Hydrologic Inventory and Baseline Study of the UCO Mine Permit and Adjacent Areas, Carbon County, Utah

The Scofield Mine

Prepared for
UCO, INCORPORATED
Denver, Colorado

June 1981

CONSULTANTS / ENGINEERS
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DIVISION OF
OIL, GAS & MINING

UCO, Inc. 1580 LINCOLN SUITE 530 DENVER, COLORADO 80203 (303) 837-0465

September 17, 1981

Mr. Jim Smith
Coordinator Mined Land Development
State of Utah
Division of Oil, Gas & Mining
1588 West North Temple
Salt Lake City, UT 84116

Re: Scofield Mine Alluvial Valley Floor Determination

Dear Jim:

Utah regulations (UMC Section 785.19c) state that, "Before applying for a permit to conduct, or before conducting underground coal mining activities within a valley holding a stream or in a location where the adjacent area includes any stream in the arid or semiarid regions of Utah, the applicant shall either affirmatively demonstrate to the satisfaction of the Division of Oil, Gas & Mining (DOGM), based on available field data, the lack or presence of an alluvial valley floor, or submit to the DOGM the results of a field investigation of the proposed mine plan area and adjacent area." Pursuant to said regulations, I am requesting that the DOGM make a determination regarding the existence or non-existence of an alluvial valley floor within UCO's proposed mine plan area or adjacent areas. As support for this request, I am attaching a copy of the Hydrologic Inventory and Baseline Study of the UCO Mine Permit and Adjacent Areas, Carbon County, Utah, The Scofield Mine, prepared by UCO's water resources contractor, Vaughn Hansen Associates of Salt Lake City. The section pertaining to alluvial valley floors may be found within Section 4.0, page 63, of the report. If the DOGM feels they need any further information or require more detailed study prior to making a final determination, please contact me.

I further understand that, based on UMC Section 700.5 regulations, "arid and semiarid area means, in the context of alluvial valley floors, an area where water use by native vegetation equals or exceeds that supplied by precipitation." Consequently, based on this definition, perhaps no further consideration needs to be given to our alluvial valley floor question if it can be shown that the area is neither arid or semiarid. The Hydrologic Atlas of Utah, Utah Water Research Laboratory and State of Utah Department of Natural Resources, PRWG35-1, Utah State University, Logan, Utah, 1968, by Jeppson, R. W., G. L. Ashcroft, A. L. Huber, G. V. Skogerbee, and J. M. Bagley, indicates that the normal annual precipitation within the area of concern varies from 25 inches at the mouth of

Winter Quarters Canyon to over 30 inches further up the canyon at the mine site. The altitude appears to have a large influence on the precipitation, with the higher elevations experiencing more rain and snowfall, as stated by J. C. Mundorff, 1972, Reconnaissance of Chemical Quality of Surface Water and Fluvial Sediment in the Price River Basin, Utah, Department of Natural Resources, Division of Water Rights, Technical Publication No. 39, Salt Lake City, Utah. Furthermore, in the Hydrologic Atlas of Utah, Jeppson et al indicate that annual potential evapotranspiration in the area varies from about 17 to 19 inches, with the higher use rates being at the lower elevations. Therefore, because precipitation significantly exceeds potential evapotranspiration (an ideal or upper limit of actual evapotranspiration), it appears that it may be reasonable not to classify the climate of the area as arid or semi-arid, thereby negating the need for further alluvial valley floor consideration within our area of interest. Again, please let me know how the DOGM interprets this information and if the DOGM needs additional data before making a final determination.

Thank you for your time and consideration with regard to this matter.

Sincerely,

J. Chris Carter

J. Chris Carter
Vice President of Governmental Affairs

JCC:vk

Attachment: As stated

fortified by the fact that coal in the area has a low sulphur content (U.S. Geological Survey, 1979).

2.5 Mitigation and Control Plans

As was previously discussed, no significant impacts to the groundwater system are expected from the mining operation. The groundwater monitoring plan, discussed in the following section, will provide a means to follow the possible effect of the mining activities on the groundwater system.

2.6 Groundwater Monitoring Plans

An ongoing groundwater monitoring program is being conducted at each of the stations shown on Plate 4. During the remainder of the baseline period (through October, 1981) the springs shown on Plate 4 will be monitored for flow and the water levels in the wells shown on Plate 4 will be measured bimonthly (when accessible) and both the wells and the springs will be sampled for quality quarterly (when accessible) according to the schedule outlined in Table 4.

During the operational phase of the mine, water levels in the wells on Plate 4 will be measured quarterly (when accessible). Discharge, pH, temperature, and specific conductance of the monitoring springs shown on Plate 4 will also be measured quarterly (when accessible). Water quality samples will be

Table 4. List of water quality parameters.

Field Parameters	Lab Parameters	
Water Levels or Flow	Aluminum, Dissolved	Manganese, Total
pH	Ammonia (NH_3 as N)	Manganese, Dissolved
Specific Conductance	Arsenic, Dissolved	Mercury, Dissolved
Temperature	Barium, Dissolved	Molybdenum, Dissolved
	Boron, Dissolved	Nickle, Dissolved
	Carbonate	Nitrate
	Bicarbonate	Nitrite
	Cadmium, Dissolved	Potassium
	Calcium	Phosphate, Dissolved
	Chloride	Selenium, Dissolved
	Chromium, Dissolved	Sodium
	Copper, Dissolved	Sulfate
	Fluoride	Sulfide
	Iron, Total	Total Combustible Solids*
	Iron, Dissolved	Total Dissolved Solids
	Lead, Dissolved	Total Hardness (as $CaCO_3$)
	Magnesium	

*only if visible coal fines, oil, or grease are observed.

collected biannually from the springs and wells shown on Plate 4 during high and low-flow periods as determined by baseline studies as well as from water within the mine. Water quality samples will be analyzed according to the schedule in Table 4 unless otherwise approved by the Utah Division of Oil, Gas, and Mining. Baseline data collected so far indicate that many of the parameters listed in Table 4 are of little or no concern in the UCO mine permit area. Consequently, it is expected that after the baseline period is over, a proposal to reduce the parameters of Table 4 for the operational monitoring phase will be submitted for consideration by the Division of Oil, Gas, and Mining. Mine water and sediment pond discharge will be monitored in accordance with the NPDES requirements. Results of all water quality data will be submitted to the Utah Division of Oil, Gas, and Mining quarterly.

Post-mining monitoring of groundwater will continue at representative stations determined with the aid and approval of the Utah Division of Oil, Gas and Mining. Representative groundwater stations will be monitored biannually during high and low flow conditions. Duration of monitoring and parameter selection will be determined after appropriate consultation with state and federal agencies.

3.0 SURFACE WATER HYDROLOGY

Regulations of the Utah Division of Oil, Gas, and Mining require that water monitoring programs be established in areas of underground coal mining to monitor the effects of mining activities and protect the hydrologic balance of such areas. This section outlines the surface water hydrologic investigation and the surface water monitoring plan for the UCO mine permit area.

3.1 Scope

The scope of this surface water section of this report is to describe the existing hydrologic conditions of the UCO mine permit and adjacent areas and to describe the methods that have been and will be used to predict, monitor, and mitigate the impacts of mining. Sections within this surface water section of this report will cover the following major topics: existing surface water resources, surface water development, control and diversions, effects of mining on the surface water hydrologic balance, mitigation and control plans, and surface water monitorig plans.

Information used in preparing the surface water hydrologic section of this report has been gathered by field investigations. Pertinent literature has been examined. Water quality samples have been, and will continue to be, analyzed by a certified laboratory. Water rights were determined by examining current records of the Utah Division of Water Rights.

3.2 Existing Surface Water Resources

This section of the report deals with the region in general and the UCO mine permit area more specifically. Watershed and stream characteristics are both described.

3.2.1 Regional Surface Water Hydrology

The UCO mine permit area is situated in the headwaters of the Price River Basin (see Figures 1 and 6). The surface of the mine permit area drains to the east through Winter Quarters and Woods Canyon creeks which are both tributaries of Mud Creek (sometimes called Pleasant Valley Creek).

Snowmelt is the primary source of water for the perennial streams in the basin with summer precipitation usually producing little runoff (U.S. Geological Survey, 1979). Ephemeral streams are also abundant in the Price River Basin, existing primarily at lower elevations where evapotranspiration significantly exceeds precipitation.

Water use upstream from Castle Valley (the valley containing most of the agricultural land) 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 steams and rivers in the basin occasionally

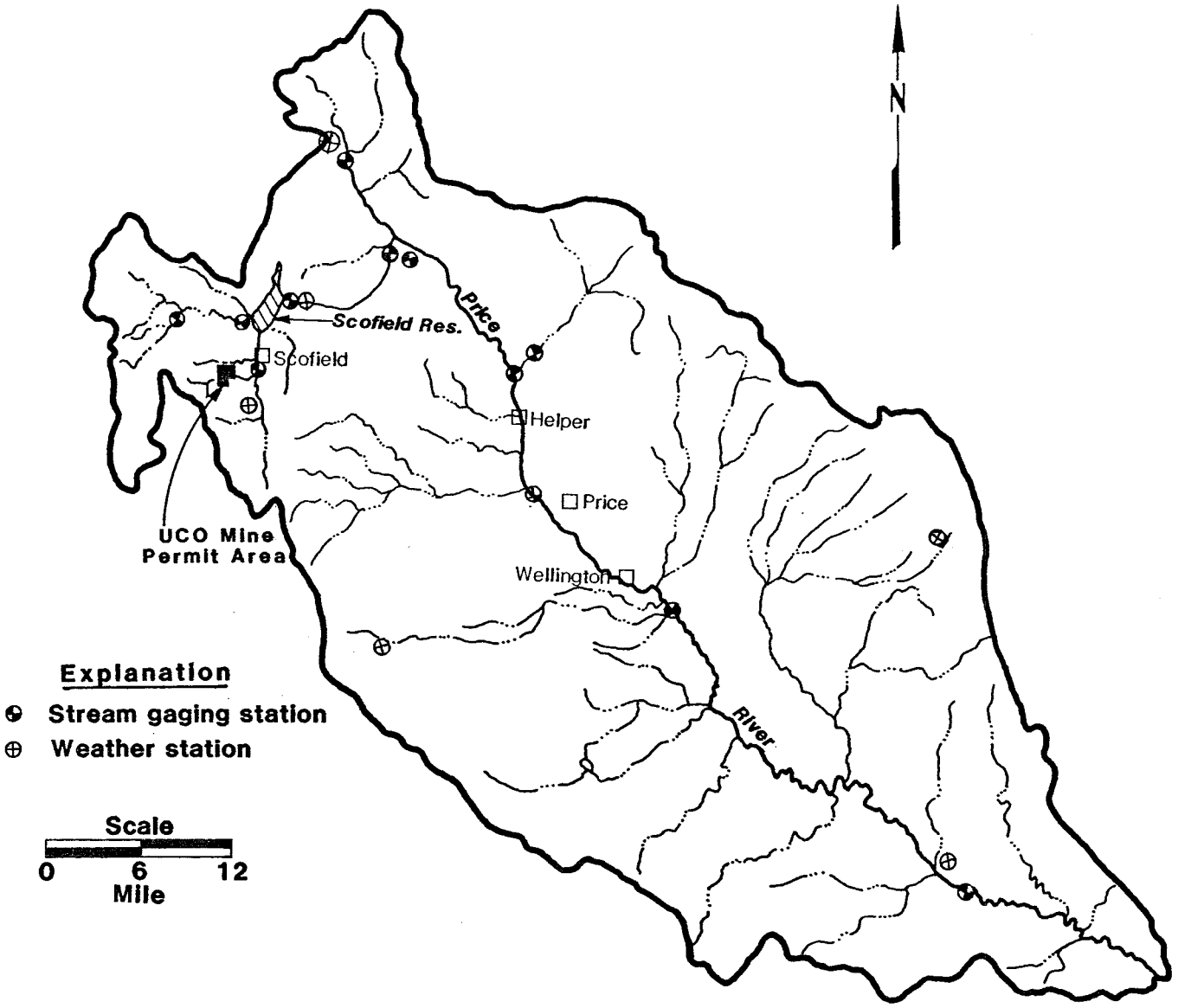

Figure 6. Price River Basin.

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 the watershed providing most of the domestic water needs of the people below. However, this quality rapidly deteriorates as the streams cross shale formations (particularly the Mancos Shale in and adjacent to Castle Valley) and receive irrigation return flows from lands situated on Mancos-derived soils (Price and Waddell, 1973). Within the basin for example, Mundorff (1972) reports that the Price River and its tributaries generally have TDS concentrations of less than 400 mg/l above the stream gaging station just above the town of Helper shown in Figure 6. The water in this area is of the calcium-bicarbonate type. Between this point and the confluence with Miller Creek, most of the flows originate on or tranverse Mancos shales. Much of the flow is derived from irrigation return flows. At Wellington, which is near the center of the basin, the Price River has an average TDS concentration of about 1700 mg/l 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 mg/l with the water type being strongly sodium-sulfate.

Sediment yield from the upper portions of the basin is probably negligible (Mundorff, 1972). According to the U.S. Soil Conservation Service (1975), erosion rates in the Price 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 river comes from limited areas covered with highly erodable shales (Mundorff, 1972) and not in the upper elevations characteristic of the UCO mine permit area.

3.2.2 Mine Plan Area Watersheds and Streams

The UCO mine permit area lies in the drainages of two perennial streams--Winter Quarters and Woods creeks. These streams and their tributaries form dendritic patterns over the area. The landscape of the area varies greatly, with most of the property being covered with conifer, aspen, or sagebrush vegetative communities on fairly steep slopes.

Watershed Characteristics. Slopes within the mine permit area vary from greater than 60 percent (31 degrees) on the south-facing slopes of Winter Quarters Canyon to less than 4 percent (2.3 degrees) along the bottom of Winter Quarters Canyon. The average slope over the area is approximately 37 percent (20 degrees) as determined from a 1:24,000 scale map of the area. Because of the ridge top location of the property and the variety of channelized flow directions, aspects also vary greatly. However, the property does have a dominant aspect to the east. The topography is rugged, with elevations ranging from about 8000 to 9500 feet above mean sea level (a range of about 1500 feet).

Water sources in the mine permit area include undeveloped springs and seeps, as well as Winter Quarters and Woods Canyon creeks, the characteristics of which will be covered in subsequent sections.

Water Quantity. The mean annual water yield from the UCO mine permit area was calculated by two separate methods and compared with an estimate of the mean annual water yield given in Jeppson et al. (1968) to increase the level of confidence. The first method of calculation, referred to as "Grunsky's Rule", was originally developed by Grunsky (1908) and later adapted by Sellars (1965). In accordance with this method, the average annual water yield can be determined from

$$Q = \alpha P^2 \quad [\text{for } P \leq 1/(2\alpha)] \qquad (4)$$

or

$$Q = P - 1/(4\alpha) \quad [\text{for } P \geq 1/(2\alpha)] \qquad (5)$$

where Q is the mean annual water yield, in inches; P is the normal annual precipitation, in inches; and α is the runoff coefficient, in inches^{-1}. An alpha (α) of 0.015 was determined from guidelines set forth by Hawkins (1976). Normal annual precipitation for the area is 28 inches (Jeppson et al., 1968). Substitution of variables results in an estimated yield of 11.2 inches.

The second method of calculation is known as Ol'deKop's formula (Sellars, 1965). According to this method, the mean

annual water yield is determined from

$$Q = P - E_o \tanh \frac{P}{E_o} \qquad (6)$$

where Q and P are as previously defined and E_o is the annual potential evapotranspiration, in inches. For the area, evapotranspiration is estimated at 17 inches. Substituting P and E_o into Equation 6, the mean annual water yield is estimated to be 12.2 inches.

Both estimates from these calculations compare favorably with the mean annual yield estimate of 10.0 inches made by Jeppson et al. (1968).

The runoff volume resulting from a particular rainfall depth was determined using the runoff curve number technique, as defined by the U.S. Soil Conservation Service (1972). According to the curve number methodology, the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (7)$$

and

$$CN = \frac{1000}{10 + S} \qquad (8)$$

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

curve number. Curve number values were chosen using information supplied by the U.S. Soil Conservation Service (1972), Hawkins (1973), and personal hydrologic judgment following field observations. Weighted curve numbers were used for heterogeneous areas. Values of P were obtained for selected durations and return periods from Miller et al. (1973). A 24-hour storm was used for design purposes.

Equation 7 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 7 is valid only when $P \geq I_a$ or $P \geq 0.2S$. Below this point, no runoff can occur.

Estimates of the peak discharge to be expected from various rainfall events were made using the dimensionless unit hydrograph method illustrated in Figure 7 which was developed by the U.S. Soil Conservation Service (1972). In this figure, D is the duration of excess rainfall; T_c is the time of concentration, T_p is the time to peak; T_r is the time of recession; T_b is the time of base, with all time units in hours; and q_p is the peak discharge, in cubic feet per second. Five separate hydrograph families have been developed by the U.S. Soil Conservation Service (1972), with the selection of the family of curves to be used based on the curve number and the rainfall depth as given in Figure 8. According to the dimensionless unit hydrograph method,

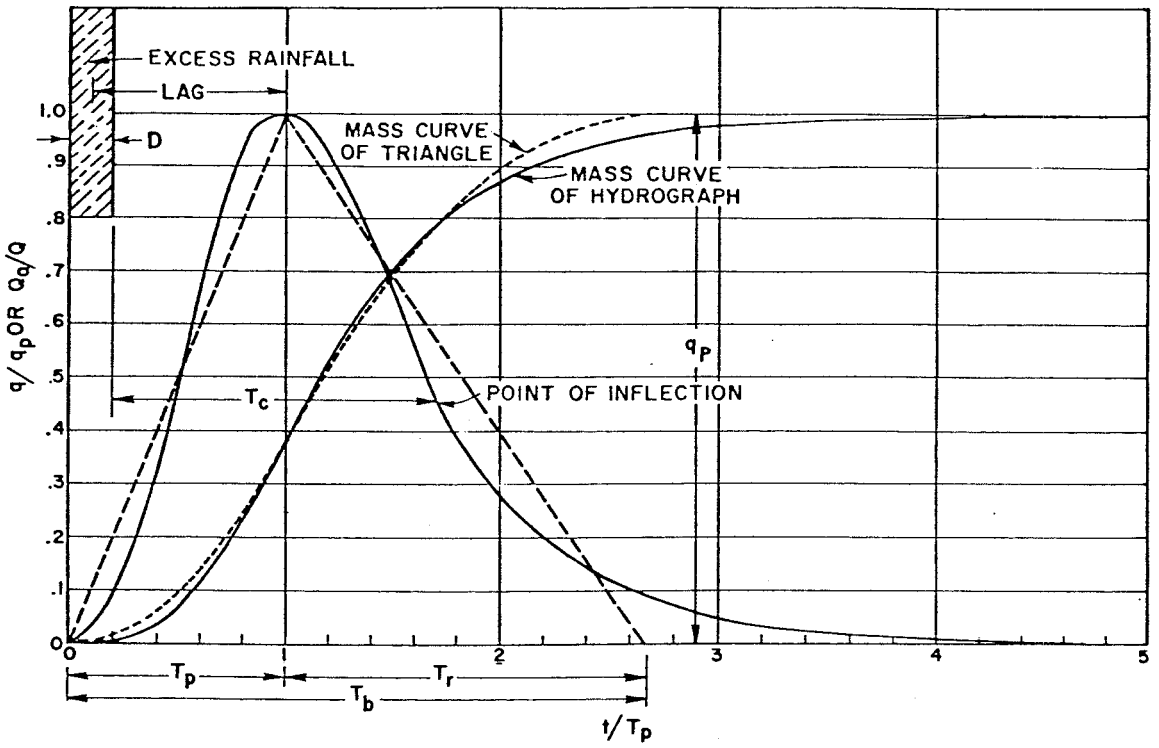

Figure 7. Dimensionless curvilinear unit hydrograph and equivalent triangular hydrograph (SCS, August, 1972).

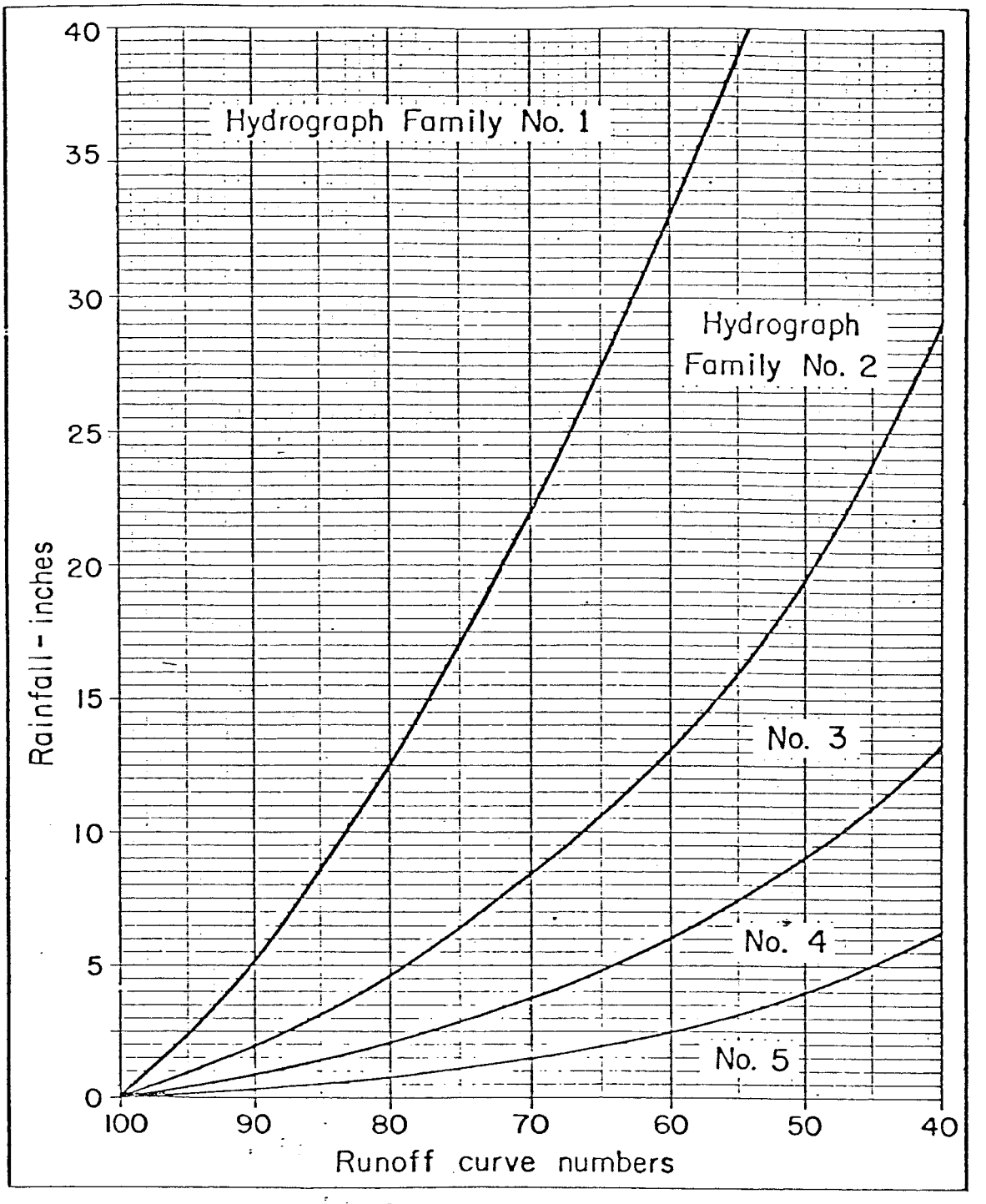

Figure 8. Chart for selecting a hydrograph family for a given rainfall and runoff curve number (from U.S. Soil Conservation Service, 1972).

one discharge and two time constants are determined from empirical equations and storm distributions. The constants are multiplied by increments of discharge and time from the dimensionless unit hydrograph to obtain the plotting points of the synthetic hydrograph.

The discharge constant used in the dimensionless unit hydrograph method is determined according to the equation

$$q_p = \frac{484\ AQ}{T_p} \tag{9}$$

where q_p is the peak discharge constant, in cubic feet per second; A is the drainage area, in square miles; Q is the runoff volume, in inches (as determined by Equation 7); T_p is the time elapsed from the beginning of runoff to the hydrograph peak, in hours; and 484 is a conversion factor. T_p is assumed to be a function of watershed lag (L), which is determined according to the equation

$$L = \frac{\ell^{0.8}\ (S+1)^{0.7}}{1900\ Y^{0.5}} \tag{10}$$

where L is the watershed lag, in hours; ℓ is the hydraulic length, or the length of the mainstream to the farthest divide, in feet; S is as previously defined; and Y is the average watershed slope, in percent. Values of Y were obtained by using methods outlined by Craig and Rankl (1977). The hydraulic length was taken from an appropriate topographic map while S was determined from Equation 8 once the runoff curve number was estimated.

According to the U.S. Soil Conservation Service (1972), the watershed lag is equal to 0.6 T_c and the time of concentration (T_c) is equal to 1.5 T_p. Combining these two expressions it can be seen that

$$T_p = 1.11L \qquad (11)$$

where both variables are as previously defined.

The two time constants utilized in the dimensionless hydrograph method are T_p (derived according to Equation 11) and D, the duration off excess rainfall. This latter value was determined using the theoretical Type II storm distribution shown in Figure 9. According to the curve number method, sufficient precipitation must fall to satisfy initial watershed abstractions before runoff will begin. This depth of rainfall is taken as 0.2S (U.S. Soil Conservation Service, 1972), where S is as previously defined. Dividing 0.2S by the total storm depth results in ratio which can be found on the ordinate of Figure 9. The corresponding time on the abscissa of the appropriate figure is the theoretical time from the beginning of rainfall to the beginning of runoff. Substracting this value from the storm duration results in D. Thus, if the runoff curve number for a particular watershed near the UCO Mine is 75, then S = 3.33 and 0.2S = 0.67. The duration of excess rainfall for the 10-year 24-hour storm (with a rainfall depth of 2.5 inches) is found by dividing 0.67 by 2.5, entering Figure 9 with the resulting ratio (0.27) and reading the corresponding storm duration during which no runoff occurs from the Type II storm curve (11.4 hours). Substracting this value from 24 results in an excess rainfall duration (D) of 12.6 hours.

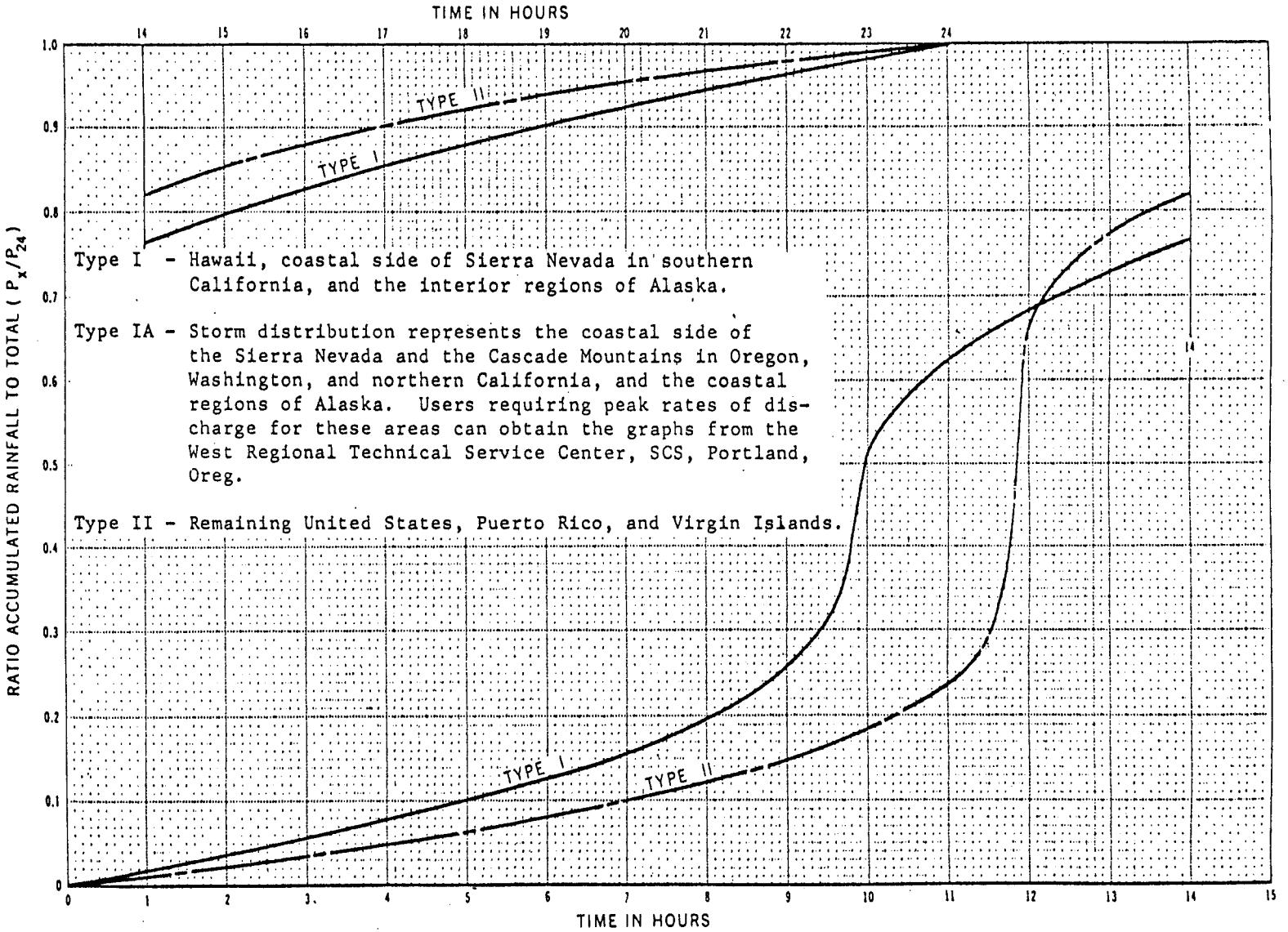

Figure 9. Twenty-four-hour rainfall distributions (from Kent, 1973).

It is known that runoff curve numbers tend to vary inversely with precipitation depth in forested mountain watersheds (Hawkins, 1973). In later studies of this phenomenon, Hawkins (1979) concluded that a relatively constant runoff source (i.e. "impervious") area produces this inverse relationship. Because wildland watersheds seldom experience overland flow, this constant source area coincides generally with the area occupied by live (perennial) streams and nearby impervious areas (roads, etc.) Hawkins (1979) found that the curve number could be expressed as

$$CN = \frac{100}{1 + P \cdot f(c)/2} \tag{12}$$

where

$$f(c) = 1 + 2C - (4C^2 + 5C)^{1/2} \tag{13}$$

and C is the fraction of the total area contained in the source area. Data were presented by Hawkins (1979) for various watersheds throughout the Rocky Mountain-Intermountain region as well as values of C determined by an iterative least square technique. Conditions at two of the watersheds studied by Hawkins (Morris Creek and West Branch of Chicken Creek, located on the Davis County Experimental Watershed near Farmington, Utah) compare favorably with the surface characteristics of the UCO property. The relationship between CN and P at these two watersheds is presented in Figure 10. Also shown on this figure for reference purpose is the curve depicting CN_o, which Hawkins (1973) defines as the curve number for a given P below which there is no runoff.

