1-1-1978

Boeing Engineering and Construction; Groundwater and Surface Water Investigation Report

C. Earl Israelsen

Frank W. Haws

BOEING ENGINEERING AND CONSTRUCTION

GROUNDWATER AND SURFACE WATER INVESTIGATION REPORT

Prepared by

The Utah Water Research Laboratory

College of Engineering

Utah State University

Logan, Utah

By

C. Earl Israelsen
Frank W. Haws

Nov 1978

WG-250

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Boeing Engineering and Construction (BEAC) is investigating the feasibility of transporting Utah coal via slurry pipeline to the west coast. Such an investigation requires an abundance of data concerning such things as the availability and quality of water which can be slurried with coal, the location of such water with respect to the deposits of coal, and the ultimate disposal of the water at the pipeline's end.

This study generated a limited amount of new data and gathered existing data and information related to surface and underground water within a 50-mile radius of Emery, Utah, but restricted primarily to the Colorado River drainage. Data were gathered also of coal and water in mines within the same area, and determinations were made of their mutual effects on each other when slurried together in the laboratory.

Tasks are listed and discussed in this report in the same order as they appear in the research proposal. Supporting data and information in the form of maps, tables, charts, and references are also included.

A. GROUNDWATER

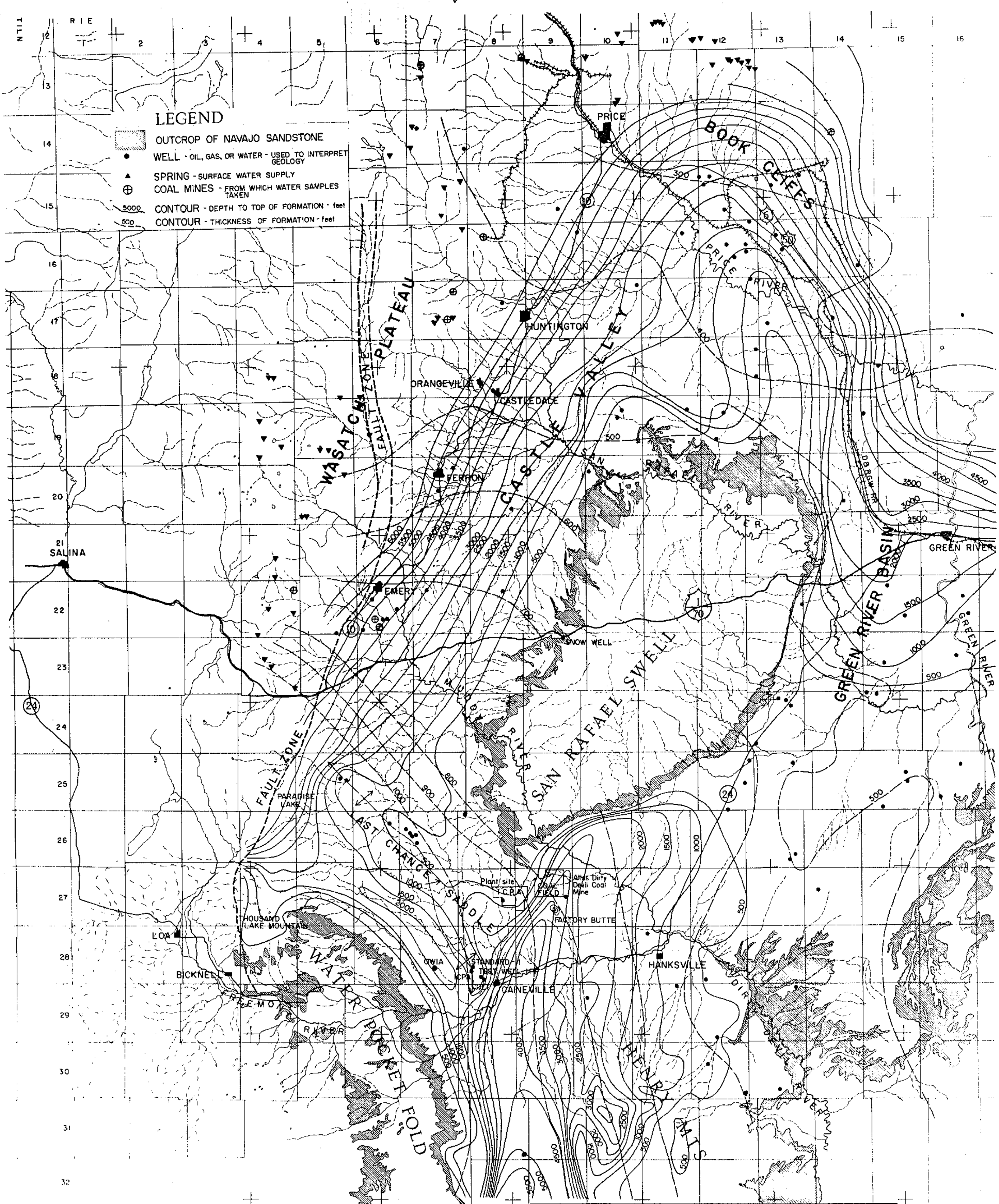
1. Define the boundaries of the Navajo Sandstone (Jn) Aquifer.

The Navajo Sandstone results from the western two-thirds of the Colorado Basin being buried during the Jurassic period by drifting sands. The formation was once a solid sand sheet interrupted only locally by playa lakes (desert lakes that dry up during the dry season). This sand sheet covered all of the eastern and southwestern portions of Utah, and parts of Nevada, Arizona, Colorado, and Wyoming. The formation pinches out eastward before reaching the San Juan mountains and Uncompahgre Plateau of Colorado. The sand sheet carried the name "Navajo" in Arizona and Utah, "Nugget" in Wyoming, and "Aztec" in Nevada. Dip directions of Navajo cross-beds indicate wind directions from the north and northwest; northwestern and west central Utah served as the source area (Hintze, 1973; Baars, 1972). Subsequent to the deposition, the sandstone and overlaying and underlying formations were uplifted and eroded in random patterns throughout the area such that at the present time the sandstone ranges from being as much as 10,000 feet below the present ground surface, being exposed at the surface, or being entirely removed by erosion.

The primary study areas of Navajo Sandstone for this report are Castle Valley which extends from Price, Utah on the north to Emery, Utah on the south and lies between the eastern slope of the Wasatch Plateau and the San Rafael Swell; and the Henry Mountain Basin which is connected with Castle Valley by the Last Chance Saddle. All of this area is underlain with the Navajo Sandstone with outcropping around the periphery of the San Rafael Swell, the Waterpocket Fold, and the Henry Mountain uplift at Dirty Devil Canyon.

The Navajo Sandstone is classed as an aquifer because of its unique physical capacity to store and conduct water. Being an eolian or wind blown sand, the grains which constitute the sandstone are relatively uniform in size with approximately 90 percent of the particles being classed as fine to very fine sand. The remainder is either medium sand or silt with no gravel or clay particles present. The porosity of the sandstone is approximately 25 percent and, because of the nature of the particle shapes, the permeability is relatively high and essentially non-directional. The formation is highly jointed and fractured as a study of the outcrop indicates, with some additional fracturing probably present in areas where folding has occurred. These joints and fractures tend to increase the effective porosity and permeability of the formation. The formations that lie immediately above (Carmel) and below (Kayenta) the Navajo Sandstone are both water deposited materials which contain a high percentage of silt and clay particles and are not good conductors of water. The Navajo Sandstone is effectively an aquifer between two aquitards or water barriers.

Recent exploration and testing of the NSA in the Henry Mountains area have been done under the direction of the Board of Directors of the Intermountain Power Project (IPP). The depths from ground surface to the top of the Navajo Sandstone, together with the thickness of the formation, based on the IPP study, are shown on Figure 1. Using geologic logs from oil and gas well exploration as tabulated by the USGS, these depth and thickness contours have been extended to include the Castle Valley area and areas east and north of the San Rafael Swell.



UTAH WATER RESEARCH LABORATORY
LOGAN, UTAH

DEPTH TO AND THICKNESS OF NAVAJO SANDSTONE

BOEING ENGINEERING AND CONSTRUCTION CO. OCTOBER 1978

SCALE ~~1:250,000~~ ~~1" = ABOUT 4 MILES~~ FIGURE 1

The portion of the Navajo Sandstone formation known to contain water and for which information is available extends under a Y-shaped area (see Figure 1) that is about 100 miles long (north-south) and up to 75 miles wide (east-west). The towns of Emery and Green River are located at the top of the Y, and Lake Powell is located at the bottom. The boundaries of the aquifer generally coincide with the limits of the exposed Navajo Sandstone. It is exposed at Thousand Lake Mountain, the Waterpocket Fold, the San Rafael Swell, the Henry Mountains, and in the canyons of the Green River, the Dirty Devil River, and the Colorado River. The Thousand Lake-Paradise fault zone forms an additional boundary on the northwest. The vertical displacement of more than 2,000 feet totally offsets the Navajo Sandstone on each side of the fault zone.

In the IPP study, an implied boundary exists across the Last Chance Saddle that separates the Castle Valley from the Paradise Basin and the Henry Mountains; roughly an area south of highway I-70. Whether this is real or not can only be determined with additional exploration. It is likely that the Navajo Sandstone north of highway I-70 is also an aquifer with the fault zone extension as one boundary, the San Rafael Swell outcrop another, and an undefined boundary to the north as the formation dips deeply to below mean sea level elevation.

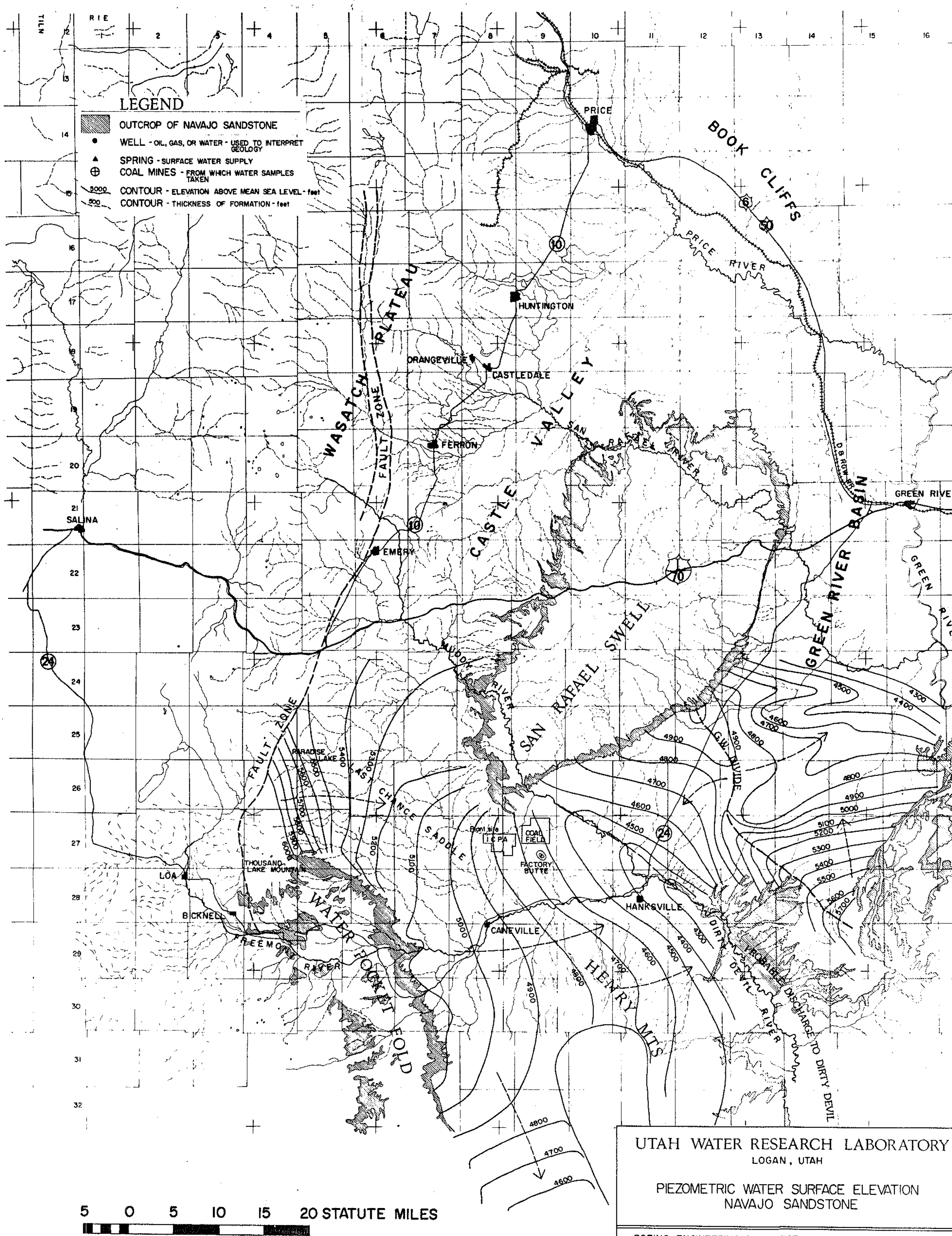
2. Define the average water level within 50 miles of Emery, Utah in the Navajo Sandstone.

