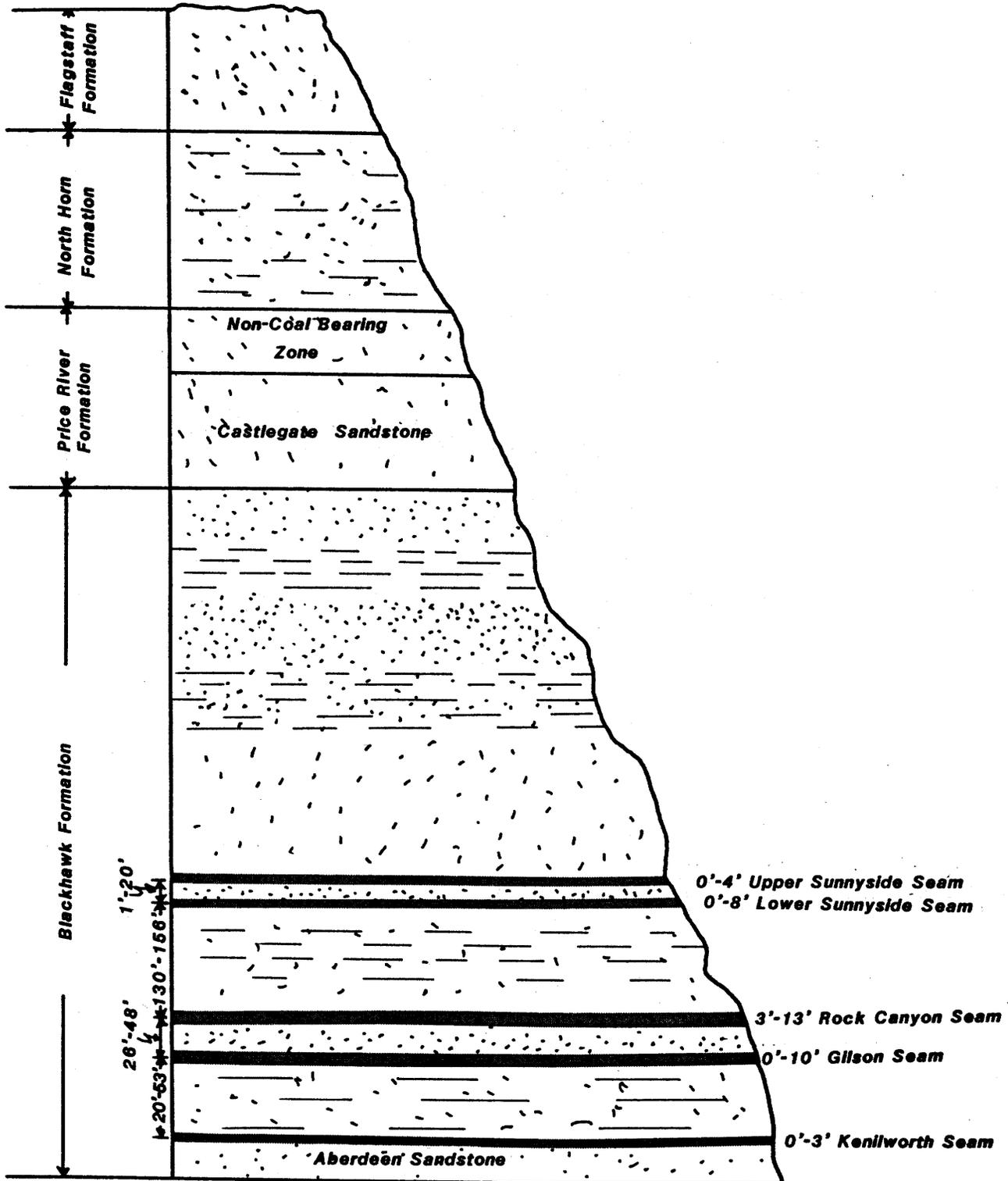


Figure 3. Generalized columnar section of the Soldier Canyon Mine lease area (Doelling, 1972 and Pollastro, 1980).

950 feet to 1050 feet (Doelling, 1972).

According to Clark (1928, p. 19):

The coal bearing part of the Blackhawk Formation consists of massive beds of gray to buff sandstone, alternating with smaller amounts of sandy shale, shale and coal beds. The sandstone is composed largely of semirounded quartz grains cemented by carbonate of lime and is reasonably well consolidated but not greatly indurated except some of the fine-grained and highly calcareous beds. The shale, as a rule, is more or less sandy and adjacent to the coal beds usually contains some carbonaceous material. The coal beds have been extensively burned at the surface, and the associated rocks are greatly altered in character and composition. At many places where coal beds have burned, the rocks overlying them have fused, and everywhere they are predominantly red instead of gray and buff, their original colors.

The dominant feature of the coal-bearing part of the Blackhawk Formation consists of the massive, cliff-forming beds of sandstone, which lie beneath many of the principal coal beds. Some of these sandstone beds are exposed for 20 to 30 miles in east-west extent.

The presence of shale layers in the Blackhawk Formation acts as an effective barrier to the vertical movement of water within the formation. Therefore, water penetrating into the Blackhawk probably percolates downward until it encounters a shale layer, which then causes horizontal movement to the surface or to another sandstone finger within the formation.

Price River Formation. Overlying the Blackhawk Formation is the Price River Formation; composed of a massive basal sandstone, referred to as the Castlegate Sandstone, and the non coal-bearing beds overlying the Castlegate (Clark, 1928).

The Castlegate Sandstone consists of massive, fine- to medium-grained sandstone beds (Doelling, 1972) which are gray to buff and composed mainly of semirounded grains of quartz (Clark, 1928). The basal portion of the Castlegate is a transition zone from sandy shale to sandstone and in many areas shale and sandy shale are encountered near the top of the sandstone bed (Clark, 1928). The Castlegate Sandstone is approximately 225 feet thick near the Soldier Canyon Mine (Doelling, 1972).

The non coal-bearing portion of the Price River Formation consists of two or more thick beds of sandstone, interbedded with thin-bedded shale and sandy shale (Clark, 1928). The sandstone layers are massive, white to gray beds, consisting of semi-angular grains of quartz. The shales are predominantly gray in color with occasional traces of olive-green shales in certain areas (Doelling, 1972). In the vicinity of the Soldier Canyon Mine, the non coal-bearing portion of the Price River Formation is approximately 150 feet thick (Doelling, 1972).

North Horn Formation. The North Horn Formation, the lower-most member of the Wasatch Formation, consists of a series of shale, sandstone, minor conglomerate and freshwater limestone. The shales vary from yellow to gray or gray-green in color and are usually calcareous and silty (Doelling, 1972; Clark, 1928). The sandstones are tan to yellow-gray, fine to coarse-grained conglomerate sandstones with interbedded highly colored sandy shale (Clark, 1928). Limestone increases near the upper

portion of the member (Doelling, 1972). Near the Soldier Canyon Mine, the North Horn appears to be 250 to 500 feet thick.

Flagstaff Limestone Formation. The Flagstaff Limestone Formation consists of thin-bedded limestones, shales and sandstones (Doelling, 1972). The varicolored shales are interbedded with lacustrine and microcrystalline limestone. The sandstones are fine- to medium-grained, reddish-brown, and generally less plentiful than the other constituents (Doelling, 1972).

Faults. There are not major faults within or adjacent to the Soldier Canyon Mine lease area. According to Pollastro (1980), no faults have been encountered in mining coal from the Soldier Canyon Mine. *cracks?*

Soils

Wilson et al. (1975) classify soils within the lease area as Badland-Rock Land Association. Badland consists of shale or interbedded sandstone and shale, while the rock land consists of bare rock outcrop with some shallow and very shallow soils over bedrock (Wilson, et al., 1975). Shallow soils are found on benches and mesas where the topography is rolling.

Runoff is classified by Wilson et al. as rapid to very rapid with very high sediment production.

Climate

The general climate of the Soldier Canyon Mine lease area is characterized by moderate amounts of precipitation, high potential evapotranspiration, low temperatures, and relatively short growing seasons.

Temperature is both spacially and seasonally variable, being strongly influenced by elevation (U.S. Geological Survey, 1979). Temperatures vary in January from a mean minimum of 6^oF to a mean maximum of 32^oF; whereas July temperatures vary from a mean minimum of 53^oF to a mean maximum of 84^oF (Jeppsen et al., 1968). The average frost free season for the lease area is 60 days (Jeppsen et al., 1968).

Precipitation is affected by altitude and topography in the area of the Soldier Canyon Mine. Jeppsen et al., 1968, indicate that the normal annual precipitation of the lease area is 14 inches with 8 inches occurring as snow from October to April and 6 inches occurring as rainfall between May and September.

The annual potential evapotranspiration of the lease area is approximately 22 inches. Due to the fact that annual potential evapotranspiration exceeds normal annual precipitation, the lease area at the Soldier Canyon Mine is not considered to be an important water source.

Vegetation

A wide variety of vegetative communities are encountered within the lease area at the Soldier Canyon Mine, resulting from the varied topography, aspect, and elevation found therein.

The lease area is covered with Pinyon-Juniper, Mountain Shrub, Sagebrush-Grass, Conifer-Aspen (Bentley et al., 1978), and Ponderosa Pine vegetative communities (U.S. Geological Survey, 1979). The Sagebrush-Grass and Mountain Shrub communities fringe and intermix with the other communities throughout the lease area.

SURFACE WATER HYDROLOGYRegional Surface Hydrologic System

The Soldier Canyon Mine lease area is situated in the Book Cliffs near the headwaters of the Price River Basin. The entire lease area drains toward Soldier Creek, a perennial tributary of the Price River.

Snowmelt is the major source of water for the perennial streams of the Price River Basin. Ephemeral streams are abundant in the basin, existing primarily at lower elevations where potential evapotranspiration exceeds precipitation.

Water use upstream from Castle Valley (the monoclinical valley containing most of the agricultural land noted in Figure 4) is primarily for stockwatering and industrial purposes (coal mining and electrical power generation). Within Castle Valley, agriculture and power production utilize nearly all of the inflowing water (Mundorff, 1972), with minimum flows in the gaged streams and rivers in the basin occasionally reaching zero. Storage reservoirs are common at higher elevations. Transbasin diversions occur throughout the area.

In general, the chemical quality of water in the headwaters of the Price River Basin is excellent, with this watershed providing most of the domestic water needs of the people below. However, this quality rapidly deteriorates downstream as the streams cross shale formations (particularly the Mancos Shale in and adjacent to Castle Valley) and