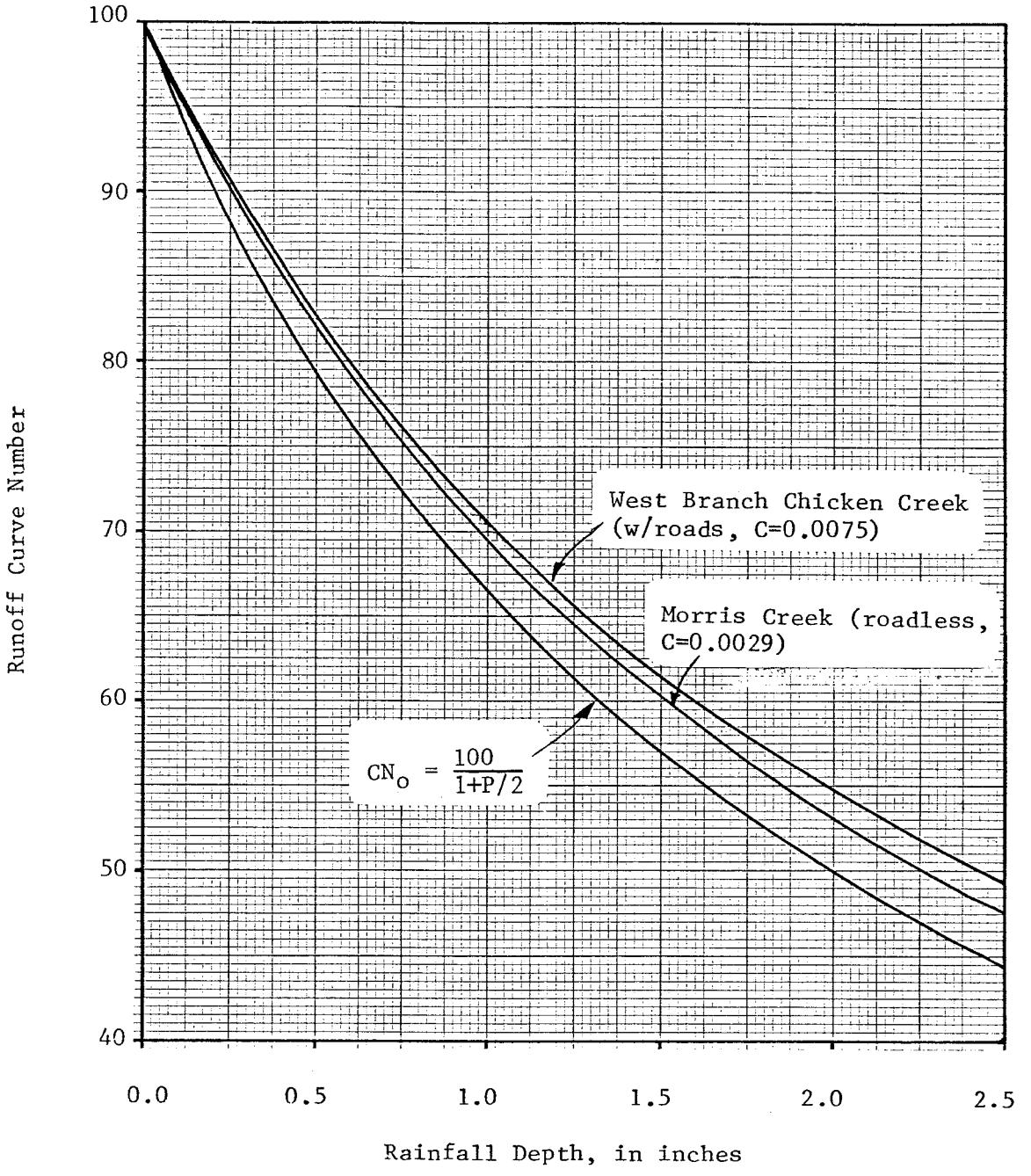

Figure 10. Variation of runoff curve number with rainfall depth at the Davis County Experimental Watershed, Utah.

The curve in Figure 10 which describes the West Branch of Chicken Creek is presumably representative of those watersheds on or near the UCO mine permit area where road development exists adjacent to the stream channel (i.e. Winter Quarters Canyon, etc.). The curve representing Morris Creek presumably describes conditions of watersheds where road development is minimal or nonexistent or where old roads located away from the channel have been reclaimed, making the live stream the major source area in the basin through channel interception (i.e. Woods Canyon, etc.). Note that runoff characteristics in a watershed can be described by both curves, depending upon the specific location of concern within the watershed (i.e. Winter Quarters Canyon as a whole is described by the upper curve in Figure 10, but sub-basins such as Box Canyon can be represented by the Morris Creek curve).

Two comments should be made about the information presented in Figure 10. First, the potential for runoff from a rainfall event on the UCO mine permit area is low. As Hawkins (1979) has indicated and as can be seen in Figure 10, the term C in Equation 13 can be thought of as equivalent to the runoff coefficient in the equation $Q = CP$ and tends to be constant for a wildland watershed conditions. This indicates that runoff from the UCO mine permit area occurs almost entirely from snowmelt, not rainfall.

A second comment is that the curves shown in Figure 10 assume that overland flow is nonexistent from the majority of the watershed. This is a reasonable assumption for the UCO mine permit area under most circumstances because of the high infiltration rate relative to storm intensity and the apparent uniform antecedent moisture conditions of the soil surface created by relatively low summer rainfall volumes. Extremes in rainfall intensity and/or soil wetness may cause areas other than the normal source areas to contribute runoff, and thus create departures from the curves shown in Figure 10. Such conditions are assumed to be rare on the UCO property. Estimates of peak rainfall related flood peaks for the major streams draining the UCO mine permit area using this method are shown in Table 5.

Estimates of peak flow recurrence intervals in the mine permit area were also determined from techniques presented by Fields (1975). According to Fields (1975), the 25- and 50-year recurrence interval flood discharge of Utah streams are related to channel geometry characteristics. Specifically, for areas similar to be UCO mine permit area, the following relationships were found to apply:

$$q_{25} = 3.7W^{1.57} \tag{14}$$

and

$$q_{50} = 3.9W^{1.58} \tag{15}$$

where W is the width of the channel bar cross-section in feet and

Table 5. 100 year, 24-hour precipitation caused floods in streams near the UCO mine permit area using the SCS synthetic hydrograph procedure.

Site Description	Area (ac)	Average Watershed Slope (%)	Incremental Time (hrs)	Curve Number	Precip. Depth (inches)	Storm Duration (hours)	Hydraulic Length (feet)	T_p (hrs)	Q (cfs)	Q_p (cfs)
Woods Canyon	3280	37.8	0.5	43	3.4	24	27,500	2.18	1140	13.7
Winter Quarters above Mud Creek	4220	38.1	0.5	43	3.4	24	26,000	2.07	1539	17.7
Winter Quarters at Mine	3480	37.2	0.5	43	3.4	24	18,500	1.60	1649	14.8

q_{25} and q_{50} are the 25- and 50-year recurrence interval flood discharges in cfs, respectively. The respective standard errors associated with Equations 14 and 15 are 28 and 33 percent.

The resulting estimates of flood frequency are presented in Table 6. Although the standard errors are relatively high for the prediction equations, the discharge estimates give an idea of the peak flows experienced in the streams.

Table 6. Flood discharge estimates of selected streams in and adjacent to the UCO mine permit area.

Stream	Channel Bar Width, in Ft.	25-Year Peak, in cfs	50-Year Peak, in cfs
Winter Quarters Creek above mine site	6.0	62	66
Winter Quarters Creek above Mud Creek	7.0	79	84
Woods Canyon Creek above Mud Creek	5.6	55	59

Snowmelt peak discharge estimates were determined two ways. First, a regional analysis of surrounding watersheds of known or estimated snowmelt peaks was performed and second, the Runoff Volume Map Procedure derived by the U.S. Soil Conservation Service (1972) was used.

A comparison of area, slope, aspect, soils, and cover characteristics shows that the Eccles Creek watershed (about two

miles south of Winter Quarters Canyon) is similar to Winter Quarters Canyon above the mine site. The aspect and area of both Canyons are similar. Both watersheds are east-facing of approximately 3500 acres. The average watershed slopes for Eccles and Winter Quarters watersheds are very similar at 31 and 27 percent respectively. The soils in each watershed are generally B/C hydrologic type soils and vegetative type and cover is essentially the same for both watersheds.

With the similarity between the two watersheds, it is felt that the peak discharge for Winter Quarters would not differ greatly from the peak on Eccles Creek. The 100-year peak flow on Eccles Creek has been estimated at 65 cfs (Vaughn Hansen Associates, 1980).

The Runoff Volume Map Procedure is a method of determining the size of principal spillway with the purpose of insuring safe design (U.S. Soil Conservation Service, 1972). This method should not be used to produce a specific flood hydrograph, but is presented here as a rough approximation of the upper limit of peak discharge for the Winter Quarters Creek within the UCO mine permit area. The upper limit of peak discharge is estimated to be 140 cfs for the 100-year peak. This estimate is not expected to be as accurate as the comparison with Eccles Creek. This is because the Eccles Creek evaluation was made using actual flow data and because Winter Quarters and Eccles Canyons are so similar.

Water Quality. Eight surface water sites on and adjacent to the UCO mine permit area were sampled in either 1980 or 1981. Appendix B contains the results of the chemical analyses of surface water samples collected during this period. All stations were established for the collection of grab samples.

As depicted in Plate 1, surface waters of the UCO mine permit area are geneally of the calcium-bicarbonate type. Total dissolved solids (TDS) concentrations ranged from 159 mg/l in a tributary to Winter Quarters Creek (Station U-3), to 350 mg/l in Mud Creek below Scofield (Station U-6). All measurements were taken between October and April of 1980-1981. Therefore, measurements were generally taken under low-flow conditions when TDS concentrations are expected to be relatively high. Experience in the area shows that from April through June, when stream discharges are highest due to direct snowmelt, a diluting effect occurs in surface waters, resultinng in lower TDS concentrations. Later in the year as flow decreases and is largely derived from groundwater, this dilution effect becomes less pronounced and TDS concentrations increase.

Suspended solids concentrations during the inventory period were found to vary from 1.0 mg/l at the mouth of Woods Canyon Creek (Station U-5) to 507 mg/l in a tributary to Winter Quarters Creek (Station U-3). It is known that suspended solids concentrations tend to vary somewhat proportionately with flow

rate (Vaughn Hansen Associates, 1979). The experience on the UCO property substantiates this in that the highest suspended solids concentrations occurred in April when flows were relatively high.

The hydrogen ion activity (pH) of the surface waters was found to be relatively constant throughout the UCO mine permit area, varying from 7.1 to 8.4. The usually slight basic condition of the surface water is due primarily to the high concentrations of bicarbonates (American Public Health Association et al., 1976). River waters with values of pH in the range of those measured throughout the mine plan area are generally not influenced by pollution (Hem, 1970).

Data gathered during 1980 and 1981 indicate that both total and dissolved iron concentrations tend to be relatively constant throughout the area. The cementing agents of the Blackhawk Formation are expected to be the major source of iron in the surface waters of the mine permit area. In the vicinity of Scofield Reservoir, it has been determined that total iron concentrations are directly related to flow rate, resulting from the probable association of iron with sediments (Vaughn Hansen Associates, 1979). Therefore, as a result of the occurrence of the Blackhawk Formation throughout the area, it is felt that total iron concentrations will increase during the high flow periods and decrease during low flow periods. Experience gained to date substantiates this as the highest iron concentrations in the surface waters were measured in April when the flows were highest.

Total and dissolved iron concentrations varied throughout the mine plan area from 0.011 to 6.55 mg/l and from 0.01 to 2.18 mg/l, respectively (the large majority of the samples had iron concentrations less than 1.0 mg/l).

Total manganese concentrations are low within and adjacent to the mine permit area, varying during the inventory period from less than 0.002 mg/l to 0.44 mg/l (both measured in a tributary to Winters Quarters Creek at Station U-3).

The Utah Division of Health has classified the waters within the UCO mine permit area as 1C (protected for domestic purposes with prior treatment by standard complete treatment processes), 3A (protected for cold water species of game fish and other cold water aquatic life), and 4 (protected for agricultural uses including irrigation of crops and stockwatering). Classifications 1C, 3A, and 4 apply to Winter Quarters and Woods Canyon creeks, which drain into Mud Creek. Tables 7 and 8 contain the numerical water quality standards applicable to these various classifications. Few exceedances of these chemical standards were noted during the baseline study. With the exception of ammonia, phosphate, and one slight exceedance of dissolved silver (0.033 mg/l at station U-1), all of the constituents were well within the limits established for the dissolved constituents in the chemical standards of Table 7.

Table 7. 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) Maximum Total Coliforms	1	50	5,000	1,000	5,000	*	*		*	*	STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS	STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS
Maximum Fecal Coliforms	*	*	2,000	200	2,000	*	*		*	*		
Physical												
Total Dissolved Gasses	*	*	*	*	*	(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	*	*	*	*	STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS (See Table 8)	*	.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									
Boron, dissolved	*	*	*	*	*	*	*		*	.75		
H_2S	*	*	*	*	*	.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		*	*		

* 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 $CaCO_3$ 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) PO_4 as P(mg/l) limit for lakes and reservoirs shall be .025.

Table 8. Numerical standards for Class 3C water use.

Physical	
Minimum D.O. (mg/1)	5
Maximum Temperature	27°C
Maximum Temperature Change	4°C
pH	6.5-9-0
Turbidity Increase (NTU)	15****
Chemical	
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
Chlrine	0.2
H_2S	0.02
Radiological (Maximum pCi/1)	
Gross Alpha	15
Gross Beta	30
Pesticides (Maximum mg/1)	
Endrin	0.004
Lindane	0.01
Methoxychlor	0.03
Toxaphene	0.005
Pollution Indicators* **	
BOD (mg/1)	5.0
NO_3 as N (mg/1)	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.

Phosphates were analyzed in either the ortho form (a portion of total phosphate) or the total form. Approximately 20 percent of the samples analyzed for orthophosphate exceeded the limit of 0.05 mg/l established for total phosphate (there is no state standard for orthophosphate concentrations). Of those samples analyzed for total phosphate, approximately 75 percent exceeded the limit of 0.05 mg/l. Total phosphate concentrations ranged from 0.02 to 19 mg/l as P. The appearance of phosphorus in the surface waters of the mine plan area can be attributed to two sources: the degredation of animal wastes from grazing stock in the area, and deriving phosphates from the phosphorous content of the soils and sediments (McElroy et al., 1976).

Another exception to the statement of few exceedances to the standard is ammonia. Of the eight stations analyzed for ammonia, only stations U-3 and U-5 exceeded the state standard of 0.02 mg/l. These exceedances were measured at 0.16 mg/l and 0.10 mg/l at stations U-3 and U-5 respectively. The reason for the appearance of ammonia in the UCO mine permit area is attributed to biological degradation of nitrogenous organic matter.

The concentrations of other constituents sampled at stations throughout the area are generally well below the state standard. In many instances, trace metal concentrations are consistently below the level of detection of routine laboratory technique (particularly arsenic, cadmium, chromium, lead, and mercury).

Water Rights. Surface water rights in and adjacent to the UCO mine permit area on file as of February 1981 with the Utah Division of Water Rights are listed on Table 9 and shown on Plate 5. All surface water rights in the area are for stockwatering except for some irrigation rights near the mouth of Winter Quarters Creek and on Mud Creek.

3.3 Surface Water Development, Control, and Diversions

This section of the report deals with the surface water supply in the area as well as the runoff and sedimentation control measures planned for the UCO mine.

3.3.1 Water Supply

The surface water supply in the mine permit and adjacent areas is extensively used for stockwatering and to a lesser extent for irrigation (see Plate 5). Little development of the surface waters has occurred for stockwatering purposes. Irrigation diversions have been constructed near the mouth of Winter Quarters Creek.

No development of surface water by the mine is proposed. Construction of water diverion structures for protection of the water resources will occur as discussed in section 3.3.2 of this report.

3.3.2 Sedimentation Control Structures and Diversions

Sedimentation control structures and runoff diverions will be designed to protect the surface water supply in Winter Quarters

Table 9. Surface water rights located on and adjacent to the UCO mine permit area.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-345	Tom Nicolaides Leon Nicolaides Mary Stahis Bessie Daraban	Green Canyon Spring Stream	0.75	Irrigation	March 1 to November 30
91-423	Nick Marakis (½ interest)	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-431	Nick Marakis (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-436	Nick Marakis (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-437	Nick Marakis (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-462	John Marakis Estate (½ interest)	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-471	John Marakis Estate (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-476	John Marakis Estate (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-477	John Marakis Estate (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-482	Robert Radakovich	Stream	----	Stockwatering	May 1 to December 15
91-483	Robert Radakovich	Winter Quarters Creek	0.443	Irrigation Stockwatering	March 1 to December 15
91-1029	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1030	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1031	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1032	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1033	U.S. Forest Service	Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1034	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1037	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1038	U.S. Forest Service	Woods Canyon Creek	----	Stockwatering	July 1 to September 30

Table 9. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1148	Leon & Tom Nicolaides	Green Canyon Stream	----	Stockwatering	January 1 to December 31
91-2018	Angelo Georgedes	Green Canyon Stream with storage	----	Stockwatering	May 1 to October 31
91-2019	Angelo Georgedes	Stream with storage	----	Stockwatering	May 1 to October 31
*91-2020	Angelo Georgedes	Green Canyon Stream	----	Stockwatering	May 1 to October 31
91-2048	John Jouflas Estate	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2146	Elrie and Bertha Simonsen	Winter Quarters Creek	----	Stockwatering	June 1 to November 30
*91-2495	Elrie and Bertha Simonsen	Woods Canyon Creek	----	Stockwatering	June 1 to November 30
91-2496	Elrie and Bertha Simonsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-2548	John Jouflas Estate (2/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2549	Lee S. Thomas (1/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2971	Lee S. Thomas (1/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2972	John Jouflas Estate (2/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2973	John Jouflas Estate	Clear Creek	0.381	Irrigation	March 1 to November 30
91-2974	Justus O. Seely	Clear Creek	0.170	Irrigation Stockwatering	March 1 to November 30
91-2977	S. J. Harkness	Clear Creek	0.075	Irrigation	March 1 to November 30
91-2978	Justus O. Seely	Clear Creek	0.683	Irrigation Stockwatering	March 1 to November 30
91-2979	S. J. Harkness	Clear Creek	0.453	Irrigation	March 1 to November 30
91-2980	Helen Miller	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2981	Orson Marsing	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2982	Lillie Pearson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2983	Thomas Biggs, Jr.	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2984	Waino E. Burton	Clear Creek	0.10	Irrigation	March 1 to November 30

Table 9. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
1-2985	Phyllis M. Conover	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2986	Willima & Armeda Sherman	Clear Creek	0.015	Irrigation	March 1 to November 30
91-2987	Leah B. Johnson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2988	E. D. & Elizabeth Jacobson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2989	Scofield Town	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2990	Della L. Madsen	Clear Creek	1.166	Irrigation	March 1 to November 30
91-2991	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2992	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2993	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2994	John B. Jones	Woods Canyon Creek	----	Irrigation	March 1 to November 30
91-2995	John B. Jones	Woods Canyon Creek	----	Irrigation	March 1 to November 30
91-2996	Gladys P. Butler (4.85/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2997	Alice M. Pannier (4.85/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2998	Boyd W. & Johannah M. Hafen (12.0/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2999	Reed & Leoan M. Gunderson	Woods Canyon Creek	0.136	Irrigation	March 1 to November 30
91-3002	Della L. Madsen	Woods Canyon Creek	0.035	Irrigation	March 1 to November 30
91-3003	Charles J. Jacobsen Evelyn M. Jacobsen Stephen C. Jacobsen Charlyn J. DAlebout (18.1/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30
91-3004	Louise M. Watts Helen L. Watts John Andy Watts (7.9/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30

Table 9. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3007	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.63	Irrigation	March 1 to November 30
91-3008	S. J. Harkness	Winter Quarters Creek	0.693	Irrigation	March 1 to November 30
91-3009	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.68	Irrigation	March 1 to November 30
91-3010	S. J. Harkness	Winter Quarters Creek	0.213	Irrigation	March 1 to November 30
91-3011	S. J. Harkness	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-3056	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Daraban	Stream	----	Stockwatering	January 1 to December 31
91-3405	Elrie & Bertha Simonsen	Woods Canyon Creek	----	Irrigation Stockwatering	March 1 to November 30
91-3622	Mae Nicolademas	Clear Creek	0.016	Irrigation	March 1 to November 30
91-3631	D. Euray Allred	Woods Canyon Creek	----	Stockwatering	May 1 to November 30
91-3633	D. Euray Allred	Winter Quarters Creek	----	Stockwatering	May 1 to November 30
91-3635	D. Euray Allred	Stream	----	Stockwatering	May 1 to November 30
91-3641	Pete Frandsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-3644	Justus O. Seely	Clear Creek	----	Stockwatering	June 1 to November 30
91-3645	S. J. Harkness	Clear Creek	----	Stockwatering	June 1 to November 30
91-3648	John B. Jones	Clear Creek	----	Stockwatering	January 1 to December 31
*91-3655	John B. Jones	Woods Canyon Creek	----	Stockwatering	January 1 to December 31
91-3658	John B. Jones	Stream with storage	----	Stockwatering	January 1 to December 31
91-3665	John Marakis Estate	Clear Creek	----	Stockwatering	January 1 to December 31
91-3666	Nick Marakis (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-3667	Angelo Georgedes	Clear Creek	----	Stockwatering Domestic	January 1 to December 31
91-3910	Reed & Leoan M. Gunderson	Clear Creek (Scofield Res.)	----	Stockwatering	May 1 to November 30
91-3911	Della L. and Hilda M. Madsen	Clear Creek (Scofield Res.)	----	Stockwatering	May 1 to November 30

Creek. The design of these structures as well as measures that will be taken to reduce erosion will be submitted at a later date.

3.4 Effects of Mining on the Surface Water Hydrologic Balance

Mining activities in the Scofield area can be expected to continue into the twenty-first century. The occurrence and quality of water in any region is highly controlled by geology. The majority of the UCO mine permit area is strong structurally and consists of the Blackhawk geologic formation. It is presumed that mining activities will have little adverse impact on the area hydrologic system.

3.4.1 Quantity

As mentioned earlier in the report, the major perennial drainages conveying runoff away from the mine permit area are streams in Winter Quarters Canyon and Woods Canyon. Mining beneath Winter Quarters Creek will be limited so that the stream will not be subsided. Consequently, subsidence will not cause any significant impact on the surface water system. Surface facilities will be located in Winter Quarters Canyon. Unless unusual flows are encountered in the mine, it is not expected that any mine water will be discharged into surface streams. If discharges become necessary, they will be made in compliance with the NPDES permit program. Even if discharges do become necessary, the volume of water will be insignificant compareed to the spring runoff snowmelt volume. As a result, it is felt that the mining operation will have no significant impact on the surface water system.

3.4.2 Quality

The quality of the flow from the headwaters of the Price River Basin is excellent. However, this quality rapidly deteriorates downstream as the streams cross shale formations and receive irrigation return flows from Mancos-derived soils. The impact of the mining on this system will be very minor.

The construction of surface facilities utilized in conjunction with the UCO Mine (yard areas, roads, etc.) will result in temporary increases in the suspended sediment concentration of the adjacent stream. However, because of the regulatory requirement that sediment control be provided for all areas of surface disturbance, concentrations should be quickly normalized.

3.5 Mitigation and Control Plans

Runoff from all distrubed areas will be passed through sediment control facilities or protected from abnormal erosion. Any discharge from facilities will be monitored in accordance with NPDES permit standards, and state and federal regulations.

The effects of the mining operation on the surface water system will be analyzed through the surface water monitoring plan described in the next section. In the unlikely event that monitoring shows that the surface water system is being adversely

affected by the mining activities, additional steps will be taken to rectify the situation in cooperation with state and federal regulatory agencies.

3.6 Surface Water Monitoring Plan

An ongoing hydrologic monitoring program is being conducted at each of the stations shown on Plate 3. Stations have been established to monitor water quality and quantity above and below the mine permit area. Each station has been sampled on a monthly basis (through April, 1981) when accessible during the baseline period. Attachment B contains tabulations of the results of the water quality analyses. During the remainder of the baseline period (May through October, 1981), the baseline monitoring program will be modified to conform with recently completed Utah State Division of Oil, Gas, and Mining Guidelines. In accordance with these guidelines, all surface water stations will be sampled bimonthly and analyzed according to the schedule outlined in Table 4.

During the operational phase of the mine, all surface water monitoring stations will be monitored quarterly for flow (when accessible) to delineate seasonal variation and correlate discharge with changes in water quality. The water quality samples will be analyzed for the parameters listed in Table 4. Future data may show that modifications of this monitoring schedule are justified. Any changes to the monitoring schedule

(frequency or parameters) will be made only with the approval of the Utah State Division of Oil, Gas, and Mining. Results of all water quality data will be submitted to that agency quarterly.

Post-mining monitoring of surface water will continue at representative stations determined with the aid and approval of the Utah Division of Oil, Gas and Mining. Representative surface water stations will be monitored biannually during high and low flow conditions. Duration of monitoring and parameter selection will be determined after appropriate consultation with state and federal agencies.

4.0 ALLUVIAL VALLEY FLOOR DETERMINATION

Utah regulations (UMC Section 785.19c) require that the presence of alluvial valley floors in or adjacent to the mine permit area be identified. The regulations (UMC Section 700.5) define an alluvial valley floor as "unconsolidated stream-laid deposits holding streams with water availability sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by unconcentrated runoff or slope wash together with talus, or other mass-movement accumulations, and windblown deposits". The existence of an alluvial valley floor is, therefore, determined to exist if:

1) Unconsolidated stream-laid deposits holding streams are present, and
2) There is sufficient water to support agricultural activities as evidenced by:
    a) The exixtence of flood irrigation in the area in question or its historical use;
    b) The capability of an area to be flood irrigated, based on stream-flow water yield, soils, water quality, topography, and regional practices; or
    c) Subirrigation of the lands in question, derived from the groundwater system of the valley floor.

4.1 Scope

The purpose of this document is to examine the potential existence of alluvial valley floors in and adjacent to the areas to be affected by surface operations associated with the UCO underground coal mine located approximately two miles west of Scofield, Carbon County, Utah.

This section of this report is divided into three parts. First, a general description of the surface operations and site disturbances associated with the UCO mine is presented. Next, discussions of geomorphic and irrigability characteristics and the water quality and availability of Mud Creek and Winter Quarters Canyon drainages as possible alluvial valley floors are presented. Finally, the conclusions of the alluvial valley floor determination are summarized.

4.2 Site Description

Surface facilities associated with the UCO mine permit area will consist of the portal area located in Winter Quarters Canyon and an access road up Winter Quarters Canyon.

The climate of the general area is semi-arid to arid and continental. Mean monthly temperatures range from about 5° F to the mid-70's. Temperatures in the region tend to be inversely related to elevation. Average annual precipitation is

approximately 28 inches. Seventy percent of the annual precipitation falls during the winter as snow with most of the remainder coming as summer thunderstorms.

4.3 Alluvial Valley Floor Characteristics

In this section of the report the various criteria for determining the existence of an alluvial valley floor are examined in relation to the UCO mine plan and adjacent areas.

4.3.1 Geomorphic Criteria

Alluvial deposits in and adjacent to the mine permit area are shown on Plate 6. Plate 6 shows the extent of the alluvium as presented by Doelling (1972). This plate shows that the alluvium is found primarily along Mud Creek in Pleasant Valley and at the mouth of Winter Quarters and Woods Canyon. Only very narrow bands of alluvium are found along the latter creeks above the canyon mouths.

4.3.2 Water Quality and Availability

The potential for flood and sub-irrigation are now evaluated in conjunction with the alluvial valley floor determination.

Flood Irrigation. Flood irrigation near the permit area is currently (and has historically been) confined to the alluvial areas of Mud Creek and the mouth of Winter Quarters Canyon. Water is diverted at several points along both creeks to irrigate fields on the alluvium.

No flood irrigation has historically been practiced on the narrow alluvium land upstream in canyons opening to Pleasant Valley. A reconnaissance survey of the surrounding region indicates that flood irrigation is also absent in other areas of similar hydrologic, geologic, and biotic characteristics. The historic lack of flood irrigation in these steep, narrow canyons suggests that such activities are not feasible in the region. Another reason for this is that the elevation is high and consequently not conducive to agricultural activities.

Water quality of both Mud Creek and Winter Quarters Canyon is very good. A detailed review of the surface water quality has been presented previously in this report.

Subirrigation. Some subirrigation of vegetation does occur on the alluvial valley floors shown in Plate 6. The subirrigated species (mainly willows) are found along the channels of Mud Creek and Winter Quarters Canyon. This suggests that subirrigation is confined to the channel areas where the water table is near the surface.

4.4 Alluvial Valley Floor Identification

Based on the foregoing reconnaissance analysis, the canyon floors opening to Pleasant Valley cannot be considered alluvial valley floors due to the very limited area for supporting an

agriculturally useful crop. The valley floors of Mud Creek and the mouth of Winter Quarters Canyon, however, can be classified as alluvial valley floors due to the presence of both flood irrigation and limited subirrigation on the alluvium. It should be noted that the potential for an agriculturally useful crop is very limited. The currently flood or subirrigated alluvial areas are located over a mile from the mine permit area and are used for pasture.

4.5 Potential Impacts to the Alluvial Valley Floors

Plate 6 shows that the UCO mine permit area is over one mile from the alluvial valley floor at the mouth of Winter Quarters Canyon. Little potential exists for the mine operation to impact the alluvial valley floor. The access road to the mine will disturb a minimal amount of alluvial area. All surface disturbances in the portal area will be protected by sediment control facilities and will be designed and constructed according to UMC standards and in an environmentally sound manner.

The hydrologic monitoring program will help determine the actual impact of surface activities and aid in selecting mitigating measures, if necessary. However, it is felt that the Scofield Mine and associated activites will have no significant hydrological impacts to the alluvial valleys. Details concerning this monitoring program are outlined in a previous section of this report.