The IPP drilled wells into the Navajo Sandstone near Caineville, Utah, and made a rather extensive study of the water bearing qualities of the aquifer. Being confined, the water in the formation is under artesian pressure, and in many areas the piezometric surface is at or above ground level. The piezometric surface has been plotted in Figure 2 and shows the general direction of flow of the water in that portion of the aquifer. Water that originates in the Thousand Lakes and Paradise Basin area flows southeasterly through the Last Chance Saddle and southerly until it discharges probably into Lake Powell or the canyons of the Dirty Devil River. No information is available on the water potential in the Navajo Sandstone northeast of Paradise Basin in the Castle Valley area. It is likely that the formation in this area contains water which may originate in the headwaters of the San Rafael and Price Rivers and from the extensive outcrop areas on the north and westerly sides of the San Rafael Swell. Except for areas near the outcrop, the depth to the top of the formation is excessive for economic drilling, however (see Figure 1).

3. Determine the average expected water quality within this 50 mile area in the Navajo Sandstone.

Numerous oil and gas wells have been drilled into and through the Navajo Sandstone, but reliable measurements of water quality in the aquifer from these are limited. Some quality measurements have been taken from a limited number of springs and wells that draw water from the Navajo but the most reliable data available to date are those obtained by the Intermountain Power Project (IPP) when they drilled two wells into the aquifer during 1975 and 1976. These data are presented in Table 1.

Measurements indicated that water quality in the Navajo varies spatially, and deteriorates with distance from the recharge source areas. Water from the Navajo is generally better in quality than that from



UTAH WATER RESEARCH LABORATORY
LOGAN, UTAH

PIEZOMETRIC WATER SURFACE ELEVATION
NAVAJO SANDSTONE

BOEING ENGINEERING AND CONSTRUCTION CO. OCTOBER 1978

SCALE FIGURE 2

Table 1. Quality analysis of water from the Navajo Sandstone Aquifer. (Data in parts per million or as indicated.)

Parameter	Well Name				
	OW-1A	OW-ICPA	OW-Stano-lind	TW-1	OW-Colt
Number of Samples	1	3	2	22	8
Temperature °C Field	---	20.1	17.6	17.5	17.3
Specific Electrical Conductance (μmhos/cm)	988	3997	2990	4315	1494
pH Units	7.97	7.63	7.62	7.81	7.71
Calcium (Ca)	128	259	136	84	102
Magnesium (Mg)	49	105	46	30	56
Total Hardness as $CaCO_3$	520	1075	530	332	469
Sodium (Na)	18	495	475	823	151
Potassium (K)	3.1	4.8	4.2	4.0	5.3
Alkalinity as $CaCO_3$ (Total)	230	197	248	237	211
Sulfate (SO_4)	304	1022	652	600	356
Chloride (Cl)	7.1	623	454	847	180
Silica (SiO_2)	13	12	8.5	9.6	9.4
Iron (Fe)	3.2	0.8	---	0.54	1.0
Boron (B)	0.03	0.30	---	0.37	0.04
Fluoride (F)	0.21	0.54	---	0.9	0.17
Nitrate (NO_3)	0.4	0.20	0.9	0.4	---
Nitrite (NO_2)	---	0.002	---	---	---
Total Kjeldahl Nitrogen (N)	0.10	---	---	0.07	0.03
Phosphate (PO_4)	---	0.2	0.03	---	---
TDS	690	2823	2008	2658	1135

Source: Preliminary Engineering and Feasibility Study, Intermountain Power Property (IPP), 1977.

either the underlying or overlying formation, the Kayenta and the Carmel. It does not meet the standards for human consumption but much of it is suitable both for livestock watering and for irrigation (see Tables 2, 3, 4 and 5). Water near the upper and lower boundaries of the Navajo may be of a lesser quality than that in the interior due to leakage from adjacent formations.

4. Estimate the cost to develop the number of wells needed to pump 8,000 acre-feet per year from the NSA.

   a) Well drilling
   b) Pumps
   c) Cost of water rights
   d) Collection system

The cost to develop wells and install a collection system to pump 8,000 acre feet of water per year from the Navajo is dependent on several variables, the most important of which is probably location. As indicated on the map (Figure 1), the depth from ground surface to the top of the Navajo varies throughout the study area from a few hundred to several thousands of feet. Wells drilled at some locations will be under artesian pressure as is the IPP test well TW-1, and others near the outcropped area may have no artesian pressure at all. Surface terrain plays an important role as well and would affect such things as accessibility for drilling and the cost of installing a pipeline network for interconnecting the wells.

Reasonably accurate estimates cannot be made until the locations of the wells have been determined because this will directly and significantly affect cost of drilling, water rights, and the collection system. However, the following general guidelines can be used for making estimates.

Table 2. Recommended surface water criteria for public water supplies (mg/l except where specified).

Elements	Public Water Supply Sources
Ag	No limit recommended
As	0.1
B	Limit not yet determined
Ba	1.0
Cd	0.010
Cl	250.0
Cr	0.05
Cu	1.0
F	Range from 1.4 to 2.4*
Fe	0.3
Hg	0.002
Mn	0.05
NH_3	0.5
NO_3 (as N)	10.0
NO_2 (as N)	1.0
Pb	0.05
Se	0.01
$SO_4^=$	250.0
Zn	5.0
pH, pH units	5.0 - 9.0
CN	0.2

*Recommended upper limit dependent upon maximum daily air temperature.

Source: Water Quality Criteria 1972, EPA-R3-73-033, National Academy of Sciences and National Academy of Engineering, Washington, D.C., March 1973.

Table 3. EPA interim primary drinking water regulations established December 1975 - effective July 1977. (Concentrations in mg/l.)

Element	Upper Limits
Ag	0.05
As	0.05
Ba	1.0
Cd	0.010
Cr	0.05
F	Dependent upon air temperature*
Hg	0.002
NO_3 (as N)	10.0
Pb	0.05
Se	0.01
Radium 226	Combined Ra-226 and Ra-228, 5.0 pCi/l.
	Gross alpha particle activity, 15 pCi/l.

*Maximum allowable fluoride concentration.

Air Temperature		Conc.
(°F)	(°C)	(mg/l)
53.7 & below	12.0 & below	2.4
53.8 - 58.3	12.1 - 14.6	2.2
58.4 - 63.8	14.7 - 17.6	2.0
63.9 - 70.6	17.7 - 21.4	1.8
70.7 - 79.2	21.5 - 26.2	1.6
79.3 - 90.5	26.3 - 32.5	1.4

Table 4. Recommended upper limits for livestock (mg/l except where specified).

Elements	Livestock Waters
As	0.2
B	5.0
Cd	50.0 μg/l
Co	1.0
Cr	1.0
Cu	0.5
F	2.0
Hg	10.0 μg/l
Mo	Limit not yet determined
NO_2 (as N)	10 ppm
$NO_3 + NO_2$ (as N)	100 ppm
Pb	0.1
Ra-226	5.0 pCi/l
Se	0.05
V	0.1
Zn	25.0
TDS	3000

Source: Water Quality Criteria 1972, EPA-R3-73-033, National Academy of Sciences and National Academy of Engineering, Washington, D.C., March 1973.

Table 5. Recommended limits for irrigation water.

Element	Recommended Limits for Continuous Use on All Soils (mg/1)	Recommended Limits for Use on Fine-Textured Alkaline or Neutral Soils For Up to 20 Years (mg/1)
Al	5.0	20
As	0.10	2
B	0.75	2.0
Be	0.10	0.50
Cd	0.010	0.050
Co	0.050	5.0
Cr	0.1	1.0
Cu	0.20	5.0
F	1.0	15.0
Fe	5.0	20.0
Pb	5.0	10.0
Li	2.5	2.5
Mn	0.20	10.0
Mo	0.010	0.050
Ni	0.20	2.0
Se	0.02	0.02
V	0.10	1.0
Zn	2.0	10

Source: Water Quality Criteria 1972, EPA-R3-73-033, National Academy of Sciences and National Academy of Engineering, Washington, D.C., March 1973.

a & b) Well drilling and pumps. Very few wells have been drilled into the Navajo for the purpose of developing water, i.e., most of the available data which have been utilized for determining the depth to and the thickness of the Navajo Sandstone Aquifer, as well as the piezometric surface, have been extracted from oil and gas exploration wells which penetrate far beyond the Navajo, sometimes to several thousands of feet.

The Intermountain Power Project (IPP) drilled one test well and one observation well into the Navajo in 1975, and these have provided the most recent and reliable drilling-cost data that we've been able to find.

Test well TW-1 was drilled by R. Johnson Drilling Co. using a Hopper Drilling Rig. This well is located 1 1/2 miles west of Caineville in the Red Desert and was drilled into the Navajo on the Caineville anticline. It was drilled with an 18 1/2" roller bit to a depth of 53 feet, a 15" RB to 447 feet, and a 9 7/8" RB to 1,685 feet.

Observation wells OW-1 and OW-1A were drilled by K. O. Burt Drilling Co. using a Portadrill TK 10 2,000 drill rig. They were drilled into the Navajo on the west flank of the Saleratus Creek syncline in North Blue Flats, approximately 5 miles west of TW-1, and 7 1/2 miles west of Caineville. Observation well OW-1 was drilled with a 15" reamer to 60 feet and a 9 7/8" roller bit to 1,615 feet. At this point a malfunction caused the drill string to be dropped to the bottom of the hole, and it could not be recovered. The well was abandoned and a new hole, OW-1A, was drilled. It was drilled with a 15" reamer to 50 feet, a 9 7/8" roller bit to 2,344 feet.

Personal communication with Mr. K. O. Burt provided the following best-estimate of cost of well-drilling into the Navajo in the Caineville area:

Assume well-depth of 1,700 feet

Drilling	$ 100 per foot
Bits, mud, casing, cementing and test-pumping	$ 30,000 to $50,000
Pump and Motor	$ 15,000
Total cost per well	$235,000

Based on data and experience gathered by the IPP, three wells in the Caineville area should be able to supply 8,000 acre feet of water per year. Each would be flowing at a rate of about 1,653 gallons per minute, or 3.68 cubic feet per second (cfs). The cost of three wells would be approximately $705,000.

c) Collection system. If the wells were located in relatively flat terrain, the collection system could presumably consist of open concrete-lined ditches, all bringing the water from the wells into an open storage pond. Alternatives to the open ditches are concrete, plastic, or steel pipe. Installation costs of each of these alternatives are affected by the type of terrain, which again can be ascertained only after exact locations of the wells have been determined.

Table 6 presents unit costs of some of the currently available materials and provides a means of comparing alternatives. A price range indicates variations in quotations from different suppliers. Table 6 presents also examples of head loss concrete and plastic pipe of various diameters. These are calculated for a flow rate of 1,650 gpm,

Table 6. Pipe costs in dollars per lineal foot, and examples of head loss.