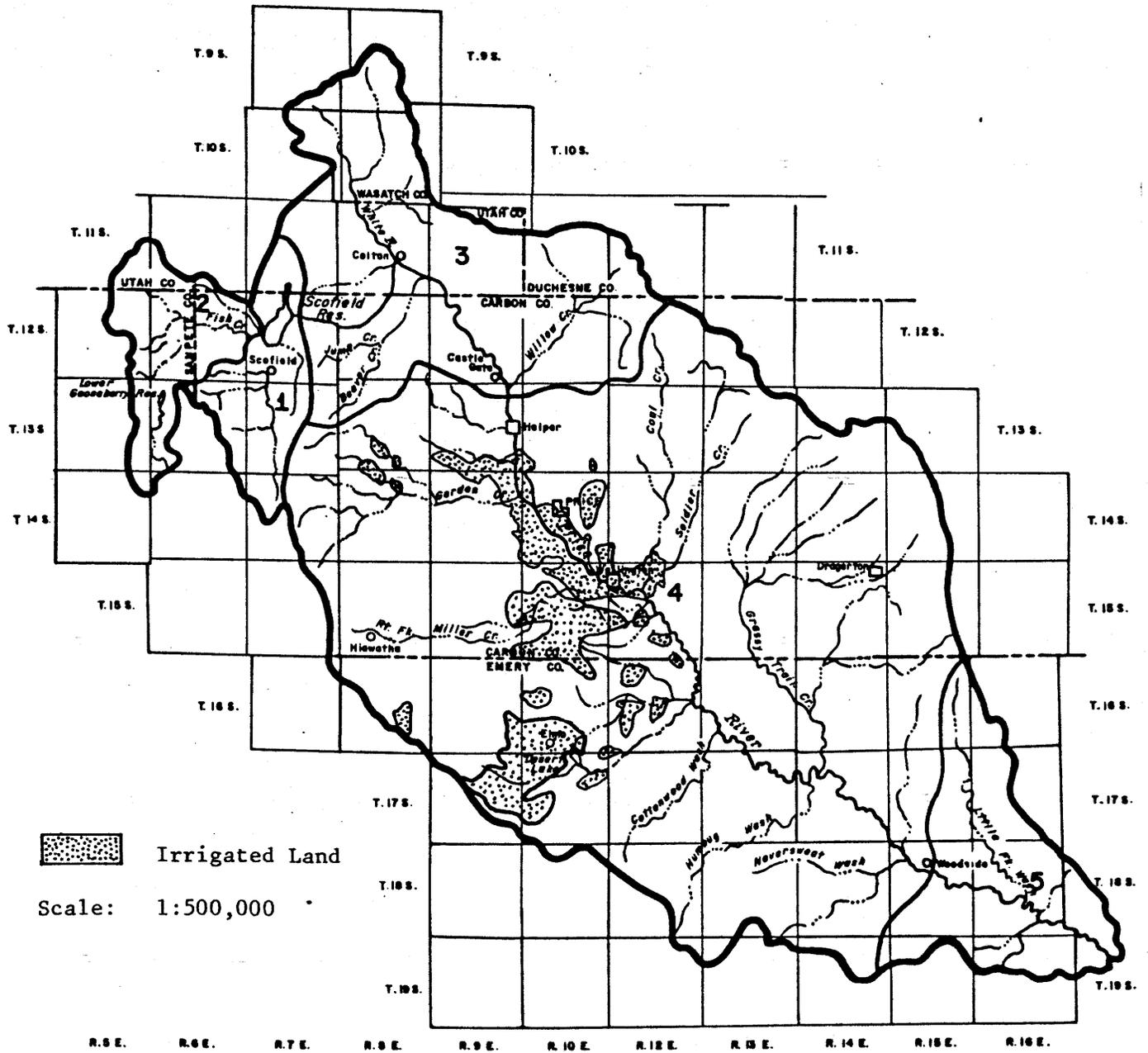


Figure 4. Price River Basin. (Adapted from the Utah Division of Water Resources, 1975.)

receive irrigation return flows from lands situated on Mancos-derived soils (Price and Waddell, 1973). Within the Price River Basin, for example, Mundorff (1972) reports that the Price River and its tributaries generally have a dissolved solids concentration of less than 400 milligrams per liter upstream from Helper. The water in this area is of a calcium bicarbonate type. Between this point and the confluence with Miller Creek, most of the flows originate on or traverse Mancos shales. Much of the flow is derived from irrigation return flows. The Price River at Wellington, which is near the center of the basin, has an average dissolved solids content of about 1700 milligrams per liter and is of a mixed chemical type (calcium-magnesium-sodium-sulfate). At Woodside, which is about 22 miles upstream from the confluence of the Price River with the Green River, the weighted average dissolved solids content has generally been between 2000 and 4000 milligrams per liter, with the water type being strongly sodium sulfate.

Sediment yield from the upper portion of the basin is probably negligible (Mundorff, 1972). According to the U.S. Soil Conservation Service (1975), erosion rates in the Price and San Rafael River Basin vary from 0.1 to 3.0 acre-feet per square mile per year. The bulk of the sediment yielded each year at the mouth of the Price River comes from limited areas covered with highly erodable shales (Mundorff, 1972).

Drainage Basin Characteristics

The lease area of the Soldier Canyon Mine is part of the Soldier Creek perennial watershed. Stream channels from the lease area flow in all directions except north.

Topography in the area is rugged, with elevations varying from 6600 feet to approximately 8300 feet above sea level. Slopes vary from vertical cliffs to less than 2 percent (1.2 degrees) along the ridges. The dominant aspect of the Soldier Canyon Mine lease area is to the south and east on the west side of Soldier Creek and to the south and west on the east side of Soldier Creek.

Water sources within or adjacent to the lease area at the Soldier Canyon Mine are a few springs and streams, which will be discussed in subsequent sections of this report. There are no major water bodies located within or adjacent to the lease area.

Rainfall-runoff relationships for the Soldier Canyon Mine lease area were determined from the runoff curve number technique as defined by the U.S. Soil Conservation Service (1972). According to the curve number technique, the algebraic and hydrologic relationship between storm rainfall, soil moisture storage, and runoff can be expressed by the following equations:

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \quad (1)$$

and

$$CN = \frac{1000}{10+S} \quad (2)$$

where Q is the direct runoff depth in inches, P is the storm rainfall depth in inches, S is a watershed storage factor, in inches, defined originally as the maximum possible difference between P and Q , and CN is a dimensionless expression of S referred to as the curve number.

Hawkins (1973) indicates that runoff curve numbers tend to vary inversely with precipitation depth in forested mountain watersheds. In the vicinity of the Soldier Canyon Mine lease area the exact relationship between runoff curve numbers and precipitation depth is undetermined. Therefore, an average curve number of 75 was determined for the lease area based upon vegetative type, hydrologic soil grouping, and ground cover density (as outlined by the U.S. Soil Conservation Service, 1972).

Equation (1) is based upon the assumption that $I_a = 0.2S$, where I_a is the initial abstraction from storm rainfall, defined as the rainfall which must fall before runoff begins (i.e. to satisfy interception, evaporation, and soil-water storage). Therefore, determination of runoff from equation (1) is valid only when $P \geq I_a$ or $P \geq 0.2S$. Below this point, no runoff can occur. Based on the average curve number of 75 for the lease area and equation (2), I_a is equal to 0.67 inches. Figure 5 illustrates the rainfall-runoff relationship for the lease area.

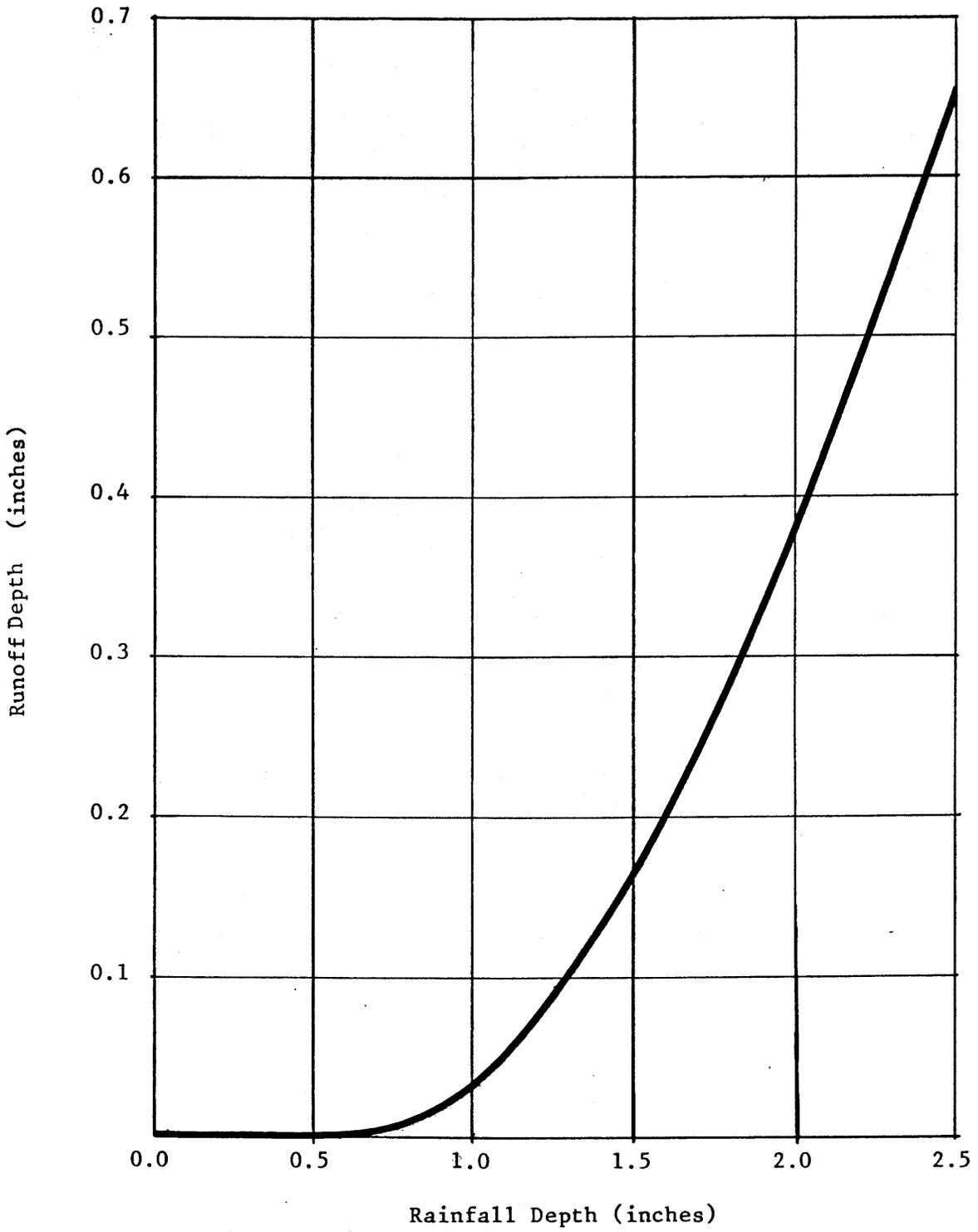


Figure 5. Runoff Depth versus rainfall depth for the Soldier Canyon Mine lease area.

Flow Characteristics

According to Jeppson et al. (1968), the mean annual water yield for the Soldier Canyon Mine lease area is approximately 1.0 inch. Two additional hydrologic methods were used to estimate the mean annual water yield to increase the confidence level of the estimate. The first, "Grunsky's Rule", was originally developed by Grunsky (1908) and later adapted by Sellars (1965). According to Grunsky, the average annual water yield can be determined from

$$Q = \alpha P^2 \quad (\text{for } P \geq 1/(2\alpha)) \quad (3)$$

and

$$A = P - 1/(4\alpha) \quad (\text{for } P \leq 1/(2\alpha)) \quad (4)$$

where Q is the mean annual water yield in inches, P is the normal annual precipitation in inches, and α is a runoff coefficient in inches⁻¹. Alpha (α) for the lease area was estimated to be 0.009 inches⁻¹ from guidelines set forth by Hawkins (1976). In accordance with equations (3) and (4), $1/(2\alpha)$ equals 55.6 which is greater than the normal annual precipitation of 14 inches determined from Jeppson et al. (1968). Therefore, equation (3) is applicable to the lease area and, according to Grunsky's Rule, the mean annual water yield from the lease area is 0.0 inches.

The second method used in estimating the mean annual water yield is known as Ol'deKop's formula (Sellars, 1965). The mean annual water yield is determined from

$$Q = P - E_o \tanh \frac{P}{E_o} \quad (5)$$

where Q and P are as previously defined and E_o is the annual potential evapotranspiration in inches. As indicated in the climatic section of this report, the mean annual precipitation and annual potential evapotranspiration for the lease area are 14 and 22 inches respectively. As estimated from Ol'deKop's formula, the mean annual water yield from the lease area is 1.6 inches. Therefore, estimates of the mean annual water yield from both Ol'deKop's and Grunsky's formulas compare favorably with the estimate from the Hydrologic Atlas of Utah prepared by Jeppson et al. (1968) which is assumed to be the true estimate.

Monthly flows for Soldier Creek were computed as the percentage of annual flow for the year 1978 to determine the seasonal distribution of flows for perennial streams in the vicinity of the lease area. The results are presented in Figure 6. The distribution of flows, as depicted in Figure 6, is typical of high mountain regions in the west, in which most of the streamflow occurs from March through June as a result of snowmelt.