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ATTACHMENT A

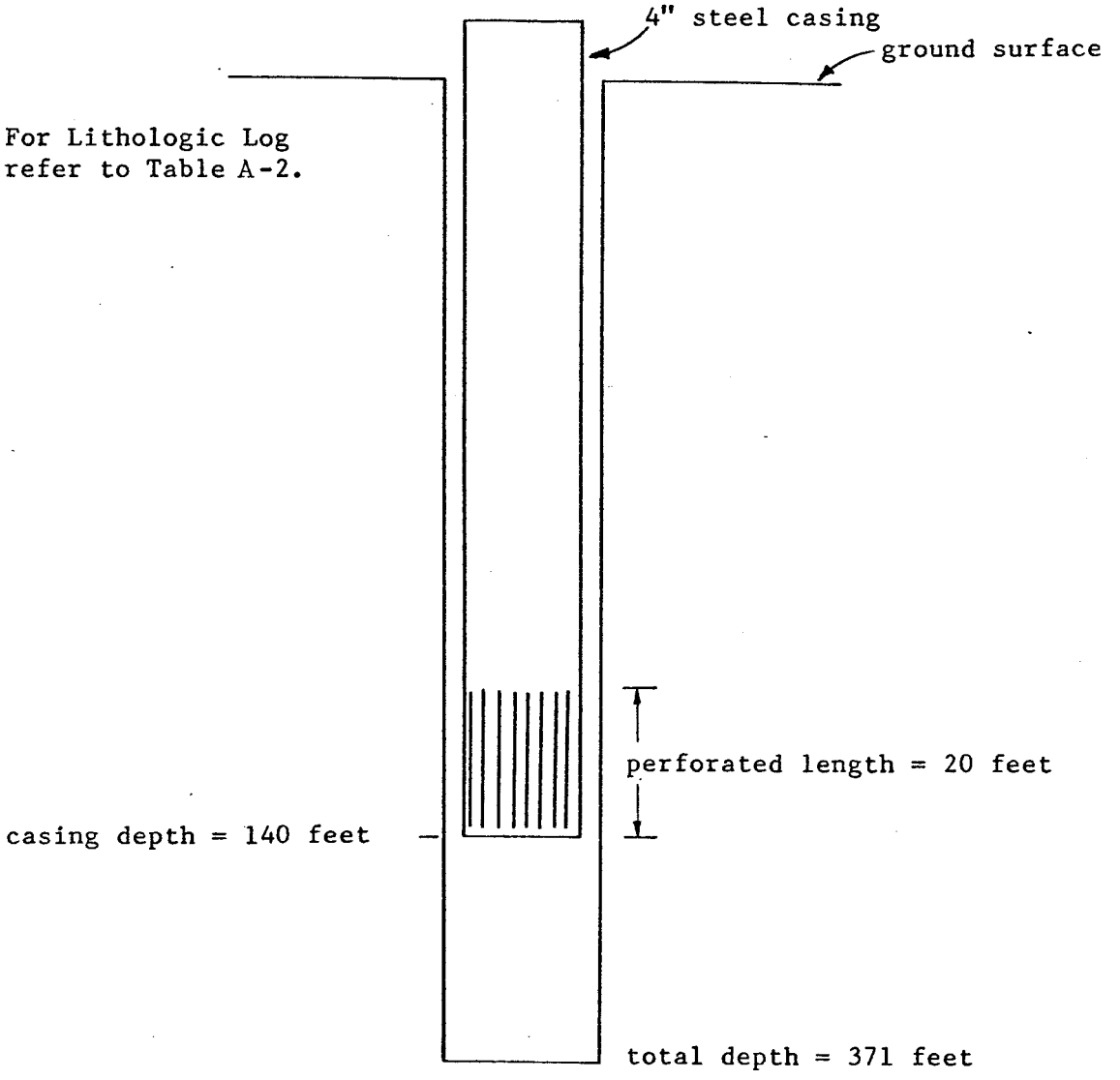
WATER WELL INFORMATION

INCLUDING

WATER LEVELS, AND AQUIFER TEST RESULTS

Table A-1. Miscellaneous information pertaining to Well WQ-1.

Location Number:	WQ-1	Hydrologic Zone Monitored:	Combined below, in, and above coal.
Date Drilled:	10/18/80	Surface Elevation:	8232 ft. MSL
Total Depth:	371 feet	Casing Depth:	140 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8138 ft. MSL	Perforated Interval:	120 to 140 feet



(Not to Scale)

Table A-2. Lithologic description of well WQ-1.

Hole Number WQ- 1

BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S)	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
7	0	7	0		090	Sand-Sh - talus, weathered, lt brown	
10	0	3	0		500	SS - red (oxidized), fgr, silty	
10	5		5		216	Sh, coal - br to bk, v. sooty (soft), mod argillaceous	
21	0	9	5		612	SS-br, frg, v. silty, mod consol, intbd clay sh	Sand poorly sorted, subangular, silty, weathered
25	0	4	0		225	Sh- gy to dk gy, soft, abundant carb stringers (rooting) argillaceous	
39	0	14	0		622	SS- lt br, v. silty, mod consol, fgr (poorly sorted)	sltst intbd lt gy w/minor carb debris
44	0	5	0		622	SS- gy to lt red, v. calcareous (v. react Hcl) intbd zones	minor calcite crystalization
52		8	0		225	Sh - dk gy, (green-gy) mod consol to soft	
54		2	0		260	Sh - dk gy, mhd, v. calcareous (react Hcl), hd drilling	
64		10	0		225	Sh - dk gy, soft, mod argillaceous	
70		6	0		321	Sh - lt to dk gy, argillaceous, v. silty, minor vhd calcareous stringers	Water (minor) @ 69' - switched to H_2O injection
105	0	35	0		632	SS - dk gy, vhd (v. calcareous) zones 0-1.0', generally mod consol, vfgr to fgr down section - flowing 8-10 gpm	- mod argillaceous 100.0 - 105.0
114		9	0		311	Sh- gy, v. soft, v. argillaceous, minor carb debris	mod to unconsol
160		46	0		510	SS- gy, mod consol, v silty, fgr, lt gy, vfgr down unit 120-130', pyrite noted 150-155', mgr, poorly consol 130-160	
172		12	0		622	SS- gy, vhd, v calcareous (v react Hcl) hd drilling	large 1-2" ss fragments caving in from above
191		19	0		622	SS- gy, hd, (not as hard as above) v fgr (almost silt) calcareous	still caving, trouble changing pipe
229		38	0		510	Above lithology continues except there are occasional sandy shale zones ~ 3' max	Water flow measured at 5½ gpm
252		23	0		625	SS- gy, vhd, vfgr to fgr, calcareous (few coal chips)	impossible to tell where small amount of coal comes from
262		10	0			SS - gy, hd, fgr, w/interbeds of siltstone	
272		10	0		510	SS -gy, fgr, softer	
280		8	0		320	Shale, dk gy, sandy	
340		60	0		510	SS -gy, fgr, hd w/shale interbed	shale lenses read from geolograph
364		24	0		320	SH-SS gy to dk gy, mod consol	water output dropped considerably @322
371		7	0		630	Sandstone, gy, lt gy, mhd	Drilling 3-5' per/hr pulled pipe @ 371'
							bit completely worn w/one core missing
						LOST CONE IN HOLE HAD TO ABANDON. HOLE SLOUGHED IN ON PIPE	*Surface weathered SS closing hole @ 15'
370 -	390					No sample - error on drill depth	

Table A-3. Water level measurements in Well WQ-1. Ground surface is approximately 8232 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
12-31-80	13:30	96.4	8137.6	Collar assumed to be 2.0 ft. above ground surface.
1-28-81	12:25	95.8	8138.2	"
2-11-81	Inaccessible			
3-11-81	Inaccessible			
4-22-81	12:30	95.88	8138.1	"

Table A-4. Tabulated slug test data for well WQ-1 conducted when hole terminated in the zone above the coal.

Ground Surface Elevation = 8232 ft. MSL.
Static Depth to Water = 79.8 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 371 feet
H_o = 6.75 feet

Date	Time	t (sec)	Depth to water (feet)	H (feet)	H/H_o
10/18/80	10:51	0	73.05	6.75	1.00
	10:54:45	225	76.29	3.51	0.52
	10:56:45	345	77.41	2.39	0.35
	10:58:15	375	78.12	1.68	0.25
	10:59:52	532	78.51	1.29	0.19
	11:00:30	570	78.80	1.00	0.15
	11:02:30	690	79.02	0.78	0.12
	11:03.30	750	79.15	0.65	0.10
	11:04:00	780	79.22	0.58	0.09
	11:05:00	840	79.37	0.43	0.06
	11:06:30	930	79.52	0.28	0.04
	11:07:30	990	79.60	0.20	0.030
	11:09:00	1080	79.66	0.14	0.021
	11:10:30	1170	79.71	0.09	0.013
	11:12:30	1290	79.81	0.00	0.000

At Match Line t = 83 seconds

$$T = \frac{r^2}{t\ \text{match}} = \frac{(0.255)^2}{83} = 0.00078\ \text{ft}^2/\text{sec} = 566\ \text{gpd/ft}$$

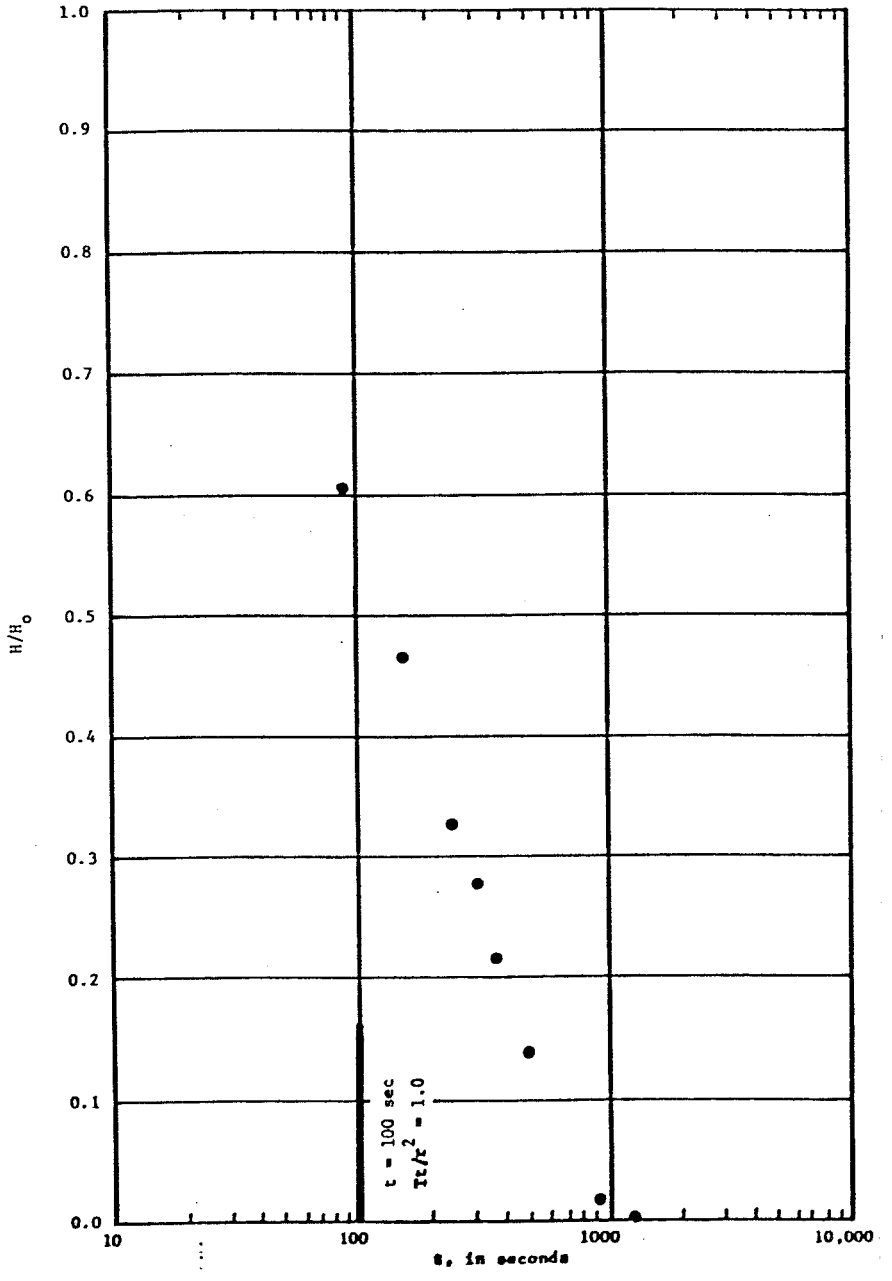
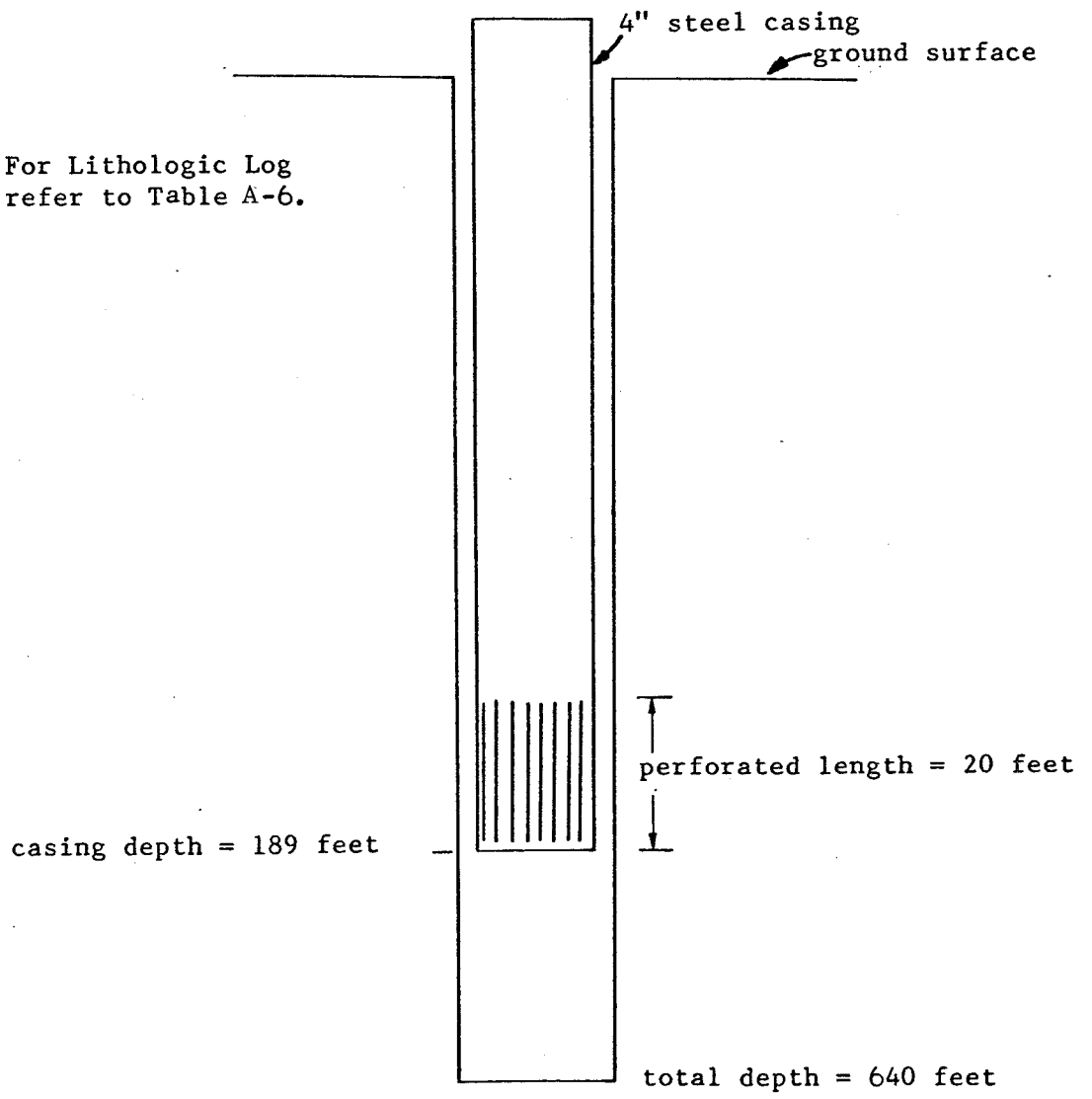


Figure A-1. Graphical results of the slug test for Well WQ-1 conducted when hole terminated in the zone above the coal.

Table A-5. Miscellaneous information pertaining to well WQ-1A.

Location Number:	WQ-1A	Hydrologic Zone Monitored:	Combined below, in and above coal.
Date Drilled:	10/23/80	Surface Elevation:	8231.9 feet MSL
Total Depth:	640 feet	Casing Depth:	189 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8127 feet MSL	Perforated Interval:	169 - 189 feet



(Not to Scale)

Table A-6. Lithologic description of well WQ-1A.

Hole Number WQ-1A

CORE INTERVAL TOP / BASE	CUT / REC.	BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S)	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
		400	0	10	0		662	Sandstone - gy to dk gy., med grain	log continued from WQ-01
		410		10	0		225	Shale - bk w/coal frags. w/intbd ss	
		420		10	0		530	SS - gy, fg to mgr, mod consol	water @ 413'
		460		40	0		530	SS - gy w/abund sh intbd, minor coal trace (bk sh)	
		470		10	0		310	Sh - dk gy, v sandy, (vfgr)	
		490		20	0		660	SS - gy, mgr, mod sh	
		499		9	0		530	SS - gy, abundant bk sh, vfgr, coal & bk sh frags.	
		500		1	0			Coal(?) - drilled very fast, very sparse cuttings	
500/514	14/14						*	Core 14.0 Rec. 14.0 100%	
		500	5		5			Sh - dk gy, hd, sl calcerous	Zone appears crystaline (like quartzite)
		501	8	1	3			SS - gy, vhd, v calcerous, vfgr, massive	" "
		502	0		2			Sh - bk to dk gy, minor coal frags	" "
		507	3	5	3			SS - gy, vhd, v calcerous, massive	
		510	0	2	7			Silst - gy, vhd, v calcerous, abundant coal frags, mass	
		510	4		4			Sh - bk, platey, mod consol, pyrite bands, intbd	Sent to lab [509.9-510.4 roof
		514	0	3	6			COAL - bk, hd, sl blky, ., broken core	[510.4-519.65 coal
								but intact, mod pyrite along cleat, minor amber noted	[519.65-520.15 floor
51-/529.1	15.1/15							v. bright (abundant vitrain)	513.8-514.0 (sent to methane lab
		519	65	5	65			COAL - intact, some gypsum crystals occasional pyrite	515.0-515.2 (Utah State Geologist)
								and amber, good cleat, v bright, no partings	518.0-518.2
		519	85		2			SS - med gr, gy - coalified roots	
		522	9	3	15			SS - med gr, subangular, massive, dk br to br	not calcareous, coalified roots in top
		525	5	2	6			SS - gy to wh, mgr, v well sorted, subangular	not calcareous
		529	1	4	6			SS - gy, mgr, subangular grains, heavy min. or	
								coffee grounds, massive	End of core
		560		30	9			SS - gy, mgr	
		570		10	0			Sh - gy, bk, sandy	poor cuttings yield
		573		3	0			Sh - gy br, argillaceous	
		574		1	0			Coal	
		577		3	0			Sh - gy br	
		591	0	24	0			SS - lt gy, mgr, v hd, sl calcareous	
		595	0	4	0			Sh - br gy, sandy	
		619		24	0			SS - gy, v hd, w/shale	
		620		1	0			Sh - intbd, not hard	
		629		9	0			COAL - carb shale	
		640		11	0			Sh - gy br, soft	
								TD 640	

Table A-7. Water level measurements in Well WQ-1A. Ground surface is 8231.9 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
12-31-80	13:45	107.4	8126.50	Collar assumed to be 2.0 ft. above ground surface.
1-28-80	12:36	111.07	8122.83	"
2-11-81	Inaccessible			
3-11-81	Inaccessible			
4-22-81	11:43	100.72	8133.18	"

Table A-8. Tabulated slug test data for well WQ-1A conducted in open open hole when hole terminated in coal zone.

Ground Surface Elevation = 8231.9 ft. MSL
Static Depth to Water = 154.85 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 520 feet
H_o = 4.85 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/23/80	0		4.85	1.00
	90	151.91	2.94	0.61
	150	152.57	2.28	0.47
	240	153.23	1.62	0.33
	300	153.51	1.34	0.28
	360	153.79	1.06	0.22
	480	154.16	0.69	0.14
	600	154.38	0.47	0.10
	900	154.75	0.10	0.02
	1260	154.83	0.02	0.004

At Match Line t = 100 seconds

$$T = \frac{r^2}{t\ match} = \frac{(0.255)^2}{100} = 0.00065\ ft^2/sec = 420\ gpd/ft$$

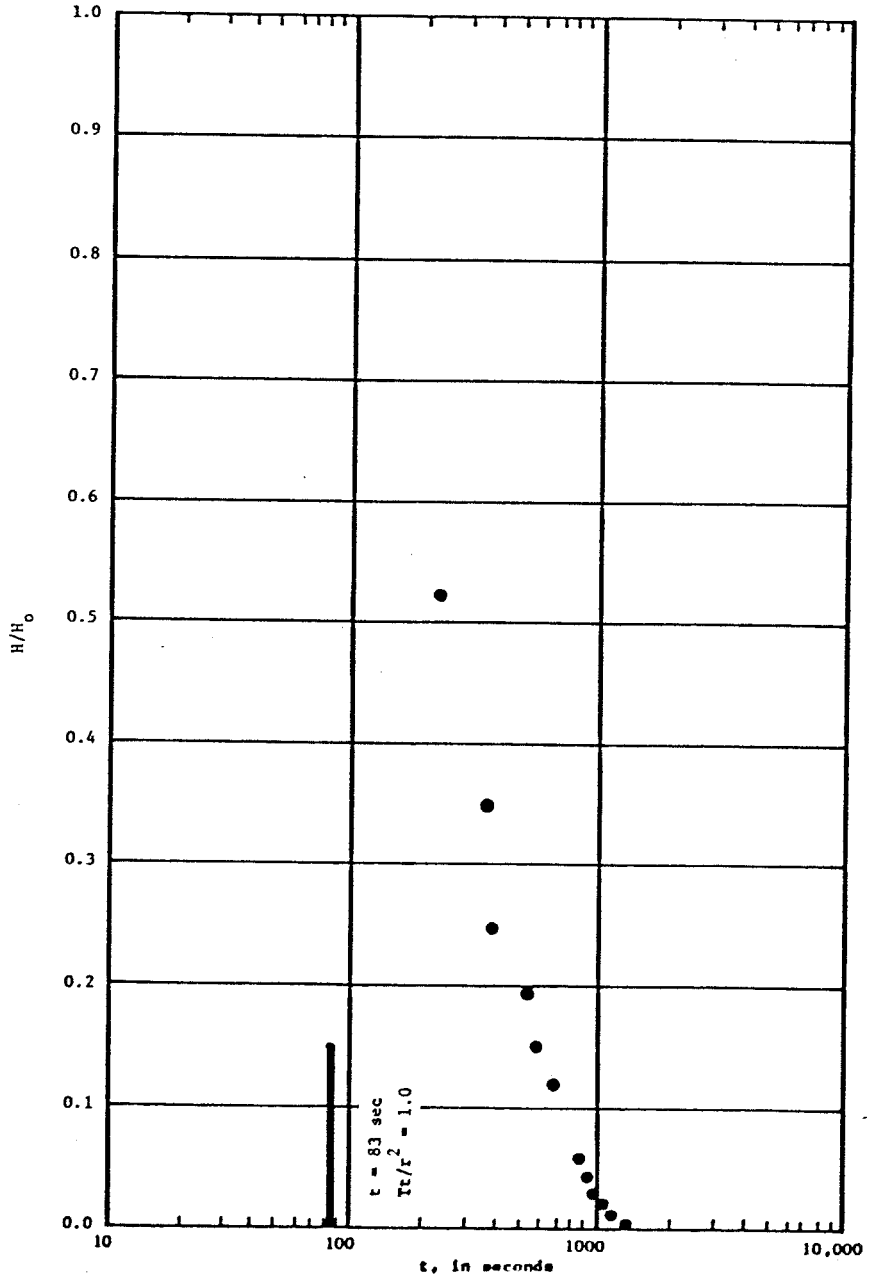


Figure A-2. Graphical results of the slug test for Well WQ-1A conducted when the hole terminated in the coal zone.

Table A-9. Tabulated slug test data for well WQ-1A conducted in open hole terminated in zone below coal.

Ground Surface Elevation = 8231.9 ft. MSL
Static Depth to Water = 116.58 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 640 feet
H_o = 9.4 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/7/80	0		9.4	1.0
	30	108.46	8.12	0.87
	90	110.47	6.11	0.65
	120	111.02	5.56	0.59
	150	111.45	5.13	0.548
	210	112.15	4.43	0.473
	270	112.72	3.86	0.413
	330	113.13	3.45	0.369
	390	113.56	3.02	0.323
	450	113.83	2.75	0.295
	510	114.05	2.53	0.271
	570	114.23	2.35	0.252
	630	114.38	2.20	0.236
	750	114.65	1.93	0.207
	930	114.89	1.69	0.182
	1110	115.04	1.54	0.166
	1410	115.11	1.47	0.150
	1710	115.28	1.30	0.140
	1950	115.32	1.26	0.136

At Match Line t = 35 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{135} = 0.00048 \text{ ft}^2/\text{sec} = 311 \text{ gpd/ft}$$

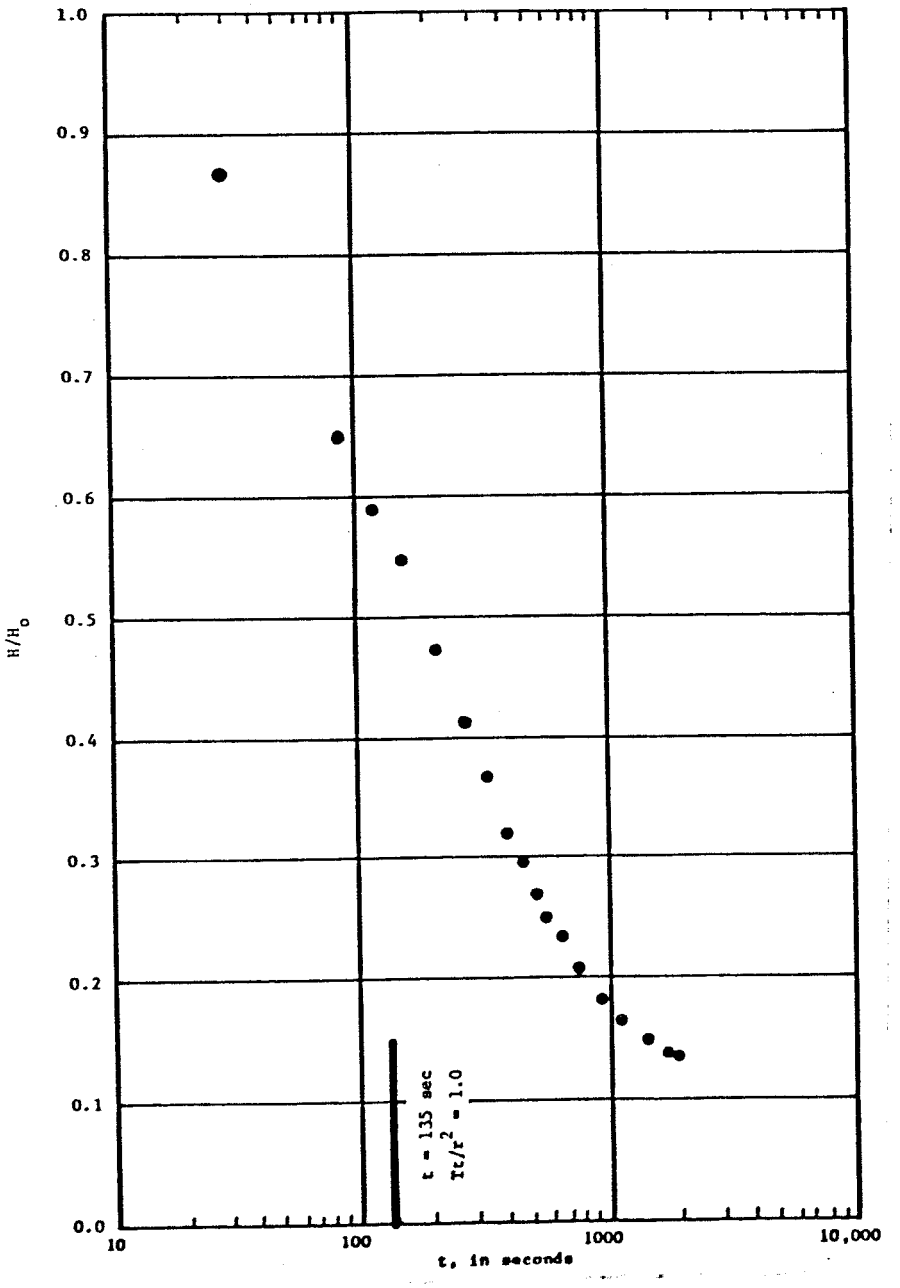


Figure A-3. Graphical results of the slug test for Well WQ-1A conducted when the hole terminated below the coal zone.

Table A-10. Tabulated drawdown and recovery data for well WQ-1A.