Pipe Material	Diameter	22 psi	80 psi	100 psi	125 psi	160 psi	200 psi
PVC	6"	0.57 to 0.66	0.99	0.96 to 1.21	1.52	1.81	2.23
	8"	0.86 to 0.95	1.75	1.76 to 2.14	2.57	3.11	3.82
	10"	1.34 to 1.44	2.74	2.76 to 3.35	3.96	4.84	5.94
	12"	1.94 to 1.95	3.96	3.99 to 4.84	5.58	6.82	8.37
Non-Reinforced Concrete	6"	0.91 to 1.33					
	8"	1.11 to 1.74					
	10"	1.49 to 2.40					
	12"	2.09 to 4.21					
	15"	3.20 to 6.01					
		(Bare Steel) 14 gauge			(Felt-wrapped) 14 gauge		
Steel	6" OD	1.59			2.00		
	6 5/8" OD	1.70			2.20		
	8" OD	2.10			2.55		
	8 5/8" OD	3.20			3.70		
	10" OD	3.65			4.20		
	10 3/4" OD	3.85			4.45		
	12" OD	4.40			5.00		
	12 3/4" OD	4.55			5.25		

Flow Rate = 1650 GPM

Concrete Pipe	Head Loss (ft/1000')	Plastic Pipe	Head Loss (ft/1000')
6" dia.	too high	8" dia.	55
8" dia.	80	10" dia.	17
10" dia.	25	12" dia.	6
12" dia.	10	15" dia.	2
15" dia.	3		

which is what would be required from each of three wells in order to provide 8,000 acre feet of water per year.

The pipelines making up the collection system should probably be buried, both for aesthetic and protection purposes. Costs of digging the trench, laying the pipe, and backfilling will vary according to type of terrain as well as kind of pipe, and the following information will provide a basis for comparisons.

Plastic (PVC) irrigation pipelines are presently being laid in fairly smooth terrain at a cost of about 65 cents per foot, which includes digging the trench, assembling and laying the pipe, and backfilling.

Steel pipe used for water transport is generally coated or wrapped to prevent rusting, and the lengths are welded together on site. The welded joints are also coated, and then cathodic protection is provided to eliminate destructive electro-chemical reaction between the metal pipe and the soil. Salinity in the water may make it desirable to coat the inside of the pipe as well. The use of concrete or plastic pipe eliminates the need of special coatings or cathodic protection.

A reasonable estimate for installing steel pipe is as follows:

Digging trench	$0.25/lineal foot
Weld, coat welds and lay pipe	0.015/pipe-dia/lineal ft
Backfill trench	0.15/lineal foot

Cathodic protection consists of welding electrodes to the pipe at intervals along the line, and would be done by the welder at little or no extra cost when he welds the pipe lengths together.

To install a 12" diameter steel pipeline, 1,000 feet long, would cost the following using the above figures:

Excavation	=	0.25 x 1,000	=	$ 250.00
Weld and lay pipe	=	0.015 x 12 x 1,000	=	180.00
Backfilling	=	0.15 x 1,000	=	150.00
		Total		$580.00

d) Cost of water rights. Surface or underground water rights are obtained by submitting an application to the State Engineer's office and paying a small filing fee. If the application is approved, the water may be diverted at the specified location and utilized. If there are objections to the application, answers must be submitted and eventually hearings held and justification presented. This all represents time and money. In any event, the State Engineer must be convinced that unappropriated water exists and that the applicant has real intent to proceed to appropriate for a beneficial use. He must also be convinced that no existing water rights will be impaired by the proposed use. Since the Navajo aquifer is unproven as to yield and recharge it may be necessary to conduct some additional explanation and testing to provide the State Engineer with confident answers. This would add to the cost of obtaining the water right. The applicant must also own land or hold a bonafide lease before the application would be approved.

Water rights that have already been approved may be purchased from others at whatever price may be negotiated--there is no "going rate." In the case of underground water rights the price may include the drilling costs, pump costs, and other costs associated with a distribution system. Sometimes it may involve purchasing a piece of land to obtain the water rights that pertain to it, or may involve purchasing someone's entire farm or several farms in order to get the amount of water required.

Several applications for water in the study area presently exist which have not yet been approved (see Table 7). It would be risky to buy them until approval could be assured. The only advantage to gaining rights this way is the priority date, which may or may not be of value is an area where such little present-use exists.

The only estimate received on the price of water that might be purchased in the study area is $1,000 per acre foot, and this apparently was not based on any first-hand knowledge of water for sale.

5. Determine or estimate separation between wells in the Navajo Sandstone Aquifer (e.g., Salt Wash Area) to prevent interference between BEAC wells, and between our wells and those belonging to others.

Extensive pumping tests were performed by the Intermountain Power Project (IPP) on the well they drilled into the Navajo Sandstone Aquifer. An observation well was drilled also at a distance of 25,185 feet from the pumped well. Three more observation wells were used in the study as well, one at a distance of 2,427 feet from the pumped well, the second at 3,113 feet, and the third at 4,963 feet. Water levels in the observation wells were measured periodically throughout the 35 day period of pumping, and for 35 days thereafter during recovery.

Data generated by the IPP are the most extensive and reliable that could be found for the area of interest, and they provide a reasonable estimate of desirable separation distances between wells pumping from the Navajo. Estimates made by the IPP from their pumping data of the

Table 7. Unapproved groundwater application on file in the State Engineer's Office--possible Navajo Sandstone.

Appl. No.	Claim No.	Applicant	Quantity cfs	ac. ft.	County
29072	95-410	C. S. Albrecht	6.0		Wayne
38367	95-644	Kemmerer Coal Co.	66.0		Emery
40508	-691	Garkane Power Assoc.	25.0		Wayne
40747	-697	Garkane Power Assoc.	70.0		Wayne
40748	-698	Garkane Power Assoc.	70.0		Wayne
41022	-705	Garkane Power Assoc.	25		Wayne
41073	-707	Garkane Power Assoc.		50,000	Wayne
41357	-718	ICPA	100	50,000	Wayne
42671	-750	Vance Taylor	6.0		Wayne
43270	-765	Robbert M. Lunnen	5.0		Wayne
44144	-1562	George Palelsas	1.0		Wayne

desirable separation distances between wells is 7,000 feet when four wells are used, each pumping 1,500 gpm (total of 9,700 acre feet per year), and 10,000 feet for six wells pumping 2,000 gpm each (total of 20,000 acre feet per year). These estimates are based on a total pumping period of 38 years at the rates indicated. For more wells, or for drastically different pumping periods or extraction rates, additional pumping tests and calculations should be made in order to determine the spacing needed to prevent excessive interference between adjacent wells.

In a personal communication with Bryce Montgomery, Geologist for the Utah Division of Water Resources, he indicated that a one-half mile spacing might be adequate in the Navajo aquifer.

6. <u>Estimate the average well depth within 50 miles of Emery, Utah, and in Salt Wash region.</u>

Since there are so few wells in the Navajo formation, an answer to this part has little meaning. The most useful information here is the map (Figure 1) showing depth to the top of the Navajo formation and the thickness of the formation. Potential well depths for any area within the mapped boundaries can thus be estimated. It is noted that the Navajo formation dips away from the exposed portions. This means wells would be progressively deeper as the distance from the outcrop increases.

Water in the Navajo formation is generally under artesian pressure and in many areas wells would flow without additional pump energy added. In any case the artesian pressure would subtract from the pumping needed.

As far as could be determined, there are no water wells in the Salt Wash region.

7. Estimate expected recharge rate of NSA for area within 50 miles of Emery, Utah.

Recharge is estimated as coming from two sources: percolation of direct precipitation into exposed Navajo Sandstone and percolation from perennial and intermittent streams flowing over the exposed Navajo.

There is no man-induced recharge into the Navajo in the area south of highway I-70, but there is a possibility of recharge from irrigated areas north of the highway, but it would have to depend on leakage through overlying formations. Exposed Navajo does not exist in the agricultural regions of the study area. The excess water percolates into formations considerably younger than the Navajo Sandstone.

Estimates of recharge to the Navajo south of highway I-70 from various sources are summarized in Table 8. USGS personnel suggest the lower figure as being more realistic than the range which has been suggested by the IPP.

Estimates of recharge to the northern portion have not been made because of a sparcity of data. Data being assembled currently by the USGS may enable such estimates to be made in the not-too-distant future. (Refer to list of project-related studies in the appendix.)

8. Other users of Navajo Sandstone Aquifer that could impact BEAC uses.

Most of the wells that have been drilled into the Navajo in the state have been for oil and/or gas exploration, and thus produce no water. Four wells known to tap the aquifer are located and used as follows:

Table 8. Navajo Sandstone recharge.

Source	Low and High Range	Annual Recharge, Acre-Feet		
		Low Estimates	High Estimates	Probable Range
Waterpocket Fold, San Rafael Swell, Direct Precipitation to Navajo, 45,400 acre-feet = 100%	5% - 20%	2,270	9,080	5,900 - 7,260
Waterpocket Fold, San Rafael Swell, Direct Precipitation to Carmel and Entrada, 90,800 acre-feet = 100%	0% - 3%	0	2,700	0 - 500
Henry Mountains, Direct Precipitation to Navajo, 5,000 acre-feet = 100%	5% - 20%	250	1,000	300 - 500
Henry Mountains, Direct Precipitation to Carmel and Entrada, 10,000 acre-feet = 100%	0% - 3%	0	300	0 - 100
Thousand Lake Mountain, Saturated Volcanic Material	---	0	5,000	1,000 - 2,000
Fremont River	1 cfs - 5 cfs	730	3,650	2,190 - 2,900
Oak and Pleasant Creeks	1/2 cfs - 2 cfs	360	1,460	550 - 730
Muddy Creek	1/2 cfs - 2 cfs	360	1,460	550 - 730
Miscellaneous Streams	1/2 cfs - 1 cfs	360	730	550 - 730
Totals		4,330	25,380	11,040 - 15,450

Source: Preliminary Engineering and Feasibility Study, Intermountain Power Project (IPP), 1977.

Well No. 1 (Approved application No. 22954(95-356)) is located about 9 miles south of Hanksville and was drilled to a depth of 500 feet. This project was approved by the state to produce 0.015 cfs of water for livestock watering. It will not be affected by pumping in the area of interest.

Well No. 2 (Approved application No. 40356(95-685)) is located approximately 16 miles south and slightly west of Caineville. It was approved for 2 cfs for stockwatering, irrigation, and domestic use. This well will not be affected by pumping in the area of interest.

Well No. 3 (Approved application No. 42596(95-748)) was approved for 0.208 cfs for stockwatering and a small freshwater fishery. This is the Stanolind Water Well located approximately 3,100 feet west of the IPP test well, and was utilized as one of the observation wells during the pumping test. It is estimated that the drawdown in this well after 38 years of normal pumping by the IPP would be 350 feet.

Well No. 4 (Approved application No. 39084(95-665)) was drilled for stockwatering, and BLM has a water right of 0.015 cfs from it. It is located about 16 miles north and slightly west of Caineville. The Navajo is only partially saturated in this area and may also be partially restricted due to igneous intrusions. Estimated drawdown from normal pumping of the proposed IPP well field would be not more than 200 feet.

In addition to these approved wells, a number of additional applications for water rights have been filed with the State Engineer's office which have not yet been approved. Any of these that become approved and those proposed by BEAC could have a mutual impact upon each other as well as on those wells already in existence. Table 7 gives a representative listing of unapproved groundwater rights applications currently on file in the State Engineer's office.

An application to appropriate water from the Navajo or Ferron aquifers would likely be protested by some of the existing applicants and/or users. These would include the Garkane Power Company, a member of the ICPA, and a holder of several unapproved applications in Wayne County; the Consolidated Coal Co.; the Kemmerer Coal Co.; Utah Power and Light Co.; the U.S. Bureau of Land Management; the U.S. Forest Service; Utah Division of Water Resources; Mt. State Resources; some of the Wayne County irrigation companies; and some private individuals. Protests may also be expected for the Wayne County Water Conservation District and possibly from the Central Utah Water Conservancy District.