As mentioned previously, all of the lease area drains toward Soldier Creek. The U.S. Geological Survey has established a gaging station on Soldier Creek just below the Soldier Canyon Mine and has obtained periodic measurements of discharge and water quality from July through November. Eureka Energy Company also maintains a gaging station upstream from the mine near the junction of Soldier Creek with the tributary from Pine Canyon. Data is available from both gaging stations since 1978. Based upon the

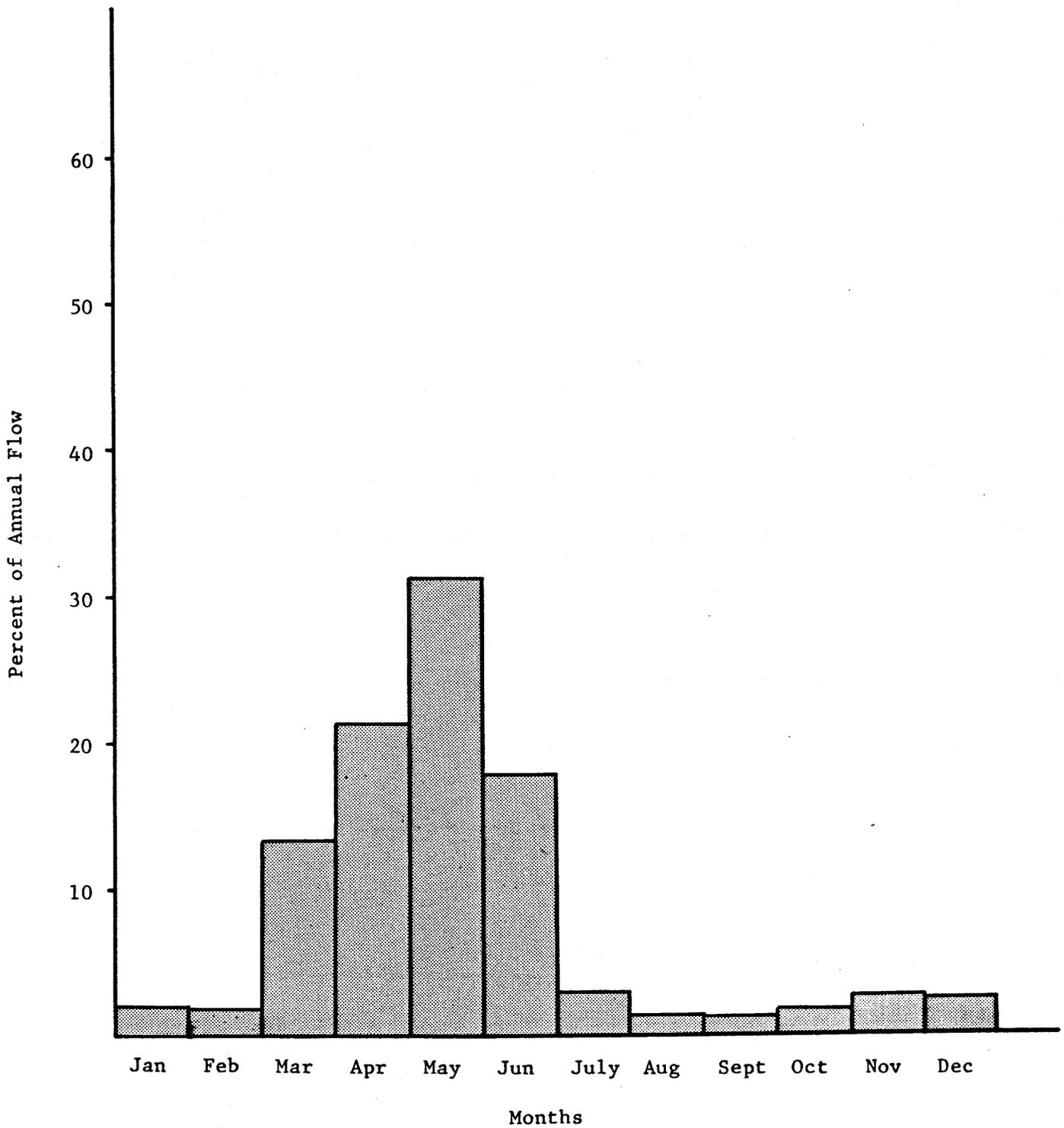


Figure 6. Monthly distribution of flows for Soldier Creek, near the Soldier Canyon Mine, for the year 1978.

periodic measurements of these two sites since 1978, the maximum measured flow of Soldier Creek is 19.0 cubic feet per second and the minimum measured flow is 0.1 cubic feet per second. Peak discharges in Soldier Creek are expected to be much higher than these periodic measurements. Summer thunderstorms, common in this area, would produce flows well in excess to these measured values.

How often is periodic??

Estimates of peak flow recurrence intervals for Soldier Creek near the Soldier Canyon Mine were prepared by Vaughn Hansen Associates (July, 1979). Peak flow estimates were determined from the runoff curve number and unit hydrograph technique as defined by the U.S. Soil Conservation Service (1972). According to Vaughn Hansen Associates (July, 1979) the estimated peak discharge of Soldier Creek from the 10-year, 24-hour event is 285 cubic feet per second, and the peak discharge from the 25-year, 6-hour event is 391 cubic feet per second.

Surface Water Quality

Surface water quality data were collected during the fall period of analysis (September-October, 1979) from two sites on Soldier Creek (18-1 and 18-2) within the Soldier Canyon Mine lease area (see Figure 7).

Not often enough to determine base line

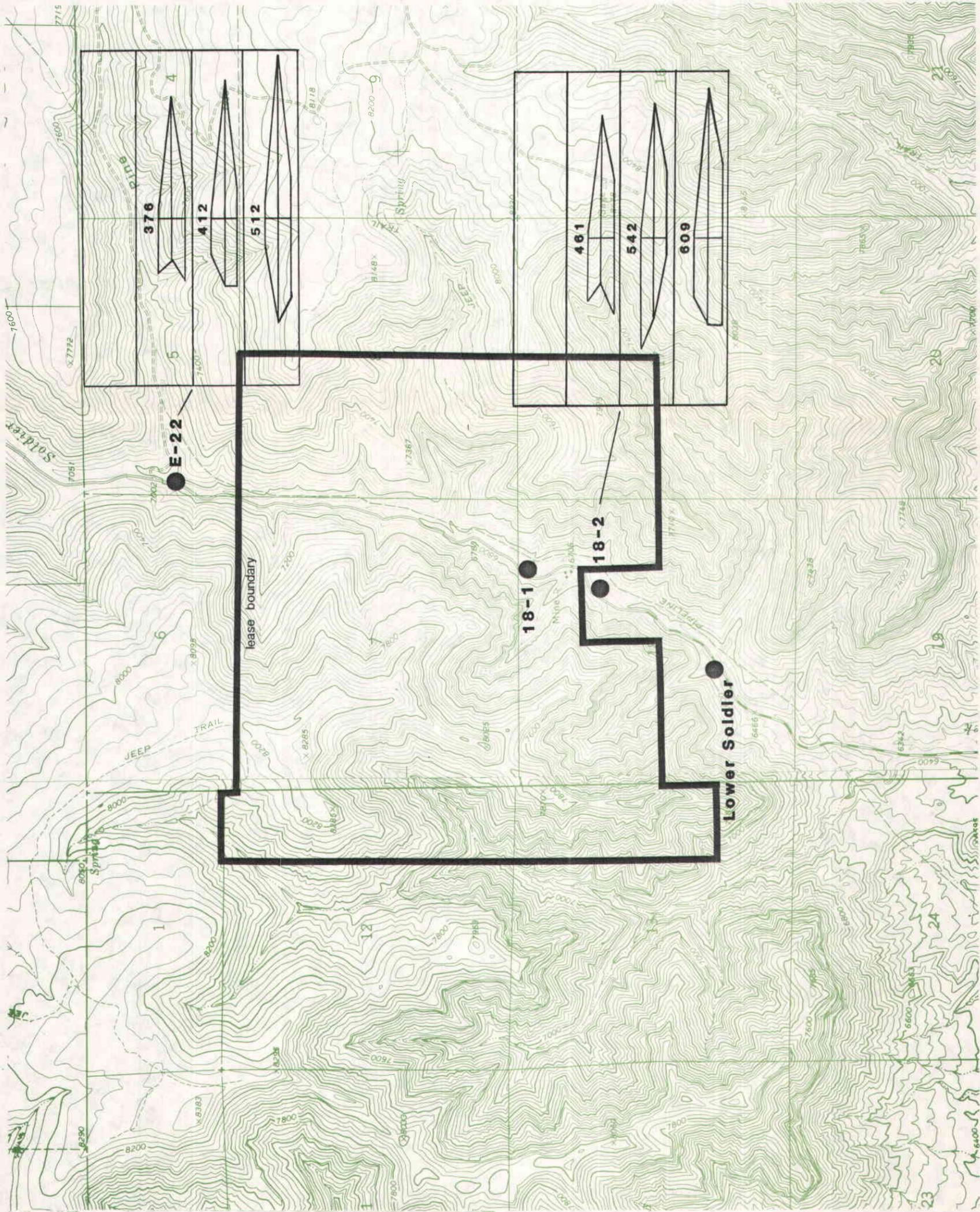
These stations were located to obtain data from Soldier Creek both above and below existing surface facilities of the Soldier Canyon Mine. Additional water quality data were obtained from unpublished data of the U.S. Geological Survey and Eureka Energy Company of Salt Lake City, Utah, for two gaging stations on Soldier Creek. The USGS gaging station is

How would we receive this info.?

located immediately downstream from the Soldier Canyon Mine and the Eureka Energy Company gaging station is located upstream from the mine, below the confluence of Soldier Creek and its Pine Canyon tributary.

How far is immediate?

How far upstream? Any other inputs or tributaries?



LEGEND

● Surface water quality sampling sites.

JAN-MARCH
APR-JUNE
JULY-SEPT
OCT-DEC

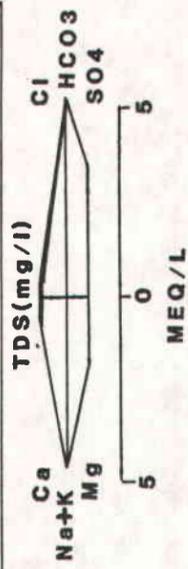


Figure 7. Surface water sampling stations with seasonal variations in major chemical constituents in the property area.

Water quality samples collected by Vaughn Hansen Associates were analyzed according to the schedule of parameters listed in Table 1. Attachment A summarizes the analytical methods used in both the field and laboratory and Attachment B contains the results of the chemical analyses of surface water samples collected within the lease area during the study period. Field analyses were completed at the time of sample collection, and samples were preserved for laboratory analysis according to the methods outlined by the American Public Health Association et al. (1976).

Table 1. Comprehensive water quality analytical schedule.

Field Measurements	Laboratory Measurements	
Discharge	Acidity (as CaCO ₃)	Magnesium
pH	Alkalinity (as CaCO ₃)	Manganese, Total
Specific Conductance	Arsenic, Total	Mercury, Total
Temperature, Air	Barium, Total	Nitrate (NO ₃ as N)
Temperature, Water	Bicarbonate	Oil and Grease
	Boron, Total	Phenol
	Cadmium, Total	Phosphate (PO ₄ as P) Ortho
	Calcium	Potassium
	Chloride	Selenium, Total
	Chromium, Total	Silver, Total
	Copper, Total	Sodium
	Fluoride	Sulfate
	Iron, Total	Suspended Solids
	Iron, Dissolved	Total Dissolved Solids
	Lead, Total	Zinc, Total

Where data were available, seasonal variations in water quality as indexed by major cations and anions were determined and are illustrated

in Figure 7. Total dissolved solids concentrations were lowest during the months of April through June when flows were highest. This inverse relationship is caused by a dilution effect from snowmelt in the early spring and runoff period. Later in the year as flow decreases and the majority of flow is derived from groundwater, this diluting effect is less pronounced, resulting in increased total dissolved solids concentrations. Total dissolved solids concentrations for Soldier Creek were relatively high for a mountain stream, ranging from 374 milligrams per liter during the high flow season to 860 milligrams per liter during the low flow season in the vicinity of the lease area.

Concentration of salts also due to evap.

where's the data

From the data gathered during the fall period of analysis and other previously mentioned sources, suspended solids concentrations of Soldier Creek were found to vary from 1.0 to 1,644 milligrams per liter. All suspended solids concentrations measured during the summer and fall seasons of the year were less than 17 milligrams per liter. The only suspended solids concentration to exceed 17 milligrams per liter (1,644 mg/l) was measured in April during the snowmelt runoff period. Suspended solids concentrations are generally higher during the snowmelt runoff period than during the portion of the year when baseflow conditions exists. During the runoff period it is not uncommon for suspended solids concentrations in Soldier Creek to naturally and significantly exceed the federal coal mining effluent standard of 45 milligrams per liter (see OSM regulation section 817.42).