Date	Time	t (min)	t' (min)	t/t'	Depth water (ft)	Drawdown (ft)	Remarks
5-15-81	3:40	0			103.88	0	
		1			105.29	1.41	
		3			105.89	2.01	
		6			105.99	2.11	
		9			106.18	2.30	
		11			106.45	2.57	
		15			107.05	3.17	
		19			107.48	3.60	Flow - 5.9 gpm
		21			107.97	4.09	Hole is cased to
		26			109.03	5.15	depth of 126 feet.
		29			109.85	5.97	Casing is perforated in
		35			110.70	6.82	lower 20 feet
		40			111.35	7.47	
		45			111.88	8.00	
		52			112.32	8.44	
		62			113.63	9.75	
		70			114.46	10.58	
		80			115.83	11.95	
		90			116.93	13.05	
		100			117.90	14.02	
		110			118.55	14.67	
		120	0		119.06	15.18	
		120.5	0.5	241	118.67	14.79	
		121.0	1.0	121	116.44	12.56	
		121.5	1.5	81	115.95	12.07	
		122.0	2.0	61	115.77	11.89	
		122.5	2.5	49	115.58	11.70	
		123	3	41	115.34	11.46	
		124	4	31	114.97	11.09	
		125	5	25	114.67	10.79	
		126	6	21	114.58	10.70	
		126.5	6.5	19.5	113.98	10.10	
		128	8	16.0	113.93	10.05	
		130	10	13.0	113.60	9.72	
		132	12	11.0	113.41	9.53	
		134	14	9.6	113.23	9.35	
		136	16	8.5	113.05	9.17	
		138	18	7.7	112.93	9.05	
		140	20	7.0	112.77	8.89	
		145	25	5.8	112.47	8.59	
		150	30	5.0	112.23	8.35	
		160	40	4.0	111.78	7.90	
		170	50	3.4	111.38	7.50	
		180	60	3.0	111.08	7.20	

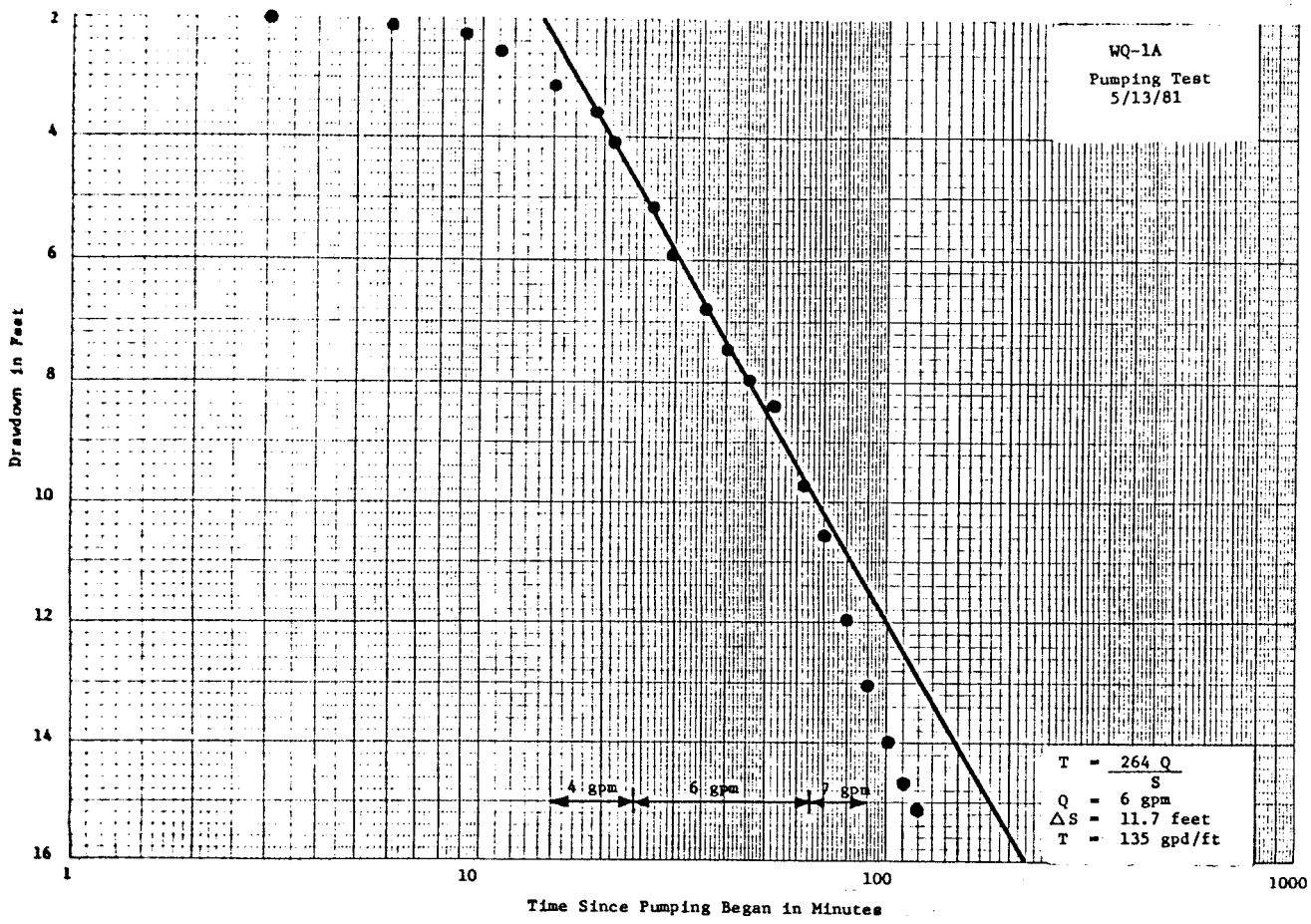


Figure A- 4. Graphical results of the drawdown test for Well WQ-1A.

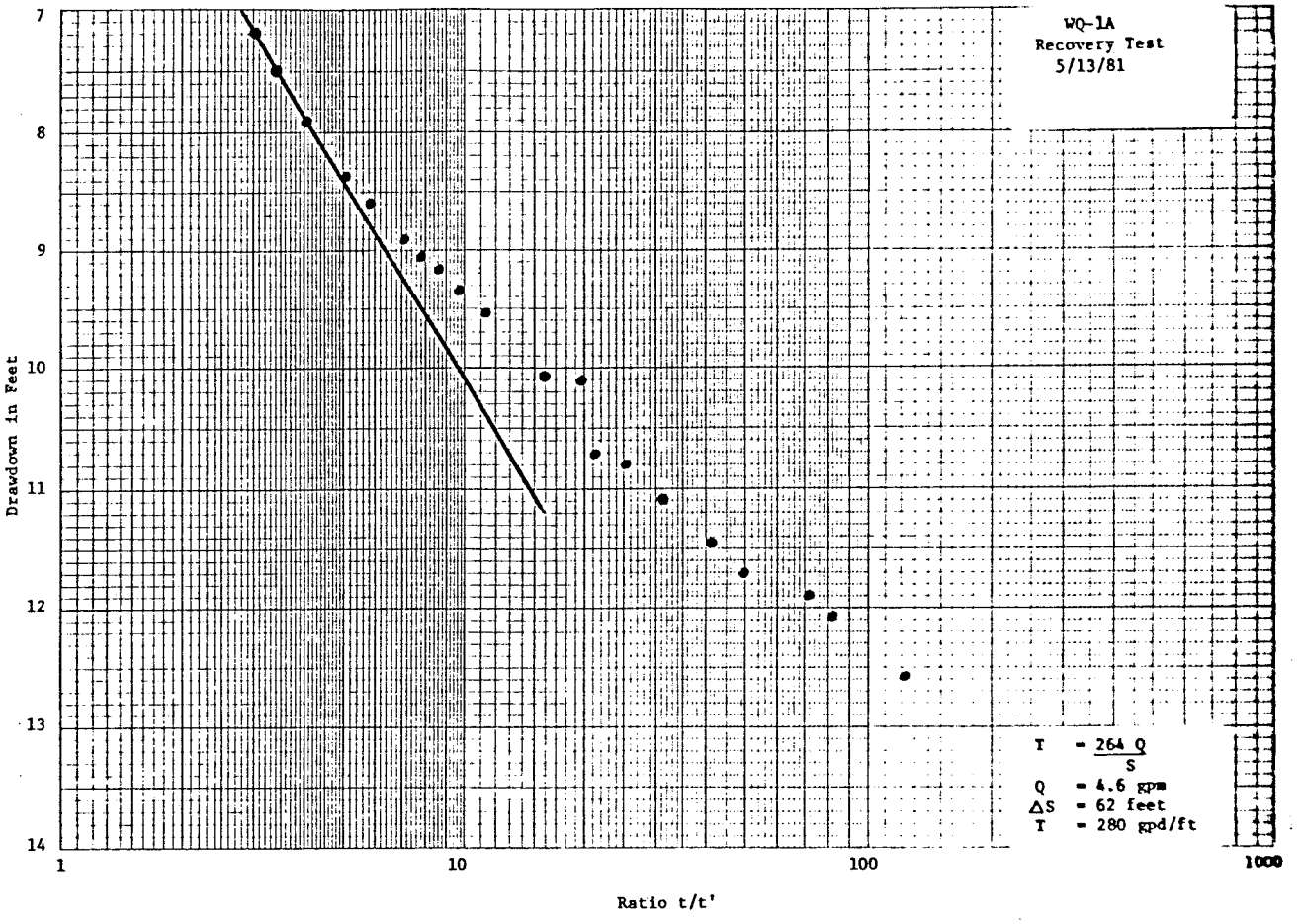
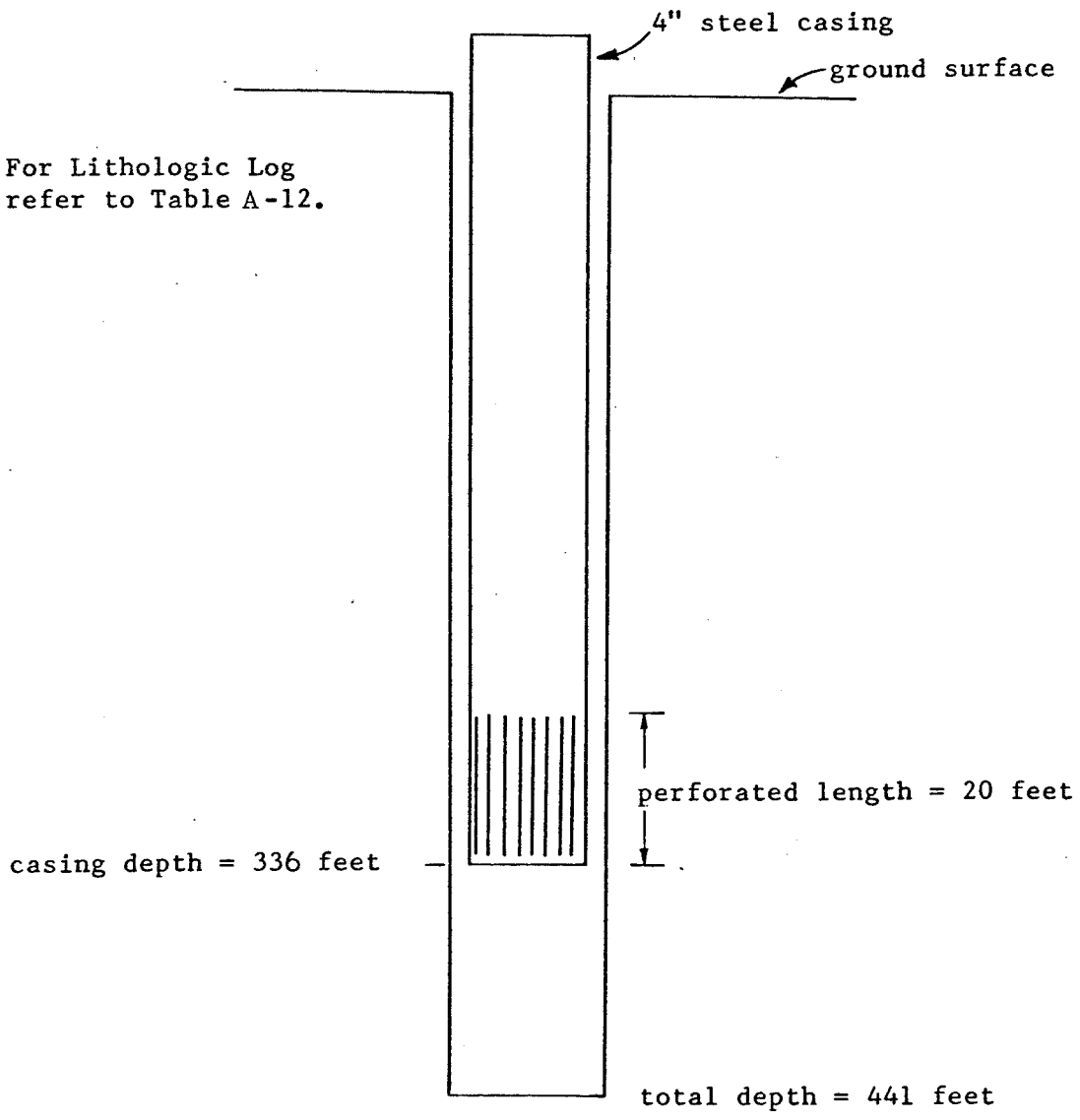


Figure A-5. Graphical results of the recovery test conducted in Well WQ-1A.

Table A-11. Miscellaneous information pertaining to Well WQ-6.

Location Number:	WQ-6	Hydrologic Zone Monitored:	Combined below, in, and above coal
Date Drilled:	10/29/80	Surface Elevation:	8167.06 feet MSL
Total Depth:	441 feet	Casing Depth:	336 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8053 feet MSL	Perforated Interval:	316 - 336 feet



(Not to Scale)

Table A-12. Lithologic description of well WQ-6.

Hole Number WQ-06

CORE INTERVAL TOP / BASE	CUT / REC.	BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S)	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
		17	0	17	0			Clay, soft, br, sandy w/depth	
		33	0	16	0			Sh - br, lot of clay, sandy	
		36	0	3	0			Sh - gy to dk gy, sandy, mod consol	Set 34'of casing
		38	0	2	0			SS - gy br, fgr, mgr, hd v calcareous	Looks like limestone!!
		44	0	6	0			Sh - dk gy to bk, soft silty	
		54	0	10	0			SS - lt gy, fgr, hd	
		71	0	17	0			Sh - bk, mod consol, silty to sandy	
		74	0	3	0			SS - lt gy, calcareous	
		79	0	5	0			Sh - gy to dk gy, silty	
		120	0	41	0			SS - lt gy, fgr, v hd	
		138	0	18	0			SS:Sh gy to dk gy, minor bk sh zones	
		144	0	6	0			Sh - gy to dk gy, min to mod ss (mgr)	
		148	0	4	0			COAL w/bk sh	
		207	0	59	0			SS - gy, mgr to crsgr, v silty, unconsol	
								w/mod dk gy shale zones, hd zones (calcareous?)	
		212		5	[illegible]			Sh - dk gy, mod ss and silst	
		216		4	0			SS - lt gy, mgr, mod to well consol	
		235	0	19	0			Sh - dk gy, as previous and mod carb frags	
		238	0	3	0			SS - gy, mgr to crsgr,	
		250	0	12	0			Sh - dk gy, mod consol, min bk carb	
		296	0	46	0			SS - lt gy w/sh intbds, (ss v hd)	
		310						Sh - dk gy to bk, silty, soft, some ss streaks 300 to 310	
310/325	15/14.6	310	4		4			Lost top 0.4'	
		311	8	1	4			Silst - gy, massive, calcareous	Hard
		312	2		4			Sh - gy, only sl calcareous	
		320	7	8	5			SS - lt gy, vfgr, massive w/clay and carb debris in	Has crystalline texture (sugary)
								distorted beds (burrowed) [fgr @316']	
		321			3			Sh - gy w/carb frags	
325/340	15/15	331	35	10	35			COAL - v bright, (vitrain) good cleat, blky, resin	Very clean
								crystals (amber) pyrite along fracture, some gypsum	Sent to Lab:
		331	55		2			SS - mgr, dk br, coal lenses	Roof 320.5-321
		332	55	1	0			SS - mgr, br	COAL 321-331.35
		340	0	7	45			SS - lt gy, mgr to fgr, mod calcareous, massive	Floor 331.35-331.85
								well sorted	
								END CORE 340	Methane Test - Utah G. S.
									321-321.2 (0.2')
									327-327.2 (0.2')
									328.8-329.0(0.2')

Table A-13. Water level measurements in Well WQ-6. Ground surface is 8167.06 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
12-31-80	14:15	116.05	8053.01	Collar assumed to be 2.0 ft. above ground surface.
2-11-81	Inaccessible			
3-11-81	Inaccessible			
4-22-81	11:00	90.5	8078.56	

Table A-14. Tabulated slug test data for well WQ-6 conducted in open hole when hole terminated in zone above coal.

Ground Surface Elevation = 8167.06 ft. MSL
Static Depth to Water = 88.65 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 200 feet
H_o = 12.15 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/29/80	0		12.15	1.0
	60	80.33	8.32	0.68
	120	83.00	5.65	0.47
	180	85.26	3.39	0.28
	240	86.62	2.03	0.17
	300	87.33	1.32	0.11
	360	87.87	0.78	0.064
	420	88.21	0.44	0.036
	480	88.38	0.27	0.022
	540	88.50	0.15	0.012
	600	88.56	0.09	0.007
	720	88.60	0.05	0.004
	840	88.63	0.02	0.002
	1560	88.63	0.02	0.002

At Match Line t = 35 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{35} = 0.00186 \text{ ft}^2/\text{sec} = 1201 \text{ gpd/ft}$$

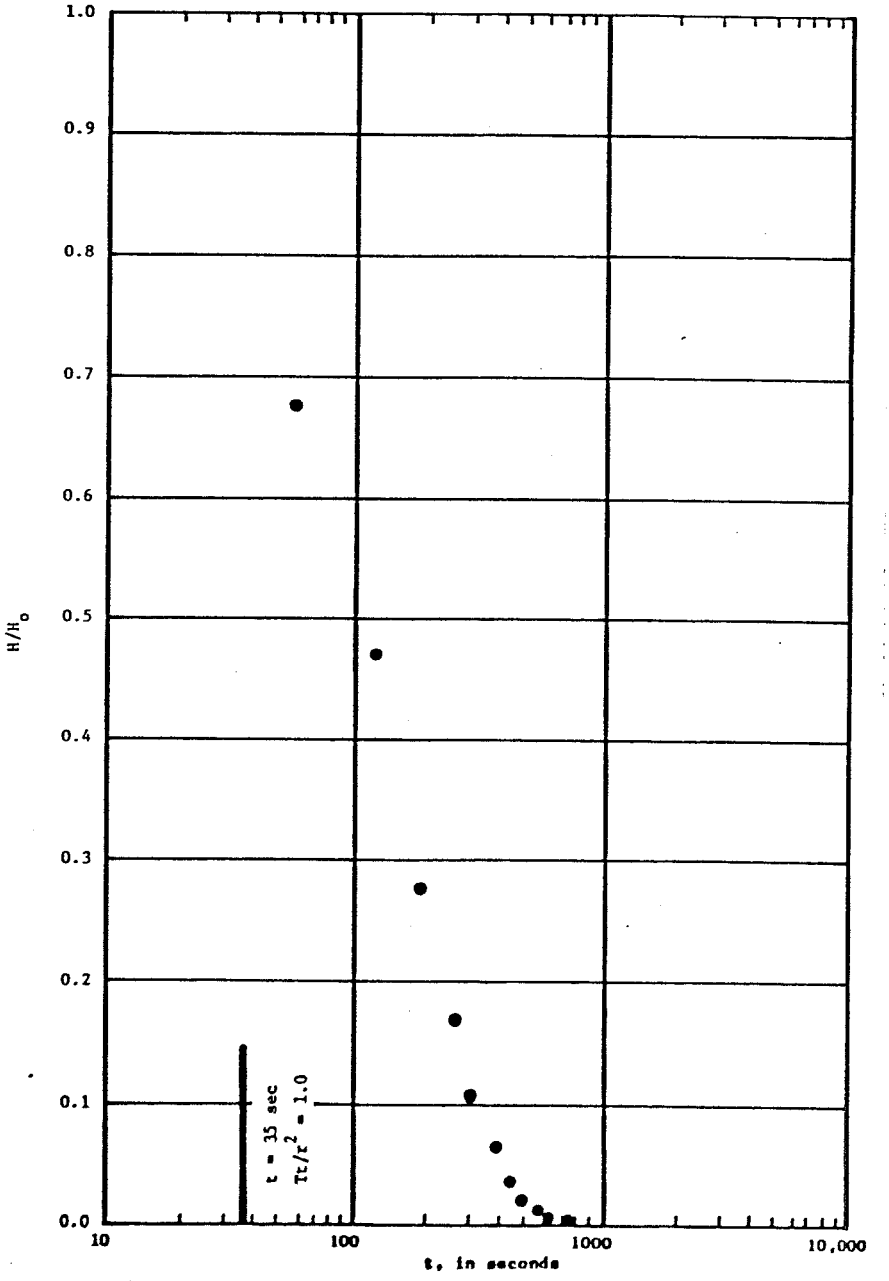


Figure A-6. Graphical results of the slug test for Well WQ-6 conducted when the hole terminated above the coal zone.

Table A-15. Tabulated slug test data for well WQ-6 conducted in open hole when hole terminated in the coal zone.

Ground Surface Elevation = 8167.06 ft. MSL
Static Depth to Water = 95.2 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 345 feet
H_o = 15.20 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/29/80	0		15.20	1.0
	60	84.95	10.25	0.67
	120	88.24	6.96	0.46
	180	90.67	4.53	0.30
	240	92.34	2.86	0.19
	300	93.40	1.80	0.12
	360	94.16	1.04	0.068
	420	94.56	0.64	0.042
	480	94.80	0.40	0.026
	540	94.92	0.28	0.018
	600	94.98	0.22	0.014
	720	95.05	0.15	0.010
	840	95.06	0.14	0.009
	960	95.07	0.13	0.009
	1080	95.07	0.13	0.009
	1200	95.08	0.12	0.008

At Match Line t = 23 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{23} = 0{,}000283 \text{ ft}^2/\text{sec} = 1828 \text{ gpd/ft}$$

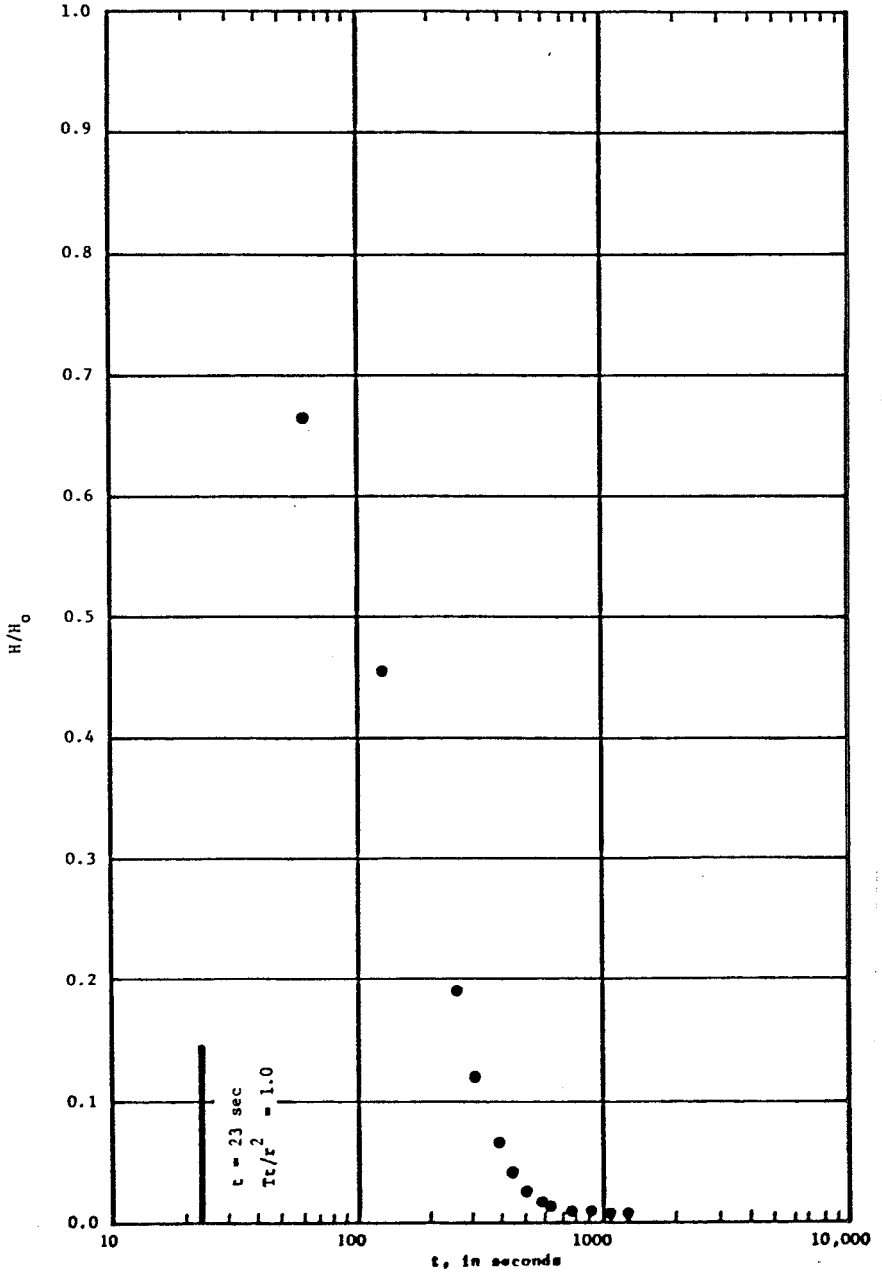


Figure A-7. Graphical results of the slug test for Well WQ-6 conducted when the hole terminated in the coal zone.

Table A-16. Tabulated slug test data for well WQ-6 conducted in open hole when hole terminated in the zone below the coal.

Ground Surface Elevation = 8167.06 ft. MSL
Static Depth to Water = 99.12 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 441 feet
H_o = 10.82 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/30/80	0		10.82	1.0
	30	89.66	9.46	0.87
	60	91.46	7.66	0.71
	120	94.30	4.82	0.45
	180	95.27	3.85	0.36
	210	96.17	2.95	0.27
	240	97.23	1.89	0.17
	300	98.08	1.04	0.10
	390	98.38	0.74	0.07
	420	98.48	0.64	0.06
	480	98.57	0.55	0.05
	540	98.68	0.44	0.041
	600	98.70	0.42	0.039
	660	98.72	0.40	0.037

At Match Line t = 23 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{23} = 0.00283 \text{ ft}^2/\text{sec} = 1828 \text{ gpd/ft}$$

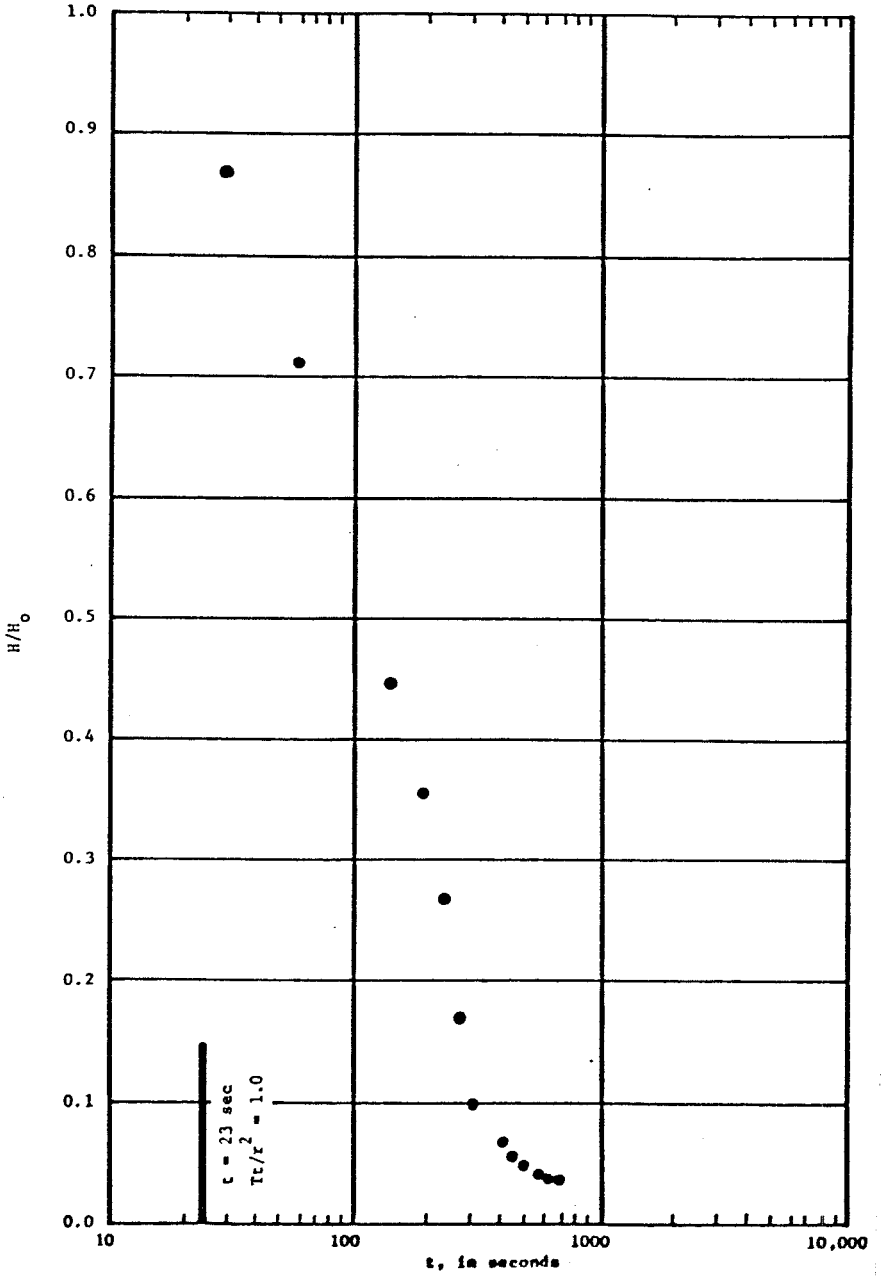


Figure A-8. Graphical results of the slug test for Well WQ-6 conducted when the hole terminated below the coal zone.

Table A-17. Tabulated recovery data for well WQ-6.