B. SURFACE WATER

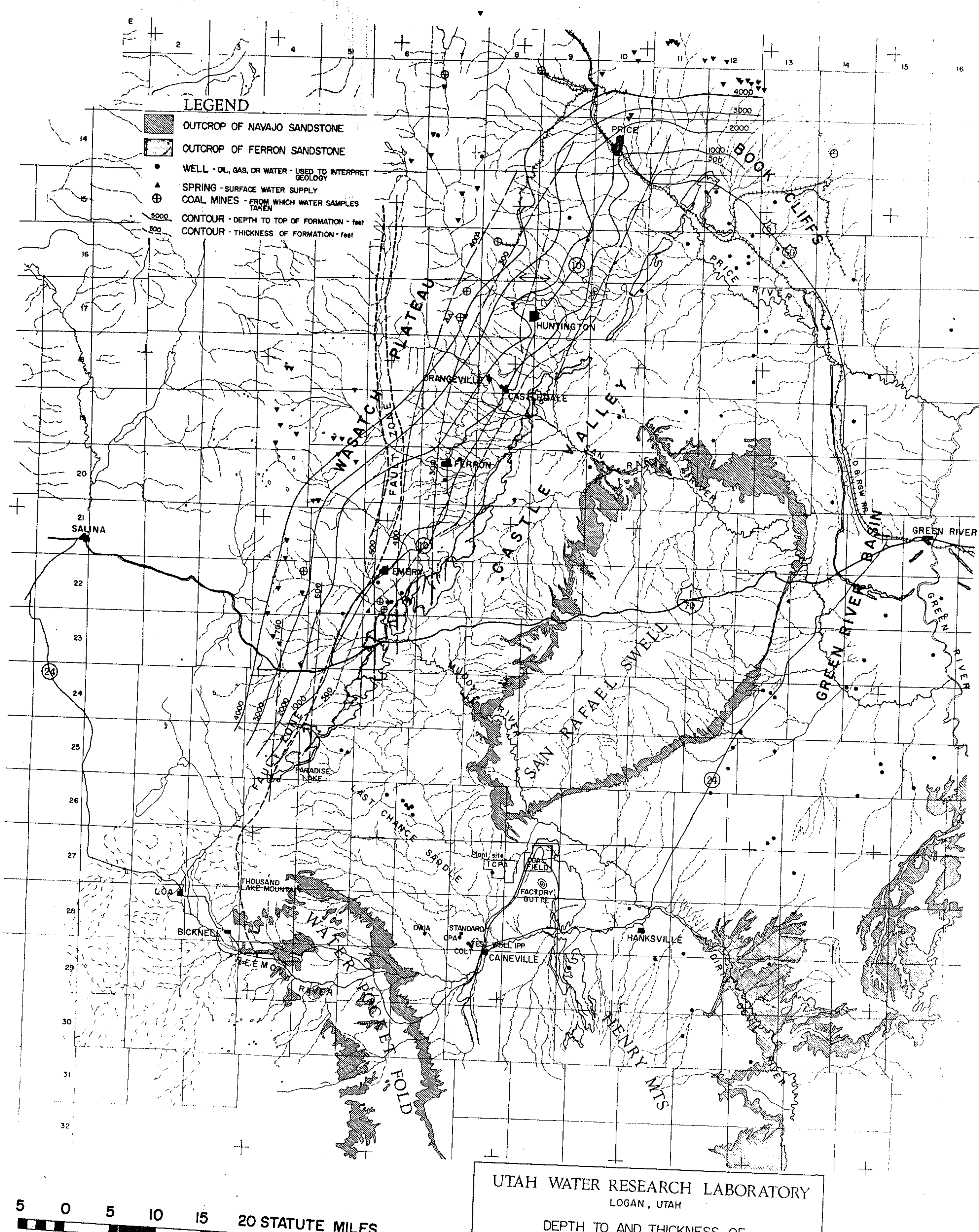
1. Define the average water level of shallow (<800 feet) groundwater (SGW) within 50 miles of Emery, Utah.

For this study shallow groundwater (SGW) and surface water are considered together. Also, because the top of the Navajo Sandstone Aquifer (NSA) is less than 800 feet from the ground surface in some parts of the study area, another distinction is necessary which excludes all NSA water from the SGW designation.

There is very little quaternary material in this area and what does exist is mostly wind blown sand (sand dunes) and some alluvium along the upper parts of the perrenial streams. Most of the agricultural activity is within the alluvial sands which are shallow and overlie members of the mancos shale formations. Some shallow water table conditions exist in these areas but recoverable water is not generally practiced and would probably be of low quality.

The Ferron Sandstone member of the mancos shale appears to be the most likely source of large quantities of good quality water. It is also interbedded with numerous coal seams which do not appear to conduct water. Figure 3 has been prepared from limited geologic data to indicate the extent of the Ferron Sandstone and to show the location of existing water wells.

Very few water wells exist in the area of interest, so data from oil and gas exploration wells have been utilized to define the aquifer. Eight water wells have been drilled in the southern portion of the Ferron, including one that provides the domestic supply for Emery City. Wells in the northern portion of the mapped area north



UTAH WATER RESEARCH LABORATORY
LOGAN, UTAH

DEPTH TO AND THICKNESS OF
FERRON SANDSTONE

BOEING ENGINEERING AND CONSTRUCTION CO. OCTOBER 1978

SCALE

of Price, produce good water but do not penetrate the Ferron Sandstone. Generally the wells in the Ferron have artesian pressure with the piezometric surface varying from 67 feet below ground surface to 49 feet above.

2. <u>Determine the average expected water quality of SGW within 50 miles of Emery, Utah.</u>

Generally speaking SGW in the area of interest is of a quality suitable for irrigation, even though it varies considerably throughout the region. Particular locations at certain times of the year may contain excess concentrations of particular constituents as noted in Tables 9 and 10 . Samples from which these data were extracted were obtained from selected streams, mines, wells and springs throughout the study area.

Data in Table 9 pertain entirely to surface streams, and constitute part of the 208 Waste Water Quality Management Study for the State of Utah required by the Environmental Protection Agency. Note that concentrations of various constituents in excess of those recommended for irrigation water are identified. Those values singly underlined exceed the recommended limits for irrigation water applied on a continuous basis to all soils. Double underlining indicates exceeding the recommended limit for use on five-textured alkaline or neutral soils for up to 20 years.

The table indicates that concentrations of Arsenic and Selenium exceed the limits at nearly all locations, which is probably not a fact, because sampling by others do not produce the same results. (See for example water analyses from selected stream sites in material appended to the report.)

Table 9. Chemical analyses of selected surface water samples.

TDS	Sample Location (Surface)	Al	As	B	Be	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	V	Zn
	Recommended Limit Continuous Use On All Soils	5.0	0.10	0.75	0.10	0.010	0.050	0.1	0.2	1.0	5.0	5.0	2.5	0.20	0.010	0.20	0.02	0.10	2.0
	Recommended Limits Fine Textured Or Neutral Soils Up To 20 Years	20	2	2.0	0.50	0.050	5.0	1.0	5.0	15.0	20.0	10.0	2.5	10.0	0.050	2.0	0.02	1.0	10
364	Huntington Creek above UP&L Diversions	0.622	<0.01	0.16	<0.001	0.009	<0.001	<0.01	0.313	<0.34	0.440	0.013	-	0.054	0.011	0.012	0.22	0.019	5.53
1260	Huntington Creek below UP&L Diversions	0.310	0.003	0.12	<0.001	0.004	<0.001	<0.01	0.085	0.34	0.297	0.016	-	0.055	<0.001	<0.01	0.055	0.018	0.031
2747	Huntington Creek at U-10	<0.01	0.02	0.29	-	0.004	-	<0.01	0.03	0.98	0.570	0.48	-	0.196	-	0.022	0.300	-	0.032
4740	Huntington Creek NE of Lawrence	<0.01	0.066	0.4	-	0.012	-	<0.01	0.017	1.28	0.52	0.048	-	1.40	-	0.082	0.210	-	0.053
7000	Huntington Creek East of Castle Dale	0.12	0.087	0.285	<0.001	0.006	0.038	0.032	0.036	1.37	2.804	0.063	-	0.194	0.023	0.08	0.135	0.032	0.819
405	Cottonwood Creek above Orangeville	0.025	0.01	0.18	<0.001	0.012	<0.001	<0.01	0.015	0.56	0.16	<0.01	-	0.013	0.007	0.041	0.016	<0.001	0.12
1801	Cottonwood Creek above U-57	<0.01	0.021	0.14	-	0.004	-	<0.01	0.02	0.89	0.50	0.04	-	0.018	-	0.012	0.188	-	0.03
1790	Cottonwood Creek below Orangeville	<0.01	0.203	0.19	-	0.006	-	<0.01	0.01	0.84	0.285	0.037	-	0.062	-	<0.01	0.513	-	0.02
2397	Cottonwood Creek at old U-10	<0.01	0.015	0.28	<0.001	0.006	0.004	<0.01	0.04	1.00	1.33	0.045	-	0.097	0.009	0.02	0.120	<0.001	0.17
3230	Cottonwood Creek above Rock Canyon Creek	0.640	0.025	0.230	<0.001	0.003	0.026	0.033	0.019	1.03	0.452	0.055	-	0.098	0.035	0.040	0.100	<0.001	2.610
5610	Rock Canyon Creek at U-10	0.297	0.181	0.055	<0.001	0.006	0.037	0.038	0.026	1.37	0.780	0.071	-	0.188	0.006	0.193	0.042	<0.001	0.796
5360	Rock Canyon Creek above Cottonwood Creek	0.750	0.125	0.030	<0.001	0.005	0.048	0.034	0.025	1.41	5.80	0.08	-	1.04	<0.001	0.159	0.135	<0.001	0.172
1538	Ferron Creek above Millsite Res.	0.440	<0.01	0.080	<0.001	<0.001	0.004	<0.01	0.03	0.82	0.30	0.02	-	0.030	<0.001	<0.01	0.040	<0.001	1.180
2989	Ferron Creek below Millsite Res.	0.110	0.026	0.235	<0.001	0.003	0.015	0.030	0.04	1.09	0.305	0.09	-	0.082	0.055	0.010	0.140	0.028	0.060
1706	Ferron Creek below Ferron	<0.01	0.180	0.13	-	0.005	-	<0.01	0.02	0.85	0.42	0.015	-	0.025	-	0.020	0.200	-	0.05
3639	Ferron Creek at Paradise Ranch	0.208	0.135	0.355	<0.001	0.015	0.072	0.035	0.761	1.12	1.075	0.059	-	0.070	<0.001	0.068	0.750	<0.001	0.41
483	Muddy Creek North of Emery	0.02	<0.001	<0.01	<0.001	<0.001	<0.001	<0.01	<0.01	0.50	0.057	0.095	-	<0.01	0.007	<0.01	<0.01	<0.001	0.013
5270	Muddy Creek at I-70	1.48	0.410	0.350	-	0.007	-	<0.01	0.04	1.28	54.0	0.045	-	0.170	-	0.09	0.490	-	0.14
3960	One-half mile above Consolidated Mine	-	0.002	0.300	-	-	-	0.005	0.020	0.58	15.30	0.100	-	0.020	-	-	0.002	-	-
6750	Christiansen Wash above Quitchupah Creek	-	0.165	0.450	-	-	-	0.005	0.050	1.39	17.80	0.100	-	0.088	-	-	0.489	-	0.030
640	Trail Creek above Co-op Mine	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.34	0.051	<0.001	-	0.009	<0.001	<0.001	<0.001	<0.001	0.116
700	Trail Creek below Co-op Mine at Hiway	0.021	<0.001	0.325	<0.001	<0.001	<0.001	<0.001	0.006	0.41	0.320	0.015	-	0.041	<0.001	<0.001	0.004	<0.001	0.490
-	North Emery Wash - 1.5 mi. N. of Emery	-	0.279	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	0.426	-	-
-	Wash 3.8 miles E. of Clawson	-	1.363	-	-	0.26	-	-	-	-	-	-	-	-	-	-	2.366	-	-
4410	Lower Quitchupah Creek above Ivie Creek	-	0.240	-	-	-	-	-	-	1.23	0.207	0.014	-	0.038	-	-	0.290	-	-
6350	Quitchupah Creek below Christiansen Wash	-	0.305	0.420	-	-	-	0.003	-	1.37	0.040	0.050	-	0.064	-	-	0.528	-	-
5100	Lower Ivie Creek - above Muddy	-	0.122	-	-	-	-	-	-	1.20	0.119	<0.001	-	0.032	-	-	0.380	-	-
	Upper Ivie Creek - above Quitchupah	-	0.030	-	-	-	-	-	-	1.28	0.136	0.017	-	0.086	-	-	0.318	-	-
2210	Muddy River above Miller Canyon	-	0.041	-	-	-	-	-	-	0.91	0.308	0.003	-	0.029	-	-	0.495	-	-
5380	Muddy River above Ivie Creek	-	0.112	-	-	-	-	-	-	1.23	0.350	0.017	-	0.087	-	-	0.415	-	-

Table 10. Ghemical analyses of selected well and mine samples.