The hydrogen ion activity (pH) of Soldier Creek was found to vary in the vicinity of the lease area from 7.4 to 8.7 units. The basic condition of Soldier Creek is probably due to the high concentration of bicarbonates (American Public Health Association et al., 1976). Most natural waters are buffered to some extent by reactions involving dissolved carbon dioxide species, with the most effective buffering action from these species being within the range from 6.0 to 8.5 pH units. Therefore, the relatively constant and basic pH coupled with low acidity and high alkalinity concentrations, indicates that waters in the area are not significantly influenced by pollution (Hem, 1970).

? (what is your definition of pollution?)

Data gathered by Vaughn Hansen Associates during the fall period of analysis (September - October, 1979), data from Eureka Energy Company, and data obtained from the USGS indicate that both total and dissolved iron concentrations are somewhat related to flowrate, with higher concentrations occurring during the snowmelt runoff period when suspended sediment concentrations are high and with lower concentrations occurring during baseflow conditions. Data from Eureka Energy Company and data obtained during the fall study period indicate that dissolved iron concentrations in Soldier Creek have varied from less than 0.01 milligrams per liter to 0.385 milligrams per liter, with the higher concentrations occurring in April and May during the snowmelt runoff period and the lower concentrations occurring during summer and fall baseflow conditions.

With the exception of data gathered during the fall period of analysis, data was not available to compare total iron with dissolved iron

concentrations. From the fall period of analysis, dissolved iron concentrations were approximately one-tenth to one-twentieth of the concurrent total iron concentrations, with the dissolved and total iron concentrations varying from less than 0.01 to 0.02 and 0.19 to 0.37 milligrams per liter, respectively.

Total manganese concentrations were low in Soldier Creek, varying from 0.009 to 0.119 milligrams per liter. No distinct seasonal variation in manganese concentrations can be determined.

The Utah Division of Health has classified the waters within the Soldier Canyon Mine lease area as 3C (protected for non-game fish and other aquatic life) and 4 (protected for agricultural uses including irrigation of crops and stockwatering). Tables 2 and 3 contain the numerical water quality standards applicable to these various classifications. Few exceedances of these chemical standards were noted from data gathered during the baseline study and other previously noted sources. Most of the chemical standards in Tables 2 and 3 are for dissolved rather than total constituents, while most of the various water quality parameters analyzed during the fall period were analyzed for the total rather than the dissolved form of the constituents. With the exception of cyanide, phenol, copper, barium and zinc; all of the total constituents were well within the limits established for the dissolved constituents in the chemical standards of Tables 2 and 3.

How many?

Table 2. Utah Division of Health numerical standards for water in the State.

Constituent	CLASSES											
	Domestic Source			Recreation & Aesthetics		Aquatic Wildlife			Agri-culture	Indus-try	Special	
	1A	1B	1C	2A	2B	3A	3B	3C	3D	4	5	6
Bacteriological (No./100 ml)												
(30-day Geometric Mean)	1	50	5,000	1,000	5,000	*	*		*	*		
Maximum Total Coliforms	*	*	2,000	200	2,000	*	*		*	*		
Maximum Fecal Coliforms												
Physical												
Total Dissolved Gases	*	*	*	*	*	(b)	(b)		*	*		
Minimum DO (mg/l) (a)	*	*	5.5	5.5	5.5	6.0	5.5		5.5	*		
Maximum Temperature	*	*	*	*	*	20°C	27°C		*	*		
Maximum Temp. Change	*	*	*	*	*	2°C	4°C		*	*		
pH	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0		6.5-9.0	6.5-9.0		
Turbidity increase (c)	*	*	*	10 NTU	10 NTU	10 NTU	10 NTU		15 NTU	*		
Chemical (Maximum mg/l)												
Arsenic, dissolved	.05	.05	.05	*	*	*	*		*	.1		
Barium, dissolved	1	1	1	*	*	*	*		*	*		
Cadmium, dissolved	.010	.010	.010	*	*	.0004(d)	.004(d)		*	.01		
Chromium, dissolved	.05	.05	.05	*	*	.10	.10		.10	.10		
Copper, dissolved	*	*	*	*	*	.01	.01		*	.2		
Cyanide	*	*	*	*	*	.005	.005		*	*		
Iron, dissolved	*	*	*	*	*	1.0	1.0		1.0	*		
Lead, dissolved	.05	.05	.05	*	*	.05	.05		*	.1		
Mercury, total	.002	.002	.002	*	*	.00005	.00005		.00005	*		
Phenol	*	*	*	*	*	.01	.01		*	*		
Selenium, dissolved	.01	.01	.01	*	*	.05	.05		*	.05		
Silver, dissolved	.05	.05	.05	*	*	.01	.01		*	*		
Zinc, dissolved	*	*	*	*	*	.05	.05		*	*		
NH ₃ as N (un-ionized)	*	*	*	*	*	.02	.02		*	*		
Chlorine	*	*	*	*	*	.002	.01		*	*		
Fluoride, dissolved (e)	1.4-2.4	1.4-2.4	1.4-2.4	*	*	*	*		*	*		
NO ₃ as N	10	10	10	*	*	*	*		*	*		
BcPon, dissolved	*	*	*	*	*	*	*		*	.75		
H ₂ S	*	*	*	*	*	.002	.002		*	*		
TDS (f)	*	*	*	*	*	*	*		*	1200		
Radiological (Maximum pCi/l)												
Gross Alpha	15	15	15	*	*	15(g)	15(g)		15(g)	15(g)		
Radium 226, 228 combined	5	5	5	*	*	*	*		*	*		
Strontium 90	8	8	8	*	*	*	*		*	*		
Tritium	20,000	20,000	20,000	*	*	*	*		*	*		
Pesticides (Maximum ug/l)												
Endrin	.2	.2	.2	*	*	.004	.004		.004	*		
Lindane	4	4	4	*	*	.01	.01		.01	*		
Methoxychlor	100	100	100	*	*	.03	.03		.03	*		
Toxaphene	5	5	5	*	*	.005	.005		.005	*		
2, 4-D	100	100	100	*	*	*	*		*	*		
2, 4, 5-TP	10	10	10	*	*	*	*		*	*		
Pollution Indicators (g)												
Gross Beta (pCi/l)	50	50	50	*	*	50	50		50	50		
BOD (mg/l)	*	*	5	5	5	5	5		5	5		
NO ₃ as N (mg/l)	*	*	*	4	4	4	4		*	*		
PO ₄ as P (mg/l)(h)	*	*	*	.05	.05	.05	.05		*	*		

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS (see Table 3)

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS

* Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.

(a) These limits are not applicable to lower water levels in deep impoundments.

(b) Not to exceed 110% of saturation.

(c) For Classes 2A, 2B, 3A, and 3B at background levels of 100 NTUs or greater, a 10% increase limit will be used instead of the numeric values listed. For Class 3D at background levels of 150 NTUs or greater, a 10% increase limit will be used instead of the numeric value listed. Short term variances may be considered on a case-by-case basis.

(d) Limit shall be increased threefold if CaCO₃ hardness in water exceeds 150 mg/l.

(e) Maximum concentration varies according to the daily maximum mean air temperature.

Temp. °C	mg/l
12.0 and below	2.4
12.1 to 14.6	2.2
14.7 to 17.6	2.0
17.7 to 21.4	1.8
21.5 to 26.2	1.6
26.3 to 32.5	1.4

(f) Total dissolved solids (TDS) limit may be adjusted on a case-by-case basis.

(g) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

(h) PO₄ as P(mg/l) limit for lakes and reservoirs shall be .025.

Table 3. Numerical standards for class 3C water use. (see Table 2).

<u>Physical</u>	
Minimum D.O. (mg/l)	5
Maximum Temperature	27°C
Maximum Temperature Change	4°C
pH	6.5-9.0
Turbidity Increase (NTU)	15****
<u>Chemical (Maximum Mg/l)</u>	
Cadmium, dissolved	0.004
Chromium, dissolved	0.1
Copper, dissolved	0.01
Cyanide	0.005
Iron, dissolved	1.0
Lead, dissolved	0.05
Mercury, total	0.0005
Phenol	0.01
Selenium, dissolved	0.05
Silver, dissolved	0.01
Zinc, dissolved	0.05
Chlorine	0.2
H ₂ S	0.02
<u>Radiological (Maximum pCi/l)</u>	
Gross Alpha	15
Gross Beta	30
<u>Pesticides (Maximum mg/l)</u>	
Endrin	0.004
Lindane	0.01
Methoxychlor	0.03
Toxaphene	0.005
<u>Pollution Indicators***</u>	
BOD (mg/l)	5.0
NO ₃ as N (mg/l)	4.0

***Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

****At background levels of 150 NTU's or greater, a 10% increase limit will be used instead of the numeric values. Short term variances may be considered on a case-by-case basis.

Phenol concentrations of Soldier Creek were found to exceed state standards for Class 3C waters (0.01 milligrams per liter) in only one sample. At Station 18-1, immediately upstream from the Soldier Canyon Mine surface facilities, a phenol concentration of 0.026 milligrams per liter was measured. The occurrence of phenolic compounds in surface waters is generally considered an indicator of waste products, however the U.S. Environmental Protection Agency indicates that phenolic compounds also arise from naturally occurring organic sources. Therefore, the breakdown of organic residue in the area (both plant and animal) may be the source of phenol occurrences.

Cyanide concentrations were found to exceed state standards for Class 3C waters (0.005 milligrams per liter) in only one sample. The cyanide concentration of a sample collected by Eureka Energy Company, upstream from the Soldier Canyon Mine near the confluence of Soldier Creek with the Pine Canyon tributary, was measured at 0.02 milligrams per liter. The reason for the occurrence of cyanide in this one sample is not known since the appearance of cyanide is generally associated with industrial waste (Hem, 1970).

Concentrations of barium, copper, and zinc slightly exceeded state standards for Class 3C (0.01 mg/l dissolved copper and 0.05 mg/l dissolved zinc) and Class 4 waters (0.1 mg/l dissolved barium) in one or two samples collected by Eureka Energy Company at station E-22. In one sample, the dissolved barium concentration was measured at 0.14 milligrams

per liter. In two samples the dissolved copper concentration was measured at 0.012 milligrams per liter, and in one sample the dissolved zinc concentration was measured at 0.061 milligrams per liter.

Sediment Yield

Estimates of the average annual sediment yield to be expected from the mine lease area were made using the PSIAC method (Pacific Southwest Inter-Agency Committee, 1968) and the Universal Soil Loss Equation (U.S. Soil Conservation Service, 1977; Clyde et al., 1978). Tables 4 and 5 contain the parameter estimates and sediment yield computation results of the respective methods. Using a sediment delivery ratio of 24 percent (based on Renfro, 1975), the average annual sediment yield predicted by the Universal Soil Loss Equation is 1.0 ton per acre. This converts to 0.37 acre-feet per square mile if a sediment unit weight of 80 pounds per cubic foot is assumed (see Flaxman, 1975). This compares favorably with the estimate made by the PSIAC method, considering the accuracy of the methods. The sediment delivery ratio estimate probably accounts for a majority of the difference.

Assuming an average from the two methods of 0.39 acre-feet per square mile, the Soldier Canyon Mine lease area yields a yearly average of 1.04 acre-feet of sediment to the Price River Basin. Although no published sediment yield data are available for the upland areas of the basin, this is undoubtedly only a small portion of the total amount of sediment yielded from the mountainous areas of the Price River Basin.

Table 4. Average annual sediment yield estimate of Soldier Canyon Mine lease area using the PSIAC method.

Factor	Description	Rating
Surface Geology	Sandstones and interbedded shales and sandstones, moderately fractured.	6
Soils	High percentage of rock fragments.	0
Climate	Precipitation primarily as snow.	0
Runoff	High peak flows per unit area.	0
Topography	Steep upland slopes, high relief and little flood plain development.	10
Ground Cover	Area mostly protected by vegetation.	-5
Land Use	Ordinary road construction, less than 50% intensively grazed.	0
Upland Erosion	About 25% of area characterized by landslide erosion.	10
Channel Erosion	Moderate flow depths, occasional bank erosion.	10
Total		46

Sediment Yield (from Figure 8) = $0.41 \text{ AF/mi}^2/\text{yr.}$

Table 5. Average annual sediment estimate of the Soldier Canyon Mine lease area using the Universal Soil Loss Equation.