Date	Time	t (min)	t' (min)	t/t'	Depth Water (feet)	Drawdown (feet)	Remarks
5-15-81	1:40	0	-	-	107.32		
		3	-	-			
		6	-	-			
		14	-	-			
		19	-	-			
		25	-	-			Flow = 4.6 gpm
		27	0	-			
		30.5	3.5	8.7	145.55	38.23	Hole is cased to a depth of 336 feet.
		32	5	6.4	143.51	36.19	
		34	7	4.9	140.50	33.18	
		36	9	4.0	137.86	30.54	Casing is perforated in lower 20 feet.
		38	11	3.5	135.43	28.11	
		40	13	3.1	133.19	25.87	
		42	15	2.8	131.07	23.75	
		46	19	2.4	127.67	20.35	
		48	21	2.3	126.11	18.79	
		50	23	2.2	124.83	17.51	
		55	28	2.0	122.24	14.92	
		70	43	1.6	117.02	9.70	
		80	53	1.5	115.15	7.83	
		90	63	1.4	113.91	6.59	

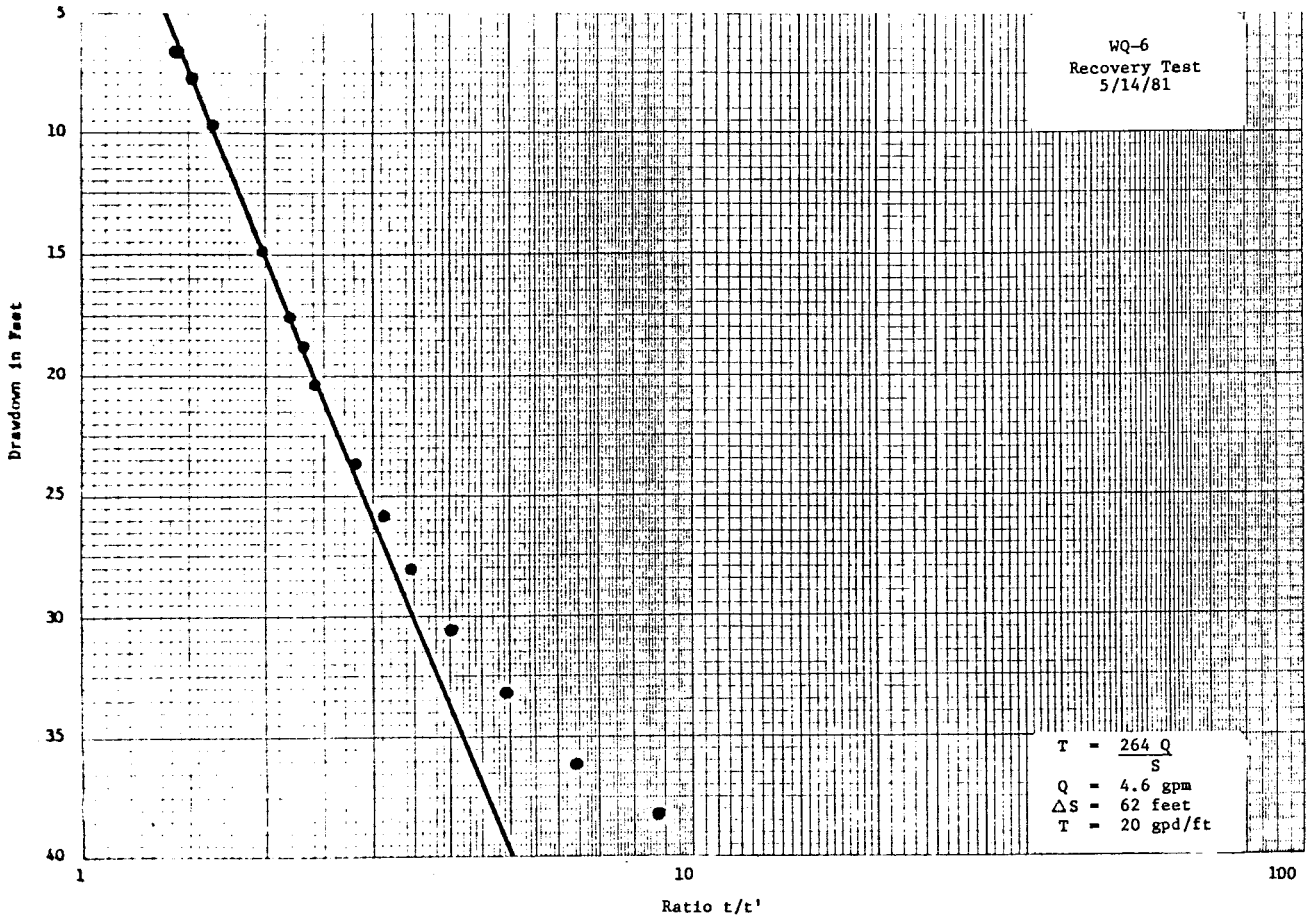
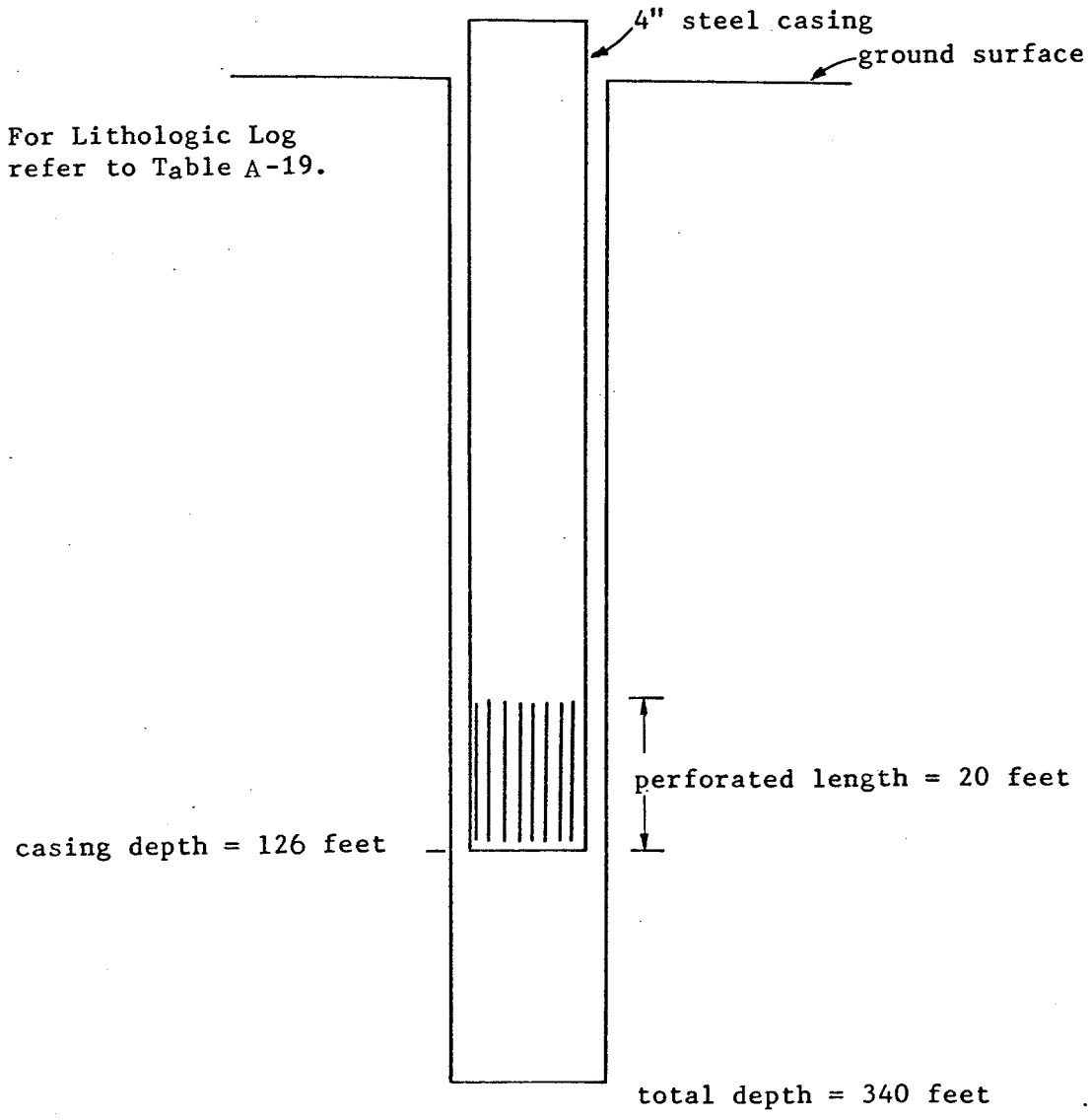


Figure A-9. Graphical results of the recovery test conducted in Well WQ-6.

Table A-18. Miscellaneous information pertaining to Well WQ-8.

Location Number:	WQ-8	Hydrologic Zone Monitored:	Combined below, in, and above coal.
Date Drilled:	11/7/80	Surface Elevation:	8120.75 feet MSL
Total Depth:	340 feet	Casing Depth:	126 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8058 feet MSL	Perforated Interval:	106 - 126 feet



(Not to Scale)

Table A-19. Lithologic description of well WQ-8.

Hole Number WQ-8

CORE INTERVAL TOP / BASE	CUT / REC.	BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S)	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
		40	0	40	0			Sand - topsoil & talus, br to lt br, fgr, v silty	
		60	0	20	0			SS - br, mgr, mod gy sh frags	
		66	0	6	0			Sh - gy, argillaceous	
		68	0	2	0			Coal - bk, hd, abundant carb sh frags	
		90		22	0			Sh - gy to dk gy, mhd mod consol, min sand, mod bk sh	
		108	0	18	0			Sh - w/ss (mod) as above	
		109	0	1	0			Coal - abund bk sh	Sh drills fairly hd w/ mod t minor intbd
		115	0	6	0			Sh - w/ss as previous	ss, minor water, less than 1 gpm, apparant
		117	0	2	0			Coal & sh (bk) - hd,	from coal @ 66'
		160	0	43	0			Sh w/ss (mod) dk gy sh, vfgr sand	
		170	0	10	0			SS - gy w/mod sh intbd, mhd, fgr to mgr	
		197	0	27	0			Sh - gy to dk gy, mod consol, min carb frags, mod to abundant ss	
		221		24	0			SS - lt gy to gy, vhd, fgr to vfgr	
		230		9	0			Sh - gy, soft, mod consol, argillaceous	
								BEGIN CORE 230.0	
230/245	15/11.9	231	8	1	8			SS - lt gy, vhd, v silty, vfgr, appears calcareous, intact core	
		232	0		8			Sh - gy, pbdd, mhd, intact core slickenslides	
		233	0		4			Sh - as above, v broken, appears to be where loss	
		233	9		9		LOST??	occur (primary loss) rounded frags	Lost
		234	2		3			Clay - gy, v soft, mod swelling, pve, pbdd	
		234	4		2			Sh - gy, , soft to mhd, mod coal and carb stringers	
		234	5		1			Sh - bk, v carb, abundant coal bands	
		242	8	8	3			COAL - bk, mhd, blky, btm 3.5'	
		245	0	2	2	LOST		minor pyrite and amber along cleats noted	Lost
245/260	15/15	245	5	0	5			COAL - bk, broken, blky, as above	Sent to lab
		246	2	0	7			SS - br, carb and coal rooting throughout, massive fgr	Roof 233.9-234.5
									Coal 234.5-245.5 (11.0-lost 2.2)
									Floor 245.5-246.0
		248	3	2	1				
		260	4	12	4			SS - lt gy, massive, fgr, coffee grounds or heavy min	
								in btm 6'	
									~~Log 236.0-247.0 (11.0')~~
									~~Core 8.8~~
									Lost 2.2'coal @ btm

Table A-20. Water level measurements in Well WQ-8. Ground surface is 8120.75 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
2-11-81	Inaccessible			Collar assumed to be 2.0 ft. above ground surface.
3-11-81	Inaccessible			
4-22-81	14:05	64.86	8057.89	"

Table A-21. Tabulated slug test data for well WQ-8 conducted in open hole when hole terminated in the zone above the coal.

Ground Surface Elevation = 8120.75 ft. MSL
Static Depth to Water = 63.0 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 161 feet
H_o = 41.5 feet

At Match Line t = 500 seconds

$$T = \frac{r^2}{t\,match} = \frac{(0.255)^2}{500} = 0.00013\ ft^2/sec = 84\ gpd/ft$$

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/7/80	0		41.5	1.0
	65	25.0	38.00	0.92
	125	26.45	36.55	0.88
	185	27.80	35.20	0.85
	240	29.00	34.00	0.82
	300	29.98	33.02	0.80
	360	30.83	32.17	0.775
	420	31.71	31.29	0.754
	480	32.70	30.30	0.730
	540	33.57	29.43	0.709
	600	34.41	28.59	0.689
	660	35.25	27.75	0.669
	720	36.13	26.87	0.647
	840	37.73	25.27	0.609
	960	39.25	23.75	0.572
	1020	39.97	23.03	0.555
	1320	43.37	19.63	0.473
	1620	45.93	17.07	0.411
	1920	50.49	12.51	0.301
	2220	52.20	10.80	0.260
	2520	53.78	9.22	0.222
	2820	55.15	7.85	0.189
	3120	56.33	6.67	0.161
	3420	57.31	5.69	0.137
	3720	58.28	4.72	0.114

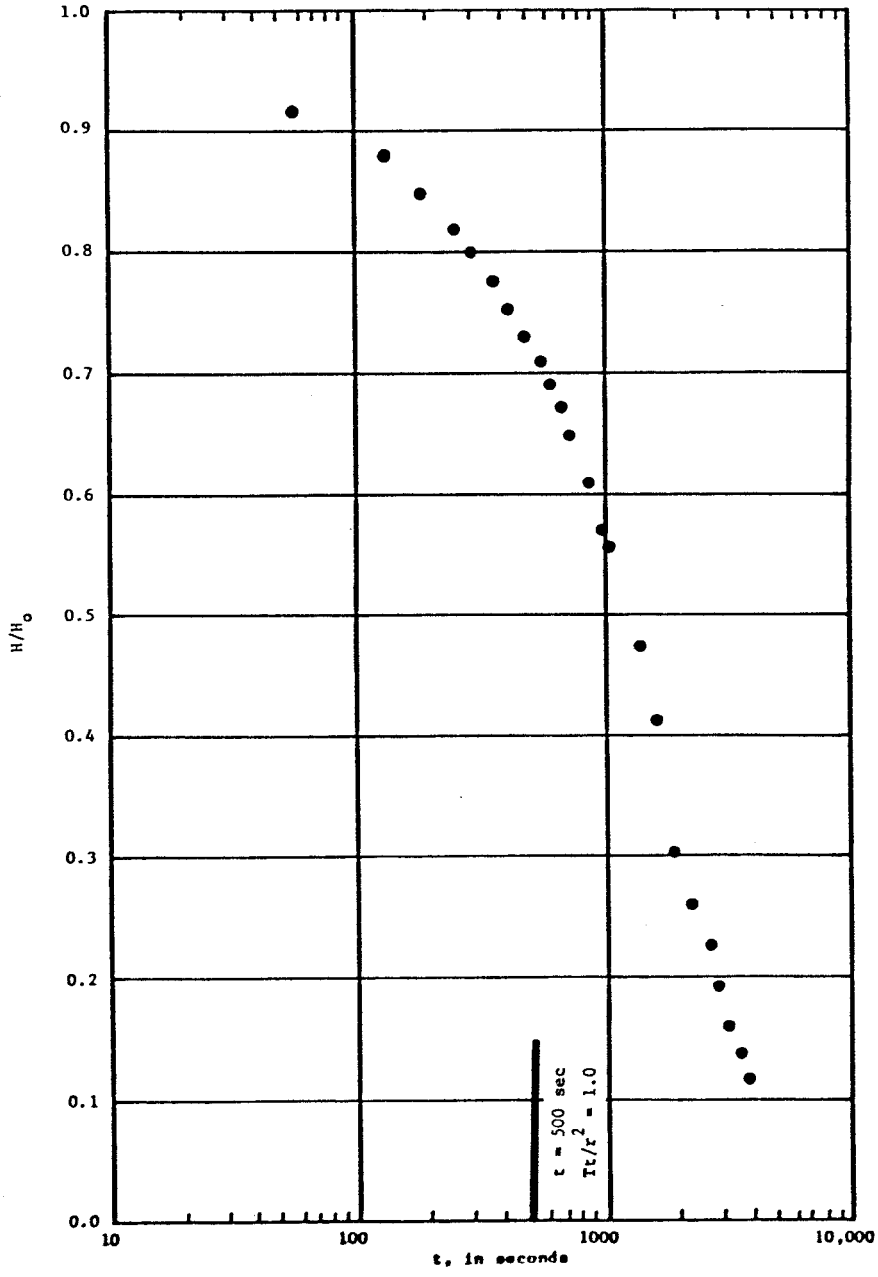


Figure A-10. Graphical results of the slug test conducted in Well WQ-8 when the hole terminated above the coal zone.

Table A-22. Tabulated slug test data for well WQ-8 conducted in open hole when hole terminated in the coal zone.

Ground Surface Elevation = 8120.75 ft. MSL
Static Depth to Water = 64.0 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 260 feet
H_o = 20.0 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/8-80	0		20.00	1.00
	45	47.02	16.98	0.85
	120	50.93	13.07	0.65
	180	52.37	11.63	0.58
	240	53.44	10.56	0.53
	300	54.36	9.64	0.48
	360	55.03	8.97	0.45
	420	55.72	8.28	0.414
	540	56.93	7.07	0.354
	600	57.53	6.47	0.324
	720	58.53	5.47	0.274
	840	59.45	4.55	0.228
	960	60.24	3.76	0.188
	1080	60.92	3.08	0.154
	1200	61.48	2.52	0.126
	1320	61.99	2.01	0.101
	1440	62.40	1.60	0.080
	1560	62.70	1.30	0.065
	1680	62.91	1.09	0.055

At Match Line t = 135 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{135} = 0.00048 \text{ ft}^2/\text{sec} = 312 \text{ gpd/ft}$$

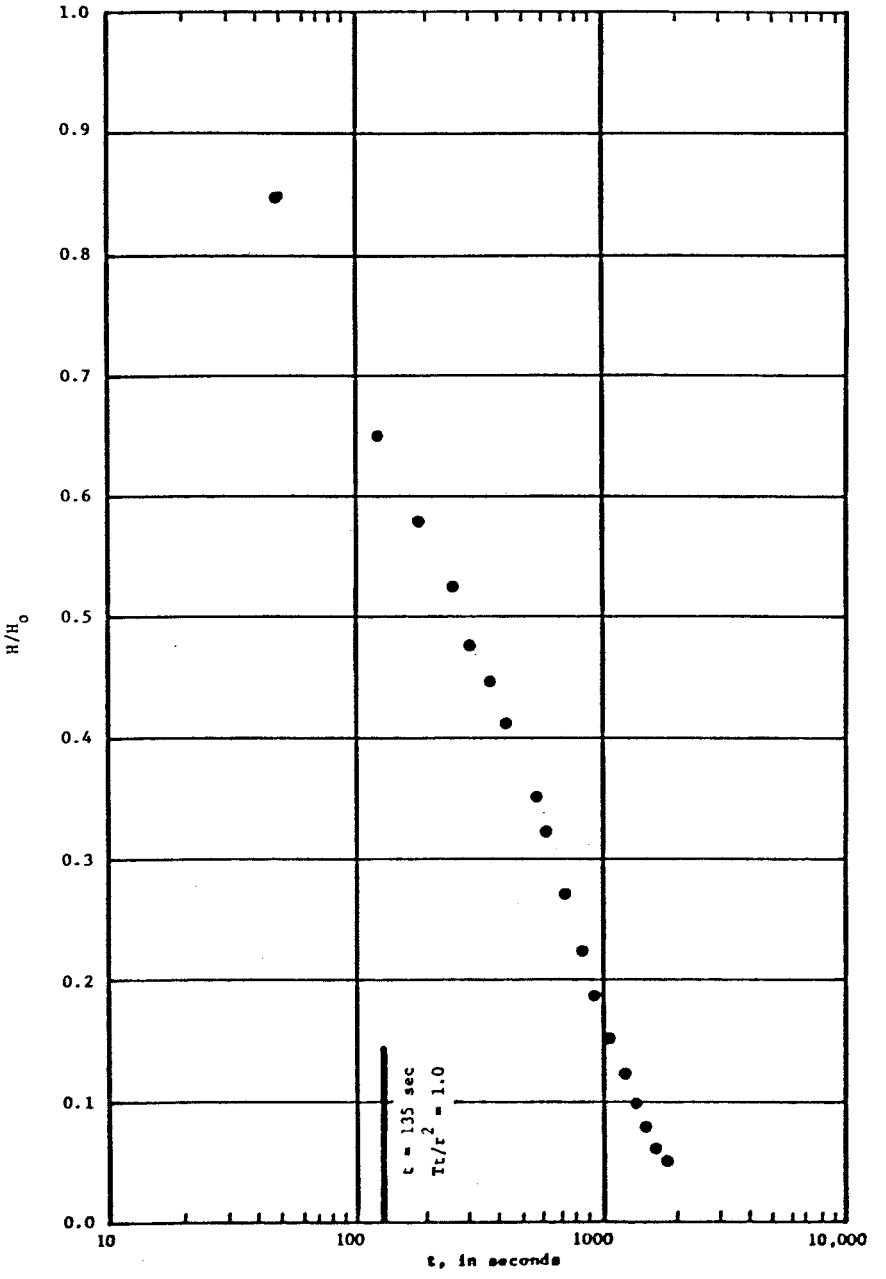


Figure A-11. Graphical results of the slug test for Well WQ-8 when the hole terminated in the coal zone.

Table A-23. Tabulated slug test data for well WQ-8 conducted in open hole when hole terminated in the zone below the coal.

Ground Surface Elevation = 8120.75 ft. MSL
Static Depth to Water = 60.22 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 340 feet
H_o = 27.8 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/12/80	0		27.8	1.000
	30	33.67	26.55	0.955
	90	36.11	24.11	0.867
	120	37.19	23.03	0.828
	180	39.80	20.42	0.735
	240	42.09	18.13	0.652
	300	44.00	16.22	0.583
	360	45.83	14.39	0.518
	420	47.33	12.89	0.464
	480	48.78	11.44	0.412
	540	49.98	10.24	0.368
	600	51.08	9.14	0.329
	780	53.78	6.44	0.232
	900	55.16	5.06	0.182
	1020	56.31	3.91	0.141
	1200	57.57	2.65	0.095
	1500	58.67	1.55	0.056
	1800	59.09	1.13	0.041
	2100	59.28	0.94	0.034
	2400	59.38	0.84	0.030

At Match Line t = 114 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{114} = 0.00057 \text{ ft}^2/\text{sec} = 368 \text{ gpd/ft}$$

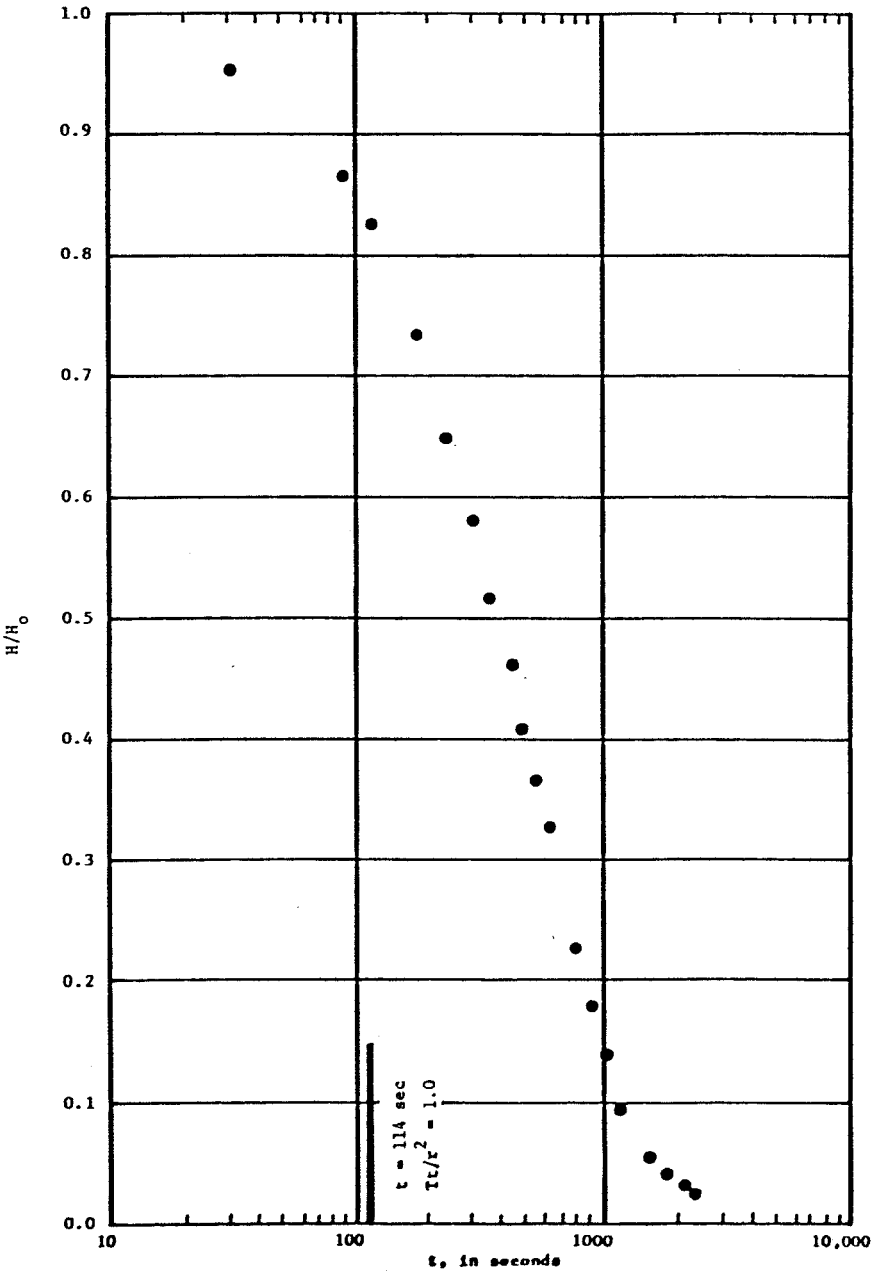


Figure A-12. Graphical results of the slug test for Well WQ-8 when the hole terminated below the coal zone.

ATTACHMENT B

WATER QUALITY ANALYSES

Table B-1. Results of chemical analyses of surface water quality samples collected at Station U-1.

Date	10-22-80	11-7 80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	1.2	1.6	1.7		Inaccessible	Inaccessible
Specific Conductance, umhos/cm	400	420	225	215		
Temperature, Air	10	6	1	5		
Temperature, Water	4	1	0	0		
pH	7.8	7.8	7.1	7.7		
Oil & Grease	5.80	<0.01	3.80	0.40		
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01	<0.01		
Nitrate as NO3-N mg/l	0.07	0.15	0.28	0.23		
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.03	0.20	0.10	0.10		
Phosphate as PO4-P Total mg/l	0.040	0.160	0.120	0.060		
Phosphate as PO4-P Ortho mg/l	<0.001	<0.001	0.040	0.040		
Sulfate as SO4 mg/l	16.5	18.0	15.0	12.0		
Sulfide mg/l						
Total Suspended Solids mg/l	6.0	4.0	1.0	26.0		
Total Dissolved Solids mg/l	260	252	235	252		
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01	<0.01		
Bicarbonate as HCO3 mg/l	280.60	275.72	273.28	283.04		
Alkalinity as CaCO3 (Total) mg/l	230	226	224	232		
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	4.0	26.0	8.0	16.0		
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001	<0.001		
Barium as Ba (Total) mg/l	0.050	0.024	0.035	0.055		
Boron as B (Total) mg/l	0.036	0.066	0.080	0.020		
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001	0.001		
Calcium as Ca mg/l	71.20	76.80	71.20	68.00		
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001	<0.001		
Copper as Cu (Total) mg/l	<0.001	<0.001	0.010	0.002		
Iron as Fe (Total) mg/l	0.144	0.850	0.230	0.230		
Lead as Pb (Total) mg/l	<0.001	0.010	0.003	0.002		
Magnesium as Mg mg/l	13.92	9.12	12.48	12.00		
Manganese as Mn (Total) mg/l	0.015	0.030	0.035	0.030		
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002	<0.0002		
Molybdenum as Mo (Total) mg/l	< 0.001	< 0.001	< 0.001	< 0.001		
Potasssium as K mg/l	1.58	1.44	1.50	1.53		
Selenium as Se (Total) mg/l	<0.001	<0.001	0.003	<0.001		
Silver as As (Total) mg/l	0.002	<0.001	<0.001	<0.001		
Sodium as Na mg/l	6.40	6.80	4.20	12.00		
Zinc as Zn (Total) mg/l	0.005	0.022	0.005	0.015		
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.035	0.020	0.025	0.020		
Boron as B (Dissolved) mg/l	0.005	0.030	0.070	0.015		
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Chloride as Cl (Dissolved) mg/l	4.7	3.6	0.44	5.35		
Chromium as Cr (Dissolved) mg/l	0.001	0.001	0.001	0.001		
Copper as Cu (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Fluoride as F (Dissolved) mg/l	0.11	0.11	0.09	0.19		
Iron as Fe (Dissolved) mg/l	0.065	0.830	0.040	0.010		
Lead as Pb (Dissolved) mg/l	<0.001	0.007	<0.001	0.002		
Manganese as Mn (Dissolved) mg/l			0.035			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Zinc as Zn (Dissolved) mg/l	0.002	0.020	0.005	0.005		

Table B-1. (Continued)

Date	4-22-81
Flow, cfs	
Specific Conductance, umhos/cm	330
Temperature, Air	
Temperature, Water	8
pH	8.3
Oil & Grease	
Ammonia as NH3-N mg/l	<0.01
Nitrate as NO3-N mg/l	0.36
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	0.110
Phosphate as PO4-P Ortho mg/l	0.030
Sulfate as SO4 mg/l	15.0
Sulfide mg/l	
Total Suspended Solids mg/l	21.0
Total Dissolved Solids mg/l	175
Total Combustible Solids	
Carbonate as CO3 mg/l	9.60
Bicarbonate as HCO3 mg/l	151.28
Alkalinity as CaCO3 (Total) mg/l	140
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	<0.01
Arsenic as As (Total) mg/l	<0.001
Barium as Ba (Total) mg/l	0.015
Boron as B (Total) mg/l	0.015
Cadmium as Cd (Total) mg/l	<0.001
Calcium as Ca mg/l	57.60
Chromium as Cr (Total) mg/l	<0.001
Copper as Cu (Total) mg/l	0.010
Iron as Fe (Total) mg/l	0.080
Lead as Pb (Total) mg/l	0.002
Magnesium as Mg mg/l	5.28
Manganese as Mn (Total) mg/l	0.030
Mercury as Hg (Total) mg/l	< 0.0002
Molybdenum as Mo (Total) mg/l	< 0.001
Potasssium as K mg/l	1.30
Selenium as Se (Total) mg/l	< 0.001
Silver as As (Total) mg/l	0.076
Sodium as Na mg/l	3.50
Zinc as Zn (Total) mg/l	0.010
Arsenic as As (Dissolved) mg/l	< 0.001
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	0.010
Boron as B (Dissolved) mg/l	0.010
Cadmium as Cd (Dissolved) mg/l	< 0.001
Chloride as Cl (Dissolved) mg/l	
Chromium as Cr (Dissolved) mg/l	< 0.001
Copper as Cu (Dissolved) mg/l	< 0.001
Fluoride as F (Dissolved) mg/l	
Iron as Fe (Dissolved) mg/l	0.080
Lead as Pb (Dissolved) mg/l	< 0.001
Manganese as Mn (Dissolved) mg/l	0.010
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	< 0.001
Silver as As (Dissolved) mg/l	0.033
Zinc as Zn (Dissolved) mg/l	0.002

Table B-2. Results of chemical analyses of surface water quality samples collected at Station U-2.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.03		0.003	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	560	680	352			
Temperature, Air	10		1			
Temperature, Water	5		2			
pH	7.5	7.3	7.0			
Oil & Grease	1.80	< 0.01	2.00			
Ammonia as NH3-N mg/l	< 0.01	< 0.01	< 0.01			
Nitrate as NO3-N mg/l	0.05	0.05	0.12			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.10	0.05	0.12			
Phosphate as PO4-P Total mg/l	0.035	0.100	0.170			
Phosphate as PO4-P Ortho mg/l	0.030	< 0.001	0.040			
Sulfate as SO4 mg/l	18.0	42.0	34.5			
Sulfide mg/l						
Total Suspended Solids mg/l	16.0	12.0	8.0			
Total Dissolved Solids mg/l	362	360	396			
Total Combustible Solids						
Carbonate as CO3 mg/l	< 0.01	< 0.01	< 0.01			
Bicarbonate as HCO3 mg/l	400.16	397.72	448.96			
Alkalinity as CaCO3 (Total) mg/l	328	326	368			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	12.0	44.0	20.0			
Arsenic as As (Total) mg/l	< 0.001	< 0.001	< 0.001			
Barium as Ba (Total) mg/l	0.133	0.086	0.050			
Boron as B (Total) mg/l	0.025	0.070	0.085			
Cadmium as Cd (Total) mg/l	< 0.001	< 0.001	< 0.001			
Calcium as Ca mg/l	80.80	83.20	94.40			
Chromium as Cr (Total) mg/l	< 0.001	< 0.001	< 0.001			
Copper as Cu (Total) mg/l	0.003	0.015	0.006			
Iron as Fe (Total) mg/l	0.166	0.660	0.310			
Lead as Pb (Total) mg/l	< 0.001	0.009	0.004			
Magnesium as Mg mg/l	30.24	30.24	39.36			
Manganese as Mn (Total) mg/l	0.014	0.010	0.010			
Mercury as Hg (Total) mg/l	< 0.0002	< 0.0002	< 0.0002			
Molybdenum as Mo (Total) mg/l	< 0.001	< 0.001	< 0.001			
Potasssium as K mg/l	2.91	2.69	2.70			
Selenium as Se (Total) mg/l	< 0.001	< 0.001	0.003			
Silver as As (Total) mg/l	< 0.001	< 0.001	< 0.001			
Sodium as Na mg/l	10.00	19.00	4.80			
Zinc as Zn (Total) mg/l	0.011	0.035	0.005			
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.024	0.040	0.040			
Boron as B (Dissolved) mg/l	0.010	0.060	0.075			
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			
Chloride as Cl (Dissolved) mg/l	5.4	3.7	0.51			
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			
Copper as Cu (Dissolved) mg/l	< 0.001	0.010	< 0.001			
Fluoride as F (Dissolved) mg/l	0.21	0.16	0.13			
Iron as Fe (Dissolved) mg/l	0.095	0.630	0.120			
Lead as Pb (Dissolved) mg/l	< 0.001	0.006	< 0.001			
Manganese as Mn (Dissolved) mg/l			0.010			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001	0.001			
Silver as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			
Zinc as Zn (Dissolved) mg/l	0.008	0.030	0.005			

Table B-2. (Continued)

Date	4-22-81
Flow, cfs	0.02
Specific Conductance, umhos/cm	480
Temperature, Air	
Temperature, Water	3
pH	8.3
Oil & Grease	
Ammonia as NH3-N mg/l	<0.01
Nitrate as NO3-N mg/l	0.14
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	0.160
Phosphate as PO4-P Ortho mg/l	0.004
Sulfate as SO4 mg/l	24.0
Sulfide mg/l	
Total Suspended Solids mg/l	36.0
Total Dissolved Solids mg/l	260
Total Combustible Solids	
Carbonate as CO3 mg/l	12.00
Bicarbonate as HCO3 mg/l	253.76
Alkalinity as CaCO3 (Total) mg/l	228
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	<0.01
Arsenic as As (Total) mg/l	<0.001
Barium as Ba (Total) mg/l	0.030
Boron as B (Total) mg/l	0.036
Cadmium as Cd (Total) mg/l	<0.001
Calcium as Ca mg/l	67.20
Chromium as Cr (Total) mg/l	<0.001
Copper as Cu (Total) mg/l	0.010
Iron as Fe (Total) mg/l	0.510
Lead as Pb (Total) mg/l	0.004
Magnesium as Mg mg/l	21.12
Manganese as Mn (Total) mg/l	0.020
Mercury as Hg (Total) mg/l	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001
Potasssium as K mg/l	2.30
Selenium as Se (Total) mg/l	0.002
Silver as As (Total) mg/l	0.003
Sodium as Na mg/l	3.50
Zinc as Zn (Total) mg/l	0.020
Arsenic as As (Dissolved) mg/l	<0.001
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	0.022
Boron as B (Dissolved) mg/l	0.036
Cadmium as Cd (Dissolved) mg/l	<0.001
Chloride as Cl (Dissolved) mg/l	6.00
Chromium as Cr (Dissolved) mg/l	<0.001
Copper as Cu (Dissolved) mg/l	0.010
Fluoride as F (Dissolved) mg/l	0.20
Iron as Fe (Dissolved) mg/l	0.160
Lead as Pb (Dissolved) mg/l	0.004
Manganese as Mn (Dissolved) mg/l	0.020
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	<0.001
Silver as As (Dissolved) mg/l	0.002
Zinc as Zn (Dissolved) mg/l	0.010

Table B-3. Results of chemical analyses of surface water quality samples collected at Station U-3.