TDS	Sample Location	Al	As	B	Be	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	V	Zn
	Recommended Limit Continuous Use On All Soils	5.0	0.10	0.75	0.10	0.010	0.050	0.1	0.2	1.0	5.0	5.0	2.5	0.20	0.010	0.20	0.02	0.10	2.0
	Recommended Limits Fine Textured Or Neutral Soils Up To 20 Years	20	2	2.0	0.50	0.050	5.0	1.0	5.0	15.0	20.0	10.0	2.5	10.0	0.050	2.0	0.02	1.0	10
TDS	Sample Location (Underground)																		
710	Co-op Mine Water	0.030	<0.001	0.350	<0.001	<0.001	<0.001	<0.001	0.009	0.59	0.066	0.005	-	0.017	<0.001	<0.001	0.011	<0.001	0.077
4970	Consolidated Mine Waste at Pump	-	0.001	0.460	-	-	-	-	0.050	0.74	1.45	0.050	-	0.005	-	-	0.0013	-	-
6305	Consolidation Coal Co. Mine	0.680	<0.001	0.772	<0.1	0.009	0.002	<0.016	0.032	0.23	<0.076	<0.001	0.380	0.022	0.018	<0.070	<0.001	<0.012	0.055
676	Braztah Peerless Mine	0.320	<0.001	<0.122	<0.1	<0.004	<0.002	<0.016	<0.012	0.16	<0.076	<0.001	<0.020	0.144	<0.003	<0.070	0.003	<0.012	0.022
398	Coastal States Convulsion Mine	0.306	<0.001	-	-	-	-	<0.010	<0.011	-	-	<0.001	-	<0.005	-	-	0.001	-	<0.004
612	UP&L Wilberg Mine	0.156	<0.001	0.070		0.046		<0.010	<0.011	0.2	1.64	0.003		0.012			<0.001		0.004
800	UP&L Deercreek Mine		<0.001	0.160		<0.001		<0.001	0.016	0.24	0.151	<0.001		0.037			<0.001		0.025
767	Emery City Well	0.380	<0.001	0.300	<0.1	<0.004	<0.002	<0.016	<0.012	0.33	<0.076	<0.001	<0.020	<0.009	0.018	<0.070	<0.001	<0.012	0.018
6560	Atlas-Dirty Devil Coal Co. Well	0.870	0.001	0.189	0.2	0.013	<0.002	<0.016	0.022	0.10	<0.076	<0.001	0.030	0.115	0.010	<0.070	<0.001	<0.012	0.028
2134	IPP Well near Caineville	0.400	<0.001	0.633	<0.1	0.004	<0.002	<0.016	<0.012	0.29	<0.076	0.019	<0.020	0.164	0.023	<0.070	<0.001	<0.012	0.006

Perhaps there exists a problem with the analysis procedure for these two elements in whatever laboratory did the work, and additional samples from the same locations should be run again before any conclusions are drawn. Water from these streams has been used for irrigation for many years and no apparent problem has resulted from its use.

3. Estimate cost to develop the number of wells needed to pump 8,000 acre feet per year from SGW.

Cost estimates presented under item A-4 for the NSA are valid also for the SGW.

4. Determine or estimate separation between wells in SGW in area of interest to prevent interference between our own wells and between ours and other water rights users.

Insufficient data are available from which to make this determination. Most of the existing wells are under artesian pressure, and one flows as much as 300 gpm without pumping. The few existing wells apparently do not interfere with each other at present because the total use rate for each is so low. Carefully designed and executed pumping and recovery tests would have to be conducted of wells in the area of interest before reasonable estimates could be made of desirable spacing between wells.

5. Estimate the average well depth in the area of interest for SGW.

Plotted on Figure 3 are the locations of all of the wells in the study area for which data are available, and most of these are oil and gas exploration wells that are as deep as several thousands of feet.

Water wells in the vicinity of Emery, Utah, are few in number but are of particular interest because they apparently all draw water from the Ferron Sandstone Aquifer which is a promising source of additional water.

The Ferron Sandstone Aquifer is exposed throughout much of the study area, but in other locations it is deeply covered with overburden material. Thus, wells drilled into the formation can vary in depth from a few feet to several hundreds of feet. Seven of the eight existing water wells are located in Township 22S R6E, and the eighth is a short distance to the east. These wells vary in depth from 130 feet (E.C. = 3,700) to 1,600 feet (E.C. = 1,080).

6. <u>Estimate the expected recharge rate of SGW in the area of interest.</u>

Climatological and stream gaging stations in the area of interest provide many years of precipitation and streamflow data. Apparently, no specific studies have been made to determine the recharge rate to shallow groundwater aquifers, and particularly to the Ferron Sandstone. However, at the present time the usage rate from these underground sources is so low that it appears that the recharge rate far exceeds the amount being extracted. Carefully planned and executed pumping tests are needed to obtain reliable estimates of recharge rates.

7. <u>Other users of SGW which could affect or impact our uses.</u>

All of the communities, industries, and irrigators in the area of interest are utilizing SGW, and could affect or would be affected by any use by BEAC. Generally speaking most of the surface supplies are fully allocated, and applications for groundwater would most certainly be protested by present users and others with prior applications, not yet approved.

Water wells presently existing in the vicinity of Emery, Utah, are the following:

a) Emery City Well. This well is located in T22S R6E and supplies culinary water to the city of Emery. It is 1,600 feet deep (which is near the bottom of the Ferron Sandstone formation), has a specific conductance of 1,080, and a temperature of 79°F. The piezometric head level during the period 1975-76 varied between 35.10 and 48.3 feet above ground surface, and the well flows under this artesian head at the rate of 300 gpm.

b) Kemmerer Coal Co. Well. Located in T22S R6E, the well is 1,554 feet deep, the specific conductivity of the water is 990 mm with a temperature of 80°F. Piezometric level during the period 1975-77 varied from 45.5 to 49.0 feet above ground surface, and the well flows at the rate of 239 gpm.

c) Consolidated Coal Co. Wells. These wells are four in number and are all located in T22S R6E, southeast of the city of Emery. The first well is 355 feet deep, with a static head between 21.67 and 25.9 feet below ground level. The second is 400 feet deep with water level 7.3 to 8.5 feet below the surface. Number 3 is 236 feet deep with static head between -22 and -23.2 feet. The fourth has a depth of 256 feet and a water level of -23.17 to -24.36 feet.

d) E. B. Bryant Well. Located in T22S R6E this well is 406 feet deep and the water has a specific conductivity of 1,800 and temperature of 55°F. Artesian head is 3.53 feet above ground surface and the well flows at a rate of 30 gpm.

e) Cedar Ridge Land and Livestock Co. Well. This well is located in Section 8 of T22S R7E and is 130 feet deep with specific conductivity of the water 3,700. Water level in the well stands at 67 feet below ground level.

C. COAL MINE WATER

1. Repeat Applicable Portions of A or B to Water Found in Coal Mines of the Area of Interest

The only portions of A and B that relate to water in coal mines are those having to do with quantity and quality. In general, quantities of water in coal mines in most of the area of interest, particularly the southern half or two-thirds, are relatively small and of fairly good quality. Some of the mines in the northern portion of the area, near Price, have larger quantities, and some of the abandoned ones are nearly filled. For example, the Braztah Peerless Mine in Price Canyon, which was abandoned about 50 years ago, has filled to a depth of 200 feet. It is estimated that the mine contains approximately 900 acre feet of water, and it all must be pumped out before mining can continue in another coal seam beneath it.

Samples were collected from some of the mines and analyzed at the UWRL. Additional quantity and quality data were gathered from all other known sources, and these are summarized in Table 10.

Very little water exists in the coal itself, but enters the mines from adjacent formations. Mine operators monitor the water regularly so as to be able to protect themselves and their operation from any possible adverse effects. Part of the water in each mine is treated and used for dust control and other in-mine purposes. The remainder is treated as necessary to meet environmental requirements and discharged from the mine.

Water in coal mines in the study area probably is not present in sufficient quantity and aerial concentration to sustain a coal slurry operation of any significant size. Another difficulty in obtaining rights to such water would be in proving that it is not now a part of some other water supply which has already been allocated.

D. SLURRIES

1. Residential effects of water quality of A, B, and C above on coal in slurry or as a user product.

2. Residential effect of Emery/Salina coal on waters of A, B, and C above for agricultural uses.

The apparently two most probable sources of water for slurrying, coal are the Navajo Sandstone Aquifer (NSA) and the Ferron Sandstone Aquifer (FSA). Therefore all of the coal slurries that were tested in the laboratory were prepared using water from these two locations. Coal samples were obtained from a mine in Salina Canyon belonging to the Coastal States Coal Company, from a Consolidation Coal Company mine near Emery, from the Utah Power and Light Company, Wilberg Mine near Orangeville, and from the Braztah Mine near Price.

Slurries were made with coal from three of the mines using water from both the NSA and the FSA. There was only sufficient coal from the Coastal States Mine sample to slurry with water from the NSA. Coal samples were ground according to the particle size analyses shown in Table 11 . Each sample was prepared by mixing 250 g of coal with 250 ml of water and placed in a mechanical shaker where it was vigorously agitated for six days. The water was then drained from the sample and analyzed for the various constituents shown in Tables 12 and 13. Clean samples of the water before slurrying were subjected to the same analyses, and these results are presented also in Tables 12 and 13.

Table 11. Sieve analysis of coal samples.

Coal Sample from Braztah Mine

Sieve (mm)	Weight (g)	% Total Wt. Retained
1.168 (14)	0.02	--
0.500 (35)	31.3	6.3
0.246 (60)	158.2	31.6
0.147 (100)	91.0	18.2
0.074 (200)	84.3	16.9
0.043 (325)	112.5	22.5
<0.043	16.8	3.4
	494.1g	98.9%

Coal Sample from Coastal States Coal Mine

Sieve (mm)	Weight (g)	% Total Wt. Retained
1.168 (14)	0.05	0
0.500 (35)	6.9	1.4
0.246 (60)	115.8	23.2
0.147 (100)	124.8	25.0
0.074 (200)	101.3	20.3
0.043 (325)	91.1	18.2
<0.043	57.5	11.5
	497.5g	99.6%

Coal Sample from Consolidation Coal Co. Mine

Sieve (mm)	Weight (g)	% Total Wt. Retained
1.168 (14)	<0.1	0
0.500 (35)	30.5	6.1
0.246 (60)	174.5	34.9
0.147 (100)	100.8	20.2
0.074 (200)	78.9	15.8
0.043 (325)	43.6	8.7
<0.043	71.2	14.2
	499.5g	99.9%

Coal Sample from UP&L Wilberg Coal Mine

Sieve (mm)	Weight (g)	% Total Wt. Retained
1.168 (14)	0.1	--
0.500 (35)	16.6	3.3
0.246 (60)	157.4	31.5
0.147 (100)	107.1	21.4
0.074 (200)	87.6	17.5
0.043 (325)	86.9	17.4
<0.043	42.6	8.5
	498.3g	99.6%

Table 12 . Coal slurries with water from Navajo Sandstone Aquifer.