Equation: $A = RKLSCP$

Variable		
R	Rainfall factor	16
K	Soil erodability factor	0.20
L	Slope length factor (1000 ft.)	LS = 95
S	Slope gradient factor (61%)	
C	Cropping management factor	0.013
P	Erosion control practice factor	1.0
A	Estimated soil loss (tons/acre/year)	3.95

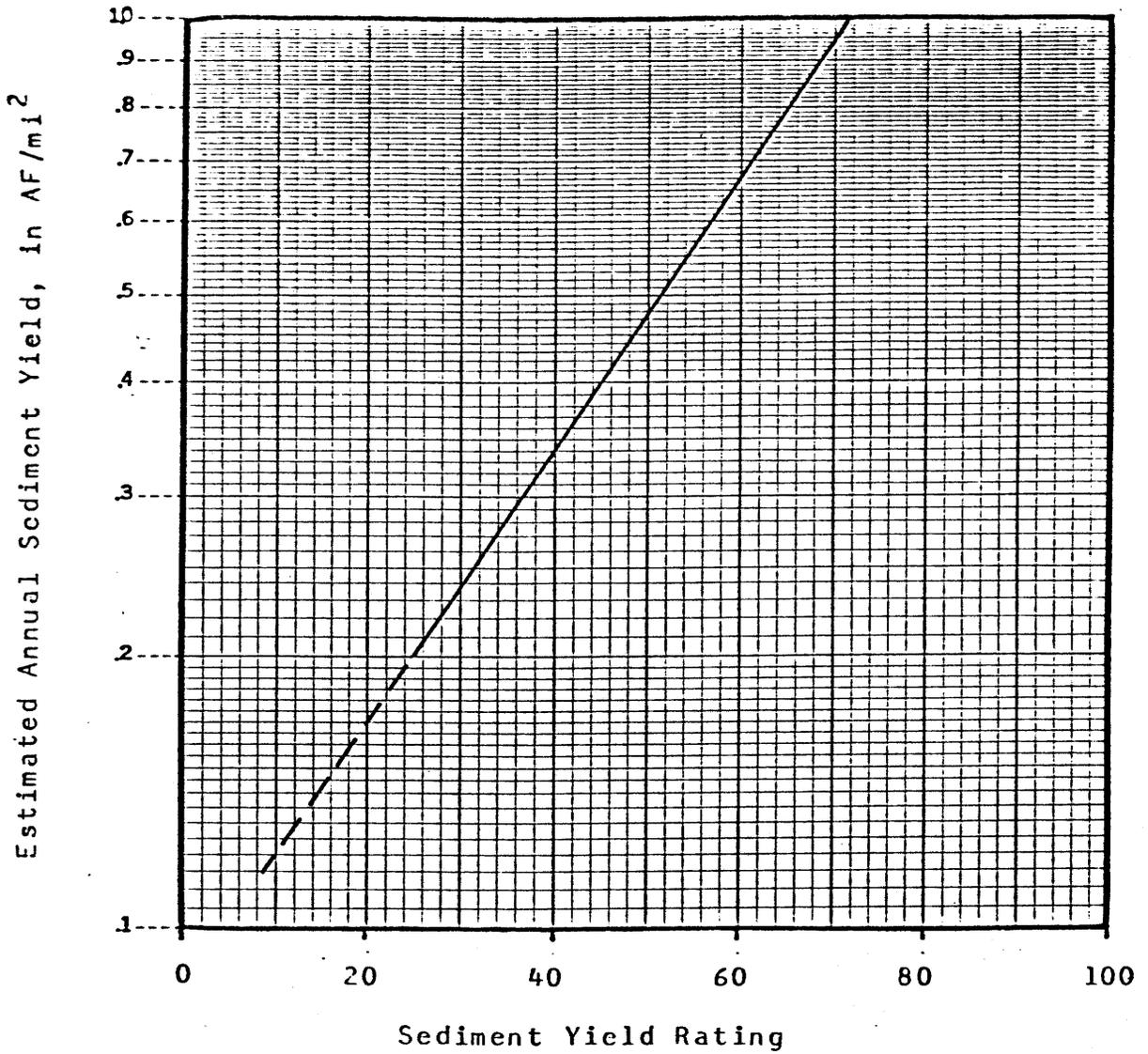


Figure 8. Sediment yield as determined by the PSIAC method (adapted from Shown, 1970).

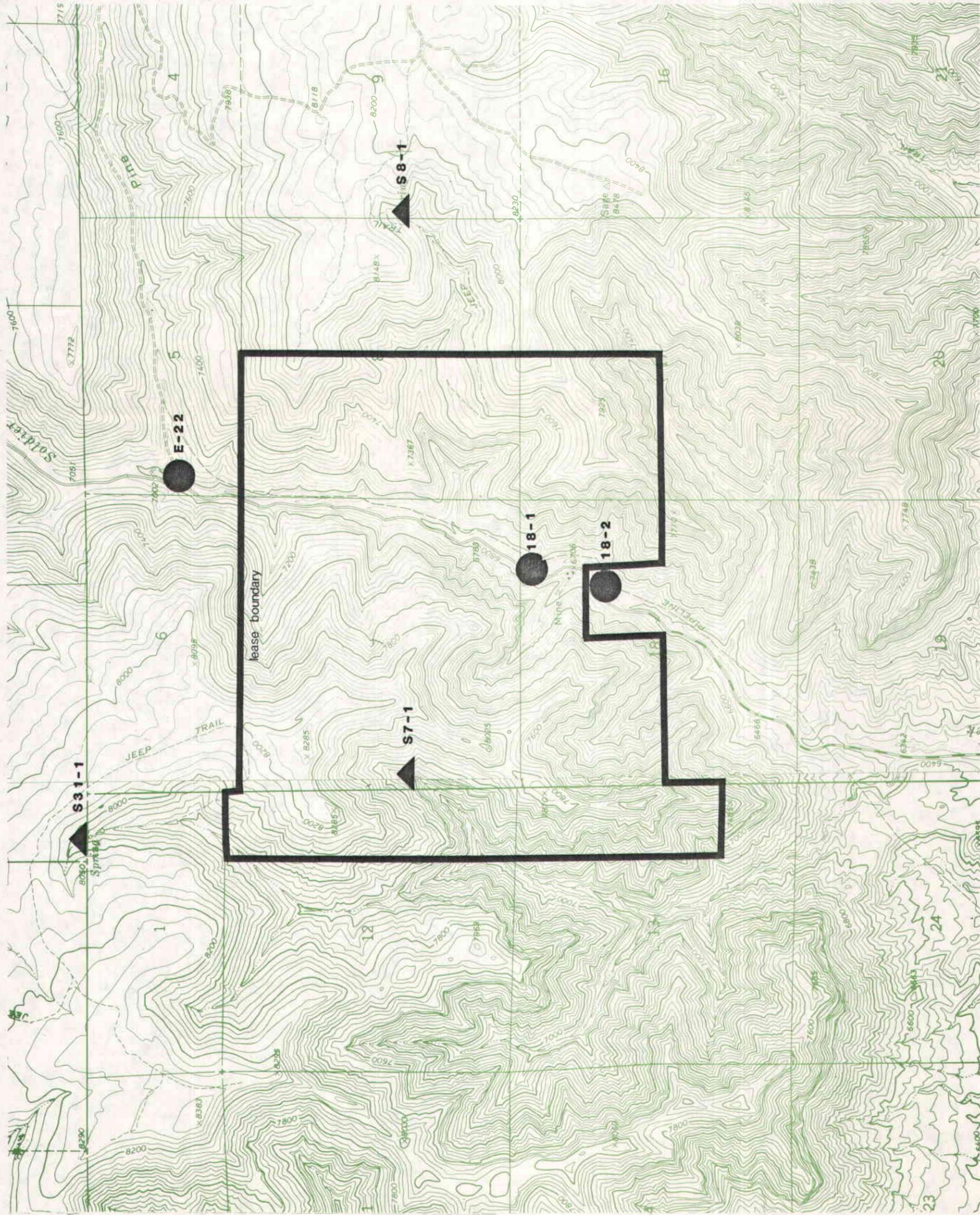
Surface Water Monitoring Program

An ongoing hydrologic monitoring program will be conducted at the stations shown in Figure 9. Stations 18-1 and 18-2 were selected to monitor the impacts of surface drainage from the surface mine facilities. Station E-22 was selected upstream from the Soldier Canyon Mine lease area to monitor any impacts on the surface hydrologic system from underground mining activities.

only annually?

Samples will be collected from all surface water stations shown on Figure 9 annually and analyzed as outlined in the comprehensive schedule given in Table 1 (or an approved abbreviated schedule) with the exception of orthophosphates and cyanide. Total phosphate will be analyzed in place of orthophosphate because state standards are based upon the total form. Cyanide will be added to the comprehensive schedule due to the appearance of background cyanide concentrations in a sample collection from Soldier Creek by Eureka Energy Company as previously discussed in this section. These samples will be collected during the month of August each year to allow sufficient time prior to snowfall to collect additional data if the laboratory results show unique, unexpected conditions. Samples will be analyzed according to Attachment A and preserved as previously outlined.

In addition to the annual comprehensive sampling in August, surface water samples will be gathered and analyzed on a quarterly basis (November, February, and May) throughout the period of mine operation. These samples will be analyzed in accordance with the parameters listed in the abbreviated schedule of Table 6.



LEGEND

- Surface Water Sampling Site
- ▲ Spring Sampling Site

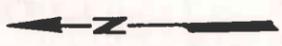


Figure 9. Location of ongoing hydrologic monitoring stations within and adjacent to the Soldier Canyon Mine lease area.

The derivation of Table 6 was based on the need to clarify background conditions and future impacts. Because of the relatively high chemical quality of waters in the Soldier Canyon Mine lease area, as determined by the inventory, suspended solids has been included in the abbreviated schedule as the single most important impact indicator. Phenol and cyanide are included because of the background concentrations found previously. Total dissolved solids, specific conductance, temperature, and the major cations and anions are included as indexes of major change. Total iron, total manganese, and pH determinations are required by OSM regulations. Certain parameters of Table 6 may be dropped or the frequency of sampling altered with the concurrence of the regulatory agency if subsequent data justifies such an alteration.

Surface water monitoring will continue on a quarterly basis (August, November, February, and May) during post-mining operations until the reclamation effort is approved by the regulatory agency. Post-mining samples will be analyzed in accordance with the abbreviated water quality

Table 6. Abbreviated water quality analytical schedule.

Field Measurements	Laboratory Measurements	
Discharge	Bicarbonate	Phenol
pH	Calcium	Potassium
Specific Conductance	Chloride	Sodium
Temperature, Air	Cyanide	Sulfate
Temperature, Water	Iron, Total	Suspended Solids
	Magnesium	Total Dissolved Solids
	Manganese, Total	

analytical schedule with the exception of the August sample, which will be analyzed for the parameters as listed in Table 1 (or an approved abbreviated schedule).

An NPDES discharge permit has already been acquired by Soldier Creek Coal Company for discharge from surface mine facilities. Monitoring of all discharges will be conducted in accordance with this permit.

As required, water quality data collected from surface water monitoring stations will be submitted to the regulatory authority (Utah Division of Oil, Gas, and Mining). Such reports will normally be submitted within 60 to 90 days of the end of each quarter, depending upon the speed of the laboratory analyses.

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of an enough*

GROUNDWATER HYDROLOGY

Regional Groundwater Hydrologic System

The principal factor controlling the occurrence and availability of groundwater in any area is geology. As noted by Price and Waddell (1972), nearly all of the region surrounding the Soldier Canyon Mine lease area is underlain by rocks of continental and marine origin, consisting predominately of interbedded sandstones and shales. Although some of the sandstones in the region serve as the principle water bearing strata, their ability to yield water for extended periods of time is largely controlled by the fact that the sandstone beds are relatively impermeable and by the existence of the impermeable interbedded shale layers, which prevent the downward movement of a significant amount of water.