Date	10-22-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.04			Inaccessible	Inaccessible	0.02
Specific Conductance, umhos/cm	450	600	205			280
Temperature, Air	11		6			
Temperature, Water	3		0			2
pH	7.6	7.6	7.8			8.1
Oil & Grease	0.80	< 0.01	1.20			
Ammonia as NH3-N mg/l	< 0.01	< 0.01	0.16			< 0.01
Nitrate as NO3-N mg/l	0.15	0.20	0.25			0.18
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.05	0.12	0.15			
Phosphate as PO4-P Total mg/l	0.040	0.160	0.180			0.770
Phosphate as PO4-P Ortho mg/l	0.020	< 0.001	0.160			0.090
Sulfate as SO4 mg/l	39.0	15.0	12.00			9.0
Sulfide mg/l						
Total Suspended Solids mg/l	24.0	33.0	2.0			507
Total Dissolved Solids mg/l	288	260	230			159
Total Combustible Solids						
Carbonate as CO3 mg/l	< 0.01	< 0.01	< 0.01			4.80
Bicarbonate as HCO3 mg/l	283.04	292.80	265.96			161.04
Alkalinity as CaCO3 (Total) mg/l	232	240	218			140
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	12.0	24.0	10.0			< 0.01
Arsenic as As (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Barium as Ba (Total) mg/l	0.036	0.050	0.050			0.060
Boron as B (Total) mg/l	0.015	0.068	0.025			0.030
Cadmium as Cd (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Calcium as Ca mg/l	62.40	72.00	68.80			44.80
Chromium as Cr (Total) mg/l	< 0.001	< 0.001	< 0.001			0.002
Copper as Cu (Total) mg/l	0.002	< 0.001	0.015			0.030
Iron as Fe (Total) mg/l	0.117	0.280	0.170			6.550
Lead as Pb (Total) mg/l	< 0.001	< 0.001	0.009			0.013
Magnesium as Mg mg/l	20.64	12.00	12.00			9.12
Manganese as Mn (Total) mg/l	0.002	0.030	0.020			0.440
Mercury as Hg (Total) mg/l	0.0002	0.0002	0.0002			< 0.0002
Molybdenum as Mo (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Potasssium as K mg/l	1.62	1.61	1.48			2.02
Selenium as Se (Total) mg/l	< 0.001	< 0.001	< 0.001			0.002
Silver as As (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Sodium as Na mg/l	14.20	11.00	6.00			2.50
Zinc as Zn (Total) mg/l	0.009	0.011	0.020			0.060
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.025	0.030	0.020			0.035
Boron as B (Dissolved) mg/l	0.006	0.060	0.015			0.020
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Chloride as Cl (Dissolved) mg/l	3.9	3.5	5.62			
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Copper as Cu (Dissolved) mg/l	< 0.001	< 0.001	0.010			0.010
Fluoride as F (Dissolved) mg/l	0.17	0.03	0.17			
Iron as Fe (Dissolved) mg/l	0.088	0.020	0.020			2.180
Lead as Pb (Dissolved) mg/l	< 0.001	< 0.001	0.001			0.005
Manganese as Mn (Dissolved) mg/l						0.420
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Silver as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Zinc as Zn (Dissolved) mg/l	0.004	0.010	0.002			0.023

Table B-4. Results of chemical analyses of surface water quality samples collected at Station U-4.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	1.4	1.9	1.5	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	420	430	232			
Temperature, Air	1					
Temperature, Water						
pH						
Oil & Grease	0.60	<0.01	1.80			
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01			
Nitrate as NO3-N mg/l	0.09	0.19	0.29			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.10	0.10	0.10			
Phosphate as PO4-P Total mg/l	0.065	0.140	0.130			
Phosphate as PO4-P Ortho mg/l	0.050	<0.001	0.120			
Sulfate as SO4 mg/l	45.0	18.0	30.0			
Sulfide mg/l						
Total Suspended Solids mg/l	9.0	5.0	3.0			
Total Dissolved Solids mg/l	266	240	240			
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01			
Bicarbonate as HCO3 mg/l	284.88	263.52	248.88			
Alkalinity as CaCO3 (Total) mg/l	204	216	204			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	8.0	26.0	12.0			
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001			
Barium as Ba (Total) mg/l	0.450	0.044	0.046			
Boron as B (Total) mg/l	0.010	0.050	0.065			
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001			
Calcium as Ca mg/l	67.20	71.20	69.60			
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001			
Copper as Cu (Total) mg/l	0.001	0.016	0.008			
Iron as Fe (Total) mg/l	0.159	0.960	0.160			
Lead as Pb (Total) mg/l	<0.001	0.010	<0.001			
Magnesium as Mg mg/l	19.68	10.08	13.44			
Manganese as Mn (Total) mg/l	0.007	0.030	0.025			
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002			
Molybdenum as Mo (Total) mg/l	<0.001	<0.001	<0.001			
Potasssium as K mg/l	1.43	1.54	1.40			
Selenium as Se (Total) mg/l	<0.001	<0.001	0.002			
Silver as As (Total) mg/l	<0.001	<0.001	<0.001			
Sodium as Na mg/l	4.00	7.00	3.60			
Zinc as Zn (Total) mg/l	0.012	0.038	0.007			
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.400	0.030	0.025			
Boron as B (Dissolved) mg/l	0.008	0.060	0.050			
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001			
Chloride as Cl (Dissolved) mg/l	4.1	3.5	0.34			
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001			
Copper as Cu (Dissolved) mg/l	<0.001	<0.010	<0.001			
Fluoride as F (Dissolved) mg/l	0.13	0.12	0.09			
Iron as Fe (Dissolved) mg/l	0.045	0.880	0.040			
Lead as Pb (Dissolved) mg/l	<0.001	0.008	<0.001			
Manganese as Mn (Dissolved) mg/l			0.020			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001			
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001			
Zinc as Zn (Dissolved) mg/l	0.006	0.030	0.007			

Table B-4. (Continued)

Date	4-22-81
Flow, cfs	
Specific Conductance, umhos/cm	320
Temperature, Air	
Temperature, Water	7
pH	8.40
Oil & Grease	
Ammonia as NH3-N mg/l	<0.01
Nitrate as NO3-N mg/l	0.43
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	0.085
Phosphate as PO4-P Ortho mg/l	0.070
Sulfate as SO4 mg/l	14.0
Sulfide mg/l	
Total Suspended Solids mg/l	55.0
Total Dissolved Solids mg/l	168
Total Combustible Solids	
Carbonate as CO3 mg/l	7.20
Bicarbonate as HCO3 mg/l	153.72
Alkalinity as CaCO3 (Total) mg/l	138
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	<0.01
Arsenic as As (Total) mg/l	<0.001
Barium as Ba (Total) mg/l	0.015
Boron as B (Total) mg/l	0.014
Cadmium as Cd (Total) mg/l	<0.001
Calcium as Ca mg/l	55.20
Chromium as Cr (Total) mg/l	<0.001
Copper as Cu (Total) mg/l	0.010
Iron as Fe (Total) mg/l	0.400
Lead as Pb (Total) mg/l	0.002
Magnesium as Mg mg/l	5.28
Manganese as Mn (Total) mg/l	0.020
Mercury as Hg (Total) mg/l	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001
Potasssium as K mg/l	1.18
Selenium as Se (Total) mg/l	0.002
Silver as As (Total) mg/l	<0.001
Sodium as Na mg/l	3.00
Zinc as Zn (Total) mg/l	0.010
Arsenic as As (Dissolved) mg/l	<0.001
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	0.011
Boron as B (Dissolved) mg/l	0.010
Cadmium as Cd (Dissolved) mg/l	<0.001
Chloride as Cl (Dissolved) mg/l	
Chromium as Cr (Dissolved) mg/l	<0.001
Copper as Cu (Dissolved) mg/l	<0.001
Fluoride as F (Dissolved) mg/l	
Iron as Fe (Dissolved) mg/l	0.020
Lead as Pb (Dissolved) mg/l	<0.001
Manganese as Mn (Dissolved) mg/l	<0.001
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	<0.001
Silver as As (Dissolved) mg/l	<0.001
Zinc as Zn (Dissolved) mg/l	0.002

Table B-5. Results of chemical analyses of surface water quality samples collected at Station U-5.

Date	10-22-80	11-12-80	12-12-80	1-28-81	2-11-81	3-11-81	4-8-81
Flow, cfs	0.8	0.9	1.0	1.0	1.1	1	1
Specific Conductance, umhos/cm	470	440	450	255	490	289	298
Temperature, Air	8	6	7	-2	4	6	4
Temperature, Water	4	6	2	3	4	5	6
pH	7.6	7.1	7.5	7.4	7.8	8.0	7.6
Oil & Grease	0.20	0.80	2.00	0.40	<0.01	1.50	0.60
Ammonia as NH3-N mg/l	<0.01	<0.01	0.10	<0.01	<0.01	<0.01	0.10
Nitrate as NO3-N mg/l	<0.01	0.003	0.04	<0.01	<0.01	0.02	1.29
Nitrite as No2-N mg/l							
Nitrogen as KJELDAHL (Total) mg/l	0.08	0.10	0.20	0.10	0.04	<0.01	0.12
Phosphate as PO4-P Total mg/l	0.070	0.160	0.040	0.060	0.020	0.050	0.340
Phosphate as PO4-P Ortho mg/l	0.020	0.020	0.032	0.015	<0.001	0.040	<0.001
Sulfate as SO4 mg/l	15.0	9.0	21.0	17.0	23.0	17.0	34.0
Sulfide mg/l							
Total Suspended Solids mg/l	9.0	29.0	27.0	1.0	1.0	8.0	248
Total Dissolved Solids mg/l	295	290	290	300	320	280	290
Total Combustible Solids							
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01	<0.01	4.80	<0.01	<0.01
Bicarbonate as HCO3 mg/l	317.20	334.28	336.72	331.84	331.84	350.00	287.92
Alkalinity as CaCO3 (Total) mg/l	260	274	276	272	280	250	236
Total Hardness as CaCO3 mg/l							
Acidity as CaCO3 mg/l	8.0	18.0	14.0	20.0	4.0	4.0	18.0
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Barium as Ba (Total) mg/l	0.114	0.070	0.110	0.120	0.110	0.150	0.130
Boron as B (Total) mg/l	0.014	0.100	0.095	0.050	0.035	0.035	0.046
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Calcium as Ca mg/l	76.0	70.40	66.40	78.40	80.00	76.80	77.60
Chromium as Cr (Total) mg/l	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001
Copper as Cu (Total) mg/l	<0.001	0.010	0.012	0.010	0.010	0.010	0.030
Iron as Fe (Total) mg/l	0.210	0.150	0.390	0.220	0.190	0.190	0.230
Lead as Pb (Total) mg/l	<0.001	0.010	0.007	0.013	0.003	0.005	0.011
Magnesium as Mg mg/l	10.08	16.80	26.40	21.12	24.00	18.24	18.24
Manganese as Mn (Total) mg/l	0.010	0.045	0.012	0.030	0.030	0.020	0.036
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001	0.014	<0.001	<0.001	<0.001	<0.001	<0.001
Potasssium as K mg/l	2.24	2.33	2.50	2.32	2.48	2.30	2.35
Selenium as Se (Total) mg/l	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001
Silver as As (Total) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium as Na mg/l	22.50	19.00	10.20	8.60	11.50	8.40	7.90
Zinc as Zn (Total) mg/l	0.010	0.020	0.014	0.015	0.006	0.010	0.016
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aluminum as Al (Dissolved) mg/l							
Barium as Ba (Dissolved) mg/l	0.100	0.036	0.095	0.100	0.095	0.100	0.050
Boron as B (Dissolved) mg/l	0.005	0.025	0.080	0.030	0.030	0.030	0.046
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride as Cl (Dissolved) mg/l	7.9	8.34	2.56	8.81	13.80	12.76	10.00
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper as Cu (Dissolved) mg/l	<0.001	0.003	0.010	<0.001	<0.001	<0.001	<0.001
Fluoride as F (Dissolved) mg/l	0.21	0.19	0.24	0.24	0.32	0.23	0.20
Iron as Fe (Dissolved) mg/l	0.063	0.830	0.060	0.160	0.040	0.040	0.150
Lead as Pb (Dissolved) mg/l	<0.001	0.007	0.003	0.002	0.003	<0.001	0.002
Manganese as Mn (Dissolved) mg/l						0.020	0.024
Mercury as Hg (Dissolved) mg/l						<0.0002	
Molybdenium as Mo (Dissolved) mg/l						< 0.001	
Nickel as Ni (Dissolved) mg/l						< 0.001	
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc as Zn (Dissolved) mg/l	0.003	0.013	0.013	0.003	0.006	0.005	0.005

Table B-6. Results of chemical analyses of surface water quality samples collected at Station U-6.

Date	11-12-80	12-12-80	1-28-81	2-11-81	3-11-81	4-8-81
Flow, cfs	8	6	13.4		4.2	6.6
Specific Conductance, umhos/cm	500	500	215		271	316
Temperature, Air			3		2	5
Temperature, Water			1		2	7
pH	7.3	7.6	7.7		8.3	7.4
Oil & Grease	<0.01	1.80	1.60		4.30	0.40
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Nitrate as NO3-N mg/l	0.06	0.11	0.08		0.07	<0.01
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.11	0.16	0.05		<0.01	0.15
Phosphate as PO4-P Total mg/l	0.150	0.050	0.190		0.180	0.220
Phosphate as PO4-P Ortho mg/l	0.020	0.020	0.160		0.160	<0.001
Sulfate as SO4 mg/l	63.0	40.0	41.0		59.0	60.0
Sulfide mg/l						
Total Suspended Solids mg/l	16.0	10.0	3.0		10.0	137.00
Total Dissolved Solids mg/l	330	325	316		350	320
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Bicarbonate as HCO3 mg/l	295.24	346.48	312.32		319.64	283.04
Alkalinity as CaCO3 (Total) mg/l	242	284	256		262	232
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	18.0	10.0	16.0		<0.1	24.00
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Barium as Ba (Total) mg/l	0.045	0.076	0.110		0.050	0.110
Boron as B (Total) mg/l	0.080	0.115	0.048		0.060	0.110
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Calcium as Ca mg/l	76.00	68.80	80.00		81.60	76.80
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Total) mg/l	0.005	0.011	0.003		<0.001	0.031
Iron as Fe (Total) mg/l	0.210	0.290	0.210		0.350	0.310
Lead as Pb (Total) mg/l	0.006	0.019	0.005		0.004	0.011
Magnesium as Mg mg/l	18.24	34.56	24.00		28.64	25.44
Manganese as Mn (Total) mg/l	0.050	0.008	0.040		0.050	0.011
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Potasssium as K mg/l	4.03	2.35	2.47		2.50	2.50
Selenium as Se (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.002
Silver as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Sodium as Na mg/l	22.50	6.50	5.70		9.20	10.40
Zinc as Zn (Total) mg/l	0.015	0.010	0.015		0.010	0.005
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.040	0.045	0.045		0.045	0.060
Boron as B (Dissolved) mg/l	0.035	0.010	0.035		0.040	0.060
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Chloride as Cl (Dissolved) mg/l	5.53	2.04	7.95		12.76	16.00
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Dissolved) mg/l	0.002	0.010	<0.001		<0.001	<0.001
Fluoride as F (Dissolved) mg/l	0.14	0.16	0.18		0.18	0.14
Iron as Fe (Dissolved) mg/l	0.050	0.020	0.200		0.150	0.250
Lead as Pb (Dissolved) mg/l	<0.001	<0.001	<0.005		<0.001	<0.001
Manganese as Mn (Dissolved) mg/l					0.040	0.004
Mercury as Hg (Dissolved) mg/l					<0.0002	
Molybdenium as Mo (Dissolved) mg/l					<0.001	
Nickel as Ni (Dissolved) mg/l					0.001	
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Zinc as Zn (Dissolved) mg/l	0.007	0.005	0.008		0.003	0.002

Table B-7. Results of chemical analyses of surface water quality samples collected at Station U-7.

Date	11-12-80	12-12-80	1-28-81	2-11-81	3-11-81	4-8-81
Flow, cfs	10.7	6.8				
Specific Conductance, umhos/cm	440	450	280		285	352
Temperature, Air	6	7	0		4	6
Temperature, Water	5	0			2	6
pH	7.4	7.4	7.8		8.0	7.9
Oil & Grease	0.40	4.40	0.40		10.40	0.40
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Nitrate as NO3-N mg/l	0.10	0.10	0.08		0.05	0.04
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.05	0.20	0.10		<0.01	0.11
Phosphate as PO4-P Total mg/l	0.120	0.040	0.040		0.150	0.220
Phosphate as PO4-P Ortho mg/l	0.020	0.015	0.020		0.080	0.001
Sulfate as SO4 mg/l	42.0	18.0	33.0		33.0	40.0
Sulfide mg/l						
Total Suspended Solids mg/l	9.0	7.0	14.0		7.0	28.0
Total Dissolved Solids mg/l	282	293	335		295	312
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Bicarbonate as HCO3 mg/l	283.04	346.48	353.80		295.24	292.80
Alkalinity as CaCO3 (Total) mg/l	232	284	290		242	240
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	16.0	14.0	10.0		6.0	8.0
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Barium as Ba (Total) mg/l	0.040	0.080	0.050		0.050	0.065
Boron as B (Total) mg/l	0.120	0.078	0.044		0.050	0.050
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Calcium as Ca mg/l	61.60	64.80	78.40		73.60	76.80
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Total) mg/l	0.005	0.015	0.003		<0.001	0.010
Iron as Fe (Total) mg/l	0.390	0.360	0.350		0.110	0.370
Lead as Pb (Total) mg/l	<0.001	0.017	0.004		0.003	0.003
Magnesium as Mg mg/l	25.44	30.24	24.00		23.52	23.52
Manganese as Mn (Total) mg/l	0.045	0.005	0.040		0.050	0.050
Mercury as Hg (Total) mg/l	0.0002	0.0002	0.0002		0.0002	0.0002
Molybdenum as Mo (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Potasssium as K mg/l	2.39	2.40	2.38		2.35	2.20
Selenium as Se (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Silver as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Sodium as Na mg/l	8.00	6.80	15.00		7.50	9.40
Zinc as Zn (Total) mg/l	0.005	0.010	0.015		0.017	0.012
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.035	0.050	0.050		0.050	0.050
Boron as B (Dissolved) mg/l	0.050	0.075	0.035		0.035	0.030
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Chloride as Cl (Dissolved) mg/l	5.56	1.66	7.33		14.89	18.00
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Dissolved) mg/l	<0.001	0.010	<0.001		<0.001	0.010
Fluoride as F (Dissolved) mg/l	0.11	0.18	0.20		0.18	0.16
Iron as Fe (Dissolved) mg/l	0.010	0.030	0.050		0.020	0.100
Lead as Pb (Dissolved) mg/l	<0.001	<0.001	<0.001		0.001	<0.001
Manganese as Mn (Dissolved) mg/l					0.040	0.040
Mercury as Hg (Dissolved) mg/l					<0.0002	
Molybdenium as Mo (Dissolved) mg/l					< 0.001	
Nickel as Ni (Dissolved) mg/l					< 0.001	
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Zinc as Zn (Dissolved) mg/l	0.001	0.005	0.007		0.007	0.010

Table B-8. Results of chemical analyses of surface water quality samples collected at Station U-8.

Date	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	2		Inaccessible	Inaccessible	Inaccessible	
Specific Conductance, umhos/cm	440	252				340
Temperature, Air		0				
Temperature, Water		0				6
pH	7.6	7.4				8.3
Oil & Grease	< 0.01	< 0.10				
Ammonia as NH3-N mg/l	< 0.01	< 0.01				< 0.01
Nitrate as NO3-N mg/l	0.15	0.26				0.41
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.15	0.14				
Phosphate as PO4-P Total mg/l	0.160	0.140				0.070
Phosphate as PO4-P Ortho mg/l	<0.001	0.040				0.040
Sulfate as SO4 mg/l	49.0	44.0				9.0
Sulfide mg/l						
Total Suspended Solids mg/l	15.0	2.0				24.0
Total Dissolved Solids mg/l	270	292				185
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	< 0.01				2.40
Bicarbonate as HCO3 mg/l	253.76	295.24				195.20
Alkalinity as CaCO3 (Total) mg/l	208	242				164
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	22.0	8.0				< 0.01
Arsenic as As (Total) mg/l	< 0.001	< 0.001				< 0.001
Barium as Ba (Total) mg/l	0.030	0.035				0.020
Boron as B (Total) mg/l	0.044	0.085				0.025
Cadmium as Cd (Total) mg/l	< 0.001	< 0.001				< 0.001
Calcium as Ca mg/l	74.40	82.40				56.00
Chromium as Cr (Total) mg/l	< 0.001	< 0.001				< 0.001
Copper as Cu (Total) mg/l	0.010	0.010				0.010
Iron as Fe (Total) mg/l	1.120	0.280				0.360
Lead as Pb (Total) mg/l	< 0.001	< 0.001				< 0.001
Magnesium as Mg mg/l	17.28	17.28				8.64
Manganese as Mn (Total) mg/l	0.090	0.040				0.020
Mercury as Hg (Total) mg/l	< 0.0002	< 0.0002				< 0.0002
Molybdenum as Mo (Total) mg/l	< 0.001	< 0.001				< 0.001
Potasssium as K mg/l	1.57	1.95				1.30
Selenium as Se (Total) mg/l	< 0.001	0.003				0.002
Silver as As (Total) mg/l	< 0.001	< 0.001				< 0.001
Sodium as Na mg/l	4.00	5.80				3.50
Zinc as Zn (Total) mg/l	0.020	0.010				0.010
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.020	0.025				0.018
Boron as B (Dissolved) mg/l	0.030	0.065				0.020
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Chloride as Cl (Dissolved) mg/l	4.2	0.50				
Chromium as Cr (Dissolved) mg/l	0.001	0.001				< 0.001
Copper as Cu (Dissolved) mg/l	< 0.001	0.010				< 0.001
Fluoride as F (Dissolved) mg/l	12.0	0.10				
Iron as Fe (Dissolved) mg/l	0.050	0.040				0.160
Lead as Pb (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Manganese as Mn (Dissolved) mg/l		0.040				0.020
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Silver as As (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Zinc as Zn (Dissolved) mg/l	0.010	0.010				0.005

Table B-9. Results of chemical analyses of ground water quality samples collected at Station U1-1.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.02	0.01		Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	990	520				
Temperature, Air	6	8				
Temperature, Water	5					
pH	7.2	6.9				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	12.0	13.5				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	651	312				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	756.40	346.48				
Alkalinity as CaCO3 (Total) mg/l	620					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	88.0	80.0				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	19.20	24.00				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potasssium as K mg/l	1.36	1.30				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	150	3.00				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l						
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l	0.21					
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-10. Results of chemical analyses of ground water quality samples collected at Station U1-2.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.002	0.002	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1800	680				
Temperature, Air	6	8				
Temperature, Water	4	3				
pH	7.2	7.1				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	15.0	15.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	1180	328				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	136.64	380.64				
Alkalinity as CaCO3 (Total) mg/l	1120					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	84.0	84.0				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	21.60	26.40				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potasssium as K mg/l	1.45	1.25				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	380	4.20				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	5.1	4.7				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l		0.21				
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-11. Results of chemical analyses of ground water quality samples collected at Station U1-3.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.004	0.002	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1320	600				
Temperature, Air	6	8				
Temperature, Water	6	5				
pH	7.3	7.2				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	15.0	15.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	860	290				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	988.20	326.96				
Alkalinity as CaCO3 (Total) mg/l	810					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	84.0	76.00				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	21.60	21.60				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potasssium as K mg/l	1.19	1.11				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	240	4.40				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	5.1	4.7				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l		0.21				
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-12. Results of chemical analyses of ground water quality samples collected at Station U1-4.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.007	0.004	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1450	540				
Temperature, Air		8				
Temperature, Water		5				
pH						
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	12.0	12.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	944	310				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	1098	361.12				
Alkalinity as CaCO3 (Total) mg/l	900					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	84.00	76.00				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	26.40	21.60				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potasssium as K mg/l	1.82	1.73				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	270	4.40				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	3.8	2.7				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l		0.18				
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-13. Results of chemical analyses of ground water quality samples collected at Station U1-5.

Date	10-22-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.03	0.02	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	550	510				
Temperature, Air	4	12				
Temperature, Water	4	5				
pH	7.3	7.2				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	51.0	36.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	368	340				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	353.80	375.76				
Alkalinity as CaCO3 (Total) mg/l	290	308				
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	96.0	72.0				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	14.40	31.20				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potasssium as K mg/l	2.80	2.92				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	19.00	15.00				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	3.9	4.17				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l						
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-14. Results of chemical analyses of ground water quality samples collected at Station U1-6.