	Water from Navajo Sandstone Aquifer	NSA Water after slurrying 6 days with coal from Braztah Mine	NSA Water after slurrying 6 days with coal from Coastal States Mine	NSA Water after slurrying 6 days with coal from Consolidation Mine	NSA Water after slurrying 6 days with coal from Wilberg Mine
Alkalinity (mg/l $CaCO_3$)	119	112	60	117	75
Aluminum (µg/l)	300	250	270	400	300
Arsenic (µg/l)	1.4	<0.5	<0.5	<0.5	<0.5
Barium (µg/l)	<70	73	112	144	144
Beryllium (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1
Boron (µg/l)	689	3,023	2,773	2,801	2,468
Cadmium (µg/l)	<4	<4	<4	<4	<4
Calcium (mg/l)	63	43	204	47	161
Chloride (mg/l)	698	769	746	675	710
Chromium (µg/l)	<16	<16	<16	<16	<16
Cobalt (µg/l)	< 2	< 2	< 2	< 2	< 2
Copper (µg/l)	<12	<12	<12	<12	22
Fluoride (mg/l)	0.13	0.21	0.09	0.18	0.12
Iron (µg/l)	<76	<76	<76	<76	<76
Lead (µg/l)	3	4	5	< 1	< 1
Lithium (µg/l)	<20	60	<20	40	NS
Magnesium (mg/l)	36	31	110	41	5

Table 12 . Continued.

	Water from Navajo Sandstone Aquifer	NSA Water after slurrying 6 days with coal from Braztah Mine	NSA Water after slurrying 6 days with coal from Coastal States Mine	NSA Water after slurrying 6 days with coal from Consolidation Mine	NSA Water after slurrying 6 days with coal from Wilberg Mine
Manganese (µg/l)	< 9	20	194	22	74
Mercury (µg/l)	1.1	3.2	1.4	1.7	1.7
Molybdenum (µg/l)	27	46	71	34	33
Nickel (µg/l)	<70	<70	<70	<70	<70
pH (laboratory)	8.25	8.06	7.72	7.99	7.63
Phosphorus (totol µg/l)	32	47	39	29	14
Potassium (mg/l)	3	2	6	4	9
Selenium (µg/l)	<0.6	<0.6	2.6	<1.2	1.9
Silica (mg/l)	1.7	2.2	2.9	6.1	8.1
Silver (µg/l)	< 7	< 7	< 7	< 7	< 7
Sodium (mg/l)	424	505	394	468	419
Strontium (mg/l)	< 1	< 1	< 1	< 1	< 1
Sulfate (mg/l)	616	639	704	633	690
TDS (mg/l)	2,224	2,276	2,508	2,396	2,468
Vanadium (µg/l)	<12	<12	<12	<12	<12
Zinc (µg/l)	< 5	< 5	18	14	35

Table 13 . Coal slurries with water from Ferron Sandstone Aquifer.

	Water from Ferron Sandstone Aquifer	Ferron Sandstone Water after slurrying 6 days with coal from Braztah Mine	Ferron Sandstone Water after slurrying 6 days with coal from Consolidation Mine	Ferron Sandstone Water after slurrying 6 days with coal from Wilberg Mine
Alkalinity (mg/1 $CaCO_3$)	200	211	180	88
Aluminum (µg/1)	270	610	300	770
Arsenic (µg/1)	2.5	<0.5	<0.5	NS
Barium (µg/1)	<70	88	104	<70
Beryllium (mg/1)	<0.1	0.1	<0.1	<0.1
Boron (µg/1)	300	2,829	2,773	2,440
Cadmium (µg/1)	< 4	< 4	< 4	< 4
Calcium (mg/1)	18	9	13	27
Chloride (mg/1)	22	47	29	42
Chromium (µg/1)	<16	<16	<16	<16
Cobalt (µg/1)	< 2	3	< 2	< 2
Copper (µg/1)	<12	<12	<12	<12
Fluoride (mg/1)	0.10	0.23	0.16	0.21
Iron (µg/1)	<76	<76	<76	<76
Lead (µg/1)	< 1	< 1	11	< 1
Lithium (µg/1)	<20	30	40	<20

Table 13 . Continued.

	Water from Ferron Sandstone Aquifer	Ferron Sandstone Water after slurrying 6 days with coal from Braztah Mine	Ferron Sandstone Water after slurrying 6 days with coal from Consolidation Mine	Ferron Sandstone Water after slurrying 6 days with coal from Wilberg Mine
Magnesium (mg/l)	26	18	35	40
Manganese (μg/l)	< 9	15	17	11
Mercury (μg/l)	1.0	2.7	1.1	0.7
Molybdenum (μg/l)	20	47	38	48
Nickel (μg/l)	<70	<70	<70	<70
pH (laboratory)	8.40	8.35	8.22	7.60
Phosphorus (total μg/l)	18	18	33	38
Potassium (mg/l)	3	2	2	5
Selenium (μg/l)	<0.6	<0.6	<0.6	1.0
Silica (mg/l)	3.2	4.4	2.6	5.7
Silver (μg/l)	< 7	< 7	< 7	< 7
Sodium (mg/l)	222	293	304	206
Strontium (mg/l)	< 1	< 1	< 1	< 1
Sulfate (mg/l)	356	360	443	411
TDS (mg/l)	940	528	952	780
Vanadium (μg/l)	<12	20	<12	<12
Zinc (μg/l)	< 5	< 5	< 5	73

By mutual agreement with BEAC no tests were run on the coal to determine what effects, if any, the slurrying would have on its burning properties. Any changes in quantities of constituents in the water before and after slurrying are attributed to the coal, i.e. they are either retained by the coal from the water, or leached from the coal by the water.

Referring to Table 12 and 13, the most noticeable effect of the slurrying is the large uptake by the water of Boron from the coal, and a smaller uptake of Molybdenum. The concentration of Boron in the water after slurrying exceeds the recommended limits for irrigation water both for use on fine textured alkaline or neutral soils for up to 20 years, and for continuous use on all soils (see Table 5). Molybdenum concentration in all samples exceeds the recommended limit for continuous use, and one sample exceeds the 20-year use limit as well (see Table 5). However, the molybdenum concentration in the water from both the NSA and the FSA exceeds the recommended limit for continuous use on all soils, even before it is slurried with the coal.

The minor increases or decreases in concentrations of the other constituents in the water apparently do not adversely affect its potential for use in irrigation. However, the effect of changes in concentrations of these same elements in the coal is not known.

E. ADDITIONAL INFORMATION OF INTEREST

1. Water and coal samples were gathered from the Atlas-Dirty Devil strip mine near Hanksville, Utah. According to the Monograph Series No. 2, 1972, Eastern and Northern Utah Coal Fields, this coal reserve is situated in T27S R9E in the northern end of the Henry Mountain coal field. About 26,000 acres are involved with an average of 5 feet of coal beneath a shallow overburden. Reserves are estimated to be 22,750,000 tons.

The coal appears to be of near coking quality, and the well that supplies water to the project apparently is in the Ferron Sandstone. The coal is presently being strip-mined, hauled to Green River, Utah, by truck, and shipped to Nevada by rail for use by the Nevada Power Company.

2. Mr. W. R. Snow of Price, Utah, leased a section of land (Section 2 T23S R9E SLB&M) which is immediately south of I-70 freeway, about midway between Salina and Green River, Utah. His intent was to construct a motel complex on the site, but so far has not been able to obtain access to the freeway from the State of Utah. He drilled a 700 ft deep well on the property which is approximately 1,000 feet south of the I-70 right-of-way fence. No well log has been located, and no pumping tests have been performed so we can only speculate concerning yield, drawdown, recharge rate, etc. However, an analysis of the water by Terralab, 5221 Major Street, Salt Lake City shows the water to be of fairly good quality.

3. CXM Drilling Co., Price, Utah, drilled a 1,456 ft deep well, about 12 miles east of Castle Dale, Utah, near Cleveland in the Buckhorn Wash country. The water was extremely salty and weighed 9 lbs/gal; the well has been capped and abandoned.

4. The IPP study showed that from 21,000 to 27,000 acre feet per year of water could be made available to their plant from the Fremont River. If the plant isn't built in that vicinity, presumably this same water may be available for other uses. However, some of the proponents of the ICC still think that there is an outside chance that the plant will be built near Caineville.

From a political point of view, underground water may be much more readily available for slurrying coal, than is surface water, and particularly if it is of a lesser quality.

APPENDIX

RELATED RESEARCH STUDIES

WATER RESOURCES STUDIES IN UTAH BY THE U.S. GEOLOGICAL SURVEY
July 1, 1977 to June 30, 1978

INTRODUCTION

This report summarizes the progress on water-resources studies in Utah by the U.S. Geological Survey during the period July 1, 1977 to June 30, 1978. Much of the work was done in cooperation with the State of Utah or local agencies; additional supporting funds were transferred from other Federal agencies or appropriated directly to the Geological Survey.

The State and local cooperators were:
Utah Department of Natural Resources
- Division of Water Rights
- Division of Water Resources
- Division of Oil, Gas, and Mining
- Division of Wildlife Resources
- Geological and Mineral Survey

Bear River Commission
Salt Lake County

The Federal cooperators were:
Bureau of Land Management
Bureau of Reclamation
Corps of Engineers
Environmental Protection Agency
Federal Power Commission

The program in Utah at the end of the reporting period consisted of 22 projects, and a discussion of each project is given in the following pages. In addition to the 22 projects, work has been or is being completed on reports for other projects. The status of the reports is as follows:

UT 117 "Brief overview of the hydrothermal resources of Utah". In review.

UT 118 "Hydrologic reconnaissance of Wasatch Plateau - Book Cliffs coal fields area, Utah". In review.

UT 119 "Reconnaissance of chemical quality of surface water and fluvial sediment in the Dirty Devil River basin, Utah". In review.

Short descriptions are given at the end of this report for three proposed projects to be started on or after July 1, 1978.

The following reports were released to the open file:

A digital model of ground-water flow in Spanish Valley, Grand and San Juan Counties, Utah: U.S. Geological Survey Open-File Report 77-760.

Dissolved-oxygen depletion and other effects of storing water in Flaming Gorge Reservoir, Wyoming and Utah: U.S. Geological Survey Open-File Report 78-92.

Hydrology of the Beaver Valley area, Beaver County, Utah, with emphasis on ground water: Utah Department of Natural Resources Technical Publication 63 (in press).

Hydrology and surface morphology of the Bonneville Salt Flats and Pilot Valley playa, Utah: U.S. Geological Survey Open-File Report 78-18.

Hydrologic reconnaissance of the Fish Springs Flat area, Tooele, Juab, and Millard Counties, Utah: Utah Department of Natural Resources Technical Publication 64 (in press).

Selected ground-water data, Bonneville Salt Flats and Pilot Valley, western Utah: U.S. Geological Survey open-file report (duplicated as Utah Basic-Data Release 30).

Selected hydrologic data, Parowan Valley and Cedar City Valley drainage basins, Iron County, Utah: U.S. Geological Survey open-file report (duplicated as Utah Basic-Data Release 28).

Selected hydrologic data, Wasatch Plateau-Book Cliffs coal-fields area, Utah: U.S. Geological Survey open-file report (duplicated as Utah Basic-Data Release 31) (in press).

Water resources of the northern Uinta Basin area, Utah and Colorado, with emphasis on ground-water supply: Utah Department of Natural Resources Technical Publication 62 (in press).