According to the U.S. Geological Survey (1979), groundwater in the region exists under water table, artesian, and perched conditions. Water table conditions exist primarily in shallow alluvial deposits along larger perennial streams and in relatively flat lying sedimentary rocks. Artesian conditions exist at greater depths where a confining layer overlies a more permeable member. However, pressures are generally not sufficient to produce flowing wells. Perched or impeded conditions exist where the confining layer lies beneath the water bearing strata.

The Book Cliffs, where the Soldier Canyon Mine is located, and the adjacent Wasatch Plateau act as recharge areas for regional groundwater systems (Price and Arnow, 1974). Only a small portion of the annual

precipitation, probably much less than five percent, recharges the groundwater supply (Price and Arnow, 1974; U.S. Geological Survey 1979). The depth of water infiltrating through the surface to saturated beds is small due to the presence of the relatively impermeable shale layers near the surface over much of the area and to the potential evapotranspiration being greater than the rainfall.

Price and Arnow (1974) indicate that properly constructed wells in the Price River Basin would have only limited yields (normally less than 50 gallons per minute). Wells immediately adjacent to the Soldier Canyon Mine lease area could normally be expected to yield less than 10 gallons per minute (Price and Wadell, 1973). Increased yields could possibly be expected from wells penetrating highly fractured sandstones.

how near?
Rocks in the mountainous areas near the Soldier Canyon Mine generally have low specific yields (0.2 to 0.7 percent) and low hydraulic conductivities (Price and Waddell, 1973). The volume of recoverable water in the area is small, averaging less than 600 acre-feet per square mile in the upper 100 feet of saturated rock (Price and Arnow, 1974).

The quality of groundwater in the Price River Basin deteriorates with distance downstream much the same as surface water. Dissolved solids concentrations in ground water range from less than 500 milligrams per liter near the Soldier Canyon Mine lease area to 3000 milligrams per

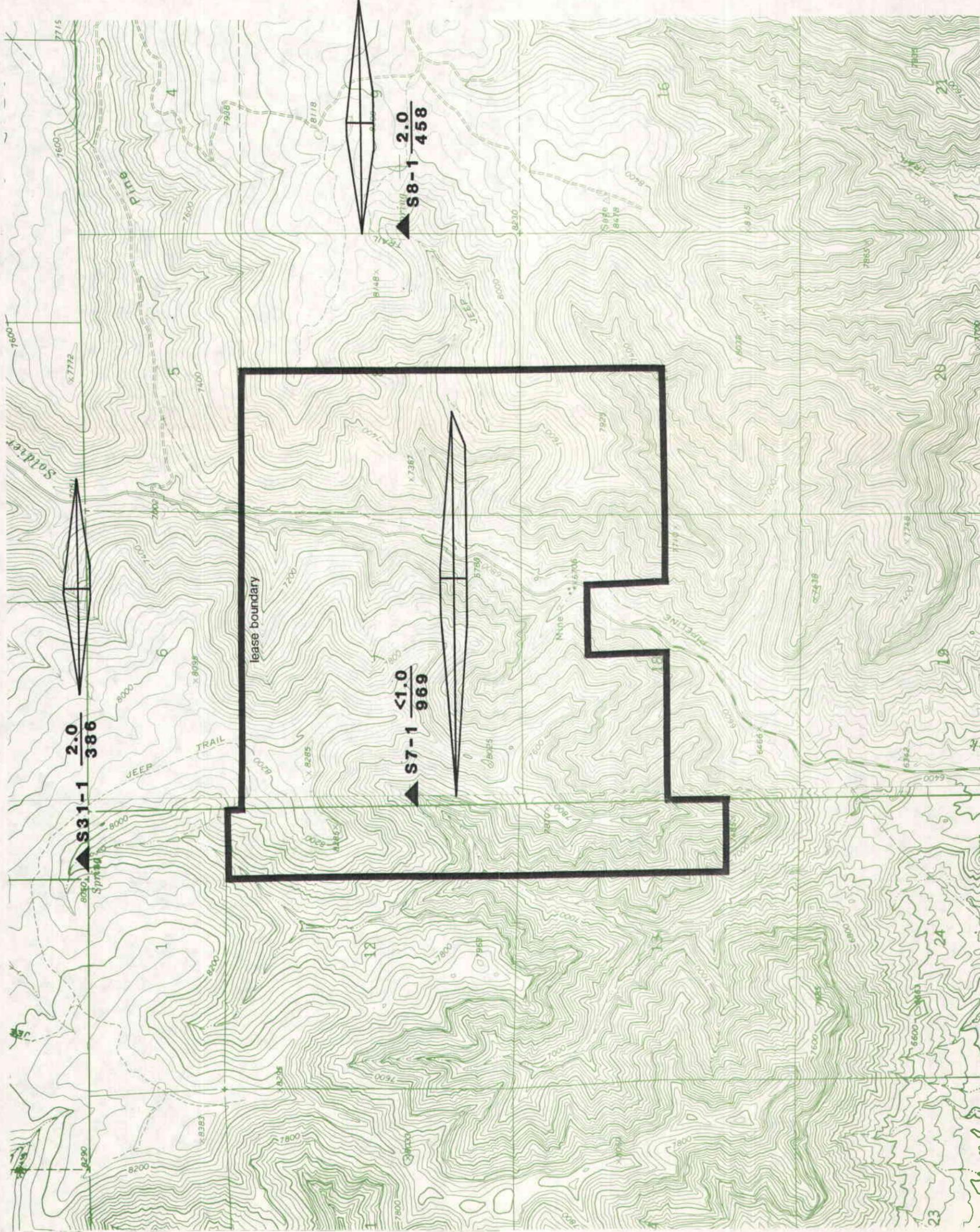
liter near the confluence of the Price River with the Green River (Price and Waddell, 1973). This increase in dissolved solids concentration is the result of increased contact of water and rock as travel distance increases, with saline shales contributing a major portion of the dissolved constituents.

Characteristics of Seeps and Springs

All springs and seeps were sampled within and adjacent to the Soldier Canyon Mine lease area during September, 1979 to obtain an index of groundwater hydrologic conditions in the area. Discharge and water temperature measurements were made and a water quality sample was collected and analyzed for the comprehensive list of parameters in Table 1. Results of the field investigation and chemical analyses are illustrated in Figure 10.

would like to see more data obtained when & where possible

Only three springs were found within or adjacent to the lease area, two of which were located outside of the lease boundary. All three of the springs were located near the base of a dominant sandstone formation. Both springs S8-1 and S31-1 issue near the interface between the Flagstaff and North Horn formations and spring S7-1 issues at the contact between the Castlegate Sandstone and non coal-bearing portion of the Price River Formation. As mentioned previously, all three of these formations consist of a series of shale and sandstone layers with both the Flagstaff and North Horn formations containing beds of limestone. Shale layers act as impeding members to deep percolation, forcing at least a portion of the water that percolates through the soil mantle to move somewhat horizontally to be discharged at the surface as spring water.



LEGEND

▲ Spring Number. $\frac{\text{Flow (gpm)}}{\text{TDS (mg/l)}}$

Na+K
 Ca
 Mg

Cl
 HCO₃
 SO₄

MEQ/L

Figure 10. Identified seeps and springs within and adjacent to the Soldier Canyon Mine lease area, with water quality data.

The three springs encountered near the Soldier Canyon Mine were located at higher elevations with recharge zones suspected to be the small areas of the nearby flats located along adjacent ridges. Flows from the springs were low during the inventory, ranging from less than one gallon per minute to two gallons per minute. Due to the localized nature of the springs, flows are expected to be higher during the snowmelt runoff period and are expected to be quite sensitive to the amount of precipitation received during any given year.

As illustrated on Figure 10, the groundwater, as indexed by springs in the lease area, is of a strong calcium bicarbonate type with high sulphate concentrations measured at spring S7-1. Total dissolved solids concentrations varied from 386 to 969 milligrams per liter. These relatively high concentrations are probably due to the prolonged contact of the water with the shale layers of the Flagstaff, North Horn, and Price River formations. Shales tend to contain an abundance of soluble minerals and allow more surface contact to water flowing through them than would be expected in coarse-textured rocks (Bently et al., 1978).

All three of the springs located during the hydrologic inventory of the lease area were selected for continued water quality and quantity monitoring. Although springs S8-1 and S31-1 are located outside of the lease area and potential area of impact from underground mining activities, they were selected for continued monitoring as an index to background conditions.

Groundwater Quality

Water quality samples were collected and analyzed for the three springs within and adjacent to the Soldier Canyon Mine lease area as an index to groundwater hydrologic conditions within the Flagstaff, North Horn, and Price River formations. In addition, a water quality sample was collected from water dripping from the ceiling within the mine to index the groundwater hydrologic conditions of the Blackhawk Formation. One additional water quality sample was collected and analyzed from groundwater encountered in an enclosed pit, dug at the mine train loadout facility near Sunnyside Junction, referred to hereafter as the "Banning Siding" sample (see Figure 1 for location).

Since no active coal exploration program is being conducted on the lease area, high cost relative to expected benefits precluded the drilling of observation wells in the area and the collection of reliable groundwater hydrology data therefrom. The cost of constructing and developing wells to obtain reliable data would have far exceeded the benefits derived therefrom considering the lack of groundwater use in the area, the absence of a significant groundwater aquifer, and the ability to obtain within the mine water quality data for the Blackhawk Formation. The three monitored springs account for nearly all groundwater use in the area.

All water samples were collected and preserved as previously outlined. The results of the chemical analyses for samples from springs, from within the mine, and from the pit at the train loadout site are presented in Attachment C.

Variability in groundwater quality in the geologic formations was analysed by comparing water quality constituents. Concentrations of the various constituents were relatively consistent between the Flagstaff and North Horn formations, with the groundwater from within these formations being primarily of a calcium-bicarbonate type (see figures 10 and 11). Groundwater in the Price River Formation is also strongly calcium-bicarbonate, but sulfate concentrations are much higher than those of the Flagstaff and North Horn formations.

According to the analysis of the sample taken from within the mine, the groundwater from the Blackhawk Formation is predominantly sodium-bicarbonate. The Blackhawk Formation is extremely discontinuous in nature; therefore the groundwater quality within the Blackhawk Formation itself is expected to be highly variable, as has been demonstrated at other locations within the Price River Basin (Vaughn Hansen Associates, December of 1979).

Phenol and total dissolved solids concentrations measured during the fall study period were the only constituents to exceed state water quality standards for the uses specified for water in the area of the Soldier Canyon Mine. None of the springs sampled exceeded state standards. The only sample to exceed state standards was taken from within the mine, having a phenol concentration of 0.012 milligrams per liter, and a total dissolved solids concentration of 1500 milligrams per liter which exceeds the state standard for Class 4 waters (1200 milligrams per liter).