Date	10-23-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.03	0.02	0.01	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	600	600	382			
Temperature, Air	4	10	1			
Temperature, Water	5	5	4			
pH	7.2	7.2	7.0			
Oil & Grease			< 0.10			
Ammonia as NH3-N mg/l			< 0.01			
Nitrate as NO3-N mg/l			0.20			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l			0.13			
Phosphate as PO4-P Total mg/l			0.100			
Phosphate as PO4-P Ortho mg/l			0.020			
Sulfate as SO4 mg/l	51.0	37.5	179			
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	390	390	470			
Total Combustible Solids						
Carbonate as CO3 mg/l			< 0.01			
Bicarbonate as HCO3 mg/l	414.80	427.00	287.92			
Alkalinity as CaCO3 (Total) mg/l	340	350	236			
Total Hardness as CaCO3 mg/l			28.0			
Acidity as CaCO3 mg/l			< 0.001			
Arsenic as As (Total) mg/l			0.048			
Barium as Ba (Total) mg/l			0.100			
Boron as B (Total) mg/l			< 0.001			
Cadmium as Cd (Total) mg/l	88.0	95.20	112			
Calcium as Ca mg/l			< 0.001			
Chromium as Cr (Total) mg/l			0.011			
Copper as Cu (Total) mg/l			0.330			
Iron as Fe (Total) mg/l			0.002			
Lead as Pb (Total) mg/l	38.40	29.28	32.64			
Magnesium as Mg mg/l			0.010			
Manganese as Mn (Total) mg/l			< 0.0002			
Mercury as Hg (Total) mg/l			< 0.001			
Molybdenum as Mo (Total) mg/l						
Potasssium as K mg/l	2.81	2.60	2.74			
Selenium as Se (Total) mg/l			0.003			
Silver as As (Total) mg/l			< 0.001			
Sodium as Na mg/l	7.00	14.00	4.90			
Zinc as Zn (Total) mg/l			0.007			
Arsenic as As (Dissolved) mg/l			< 0.001			
Aluminum as Al (Dissolved) mg/l			0.033			
Barium as Ba (Dissolved) mg/l			0.065			
Boron as B (Dissolved) mg/l			< 0.001			
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l			< 0.001			
Chromium as Cr (Dissolved) mg/l			0.010			
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l			0.260			
Iron as Fe (Dissolved) mg/l			< 0.001			
Lead as Pb (Dissolved) mg/l			0.005			
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			< 0.001			
Silver as As (Dissolved) mg/l			< 0.001			
Zinc as Zn (Dissolved) mg/l			0.005			

Table B-14. (Continued)

Date	4-22-81
Flow, cfs	Inaccessible
Specific Conductance, umhos/cm	
Temperature, Air	
Temperature, Water	
pH	
Oil & Grease	
Ammonia as NH3-N mg/l	
Nitrate as NO3-N mg/l	
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	
Phosphate as PO4-P Ortho mg/l	
Sulfate as SO4 mg/l	
Sulfide mg/l	
Total Suspended Solids mg/l	
Total Dissolved Solids mg/l	
Total Combustible Solids	
Carbonate as CO3 mg/l	
Bicarbonate as HCO3 mg/l	
Alkalinity as CaCO3 (Total) mg/l	
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	
Arsenic as As (Total) mg/l	
Barium as Ba (Total) mg/l	
Boron as B (Total) mg/l	
Cadmium as Cd (Total) mg/l	
Calcium as Ca mg/l	
Chromium as Cr (Total) mg/l	
Copper as Cu (Total) mg/l	
Iron as Fe (Total) mg/l	
Lead as Pb (Total) mg/l	
Magnesium as Mg mg/l	
Manganese as Mn (Total) mg/l	
Mercury as Hg (Total) mg/l	
Molybdenum as Mo (Total) mg/l	
Potasssium as K mg/l	
Selenium as Se (Total) mg/l	
Silver as As (Total) mg/l	
Sodium as Na mg/l	
Zinc as Zn (Total) mg/l	
Arsenic as As (Dissolved) mg/l	
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	
Boron as B (Dissolved) mg/l	
Cadmium as Cd (Dissolved) mg/l	
Chloride as Cl (Dissolved) mg/l	
Chromium as Cr (Dissolved) mg/l	
Copper as Cu (Dissolved) mg/l	
Fluoride as F (Dissolved) mg/l	
Iron as Fe (Dissolved) mg/l	
Lead as Pb (Dissolved) mg/l	
Manganese as Mn (Dissolved) mg/l	
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	
Silver as As (Dissolved) mg/l	
Zinc as Zn (Dissolved) mg/l	

Table B-15. Results of chemical analyses of ground water quality samples collected at Station U2-1.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.002	0.01	0.004	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1100	830	452			
Temperature, Air	5	7	5			
Temperature, Water	7	7	6			
pH	7.5	7.4	7.4			
Oil & Grease			2.60			
Ammonia as NH3-N mg/l			< 0.01			
Nitrate as NO3-N mg/l			0.02			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l			0.15			
Phosphate as PO4-P Total mg/l			0.210			
Phosphate as PO4-P Ortho mg/l			0.170			
Sulfate as SO4 mg/l	48.0	51.0	50.0			
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	718	460	420			
Total Combustible Solids						
Carbonate as CO3 mg/l			< 0.01			
Bicarbonate as HCO3 mg/l	719.20	414.80	378.00			
Alkalinity as CaCO3 (Total) mg/l	590	340	310			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l			16.0			
Arsenic as As (Total) mg/l			<0.001			
Barium as Ba (Total) mg/l			0.050			
Boron as B (Total) mg/l			0.090			
Cadmium as Cd (Total) mg/l			<0.001			
Calcium as Ca mg/l	116	116	108			
Chromium as Cr (Total) mg/l			<0.001			
Copper as Cu (Total) mg/l			<0.001			
Iron as Fe (Total) mg/l			1.130			
Lead as Pb (Total) mg/l			<0.001			
Magnesium as Mg mg/l	26.40	28.80	23.28			
Manganese as Mn (Total) mg/l			0.125			
Mercury as Hg (Total) mg/l			<0.0002			
Molybdenum as Mo (Total) mg/l			< 0.001			
Potasssium as K mg/l	2.89	2.73	2.36			
Selenium as Se (Total) mg/l			0.005			
Silver as As (Total) mg/l			<0.001			
Sodium as Na mg/l	130	18.0	16.30			
Zinc as Zn (Total) mg/l			0.008			
Arsenic as As (Dissolved) mg/l			<0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l			0.030			
Boron as B (Dissolved) mg/l			0.080			
Cadmium as Cd (Dissolved) mg/l			<0.001			
Chloride as Cl (Dissolved) mg/l	34.1	39.7	26.0			
Chromium as Cr (Dissolved) mg/l			<0.001			
Copper as Cu (Dissolved) mg/l			<0.001			
Fluoride as F (Dissolved) mg/l			0.21			
Iron as Fe (Dissolved) mg/l			0.334			
Lead as Pb (Dissolved) mg/l			<0.001			
Manganese as Mn (Dissolved) mg/l			0.005			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			0.003			
Silver as As (Dissolved) mg/l			< 0.001			
Zinc as Zn (Dissolved) mg/l			0.002			

Table B-15. (Continued)

Date	4-22-81
Flow, cfs	0
Specific Conductance, umhos/cm	
Temperature, Air	
Temperature, Water	
pH	
Oil & Grease	
Ammonia as NH3-N mg/l	
Nitrate as NO3-N mg/l	
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	
Phosphate as PO4-P Ortho mg/l	
Sulfate as SO4 mg/l	
Sulfide mg/l	
Total Suspended Solids mg/l	
Total Dissolved Solids mg/l	
Total Combustible Solids	
Carbonate as CO3 mg/l	
Bicarbonate as HCO3 mg/l	
Alkalinity as CaCO3 (Total) mg/l	
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	
Arsenic as As (Total) mg/l	
Barium as Ba (Total) mg/l	
Boron as B (Total) mg/l	
Cadmium as Cd (Total) mg/l	
Calcium as Ca mg/l	
Chromium as Cr (Total) mg/l	
Copper as Cu (Total) mg/l	
Iron as Fe (Total) mg/l	
Lead as Pb (Total) mg/l	
Magnesium as Mg mg/l	
Manganese as Mn (Total) mg/l	
Mercury as Hg (Total) mg/l	
Molybdenum as Mo (Total) mg/l	
Potasssium as K mg/l	
Selenium as Se (Total) mg/l	
Silver as As (Total) mg/l	
Sodium as Na mg/l	
Zinc as Zn (Total) mg/l	
Arsenic as As (Dissolved) mg/l	
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	
Boron as B (Dissolved) mg/l	
Cadmium as Cd (Dissolved) mg/l	
Chloride as Cl (Dissolved) mg/l	
Chromium as Cr (Dissolved) mg/l	
Copper as Cu (Dissolved) mg/l	
Fluoride as F (Dissolved) mg/l	
Iron as Fe (Dissolved) mg/l	
Lead as Pb (Dissolved) mg/l	
Manganese as Mn (Dissolved) mg/l	
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	
Silver as As (Dissolved) mg/l	
Zinc as Zn (Dissolved) mg/l	

Table B-16. Results of chemical analyses of ground water quality samples collected at Station U2-2.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.002	0.01	0.004	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	720	830	442			
Temperature, Air		7	11			
Temperature, Water		5	8			
pH	7.5	7.4	7.4			
Oil & Grease			1.80			
Ammonia as NH3-N mg/l			<0.01			
Nitrate as NO3-N mg/l			0.02			
Nitrite as No2-N mg/l			0.10			
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l			0.200			
Phosphate as PO4-P Ortho mg/l			0.110			
Sulfate as SO4 mg/l	130	45.0	76.0			
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	469	449	430			
Total Combustible Solids						
Carbonate as CO3 mg/l			<0.01			
Bicarbonate as HCO3 mg/l	292.80	358.52	366.00			
Alkalinity as CaCO3 (Total) mg/l	240	316	300			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l			18.0			
Arsenic as As (Total) mg/l			<0.001			
Barium as Ba (Total) mg/l			0.068			
Boron as B (Total) mg/l			0.095			
Cadmium as Cd (Total) mg/l			<0.001			
Calcium as Ca mg/l	96.00	100.00	97.60			
Chromium as Cr (Total) mg/l			<0.001			
Copper as Cu (Total) mg/l			<0.001			
Iron as Fe (Total) mg/l	0.460					
Lead as Pb (Total) mg/l			<0.001			
Magnesium as Mg mg/l	38.40	31.20	29.28			
Manganese as Mn (Total) mg/l			0.025			
Mercury as Hg (Total) mg/l			<0.0002			
Molybdenum as Mo (Total) mg/l			<0.001			
Potasssium as K mg/l	2.86	2.23	2.75			
Selenium as Se (Total) mg/l			0.004			
Silver as As (Total) mg/l			<0.001			
Sodium as Na mg/l	17.10	19.00	16.40			
Zinc as Zn (Total) mg/l			0.010			
Arsenic as As (Dissolved) mg/l			<0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l			0.030			
Boron as B (Dissolved) mg/l			0.085			
Cadmium as Cd (Dissolved) mg/l			<0.001			
Chloride as Cl (Dissolved) mg/l						
Chromium as Cr (Dissolved) mg/l			<0.001			
Copper as Cu (Dissolved) mg/l			<0.001			
Fluoride as F (Dissolved) mg/l						
Iron as Fe (Dissolved) mg/l			0.210			
Lead as Pb (Dissolved) mg/l			<0.001			
Manganese as Mn (Dissolved) mg/l			0.005			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			0.002			
Silver as As (Dissolved) mg/l			<0.001			
Zinc as Zn (Dissolved) mg/l			0.005			

Table B-16. (Continued)

Date	4-22-81
Flow, cfs	0.004
Specific Conductance, umhos/cm	740
Temperature, Air	
Temperature, Water	13
pH	8.1
Oil & Grease	
Ammonia as NH3-N mg/l	0.65
Nitrate as NO3-N mg/l	0.03
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	0.070
Phosphate as PO4-P Ortho mg/l	0.070
Sulfate as SO4 mg/l	66.0
Sulfide mg/l	
Total Suspended Solids mg/l	44.0
Total Dissolved Solids mg/l	420
Total Combustible Solids	
Carbonate as CO3 mg/l	4.80
Bicarbonate as HCO3 mg/l	322.08
Alkalinity as CaCO3 (Total) mg/l	272
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	<0.01
Arsenic as As (Total) mg/l	<0.001
Barium as Ba (Total) mg/l	0.060
Boron as B (Total) mg/l	0.058
Cadmium as Cd (Total) mg/l	<0.001
Calcium as Ca mg/l	94.40
Chromium as Cr (Total) mg/l	<0.001
Copper as Cu (Total) mg/l	0.030
Iron as Fe (Total) mg/l	3.170
Lead as Pb (Total) mg/l	0.010
Magnesium as Mg mg/l	29.76
Manganese as Mn (Total) mg/l	0.190
Mercury as Hg (Total) mg/l	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001
Potasssium as K mg/l	2.78
Selenium as Se (Total) mg/l	0.004
Silver as As (Total) mg/l	0.002
Sodium as Na mg/l	21.00
Zinc as Zn (Total) mg/l	0.050
Arsenic as As (Dissolved) mg/l	<0.001
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	0.044
Boron as B (Dissolved) mg/l	0.050
Cadmium as Cd (Dissolved) mg/l	<0.001
Chloride as Cl (Dissolved) mg/l	
Chromium as Cr (Dissolved) mg/l	<0.001
Copper as Cu (Dissolved) mg/l	0.010
Fluoride as F (Dissolved) mg/l	
Iron as Fe (Dissolved) mg/l	0.980
Lead as Pb (Dissolved) mg/l	0.002
Manganese as Mn (Dissolved) mg/l	0.180
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	0.002
Silver as As (Dissolved) mg/l	<0.001
Zinc as Zn (Dissolved) mg/l	0.020

HYDROLOGIC INVENTORY AND BASELINE STUDY OF THE UCO MINE PERMIT AND ADJACENT AREAS, CARBON COUNTY, UTAH

THE SCOFIELD MINE

Prepared for

UCO, INCORPORATED

Denver, Colorado

by

VAUGHN HANSEN ASSOCIATES

Salt Lake City, Utah

June, 1981

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2.0 GROUNDWATER HYDROLOGY

Regulations set forth by the Utah Division of Oil, Gas, and Mining (DOGM) (Utah Code Annotated 40-10 et. seq.) require that water monitoring programs be established in areas of underground coal mining to monitor the effects of mining activities and protect the hydrologic balance of such areas. Therefore, a hydrologic investigation is being conducted on the proposed UCO mine permit area. The purpose of this report is to summarize the hydrologic information now available for the UCO mine permit area. An updated report will be submitted after the baseline data collection period is completed in late 1981. The majority of the hydrology of the mine plan area is known at this time and is presented in this report. Data collected for the nearby Valley Camp and Skyline mines indicate that no major changes in the hydrologic patterns or in our recommendations presented herein are anticipated. The UCO mine permit area, located west of Scofield, Utah (see Figure 1), contains approximately 700 acres of land.

2.1 Scope

The scope of the groundwater section of this report is to describe the existing groundwater hydrologic conditions of the UCO mine permit and adjacent areas and to describe the methods that have been and will be used to predict and monitor the impacts from mining. Sections within the groundwater section of this report

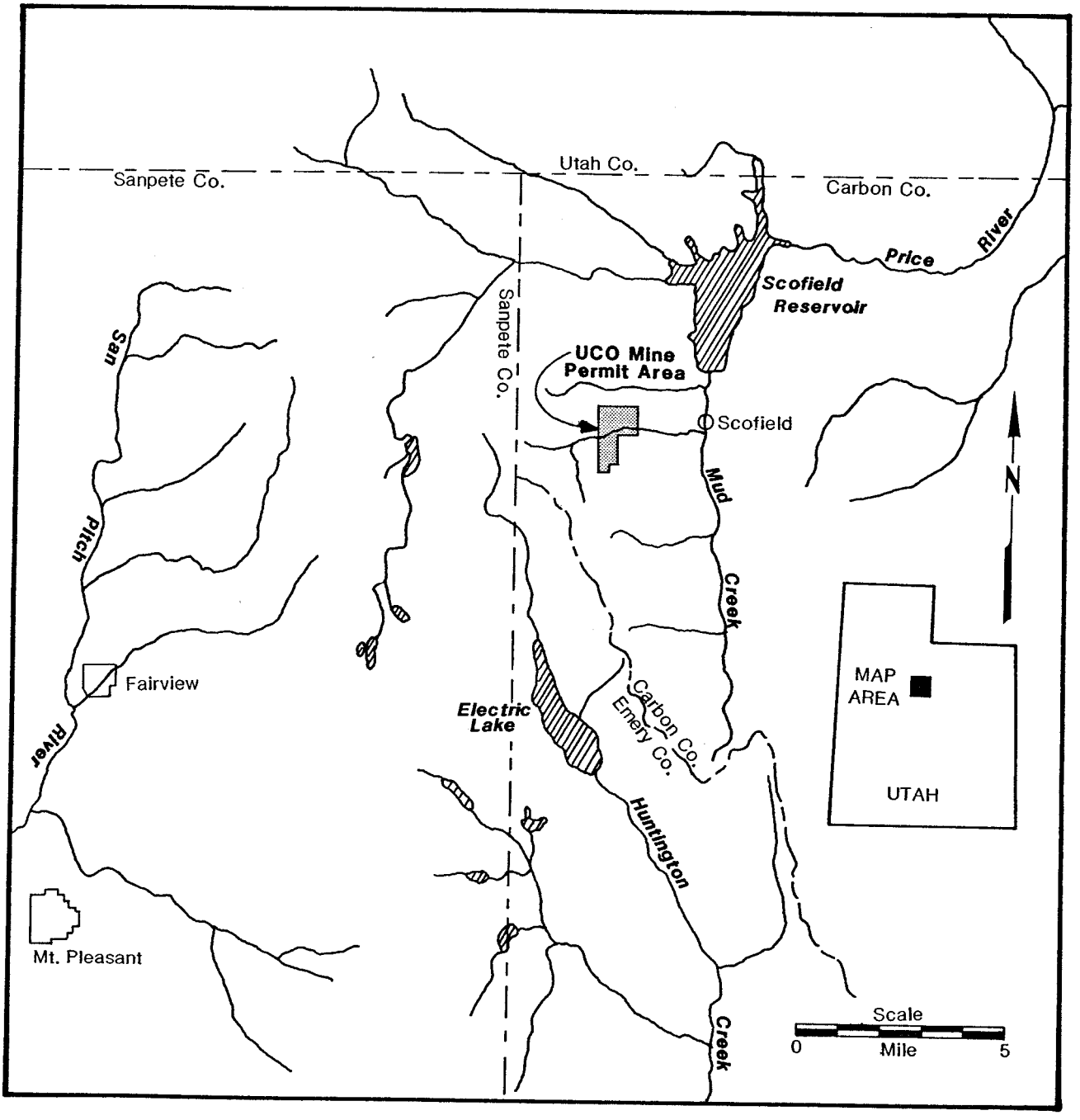

Figure 1. Location of the UCO mine permit area.

will cover the following major topics: existing groundwater resources, groundwater development and mine dewatering, effects of mining operation on the groundwater hydrologic balance, mitigation and control plans, and groundwater monitoring plans.

Information used in preparing the groundwater hydrologic section of this report has been gathered by field investigations. Pertinent literature has been examined. Water quality samples have been, and will continue to be, analyzed by a certified laboratory. Water rights were determined by examining current records of the Utah Division of Water Rights.

2.2 Existing Groundwater Resources

This section of the report deals with the groundwater resources of not only the UCO mine permit area, but also of the adjacent region. An understanding of geology as it relates to groundwater hydrology is very important, and consequently will be discussed briefly.

2.2.1 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 (1973), nearly all of the region surrounding the UCO mine permit 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 principal water-bearing strata, their ability to yield water for extended periods of time is largely controlled by the existence of the relatively impermeable interbedded shale layers, which prevent the downward movement of a significant amount of water.

Geology. The UCO mine permit area lies in the northern end of the Wasatch Plateau, on the northwest flank of the Clear Creek Anticline (Doelling, 1972). The dip of the strata is generally towards the northwest, ranging from about two to six percent (one to four degrees).

With the exception of local alluvial deposits, the only exposed unit on and immediately adjacent to the UCO mine permit area is the Cretaceous Blackhawk Formation of the Mesaverde Group (see Figure 2). The Blackhawk Formation, an interbedded formation of sandstones and shales, is Utah's chief coal producer (Stokes, 1964). The sands in this 1000-foot thick member are fine- to medium-grained and cemented by either calcite or silica with some iron discoloration. The sandstones tend to be local in extent and have locally high clay contents (Spieker, 1931; Doelling, 1972). An exception to this is the Aberdeen sandstone, a coarse-grained, light-colored sand with a thickness of 20 to 80 feet, which can be traced throughout the region (Spieker, 1931). The generally discontinuous nature of the Blackhawk sands and their apparent low specific yield (Cordova, 1964) indicate that the water yielding capabilities of the Blackhawk are only locally important.

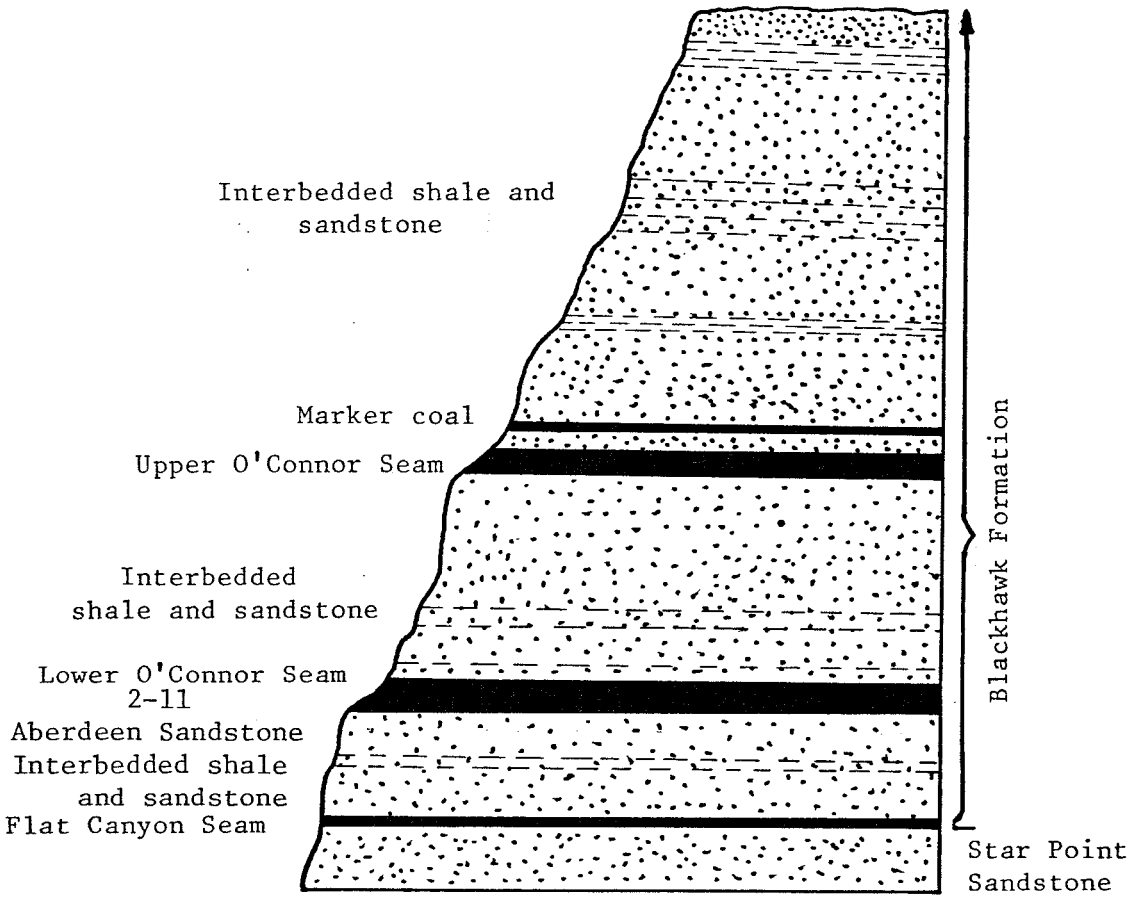

Figure 2. Generalized stratigraphic section (modified from U.S. Geological Survey, 1979).

Spieker (1931) has identified three types of shale in the Blackhawk Formation, all continental in origin---a common clay shale which is soft and granular, a carbonaceous shale, and a smoke-gray shale usually associated with the coal. As was the case with the sandstones, the shales are irregularly bedded (Spieker, 1931). The abundance of shale in the Blackhawk acts as a barrier to the downward movement of water within the formation, greatly reducing its overall vertical permeability and the amount of water which percolates through the formation to lower units. Water which reaches the Blackhawk, therefore, generally percolates downward until it meets a shale layer, which causes horizontal movement to the surface or another "drain" (i.e. sandstone finger) within the formation.

No major faults are known to exist within the UCO mine permit area. Some faulting was encountered to the east in the abandoned Winter Quarters Mine. The nearest known major faulting system is the Pleasant Valley Fault about two miles east of the mine permit area. Other identified faulting in the area has resulted in only small displacements. It is suspected that these faults have only local hydrologic importance within the Blackhawk Formation because of its high clay content, giving it an ability to seal rapidly. Tension fracturing of the members likely increases the water yielding capacity due to the creation of secondary porosity.

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.

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 amount 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.

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 in or immediately adjacent to the mine permit area could normally be expected to yield less than 10 gallons per minute. Increased yields could be expected from wells penetrating sandstones which were fractured as a result of tension.

Rocks in the mountainous areas near the mine permit area 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. Total dissolved solids (TDS) contents in groundwater range from less than 250 mg/l near the mine permit area to over 3000 mg/l near the confluence of the Price River with the Green River (Price and Waddell, 1973). This increase in the TDS concentration is the result of increased contact of water and rock as travel distance increases, with saline shales contributing the major portion of the dissolved constituents.

2.2.2 Mine Permit Area Aquifers, Seeps, and Springs

Wells have been drilled, tested, and monitored in an effort to determine aquifer characteristics in the UCO mine permit area. Seeps and springs in the area have also been identified and monitored.

Results of Aquifer Testing. In an effort to determine the aquifer characteristics within the UCO mine permit area, aquifer tests were conducted at four different wells (WQ-1, WQ-1A, WQ-6, and WQ-8 all shown on Plate 1). Initially, "slug" tests as outlined by Lohman (1972) were performed in these wells. Later, drawdown and recovery tests were conducted at wells WQ-1A and WQ-6

for comparison with the slug test results. The slug tests were conducted by rapidly injecting a quantity or "slug" of water down the well and then measuring the recovery of the water level to its original level. The data is analyzed by plotting the value of H/H_o versus time (t) on a semilog plot where H is the head inside the well at time t (in seconds) after injection of the slug above the initial head and H_o is the head inside the well above the initial head at the instant the slug is injected (see Figure 3). This plot is then superimposed over type curves presented by Lohman (1972) in which H/H_o is plotted against Tt/r^2 (T is the transmissivity in feet squared per second, r is the radius of the well or casing in feet, and H, Ho, and t are as previously defined). From the superimposed curves, a match line is selected for the value of t at

$$\frac{Tt}{r^2} = 1.0 \qquad (1)$$

The transmissivity is then determined by solving this equation for T after substituting in the match line value of t and the radius of the well (r). The resulting value of T can be converted to units of gallons per day per foot by multiplying it by a factor of 646,560. The results of the slug tests performed in the UCO wells are contained in Attachment A and summarized in Table 1. Transmissivity is a measure of the productiveness of the well. As can be seen from Table 1, the productiveness of the wells increased only slightly if at all below the coal zone. This is consistent with the experience in other drilling programs in the area which have shown that the Aberdeen Sandstone and

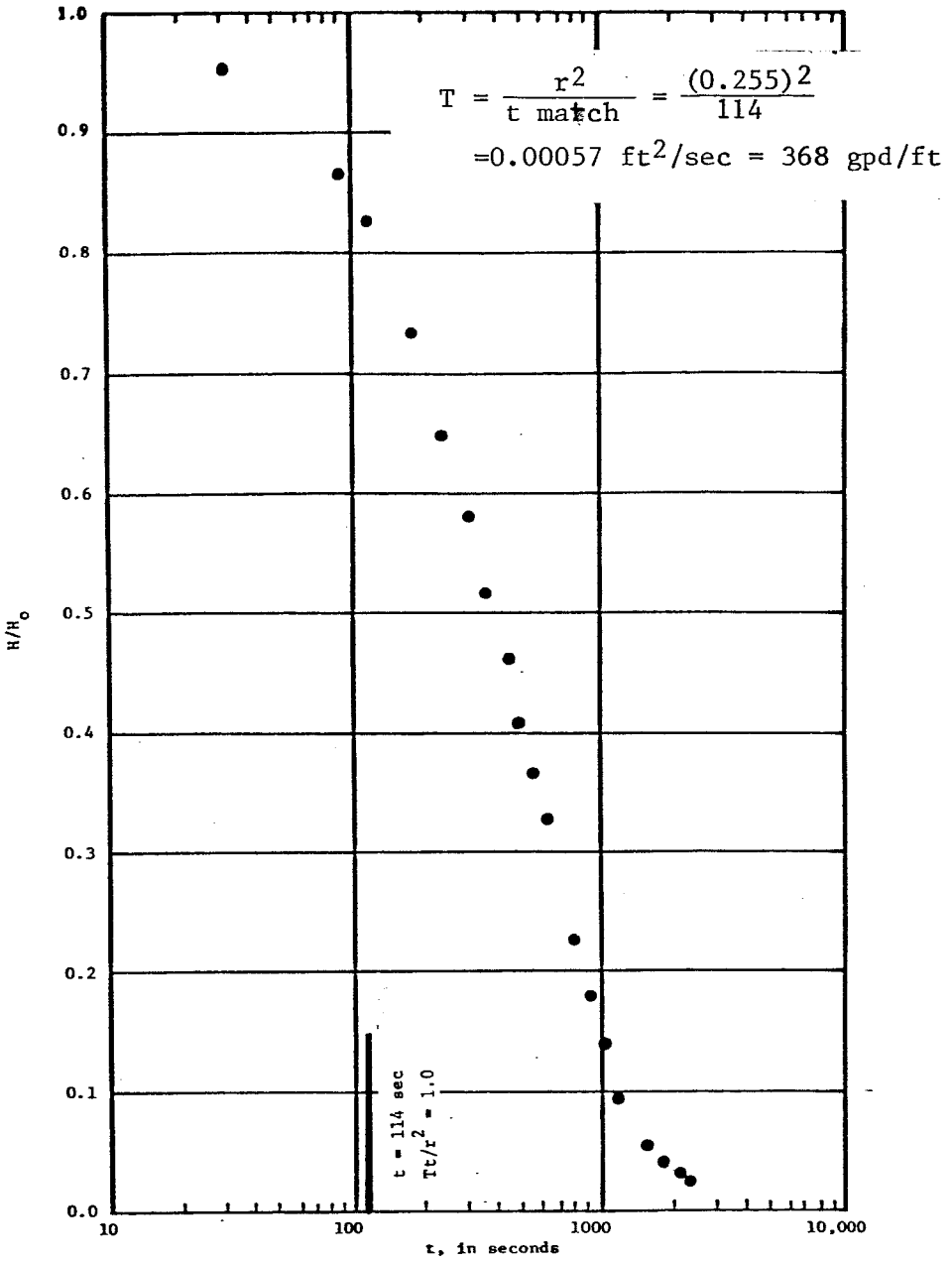

Figure 3. Graphical results of the slug test for Well WQ-8 when the hole terminated below the coal zone.

Table 1. Aquifer test results

Well	Slug Test above Coal	Slug Test at Coal Level	Slug Test below Coal	Drawdown Test	Recovery Test
*WQ-1	T = 570 gpd/ft	----	----	----	----
*WQ-1A	----	T = 420 gpd/ft	T = 310 gpd/ft	T = 135 gpd/ft	T = 280 gpd/ft
WQ-6	T = 1200 gpd/ft	T = 1830 gpd/ft	T = 1830 gpd/ft	----	----
WQ-8	T = 85 gpd/ft	T = 310 gpd/ft	T = 370 gpd/ft	----	T = 20 gpd/ft

*Well WQ-1 was abandoned at the 371 feet level because of drilling problems. Well WQ-1A was drilled about 30 feet from Well WQ-1.

Starpoint Formation which are underneath the Lower O'Connor coal seam are very impervious and produce significant amounts of water only in fracture zones.

In May of 1981, drawdown and/or recovery tests were conducted in wells WQ-1A and WQ-6 for comparison with the slug test results. Water was discharged from the well using a submersible pump. The data were analyzed over the straight-line portion of the semilog time-drawdown (or time-residual drawdown) curve using the Jacob equation (U.S. Bureau of Reclamation, 1977), which states that

$$T = \frac{2.303\ Q}{4\pi \partial s/\partial(\log\ t)} \qquad (2)$$

where T is the transmissivity, Q is the flow rate from the well during the drawdown test, s is the drawdown, and t is the time since pumping began. In the case of a recovery test, s becomes s' (the residual drawdown or difference between the measured head and the head prior to the start of pumping) and the time term becomes t/t', where t' is time since pumping ceased (U.S. Bureau of Reclamation, 1977). For a particular distance, Equation 2 is the equation of a straight-line plot of s versus log t (or s' versus log t/t'). For one log cycle, ∂ log t (or ∂ log t/t') is equal to one. With this in mind, and converting to the gallon-day-foot system of units, Equation 10 can be written as

$$T = \frac{264\ Q}{\Delta s} \qquad (3)$$

where T is the transmissivity, in gallons per day per foot; Q is the constant discharge rate, in gallons per minute; and Δs is the

drawdown difference per log cycle of time, in feet. The recovery test equation substitutes s' for s. Drawdown and recovery tests were run in Well WQ-1A. The data are plotted in Figures 4 and 5. The data are contained in Attachment A. As Table 1 shows, the estimated transmissivities from the drawdown and recovery tests are quite similar to the estimate from the slug test. The recovery test run in Well WQ-06 however, indicated that the transmissivity of the well was much less than the estimated transmissivity from the slug tests in the same well. This is expected to be a result of sloughing of the well walls around the casing through the winter period that separated the slug and recovery tests, thus sealing much or even most of the well. Consequently, the recovery test in Well WQ-06 probably only was a test of a small and quite impermeable zone in the well in the lower portion of the Blackhawk Formation. This is quite consistent with other well tests in the Blackhawk and Starpoint formations at nearby mines which show low permeabilities and transmissivities. The sloughing and sealing which apparently occurred in the Blackhawk Formation is also very consistent with other information indicating the Blackhawk has the ability to seal itself with time to significant water movement.