The following reports were published:

Climatologic and hydrologic data, southeastern Uinta Basin, Utah and Colorado, water years 1975 and 1976: U.S. Geological Survey open-file report (duplicated as Utah Basic-Data Release 29).

Hydrologic reconnaissance of the Dugway Valley-Government Creek area, west-central Utah: Utah Department of Natural Resources Technical Publication 59.

Map showing general chemical quality of ground water in the Kaiparowits coal-basin area, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-1033-A.

Map showing general availability of ground water in the Kaiparowits coal-basin area, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-1033-B.

Reconnaissance of water quality in the Duchesne River basin and some adjacent drainage areas, Utah: Utah Department of Natural Resources Technical Publication 55.

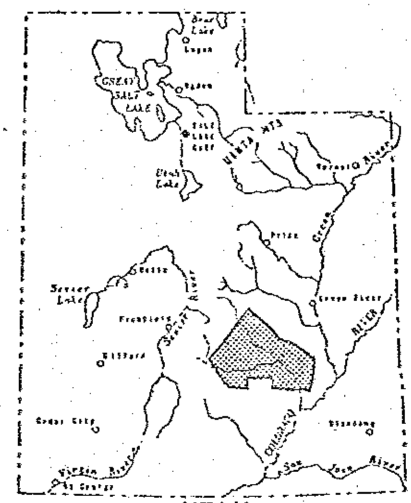
Seepage study of the Sevier Valley-Piute Canal, Sevier County, Utah: Utah Department of Natural Resources Technical Publication 58.

The historic level of Great Salt Lake, Utah, in Desertic Terminal Lakes: Proceedings of International Conference on Desertic Terminal Lakes, May 2-5, 1977, Ogden, Utah, p. 73-79.

Water resources data for Utah, water year 1976: U.S. Geological Survey Water-Data Report UT-76-1.

Current Project

Title and Number: WATER IN BEDROCK IN PARTS OF EMERY, GARFIELD, AND WAYNE COUNTIES, UTAH, WITH SPECIAL EMPHASIS ON THE NAVAJO SANDSTONE; UT 76-121 C


UTAH

Cooperating Agency: Utah Department of Natural Resources

Staff: J. W. Hood, Project Chief
T. W. Danielson, Hydrologist
Other District personnel as needed

Period of Project: July 1975 to June 1978

Objective: The principal objectives are the determination of (1) well yields from the bedrock formations, especially from the Navajo Sandstone, (2) the long-term capability of sustaining yields of suitable chemical quality, and (3) the effects of withdrawal from wells on the surface-water yields of the Colorado River basin. Implicit in these objectives is a general definition of the hydrologic system in the project area.

Approach: General definition of the hydrologic system includes the procedures used in general areal studies, including the accumulation of all available hydrologic data in the files of the Survey and from other agencies and private sources. Surface-water investigations are restricted mainly to miscellaneous measurements and water sampling at selected sites. Ground-water studies include inventory and water sampling of the few accessible wells and selected springs, test drilling, laboratory determinations of the hydraulic properties of cores and a few outcrop samples, radioisotope analysis of selected ground-water sources, infiltration-rate studies, aquifer tests, and digital modeling of the Navajo Sandstone aquifer. Tensiometers were installed at two sites in outcrops of the Navajo Sandstone.

Progress: Field work and report preparation are complete. Three reports are pending completion of review.

Plans for Next Year: None.

Reports:

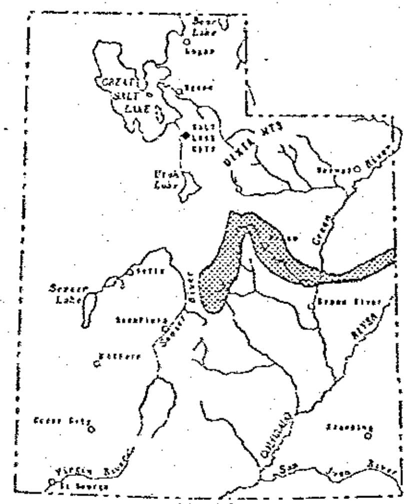
Danielson, T. W., and Hood, J. W., Recharge to the Navajo Sandstone - some methods used in its determination: Probable publication as U.S. Geol. Survey Water Resources Investigation _____ (in review).

Hood, J. W., and Danielson, T. W., Aquifer tests of the Navajo Sandstone near Caineville, Utah: Utah Dept. of Natural Resources Tech. Pub. _____ (in final review).

__________, Water in bedrock in the lower Dirty Devil River basin area, Utah, with special emphasis on the Navajo Sandstone: Utah Dept. of Natural Resources Tech. Pub. _____ (in review).

Current Project

Title and Number: SELECTED COAL-RELATED HYDROLOGIC DATA, BOOK-CLIFFS-WASATCH PLATEAU AREA, UTAH; UT 77-128 I



Cooperating Agency: U.S. Bureau of Land Management

Staff: C. T. Sumsion, Project Chief
District personnel as assigned

Period of Project: October 1976 to September 1978

Objectives: From both past and on-going drilling programs selected ground-water data are collected and tabulated to help (1) define the areal extent of aquifers that may be affected by mining and subsidence, (2) select wells for continuation and modification of the water-level monitoring program, (3) design a monitoring program to detect changes in ground-water quality, and (4) define areas for additional test drilling and chemical-quality testing.

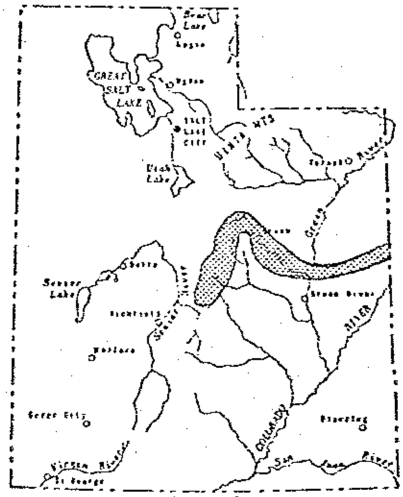
Approach: Data to fulfill the above objectives have been obtained from (1) existing file records, (2) field inquiries at drilling sites, (3) collection of test-drilliing data from all available sources, (4) field measurements of water levels, spring discharges, and water-quality parameters, (5) participation in aquifer tests by private companies and/or the USGS, and (6) collection of water samples for chemical analysis.

Progress: Hydrologic information from more than 400 sites has been collected from multiple sources, periodic measurements of water levels were made at 10 sites, and field water-quality data were collected periodically at 5 sites. Field data collection has been completed and a basic-data report is in preparation.

Plans for Next Year: None

Reports: Sumsion, C. T., Selected coal-related ground-water data, Wasatch Plateau-Book Cliffs area, Utah: U.S. Geological Survey Open-File Report (in review).

Current Project



UTAH

<u>Title and Number</u>: WATER RESOURCES MONITORING, CENTRAL UTAH COAL REGION, UTAH; UT 77-129

<u>Staff</u>: G. C. Lines, Project Chief (part time)
G. C. Plantz, Hydrologic Technician

<u>Period of Project</u>: Started October 1976; continuing

<u>Objective</u>: To determine the characteristics of the regional water-resources system and to detect and document changes in the system or in its components that may be associated with coal mining.

<u>Approach</u>: Evaluate the existing basic-data collection program for its regional surveillance value and add additional data sites or upgrade existing sites as needed. Evaluate the data so that changes due to coal mining may be detected and documented.

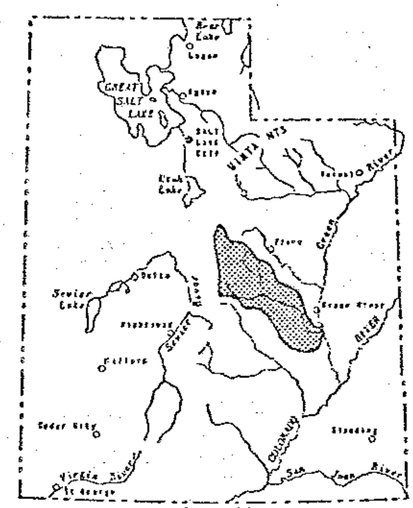
<u>Progress</u>: Existing data-collection network has been evaluated for its value in detecting changes due to coal mining. Six gaging stations have been installed in the Wasatch Plateau and Emery coal fields. Gage-house shelters for eight stations were built by private contractor. Contract specifications for operation of 12 gaging stations and miscellaneous measurements at 52 other sites have been prepared.

<u>Plans for Next Year</u>: A private contractor will operate 12 gaging stations in the Wasatch Plateau, Book Cliffs, and Emery coal fields. In addition to streamflow data, data on water quality, suspended sediment, bed material, bacteria, and benthic invertebrates will be collected at the 12 stations. Miscellaneous measurements at an additional 52 sites and chemical quality sampling at 13 of the sites will also be done by a private contractor. The data will be analyzed, quality control will be maintained, and field investigations carried out to document any changes that occur. The adequacy of the program to monitor the effects of coal mining will be evaluated, and it will be upgraded as funds permit.

<u>Reports</u>: Administrative reports will be prepared when changes in the hydrologic system, due to coal mining, can be documented.

Current Project

Title and Number: RECONNAISSANCE OF CHEMICAL QUALITY OF WATER AND FLUVIAL SEDIMENT IN THE SAN RAFAEL RIVER BASIN, UTAH; UT 78-131-C


UTAH

Cooperating Agency: Utah Department of Natural Resources

Staff: J. C. Mundorff, Project Chief (part time)
K. R. Thompson, Hydrologist, (part time)
District personnel as assigned

Period of Project: July 1977 to June 1979

Objectives: The basic objective is to define the general chemical characteristics of surface water in the 2,300-square-mile San Rafael River Basin. Seasonal variations of quality will be identified, and the general effects of natural environment and of water use will be determined. Specific problem areas for future intensive investigation will be determined.

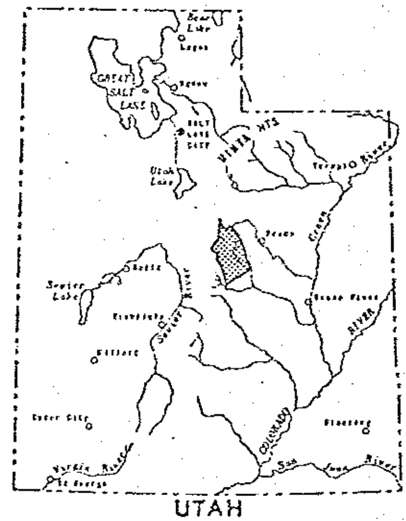
Approach: Available data from other agencies will be inventoried and compiled. These data along with information on geology, irrigation, soils, vegetation, mineral development, and runoff will be used as the basis for design of a network of about 50 water-quality observation sites at which observations will be made during periods of flow. Data on general chemistry of the water will be obtained seasonally during the period July 1977 to September 1978.

Progress: About half of the data collection was complete by June 30, 1978. The data indicate that major deterioration in water quality occurs in approximately 10-mile reaches of Huntington, Cottonwood, and Ferron Creeks downstream from points of major diversions for irrigation. For example, during the period August 10-19, 1977, dissolved-solids concentrations upstream from diversions on Huntington, Cottonwood, and Ferron Creeks were 289, 219, and 312 milligrams per liter,respectively. At the points where State Highway 10 crosses these streams, concentrations were 2,020, 933, and 975 milligrams per liter, respectively. At downstream sites on these three streams, where flow is largely depleted and is composed mainly of irrigation return flow, concentrations were 4,600 and 4,770, and 5,130 milligrams per liter respectively. Huntington and Cottonwood Creeks join to form the San Rafael River; and about half a mile downstream from this junction, Ferron Creek enters the river. The dissolved-solids concentration of the San Rafael River immediately below Ferron Creek was 5,230 milligrams per liter.

Plans for Next Year: Complete data collection by September 1 and prepare an interpretive report.

Reports: None.