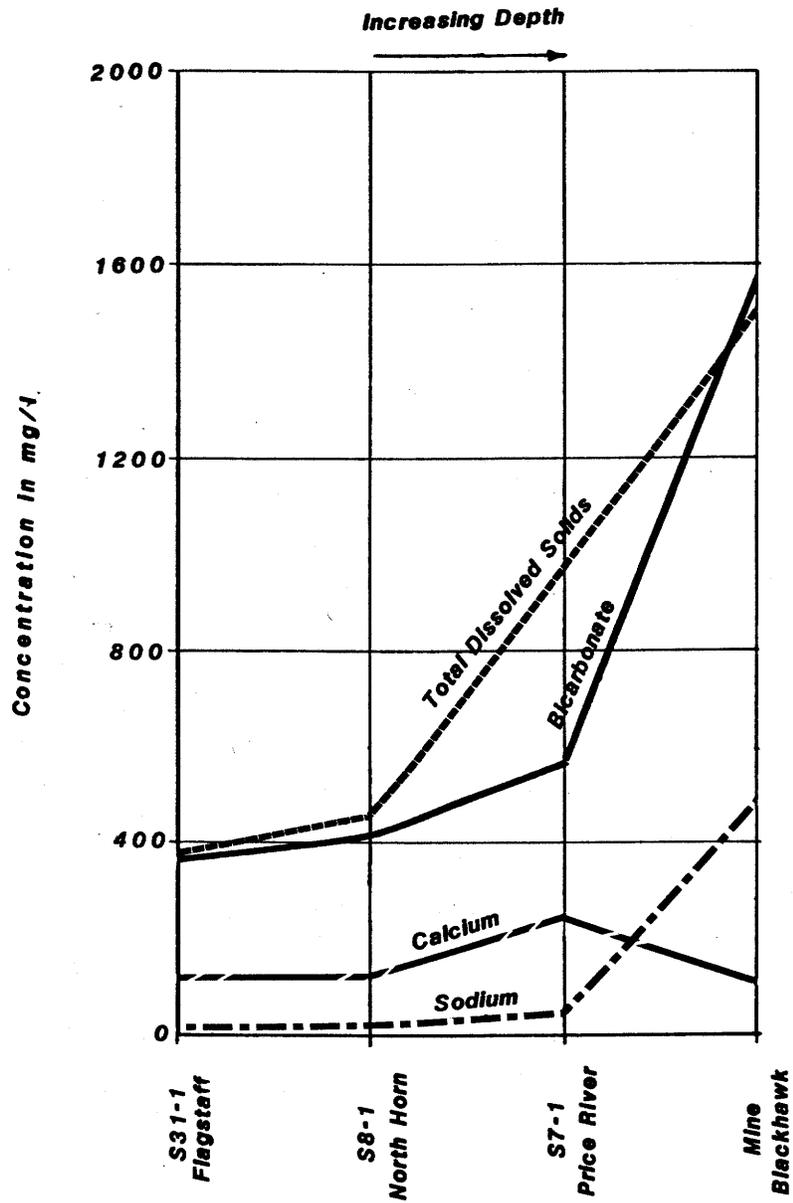


Figure 11. Comparison of water quality data collected from the springs and mine from the separate geologic formations within the Soldier Canyon Mine lease area.

Concentrations of other constituents sampled at stations throughout the vicinity of the Soldier Canyon Mine were quite low. In many cases, trace metal concentrations were consistently below the level of detection by routine laboratory techniques (particularly cadmium, lead, mercury, selenium, and silver).

*what is
throughout
the vicinity?
?*

Groundwater taken from the Banning Siding site at Sunnyside Junction was of a calcium-sulphate type. With the exception of the total dissolved solids concentration, no exceedances to state standards for water use in this area were detected. The total dissolved solids concentration at this site was measured at 2540 milligrams per liter, which exceeds the state standard for Class 4 waters (1200 milligrams per liter). However, the water quality from the Banning Siding site is of comparable quality to surface waters in the near vicinity. Total dissolved solids concentrations in Grassy Trail Creek at Sunnyside Junction have been measured in excess of 3500 milligrams per liter. Therefore, total dissolved solids concentrations naturally and significantly exceed state standards at this point.

*what is
the average?
Is this
value an
extreme?*

Groundwater Monitoring Program

An ongoing groundwater monitoring program will be conducted at each of the springs shown in Figure 9. In addition, data will be collected from within the mine and from the Banning Siding sampling station at the mine train loadout facility.

As stated previously, the quality of water issuing from springs and seeps is representative of groundwater within the various geologic formations.

Groundwater usage in the area consists almost entirely of springs; therefore, because of the desire to monitor impacts from mining activities, the monitoring of springs on the site takes on added importance.

Although Soldier Creek near the Soldier Canyon Mine is accessible most of the year, such is not the case with springs. Therefore, water quality data will be collected once a year (during the month of August) from the springs noted in Figure 9. The collection of a sample in the early spring from springs may result in the inclusion of a significant amount of snowmelt runoff, whereas a later sample would not normally allow the collection of additional data before snowfall if unique and unexpected conditions are found. Each of the water quality samples will be analyzed as outlined by the comprehensive schedule of Table 1 or an approved abbreviated schedule.

Is this sufficient?

Water quality samples will be collected quarterly from seepage near the working face of the mine and from the Banning Siding site at Sunnyside Junction. The sample taken during the month of August will be analyzed according to the schedule of Table 1. In addition to the annual comprehensive sample in August, water quality samples will be gathered from these two sites and analyzed during the months of November, February, and May throughout the period of mine operation. These samples will be analyzed in accordance with the parameters listed in the abbreviated list of Table 6.

An amendment to the existing NPDES discharge permit (as required by the regulatory agency) will be acquired to discharge water currently stored

within the mine. Monitoring of all discharges will be conducted in accordance with this permit.

As required, groundwater quality data collected from the lease area will be submitted to the Utah Division of Oil, Gas, and Mining within 60 to 90 days of the end of each quarter, depending upon the speed of laboratory analyses.

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ATTACHMENT A

Water Quality Analysis Methods

Table 7. Field methods used for the analysis of water quality samples.

Parameter	Units	Instrument
Flow	cfs	Marsh-McBirney current meter, float measurement, or volumetric measurement
Temperature	°C	Thermometer
pH	units	Beckman Model 1009 pH meter
Conductivity	micromhos/cm @ 25°C	Hydrolab TC-2 conductivity meter

Table 8. Laboratory methods used for the analysis of water quality samples, with standard reference page numbers.

Parameter	Unit	Method	1974 EPA Methods Page No.	14th Ed. Standard Methods Page No.
Acidity, as CaCO ₃	mg/l	Titration	1	273
Alkalinity, as CaCO ₃	mg/l	Manual or automated electrometric titration to pH 4.5, or automated method	3 5	278 ---
Ammonia, as N	mg/l	Manual distillation (at pH 9.5) followed by nesslerization, titration, electrode, automated phenolate	---	410
			159	412
			165	---
			168	---
Arsenic	mg/l	Digestion followed by silver diethyldithio-carbamate, or atomic absorption	---	285
			9	283
			95	159
BOD, 5-day	mg/l	Winkler (azide modification) or electrode method	--	543
Barium	mg/l	Digestion followed by atomic absorption or colorimetric	97	152
Bicarbonate	mg/l	Titration	278	--
Boron	mg/l	Colorimetric (Curcumin)	13	287
Cadmium	mg/l	Digestion followed by atomic absorption or colorimetric	101	148
			---	182
Calcium	mg/l	Digestion followed by atomic absorption or titration	103	148
			---	182

Table 8. Continued.

Parameter	Unit	Method	1974 EPA Methods Page No.	14th Ed. Standard Methods Page No.
Chloride	mg/l	Silver nitrate, mercuric nitrate, or automated colorimetric	---	303
			29	304
			31	613
Chromium, VI	mg/l	Extraction and atomic absorption, colorimetric	89	---
			105	192
Copper	mg/l	Digestion followed by atomic absorption or colorimetric	108	148
Cyanide	mg/l	Distillation followed by silver nitrate titration or pyridine pyrazolone (or barbituric acid) colorimetric	---	196
			40	361
Fluoride	mg/l	Distillation followed by ion electrode, SPANDS, or automated complexone	---	389
			65	391
			59	393
			61	164
Gross Alpha Radioactivity	pCi/l	Scintillation counter	---	641
Gross Beta Radioactivity	pCi/l	Scintillation counter	---	642
Iron	mg/l	Digestion followed by atomic absorption or colorimetric	110	148
			---	208
Lead	mg/l	Digestion followed by atomic absorption or colorimetric	112	148
			---	215

Table 8. Continued.

Parameter	Unit	Method	1974 EPA Methods Page No.	14th Ed. Standard Methods Page No.
MPN Fecal Coliform	MPN/100 ml	MPN procedure	---	922
MPN Total Coliform	MPN/100 ml	MPN procedure	---	922
Magnesium	mg/l	Digestion followed by atomic absorption or gravimetric	114 ---	148 221
Manganese	mg/l	Digestion followed by atomic absorption or colorimetric	116 ---	148 225
Mercury	mg/l	Flameless atomic absorption	118	156
Nitrate, as N	mg/l	Cadmium reduction, brucine sulfate, automated cadmium or hydrazine reduction	201 197 207	423 427 620
Oil & Grease	mg/l	Liquid extraction with freongravimetric	229	515
Phenol	mg/l	Colorimetric (4-AAP)	241	582
Phosphate, as P	mg/l	Manual or automated ascorbic acid reduction	249 256	481 624
Potassium	mg/l	Digestion followed by atomic absorption, colorimetric or flame photometric	143 --- ---	--- 235 234
Selenium	mg/l	Digestion followed by atomic absorption	145	159
Silver	mg/l	Digestion followed by atomic absorption or colorimetric	146	148

Table 8. Continued.

Parameter	Unit	Method	1974 EPA Methods Page No.	14th Ed. Standard Methods Page No.
Sodium	mg/l	Digestion followed by atomic absorption, flame photometric	147 ---	--- 250
Sulfate	mg/l	Gravimetric, turbidimetric, or automated colorimetric	--- 277, 279	493 496
Suspended Solids	mg/l	Glass fiber filtration, 105°C	268	94
Total Suspended Solids	mg/l	Glass fiber filtration, 180°C	266	92
Total Organic Carbon	mg/l	Combustion - infrared	236	532
Turbidity	NTU	Nephelometric	295	132
Zinc	mg/l	Digestion followed by atomic absorption or colorimetric	155 ---	148 265

ATTACHMENT B

Results of Surface Water

Quality Analysis

Table 9. Results of chemical analyses of surface water quality samples collected by Vaughn Hansen Associates.

Station Number		Lower Soldier	Lower Soldier	18-2	18-1	E-22	E-22
Parameter	Units	4-10-79	6-21-79	9-26-79	9-26-79	4-10-79	6-21-79
FIELD MEASUREMENTS							
Discharge	cfs	11.1	12.0	1.2	1.2	10.7	13.0
Dissolved Oxygen	mg/l		9.8				10.8
pH	units	7.88	8.0	7.6	7.60	7.93	8.0
Specific Conductance	umhos/cm @ 25° C	740	780	840	830	570	620
Temperature, Air	°C	0.0	12.0			0.0	13.0
Temperature, Water	°C		6.0	13.0	13.0		6.0
LABORATORY MEASUREMENTS							
Acidity, as CaCO ₃	mg/l			22.0	18.0		
Alkalinity, as CaCO ₃	mg/l	266.0	292.0	310.0	284.0	260.0	302.0
Ammonia, NH ₃ as N	mg/l						
Arsenic, Total	mg/l			0.002	0.002		
Arsenic, Dissolved	mg/l						
Barium, Total	mg/l			0.130	0.120		
Barium, Dissolved	mg/l						
Beryllium, Dissolved	mg/l						
Bicarbonate	mg/l	324.52	356.24	378.20	346.48	317.20	368.44
Boron, Total	mg/l			0.160	0.180		
Boron, Dissolved	mg/l						
Cadmium, Total	mg/l			<0.001	<0.001		
Cadmium, Dissolved	mg/l						
Calcium	mg/l	60.0	56.80	104.00	88.00	45.60	55.20
Chloride	mg/l	12.0	12.0	16.0	12.0	8.0	8.0
Chromium, Total	mg/l			<0.001	<0.001		
Chromium, Dissolved	mg/l						
Cobalt, Dissolved	mg/l						
Copper, Total	mg/l			<0.001	0.002		
Copper, Dissolved	mg/l						
Cyanide	mg/l						
Fluoride	mg/l			0.38	0.39		
Germanium, Dissolved	mg/l						
Gross Alpha Radioactivity	pCi/l						
Gross Beta Radioactivity	pCi/l						
Iron, Total	mg/l			0.37	0.19		
Iron, Dissolved	mg/l			0.020	<0.010		
Lead, Total	mg/l			<0.001	<0.001		
Lead, Dissolved	mg/l						
Magnesium	mg/l	39.36	45.60	9.60	19.20	32.16	36.48
Manganese, Total	mg/l			0.023	0.012		
Manganese, Dissolved	mg/l						
Mercury, Total	mg/l			<0.0002	<0.0002		
Mercury, Dissolved	mg/l						
Nitrate, NO ₃ as N	mg/l			0.04	<0.01		
Oil and Grease	mg/l			1.4	<1.0		
Phenol	mg/l				0.026		
Phosphate, PO ₄ as P Ortho	mg/l			0.15	0.100		
Potassium	mg/l	2.20	1.929	2.762	2.318	1.300	1.188
Selenium, Total	mg/l			0.002	0.003		
Selenium, Dissolved	mg/l						
Silica, as SiO ₂	mg/l						
Silver, Total	mg/l			<0.001	<0.001		
Silver, Dissolved	mg/l						
Sodium	mg/l		39.40	84.20	80.80	53.00	34.71
Sulfate	mg/l	150.0	109.0	143.0	160.0	72.0	52.0
Suspended Solids	mg/l	1644.0	1.0	17.0	6.5	1113.0	6.0
Total Dissolved Solids	mg/l	480.0	442.0	542.0	538.0	374.0	379.0
Total Organic Carbon	mg/l						
Turbidity	FTU	250				200	
Zinc, Total	mg/l			0.005	0.003		
Zinc, Dissolved	mg/l						

Table 10. Results of chemical analyses of surface water quality samples collected at Station E-22 (Data obtained from Anderson, 1979).