The quite low transmissivities and flow rates of the aquifer tests indicate that the Blackhawk Formation is, at best, a poor aquifer. The Aberdeen Sandstone below the Lower O'Connor coal seam is a very poor aquifer. The lenticular nature of the Blackhawk Formation does cause wells to have some degree of variability.

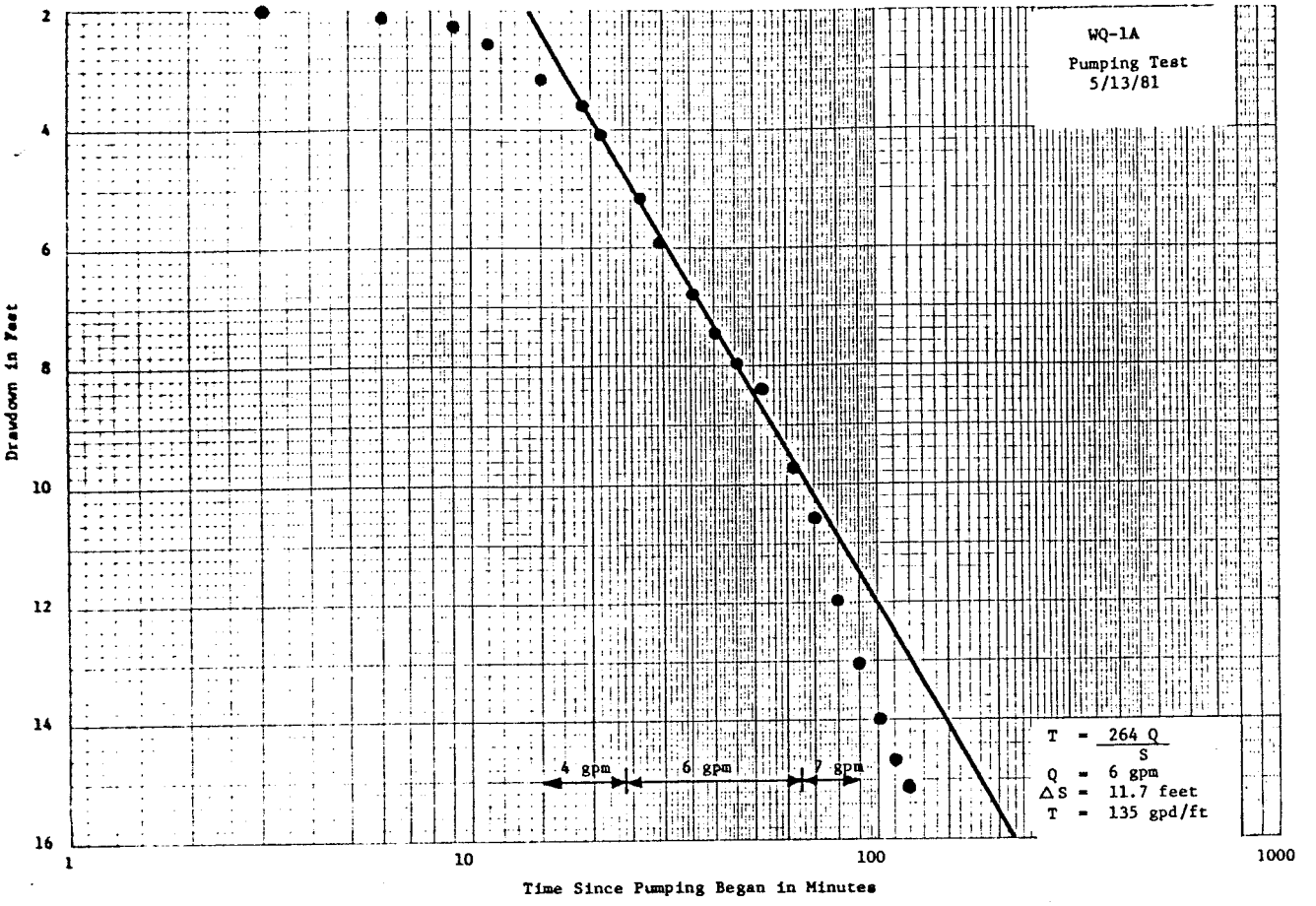

Figure 4. Graphical results of the recovery test conducted in Well WQ-1A.

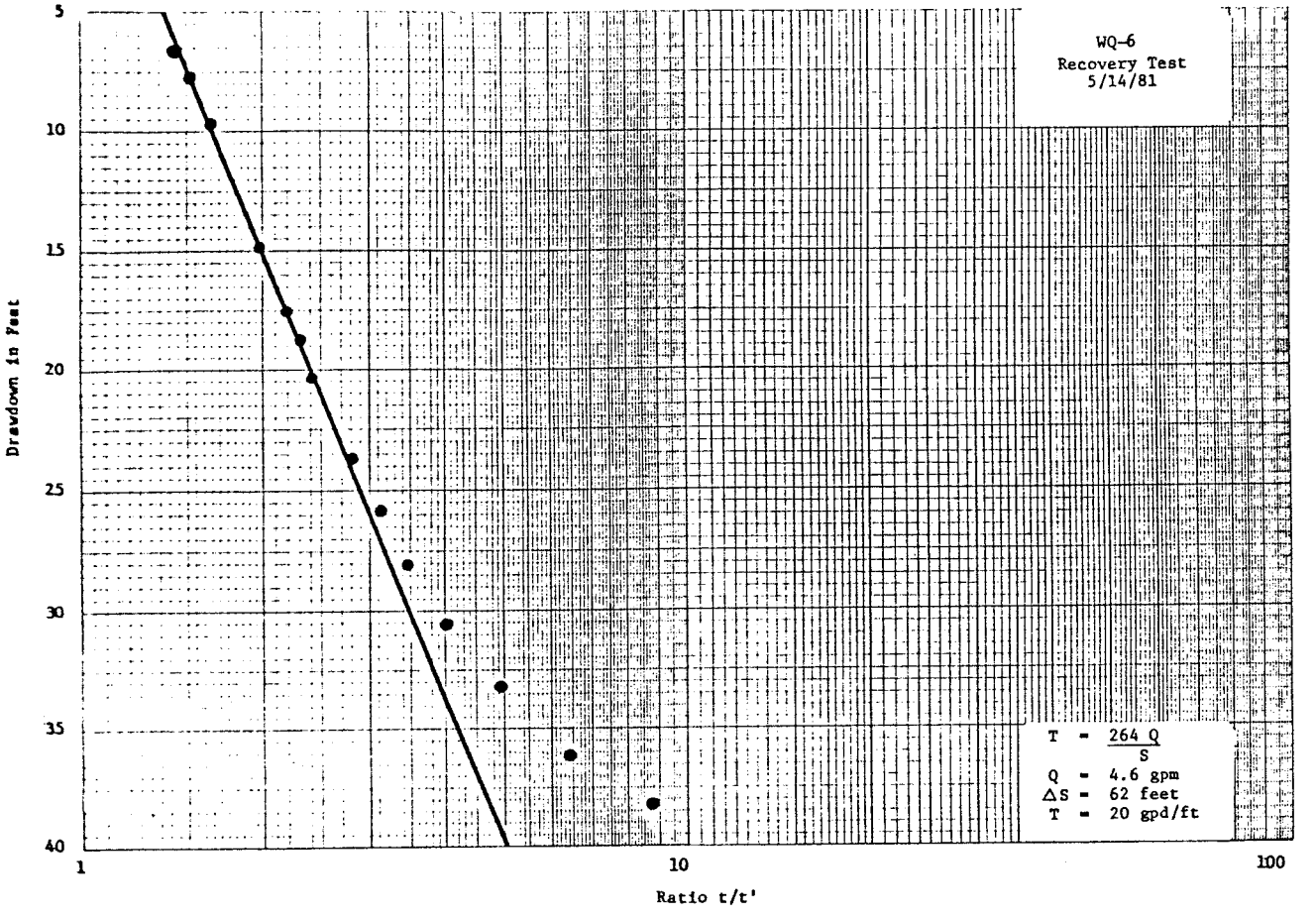

Figure 5. Graphical results of the recovery test conducted in Well WQ-6.

Characteristics of Springs and Seeps. As an index of groundwater hydrologic conditions in the mine permit area, an inventory was made of existing seeps and springs on and adjacent to the mine permit area during the fall of 1980 (i.e. the low flow season). During this time, the mine permit area was covered on foot and all seeps and springs found were noted on a map (see Plate 2).

Flows from individual springs were variable during the fall inventory. Two springs were flowing at rates greater than or equal to 10 gpm (U1-5 at 12 gpm and U1-6 at 10 gpm). Most of the springs were flowing less than three gallons per minute. Sampling of springs in the surrounding region has shown that flows from a given spring may vary by as much as an order of magnitude during the year, with the higher flows coming during the snowmelt season. All of the springs in the UCO mine permit area are located in or near canyon bottoms. Most of the springs are located on the west-facing slopes of north-south canyons. These springs are on the down-dip side of the ridges.

Groundwater Quality. Water quality samples were collected and analyzed for eight springs and four wells within and adjacent to the UCO mine permit area as an index of groundwater hydrologic conditions. The results of the chemical analyses for samples taken from wells and springs are presented in Attachment B.

Groundwater from springs and wells varied from a sodium to calcium-bicarbonate type. Cation-anion diagrams of the water samples collected from the groundwater samples are shown on Plate 1. Total dissolved solids (TDS) levels ranged from 290 to 1180 mg/l for springs, while wells ranged from 165 to 610 mg/l. The average TDS concentration from all groundwater samples collected was 451 mg/l.

Trace metal concentrations were all relatively low except for iron concentrations in the wells. All wells were cased with four inch steel pipe. The high iron concentrations in the well samples were probably caused by the iron in the steel pipe. Hydrogen ion activity as measured by pH ranged from 6.9 to 8.7 in the groundwater samples.

Water Rights. Groundwater rights in and adjacent to the UCO mine permit area on file as of February, 1981 with the Utah Division of Water Rights are listed in Table 2 and shown on Plate 3. No groundwater rights currently exist within the UCO mine permit area. Further downstream near the mouth of Winter Quarters Canyon and in Pleasant Valley Canyon, some groundwater rights have been granted. Specified uses of most of these rights are for stockwatering although some rights have been granted for irrigation and domestic uses. Table 3 lists exchanges of water rights in the area. These are also shown on Plate 3.

Table 2. Ground water rights located on and adjacent to the UCO mine permit area.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
9-200	Utah Natural Gas Company (½ interest)	Underground Water, Well	0.134	Domestic Irrigation	January 1 to December 31
91-201	Earl Thomas	Spring with storage	0.068	Stockwatering	April 15 to November 1
91-424	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-425	Nick Marakis (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-432	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-433	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-434	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-435	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-455	Robert Radakovich	Spring	0.011	Stockwatering	May 1 to December 15
91-463	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-464	John Marakis Estate (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-472	John Marakis Estate (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-473	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-474	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-475	John Marakis Estate (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-481	Robert Radakovich	Spring	0.011	Stockwatering	May 1 to December 15
91-1035	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1036	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1039	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1045	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1046	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1644	Lee Thomas (1/3 interest)	Spring	-----	Stockwatering	May 1 to October 31
91-1986	Angelo Georgedes	Spring with storage	0.05	Fish Culture	January 1 to December 31
91-2049	John Jouflas Estate (2/3 interest)	Spring	0.011	Stockwatering	May 1 to October 31

Table 2. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-2144	Elrie and Bertha Simonsen (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2145	Robert Radakovich (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2288	Elrie & Bertha Simonsen	Spring	0.011	Stockwatering	June 1 to November 30
91-2494	Elrie & Bertha Simonsen	Mooney Mine Spring	----	Irrigation Stockwatering	March 1 to November 30
91-2669	Della Simonsen	Spring	0.011	Stockwatering	April 1 to November 30
91-2970	Angelo Georgedes	Spring	0.015	Stockwatering	May 1 to October 31
91-2975	Justus O. Seely	Spring	0.011	Irrigation Stockwatering	January 1 to December 31
91-2976	Justus O. Seely	Spring	0.011	Irrigation Stockwatering	January 1 to December 31
91-3012	Angelo Georgedes	Spring	0.015	Irrigation Stockwatering	January 1 to December 31
91-3094	Scofield Town	3 Springs	0.033	Municipal	January 1 to December 31
91-3401	Waino E. Burton	Underground Water, Well	0.011	Stock & Domestic	January 1 to December 31
91-3402	Waino E. Burton	Underground Water, Well	0.011	Stock & Domestic	January 1 to December 31
91-3460	Mountain Fuel Supply Co. (½ interest)	Underground Water, Well	0.134	Domestic, Irrigation Misc.	January 1 to December 31
91-3601	Della L. Madsen	Spring	0.011	Stockwatering	June 1 to November 30
91-3634	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3638	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3668	Angelo Georgedes	Spring	0.015	Stockwatering	May 1 to October 31

Table 3. Water right exchanges near the UCO mine permit area.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-164	Louise Gorishek	Well	1.0 A.F.	Domestic	January 1 to December 31
91-452	Robert Radakovich	Well	1.0 A.F.	Stockwatering	March 1 to November 30
91-772	Valley Camp Coal Company	Well	0.446 cfs	Industrial Domestic	January 1 to December 31
91-1658	Price River Water Users Assoc.	Spring	2.0 A.F.	Domestic	January 1 to December 31

2.3 Groundwater Development and Mine Dewatering

This section of the report discusses groundwater usage in the mine plan and adjacent areas as well as the development of a water supply for the mine. The potential of mine dewatering will also be discussed.

2.3.1 Water Supply

Development of groundwater in the area has not been a common practice. Most groundwater use in the area has been confined to undeveloped springs for stockwatering purposes. Several water wells have been completed in the town of Scofield. Mining operations in surrounding canyons have drilled several water wells to provide water needed for their operation.

As indicated previously, wells in the Price River Basin generally have limited yields except where sandstones had been fractured as a result of tension. In these cases, the fractures act as conduits to convey water. Where wells have encountered these fractures, yields are larger.

Several exploration wells and a potential water supply well(s) are planned to be drilled during the summer of 1981. The locations of these sites have not been finalized. On completion of the selection process and the drilling, the results will be submitted to the Utah Division of Oil, Gas, and Mining. Water

rights owned by UCO will be transferred to the well(s) that will be used for supplying water for the mining operation.

2.3.2 Mine Dewatering

Water encountered in the mine is expected to be generally in the form of small roof leakers of usually less than five gallons per minute that dry up within a few days or weeks. It is expected that tension cracks associated with deformations will occasionally yield larger flows up to about 150 gpm. These increased flows have been encountered in other mines in the Wasatch Plateau. The water made within the mine will be used for dust suppression and fire protection within the mine. Water not used for these purposes normally will be stored in reservoirs within the mine. In the event that excess water is encountered underground, mine water will be discharged to Winter Quarters Creek under an NPDES permit.

2.4 Effects of Mining Operation on the Groundwater Hydrologic Balance

The Scofield area in the Wasatch Plateau coal field can expect mining activities to continue into the twenty-first century.

As has been noted, the occurrence and quality of water in any region is highly controlled by geology. Because the region surrounding the UCO mine permit area consists of the same geologic

formations, impacts should also be the same as those minor impacts that have occurred from mining during the past eighty or more years. Thus, it is presumed that mining activities in the Scofield area will have little adverse impact on the area hydrologic system.

2.4.1 Hydrologic Balance

Springs. The UCO mine permit area is covered entirely by the Blackhawk Formation. This formation consists of interbedded layers of sandstone and shale separated by various mineable and nonmineable coal seams. The sandstone beds are generally massive while the shale layers are bentonitic, tending to swell when wet and decompose into an impervious clay. Because of this fact, the downward percolation of water through the Blackhawk Formation is quite limited. This is why mines in the Blackhawk generally encounter only small amounts of groundwater inflow. A check of the abandoned Winter Quarters Mine, which is adjacent to the UCO mine permit area, showed that flows within the Winter Quarters Mine were generally quite low and fairly comparable to flows with other nearby mines. Exploration holes drilled for UCO show quite similar patterns of alternating layers of shales and sandstones. Consequently, it appears that the effect of mining by the UCO Mine on the groundwater will be minimal as in other nearby mines and the adjacent, abandoned Winter Quarters Mine which are also in the same Blackhawk Formation. Formations underlying the UCO mine permit area may have slightly less shale which may allow slightly more water to enter the mine than at other mines. However, this

difference, if real, is expected to be minor. Removal of water from within the mine beneath the local water table is not expected to affect the quantity or quality of flow from springs which may exist within or adjacent to the mine permit area. The water which is removed from the mine mouth, which would normally have traveled to an outlet some distance from the mine permit area, will represent only a small fraction of the water flowing from the watershed. If information obtained during the 1981 field season justifies any modifications to these conclusions, the subsequent updated report will reflect these modifications.

Subsidence. Should subsidence occur, it is felt that the quantity of water will be affected only minimally. Because of the ability of the shale material to swell and decompose into an impervious clay, fractures in the shale members do not act as conduits, but rather as barriers to potentially vertically flowing water. Thus, the quantity of water present in seeps and springs in the area should remain nearly unaffected by mining in the mine permit area. This pattern has been observed throughout the coal-mining areas in the Blackhawk Formation. A photogrammetric investigation for subsidence and subsidence related vegetative changes on the adjacent, abandoned Winter Quarters Mine was undertaken by Applied Earth Sciences of Colorado, LTD (1981). Their investigation revealed "...no unnatural breaks in the terrain". They also did not "...detect any anomalous changes in the vegetal pattern that would coincide with the occurrence of subsidence and the possible disturbance of the surface water and soil environment".

2.4.2 Quality

The mines in the coal fields of the Wasatch Plateau tend to act as interceptor drains. The groundwater that is brought to the surface has a lower dissolved solids content than would have existed if the water was to continue its downward movement through shale layers, dissolving increased amounts of salt with distance (Southeastern Utah Association of Governments, 1977; Vaughn Hansen Associates, 1979). This is shown in the generally strong calcium-bicarbonate type water and the low TDS concentrations of mine water relative to poorer quality waters from lower in the stratigraphic section.

For the reason explained above, UCO's proposed Scofield Mine may have a slightly beneficial impact on the chemical quality of water in the region, because if any water is brought to the surface and discharged into the stream channel, the TDS levels will be lower than if the water had continued to move through the shale formations (Bentley, et al., 1978). Although suspended sediment and oil and grease may increase in the mine, these constituents will be removed in keeping with regulatory requirements prior to any potential discharge into adjacent streams.

Because of the high alkalinity and low acidity concentrations in the area (differing by two orders of magnitude), acid drainage problems should not occur as a result of mining. This is

Table B-17. Results of chemical analyses of ground water quality samples collected at Well WQ-1.

Date	10-19-80	12-31-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs				Inaccessible	Inaccessible	
Specific Conductance, umhos/cm	340	295				
Temperature, Air			1			
Temperature, Water			7			
pH	8.6		8.0			8.7
Oil & Grease			1.00			
Ammonia as NH3-N mg/l			0.50			<0.01
Nitrate as NO3-N mg/l			<0.01			<0.01
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l			0.020			0.070
Phosphate as PO4-P Ortho mg/l			0.010			0.030
Sulfate as SO4 mg/l	193		58.0			90.0
Sulfide mg/l						
Total Suspended Solids mg/l						201
Total Dissolved Solids mg/l	580		300			310
Total Combustible Solids						
Carbonate as CO3 mg/l			<0.01			7.20
Bicarbonate as HCO3 mg/l	270.84		256.20			185.44
Alkalinity as CaCO3 (Total) mg/l	222		210			164
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	8.0		2.0			<0.01
Arsenic as As (Total) mg/l			<0.010			<0.001
Barium as Ba (Total) mg/l			0.050			0.005
Boron as B (Total) mg/l			0.160			0.210
Cadmium as Cd (Total) mg/l			0.001			<0.001
Calcium as Ca mg/l	13.6		33.60			17.60
Chromium as Cr (Total) mg/l			0.006			<0.001
Copper as Cu (Total) mg/l			0.015			0.050
Iron as Fe (Total) mg/l			34.00			29.000
Lead as Pb (Total) mg/l			0.134			0.025
Magnesium as Mg mg/l	1.92		19.20			16.80
Manganese as Mn (Total) mg/l	0.860		0.230			0.150
Mercury as Hg (Total) mg/l			< 0.0002			0.0002
Molybdenum as Mo (Total) mg/l			<0.001			<0.001
Potasssium as K mg/l	47.00		14.00			13.50
Selenium as Se (Total) mg/l			< 0.001			< 0.001
Silver as As (Total) mg/l			< 0.001			< 0.001
Sodium as Na mg/l	163	46.90				43.00
Zinc as Zn (Total) mg/l			0.450			0.075
Arsenic as As (Dissolved) mg/l			< 0.001			< 0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l			0.020			0.004
Boron as B (Dissolved) mg/l			0.155			0.190
Cadmium as Cd (Dissolved) mg/l			< 0.001			< 0.001
Chloride as Cl (Dissolved) mg/l	22.22		5.80			
Chromium as Cr (Dissolved) mg/l			< 0.001			< 0.001
Copper as Cu (Dissolved) mg/l			0.010			0.040
Fluoride as F (Dissolved) mg/l			0.63			
Iron as Fe (Dissolved) mg/l	0.350		0.030			25.000
Lead as Pb (Dissolved) mg/l			0.002			0.025
Manganese as Mn (Dissolved) mg/l						0.140
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			< 0.001			< 0.001
Silver as As (Dissolved) mg/l			< 0.001			< 0.001
Zinc as Zn (Dissolved) mg/l			0.012			0.070

Table B-18. Results of chemical analyses of ground water quality samples collected at Well WQ-1A.

Date	11-7-80	12-31-80	1-28-80	2-11-81	3-11-81	4-22-81
Flow, cfs				Inaccessible	Inaccessible	
Specific Conductance, umhos/cm	550	250				
Temperature, Air			No Sample			
Temperature, Water		10				
pH	7.8	7.8				8.1
Oil & Grease		2.20				
Ammonia as NH3-N mg/l		< 0.01				<0.01
Nitrate as NO3-N mg/l		< 0.01				<0.01
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l		0.300				0.180
Phosphate as PO4-P Ortho mg/l		<0.001				0.040
Sulfate as SO4 mg/l	39.0	57.0				53.0
Sulfide mg/l						
Total Suspended Solids mg/l						276
Total Dissolved Solids mg/l	340	165				185
Total Combustible Solids						
Carbonate as CO3 mg/l		<0.01				<0.01
Bicarbonate as HCO3 mg/l	322.08	85.40				107.36
Alkalinity as CaCO3 (Total) mg/l	264	70.0				88.00
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	18.0	4.0				5.00
Arsenic as As (Total) mg/l		<0.001				<0.001
Barium as Ba (Total) mg/l		0.035				0.010
Boron as B (Total) mg/l		0.050				0.065
Cadmium as Cd (Total) mg/l		<0.001				<0.001
Calcium as Ca mg/l	29.60	28.00				26.40
Chromium as Cr (Total) mg/l		<0.001				<0.001
Copper as Cu (Total) mg/l		0.170				0.030
Iron as Fe (Total) mg/l	15.800	28.700				13.900
Lead as Pb (Total) mg/l		0.072				0.019
Magnesium as Mg mg/l	13.92	10.08				12. 8
Manganese as Mn (Total) mg/l	0.250	0.305				0.140
Mercury as Hg (Total) mg/l		<0.0002				<0.0002
Molybdenum as Mo (Total) mg/l		<0.001				< 0.001
Potasssium as K mg/l	12.30	1.75				3.60
Selenium as Se (Total) mg/l		0.002				0.001
Silver as As (Total) mg/l		<0.001				<0.001
Sodium as Na mg/l	67.40	9.30				13.00
Zinc as Zn (Total) mg/l		0.045				0.085
Arsenic as As (Dissolved) mg/l		<0.001				<0.001
Aluminum as Al (Dissolved) mg/l						0.003
Barium as Ba (Dissolved) mg/l		0.015				0.050
Boron as B (Dissolved) mg/l		0.050				<0.001
Cadmium as Cd (Dissolved) mg/l		<0.001				
Chloride as Cl (Dissolved) mg/l	4.9	1.44				
Chromium as Cr (Dissolved) mg/l		<0.001				<0.001
Copper as Cu (Dissolved) mg/l		<0.001				0.030
Fluoride as F (Dissolved) mg/l		0.09				
Iron as Fe (Dissolved) mg/l	12.400	0.285				10.700
Lead as Pb (Dissolved) mg/l		<0.001				0.016
Manganese as Mn (Dissolved) mg/l		0.075				0.140
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l		<0.001				<0.001
Silver as As (Dissolved) mg/l		<0.001				<0.001
Zinc as Zn (Dissolved) mg/l		0.002				0.070

Table B-19. Results of chemical analyses of ground water quality samples collected at Well WQ-6.

Date	11-7-80	12-31-80	4-22-81
Flow, cfs			
Specific Conductance, umhos/cm	940	490	
Temperature, Air			
Temperature, Water		10	
pH	7.2	7.4	8.1
Oil & Grease		2.60	
Ammonia as NH3-N mg/l		<0.01	<0.01
Nitrate as NO3-N mg/l		<0.01	<0.01
Nitrite as No2-N mg/l			
Nitrogen as KJELDAHL (Total) mg/l		0.10	
Phosphate as PO4-P Total mg/l		0.160	0.300
Phosphate as PO4-P Ortho mg/l		0.020	0.025
Sulfate as SO4 mg/l	170	120	119
Sulfide mg/l			
Total Suspended Solids mg/l			319
Total Dissolved Solids mg/l	610	320	300
Total Combustible Solids			
Carbonate as CO3 mg/l		<0.01	<0.01
Bicarbonate as HCO3 mg/l	409.92	161.04	82.96
Alkalinity as CaCO3 (Total) mg/l	336	132	68.00
Total Hardness as CaCO3 mg/l			
Acidity as CaCO3 mg/l	6.0	12.0	3.00
Arsenic as As (Total) mg/l		<0.001	<0.001
Barium as Ba (Total) mg/l		0.039	0.025
Boron as B (Total) mg/l		0.100	0.080
Cadmium as Cd (Total) mg/l		<0.001	0.003
Calcium as Ca mg/l	100	28.00	25.60
Chromium as Cr (Total) mg/l		0.022	0.002
Copper as Cu (Total) mg/l		0.250	0.100
Iron as Fe (Total) mg/l	39.300	123	35.700
Lead as Pb (Total) mg/l		0.075	0.011
Magnesium as Mg mg/l	52.80	43.68	26.88
Manganese as Mn (Total) mg/l	0.500	0.800	0.400
Mercury as Hg (Total) mg/l		<0.0002	<0.0002
Molybdenum as Mo (Total) mg/l		<0.001	<0.001
Potasssium as K mg/l	5.10	5.90	6.50
Selenium as Se (Total) mg/l		<0.001	0.001
Silver as As (Total) mg/l		<0.001	<0.001
Sodium as Na mg/l	15.20	17.10	18.50
Zinc as Zn (Total) mg/l		0.112	0.120
Arsenic as As (Dissolved) mg/l		<0.001	<0.001
Aluminum as Al (Dissolved) mg/l			
Barium as Ba (Dissolved) mg/l		0.020	0.016
Boron as B (Dissolved) mg/l		0.010	0.070
Cadmium as Cd (Dissolved) mg/l		<0.001	0.003
Chloride as Cl (Dissolved) mg/l	36.2	23.80	
Chromium as Cr (Dissolved) mg/l		<0.001	0.001
Copper as Cu (Dissolved) mg/l		<0.001	0.090
Fluoride as F (Dissolved) mg/l		<0.01	
Iron as Fe (Dissolved) mg/l	33.400	0.510	19.000
Lead as Pb (Dissolved) mg/l		<0.001	0.011
Manganese as Mn (Dissolved) mg/l		0.215	0.330
Mercury as Hg (Dissolved) mg/l			
Molybdenium as Mo (Dissolved) mg/l			
Nickel as Ni (Dissolved) mg/l			
Selenium as Se (Dissolved) mg/l		<0.001	<0.001
Silver as As (Dissolved) mg/l		<0.001	<0.001
Zinc as Zn (Dissolved) mg/l		0.015	0.100

Table B-20. Results of chemical analyses of ground water quality samples collected at Well WQ-8.

Date	4-22-81
Flow, cfs	
Specific Conductance, umhos/cm	
Temperature, Air	
Temperature, Water	
pH	7.6
Oil & Grease	
Ammonia as NH3-N mg/l	<0.01
Nitrate as NO3-N mg/l	<0.01
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	0.150
Phosphate as PO4-P Ortho mg/l	0.060
Sulfate as SO4 mg/l	28.5
Sulfide mg/l	
Total Suspended Solids mg/l	131
Total Dissolved Solids mg/l	210
Total Combustible Solids	
Carbonate as CO3 mg/l	<0.01
Bicarbonate as HCO3 mg/l	226.92
Alkalinity as CaCO3 (Total) mg/l	186
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	3.0
Arsenic as As (Total) mg/l	<0.001
Barium as Ba (Total) mg/l	0.040
Boron as B (Total) mg/l	0.082
Cadmium as Cd (Total) mg/l	<0.001
Calcium as Ca mg/l	38.40
Chromium as Cr (Total) mg/l	<0.001
Copper as Cu (Total) mg/l	0.050
Iron as Fe (Total) mg/l	38.000
Lead as Pb (Total) mg/l	0.279
Magnesium as Mg mg/l	13.92
Manganese as Mn (Total) mg/l	0.300
Mercury as Hg (Total) mg/l	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001
Potasssium as K mg/l	1.37
Selenium as Se (Total) mg/l	0.001
Silver as As (Total) mg/l	<0.001
Sodium as Na mg/l	12.00
Zinc as Zn (Total) mg/l	0.300
Arsenic as As (Dissolved) mg/l	<0.001
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	0.020
Boron as B (Dissolved) mg/l	0.070
Cadmium as Cd (Dissolved) mg/l	<0.001
Chloride as Cl (Dissolved) mg/l	
Chromium as Cr (Dissolved) mg/l	<0.001
Copper as Cu (Dissolved) mg/l	0.040
Fluoride as F (Dissolved) mg/l	
Iron as Fe (Dissolved) mg/l	27.400
Lead as Pb (Dissolved) mg/l	0.252
Manganese as Mn (Dissolved) mg/l	0.290
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	<0.001
Silver as As (Dissolved) mg/l	<0.001
Zinc as Zn (Dissolved) mg/l	0.260