Station Number		E-22						
Parameter	Units	7-21-76	8-25-76	5-18-77	8-18-77	4-13-78	8-2-78	10-19-78
FIELD MEASUREMENTS								
Discharge	cfs	0.16	0.15	0.40	0.01	3.7	0.29	0.25
Dissolved Oxygen	mg/l	7.5	9.0					
pH	units	8.4				8.35	8.7	8.65
Specific Conductance	umhos/cm @ 25° C	700	1060	850	780	635	633	785
Temperature, Air	°C		22.0	6.2	18.3	11.0	22.0	17.0
Temperature, Water	°C	16.0	16.0	11.3	15.5	0.0	19.0	13.0
LABORATORY MEASUREMENTS								
Acidity, as CaCO ₃	mg/l							
Alkalinity, as CaCO ₃	mg/l							
Ammonia, NH ₃ as N	mg/l		0.78	0.40	0.05	0.22	<0.01	0.10
Arsenic, Total	mg/l							
Arsenic, Dissolved	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium, Total	mg/l							
Barium, Dissolved	mg/l		0.021	0.094	0.062	0.010	0.140	0.100
Beryllium, Dissolved	mg/l		<0.001	0.003	<0.001	0.005	0.011	0.005
Bicarbonate	mg/l	332.0	368.4	478.2	414.8	307.4	388.0	458.7
Boron, Total	mg/l							
Boron, Dissolved	mg/l	0.080	<0.001	0.034	0.022	0.123	0.020	0.180
Cadmium, Total	mg/l							
Cadmium, Dissolved	mg/l		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Calcium	mg/l	43.0	28.9	29.4	32.0	38.4	32.0	26.4
Chloride	mg/l	12.0	14.0	16.0	12.0	10.0	12.0	16.0
Chromium, Total	mg/l							
Chromium, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt, Dissolved	mg/l		0.011	0.009	<0.001	<0.001	0.009	<0.001
Copper, Total	mg/l							
Copper, Dissolved	mg/l		0.012	0.008	0.003	0.012	0.009	0.004
Cyanide	mg/l				<0.001	<0.010	<0.010	0.020
Fluoride	mg/l	0.4	0.5	0.62	0.37	0.58	0.49	0.45
Germanium, Dissolved	mg/l		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gross Alpha Radioactivity	pCi/l		<3.5			3.7	4.4	3.7
Gross Beta Radioactivity	pCi/l		<1.5			12.0	12.0	11.0
Iron, Total	mg/l							
Iron, Dissolved	mg/l	0.010	0.197	0.385	0.076	0.110	0.037	0.045
Lead, Total	mg/l							
Lead, Dissolved	mg/l	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium	mg/l	35.0	30.2	61.9	34.6	28.8	37.4	44.2
Manganese, Total	mg/l							
Manganese, Dissolved	mg/l		0.014	0.119	0.009	0.018	0.018	0.048
Mercury, Total	mg/l							
Mercury, Dissolved	mg/l	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nitrate, NO ₃ as N	mg/l	0.11	0.04	0.14	0.12	0.20	0.02	0.02
Oil and Grease	mg/l							
Phenol	mg/l		<1.0	<1.0	1.2	2.6	2.4	<1.0
Phosphate, PO ₄ as P Ortho	mg/l	0.01	0.085	0.260	0.020	0.020	0.023	0.065
Potassium	mg/l	2.5	4.1	2.3	3.8	1.8	1.4	1.9
Selenium, Total	mg/l							
Selenium, Dissolved	mg/l	0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001
Silica, as SiO ₂	mg/l	8.2	12.1	28.5	8.15	6.5	7.6	8.0
Silver, Total	mg/l							
Silver, Dissolved	mg/l	0.008	0.003	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	mg/l	64.0	118.0	134.4	112.0	95.2	71.1	110.0
Sulfate	mg/l	90.0	130.0	190.0	114.0	72.0	67.0	92.0
Suspended Solids	mg/l				12.0	968.0	11.0	1.0
Total Dissolved Solids	mg/l	421.0	690.0	860.0			412.0	512.0
Total Organic Carbon	mg/l		10.0	29.0	14.0	10.0	6.0	17.0
Turbidity	FTU							
Zinc, Total	mg/l							
Zinc, Dissolved	mg/l	0.000	0.050	0.014	0.007	0.061	0.021	0.003

Table 11. Results of chemical analyses of surface water quality samples collected by the U.S. Geological Survey (1978, 1979).

Station Number		18-2	18-2	18-2	18-2	18-1
Parameter	Units	7-21-76	8-16-78	10-20-78	11-17-78	7-21-76
FIELD MEASUREMENTS						
Discharge	cfs	0.37	0.45	0.35	0.66	0.46
Dissolved Oxygen	mg/l		7.6	9.2	10.8	
pH	units	8.4	8.6	8.6	8.4	8.4
Specific Conductance	umhos/cm @ 25° C	740	764	900	990	700
Temperature, Air	°C		25.0	11.0	-5.5	
Temperature, Water	°C	21.5	17.0	7.0	0.0	22.5
LABORATORY MEASUREMENTS						
Acidity, as CaCO ₃	mg/l					
Alkalinity, as CaCO ₃	mg/l		340.0	360.0	370.0	
Ammonia, NH ₃ as N	mg/l					
Arsenic, Total	mg/l					
Arsenic, Dissolved	mg/l		0.002		0.002	
Barium, Total	mg/l					
Barium, Dissolved	mg/l					
Beryllium, Dissolved	mg/l					
Bicarbonate	mg/l	337.0	358.0	402.0	448.0	332.0
Boron, Total	mg/l					
Boron, Dissolved	mg/l	0.10	0.10		0.11	0.08
Cadmium, Total	mg/l					
Cadmium, Dissolved	mg/l					
Calcium	mg/l	32.0	51.0	56.0	54.0	43.0
Chloride	mg/l	11.0	12.0	15.0	16.0	12.0
Chromium, Total	mg/l					
Chromium, Dissolved	mg/l					
Cobalt, Dissolved	mg/l					
Copper, Total	mg/l					
Copper, Dissolved	mg/l					
Cyanide	mg/l					
Fluoride	mg/l	0.40	0.40		0.40	0.40
Germanium, Dissolved	mg/l					
Gross Alpha Radioactivity	pCi/l					
Gross Beta Radioactivity	pCi/l					
Iron, Total	mg/l					
Iron, Dissolved	mg/l		0.01		0.01	
Lead, Total	mg/l					
Lead, Dissolved	mg/l		0.18		0.0	
Magnesium	mg/l	41.0	47.0	51.0	49.0	35.0
Manganese, Total	mg/l					
Manganese, Dissolved	mg/l		0.04		0.04	
Mercury, Total	mg/l					
Mercury, Dissolved	mg/l					
Nitrate, NO ₃ as N	mg/l					
Oil and Grease	mg/l		0.0		0.0	
Phenol	mg/l		0.0		0.0	
Phosphate, PO ₄ as P Ortho	mg/l		0.00		0.03	
Potassium	mg/l	3.5	3.3	3.4	2.8	2.5
Selenium, Total	mg/l					
Selenium, Dissolved	mg/l		0.001		0.003	
Silica, as SiO ₂	mg/l					
Silver, Total	mg/l					
Silver, Dissolved	mg/l					
Sodium	mg/l	66.0	70.0	90.0	91.0	64.0
Sulfate	mg/l	98.0	110.0	150.0	180.0	90.0
Suspended Solids	mg/l					
Total Dissolved Solids	mg/l	443.0	506.0	590.0	627.0	421.0
Total Organic Carbon	mg/l					
Turbidity	FTU					
Zinc, Total	mg/l					
Zinc, Dissolved	mg/l		0.003		0.01	

ATTACHMENT C

Results of Groundwater

Quality Analysis

Table 12. Results of the chemical analyses of water quality samples collected from springs, within the mine, and at the Banning Siding site at Sunnyside Junction during the fall study period.

Station Number		7-1	8-1	31-1	Mine	Banning Siding
Parameter	Units	9-26-79	9-26-79	9-26-79	9-26-79	10-10-79
FIELD MEASUREMENTS						
Discharge	gpm	<1.0	2.0	2.0	<1.0	
Dissolved Oxygen	mg/l					
pH	units	7.6	7.4	7.10	7.20	7.20
Specific Conductance	umhos/cm @ 25° C	1480	700	600	2300	3900
Temperature, Air	°C					
Temperature, Water	°C	12.0	13.0	11.0	16.0	13.0
LABORATORY MEASUREMENTS						
Acidity, as CaCO ₃	mg/l	46.0	32.0	28.0	78.0	42.0
Alkalinity, as CaCO ₃	mg/l	460.0	340.0	300.0	1296.0	354.0
Ammonia, NH ₃ as N	mg/l					
Arsenic, Total	mg/l	0.001	<0.001	<0.001	<0.001	0.002
Arsenic, Dissolved	mg/l					
Barium, Total	mg/l	0.090	0.160	0.120	7.530	0.095
Barium, Dissolved	mg/l					
Beryllium, Dissolved	mg/l					
Bicarbonate	mg/l	561.20	414.80	366.00	1581.12	431.88
Boron, Total	mg/l	0.080	0.090	0.060	1.400	0.950
Boron, Dissolved	mg/l					
Cadmium, Total	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, Dissolved	mg/l					
Calcium	mg/l	243.20	124.00	120.00	116.00	576.00
Chloride	mg/l	12.0	6.0	8.0	72.0	108.0
Chromium, Total	mg/l	0.002	<0.001	<0.001	<0.001	<0.001
Chromium, Dissolved	mg/l					
Cobalt, Dissolved	mg/l					
Copper, Total	mg/l	0.010	0.005	0.012	0.005	0.076
Copper, Dissolved	mg/l					
Cyanide	mg/l					
Fluoride	mg/l	0.40	0.29	0.27	1.27	0.12
Germanium, Dissolved	mg/l					
Gross Alpha Radioactivity	pCi/l					
Gross Beta Radioactivity	pCi/l					
Iron, Total	mg/l	0.580	5.850	0.310	0.100	0.560
Iron, Dissolved	mg/l	0.020	0.010	0.030	<0.010	0.113
Lead, Total	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Lead, Dissolved	mg/l					
Magnesium	mg/l	32.0	16.80	7.20	9.60	16.80
Manganese, Total	mg/l	7.680	0.030	0.130	0.021	0.590
Manganese, Dissolved	mg/l					
Mercury, Total	mg/l	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Mercury, Dissolved	mg/l					
Nitrate, NO ₃ as N	mg/l		0.06	0.09	<0.01	0.07
Oil and Grease	mg/l	1.4	<1.0	1.2	<1.0	3.0
Phenol	mg/l	<0.001		<0.001	0.12	0.002
Phosphate, PO ₄ as P Ortho	mg/l		0.08	0.060	0.060	0.040
Potassium	mg/l	3.847	1.240	1.161	23.400	3.990
Selenium, Total	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium, Dissolved	mg/l					
Silica, as SiO ₂	mg/l					
Silver, Total	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Silver, Dissolved	mg/l					
Sodium	mg/l	44.83	19.02	12.62	484.00	210.00
Sulfate	mg/l	350.0	76.0	52.0	<3.0	1410.0
Suspended Solids	mg/l					
Total Dissolved Solids	mg/l	969.0	458.0	386.0	1500.0	2540.0
Total Organic Carbon	mg/l					
Turbidity	FTU					
Zinc, Total	mg/l	0.011	0.009	0.004	0.006	0.021
Zinc, Dissolved	mg/l					