Current Project



Title and Number: WATER RESOURCES OF UNDERGROUND COAL-MINING AREAS IN THE HUNTINGTON AND COTTONWOOD CREEKS DRAINAGE BASINS, UTAH; UT 78-133-C

Cooperating Agency: Utah Department of Natural Resources

Staff: T. W. Danielson, Project Chief
J. R. Butler, Hydrologic Technician

Period of Project: July 1977 to June 1980

Objectives: Determine source, quantity, and quality of the baseflow of surface water in the Huntington and upper Cottonwood Creek drainages and attempt to model snowmelt runoff. Define source and movement of ground water in selected areas and determine areal extent of aquifers. Establish baseline data concerning quantity and quality of surface and ground water in areas where mining is, or is likely to be taking place and develop methods useful in determining unnatural changes in discharge.

Approach: Conduct gain-loss study on all surface water in the project area. Sample selected sites and analyze the chemistry of the water. Using physical and chemical characteristics of selected ground-water samples, separate water into groups such that tracing of the water from one area to another is possible. In addition to these characteristics determine precise elevations of spring orifices. Assemble ground-water data which may permit delineation of the areal extent of the aquifers. Use statistical methods to develop relationships between discharges of certain springs and streams.

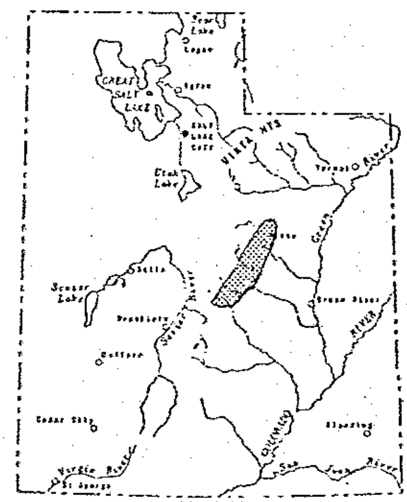
Progress: Gaging stations were installed in Tie Fork Canyon, Crandall Canyon, and Cottonwood Canyon and the gage in Huntington Canyon was reactivated. Discharge was measured periodically at several sites. About 40 springs were sampled and the chemical quality was analyzed. Biological samples were taken from several surface-water gaging sites in October 1977. Five recording rain gages were installed.

Plans for Next Year: Continue collection of spring data. Complete gain-loss study on surface water. Attempt to model snowmelt runoff in selected areas. Collect biological samples at selected surface-water sites.

Reports: None.

Current Project

Title and Number: HYDROLOGY OF THE FERRON SANDSTONE IN CASTLE VALLEY AND EFFECTS OF STRIP MINING NEAR EMERY, UTAH; UT 78-134-I


UTAH

Cooperating Agency: U.S. Bureau of Land Management

Staff: G. C. Lines, Project Chief (part time)
D. J. Morrissey, Hydrologist

Period of Project: October 1977 through September 1980

Objectives: (1) Determine the effects of stripping the upper confining layers of shale from the Ferron Sandstone aquifer and mine dewatering on:

(a) existing wells and springs;
(b) the base flow and inorganic quality of water in affected streams;
(c) quality of water in the Ferron Sandstone aquifer; and
(d) rates and directions of leakage between the aquifer and the confining layers.

(2) Determine the effects that erosion and solution of stockpiled overburden may have on the sediment and chemical characteristics of streams and the stream aquatic life. (3) Determine the recharge-discharge relationships, aquifer characteristics, and the quantity and quality of water available from the Ferron Sandstone throughout Castle Valley.

Approach: Standard techniques of hydrologic investigations will be used, including: well and spring inventory, observations of water-level fluctuations, determination of aquifer coefficients, seepage runs on streams, geophysical logging of wells, construction of a digital-computer hydrologic model.

Progress: The well inventory has been completed, and the spring inventory partially completed. Water samples and levels were obtained from approximately 15 seismic test holes into the Ferron and overlying Blue Gate Members. Three seismic holes in the Blue Gate were cased for water-level monitoring. Water levels have been measured monthly at five wells in the Ferron near the Emery Mine, and power consumption from the mine-discharge pump has been obtained monthly. Two recording rain gages have been installed. Aquifer tests have been run on two wells in southern Castle Valley and arrangements have been made for three other aquifer tests at existing wells. As part of the EMRIA drilling program, arrangements have been made for three other aquifer tests (with observation wells). Drilling specifications have been prepared for test holes at eight additional sites to define level and quality of water with depth.

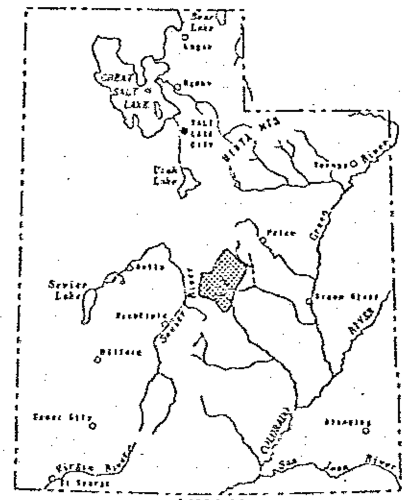
One seepage run on Quitchupah Creek and Christiansen Wash was completed. Gaging stations on these two streams are operational, and quality-of-water and sediment samples have been collected. Single-stage sediment samplers have also been installed at the two sites.

Cores for EMRIA drilling have been obtained for laboratory analysis of the rock hydraulic properties. Cores will also be used for laboratory experiments on leaching.

Plans for Next Year: Aquifer tests and sampling at EMRIA test holes and USGS wells. Seepage measurements in the fall and winter. Continued gaging station operation and chemical quality and sediment sampling. Initiate seasonal sampling for benthic invertebrates. Begin construction of a digital computer model of the ground-water system. Complete laboratory leaching experiments.

Reports: None.

Current Project


UTAH

Title and Number: HYDROLOGY OF THE CENTRAL WASATCH PLATEAU, SANPETE, SEVIER, AND EMERY COUNTIES, UTAH; UT 78-135-I

Cooperating Agency: U.S. Bureau of Land Management

Staff: G. C. Lines, Project Chief (part time)
C. T. Sumsion, Hydrologist
Vacancy, Hydrologic Technician
J. E. Tooley, Hydrologist (part time)
District Personnel as assigned

Period of Project: June 1978 through September 1981.

Objectives: (1) Define the extent and characteristics of aquifers above, within, and immediately below the coal-bearing sections of the Blackhawk Formation. Also define areas of aquifer recharge and discharge and the quantity and quality of water held in storage in each aquifer. (2) Determine the existing seasonal variability in the quantity and quality of surface water and the stream aquatic life. (3) Estimate volumes of runoff and areas inundated by runoff from storms having 1-, 10-, 25-, and 100-year recurrence intervals. (4) Determine the location and sources of water supply for significant domestic, agricultural, industrial and other uses. Identify municipal watersheds and aquifers that are the sole source of supply for public use. Determine the existing seasonal variablity in quantity and quality for the major sources of supply. (5) Where possible, predict the effects of underground coal mining and associated surface facilities on the quantity and quality of surface and ground water and stream aquatic life, with emphasis on aquifers and municipal watersheds that are the sole source of a public water supply.

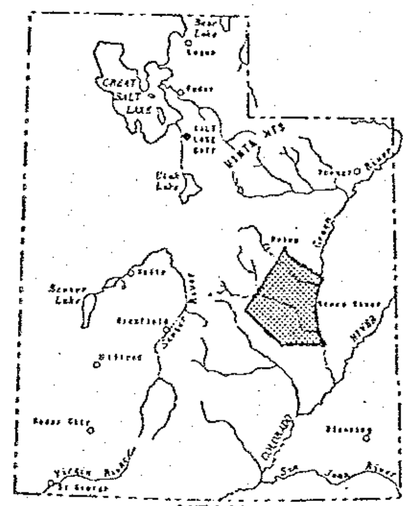
Approach: Standard techniques of hydrologic investigations will be used, including: well and spring inventory, observations of water-level fluctuations, aquifer testing, seepage runs, aquatic-biota surveys, surface-water sampling for chemical quality and sediment, flood-frequency analysis for peaks and volumes of flow.

Progress: Contact has been made with Conservation and Geologic Divisions and arrangements have been made to case and test approximately 10 test holes. Spring inventory has also been started.

Plans for Next Year: Continued data collection and analysis. Work will also be completed on a preliminary report to be used by BLM for environmental analysis.

Reports: None.

Proposed Project


UTAH

Title and Number: WATER IN BEDROCK IN THE NORTHERN SAN RAFAEL SWELL AREA, EMERY AND CARBON COUNTIES, UTAH, WITH SPECIAL EMPHASIS ON THE NAVAJO SANDSTONE; UT 136-C

Cooperating Agency: Utah Department of Natural Resources

Staff: J. W. Hood, Project Chief
Vacancy, Hydrologic Technician
Other District Personnel, as assigned

Period of Project: July 1, 1978 to June 30, 1981

Objectives: Determine or estimate so far as possible: (1) Potential well yields of the pre-Mancos Shale formations. (2) The long-term capability of the aquifers to sustain yields of water of useful chemical quality. (3) The probable effects of ground-water withdrawals on the surface-water supply of the Colorado River system. Implicit in these objectives is a general definition of the hydrologic system in the project area.

Approach: Definition of the hydrologic system will use the procedures of general areal studies, including accumulation of existing hydrologic and geologic data, and the use of existing base maps and geologic maps with minor modifications made in the field.

No surface-water gaging network is planned; concurrent and previous data will be used. Miscellaneous streamflow measurements and sampling will be done only in selected areas that may provide data significant to the ground-water evaluation.

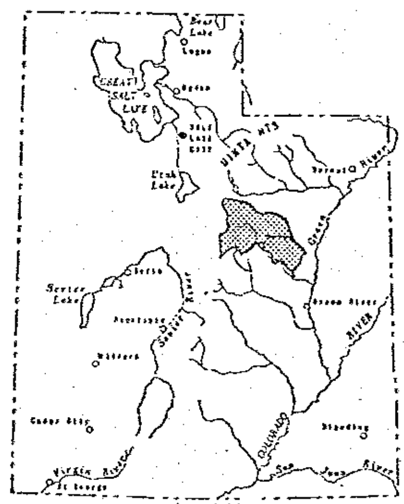
The distribution, thickness, and structural attitude of aquifers will be evaluated from existing geologic maps, photogeology, and the relatively abundant data from oil-test holes and other mineral exploration records.

The ability of the aquifers, such as the Navajo Sandstone, to take in, store and discharge ground water will be evaluated from any well tests that can be run. Such tests will be supplemented by other tests, possibly including outcrop tensiometer installation, ring-infiltrometer tests, and laboratory tests of rock specimens for hydraulic conductivity and porosity. The data obtained will be used for a generalized digital model for evaluating general conclusions and computations-construction of a predictive model is considered unrealistic, owing to the lack of data and the fracturing that modifies the basic aquifer characteristics.

Existing chemical analyses of ground water will be supplemented with selective sampling. In general, only the common dissolved constituents will be determined and evaluated for utility of the water, but some minor or trace elements may be determined for the purpose of interpreting interformational movement of water.

Proposed Project

Title and Number: HYDROLOGY OF THE PRICE RIVER BASIN, WITH EMPHASIS ON AREAS UNDERLAIN BY COAL; UT 138-I



UTAH

Cooperating Agency: U.S. Bureau of Land Management

Staff: Vacancy, Project Chief
Vacancy, Hydrologic Technician

Period of Project: October 1978 to September 1981

Objectives: To determine the effects of present and proposed coal mining on the hydrology of the Price River Basin. Specifically to determine the effects of coal mining (including the effects of existing and potential land subsidence) on surface-water quantity, quality, and biology; ground-water recharge, movement, discharge, and quality; and sediment yields.

Approach: Study the occurrence of ground water in the basin including recharge, movement, discharge, and aquifer properties. Evaluate surface-water supplies, including identification of streamflow, of flood-prone areas, biological characteristics and sediment yields. Determine surface water-ground water interrelationships and the chemical characteristics of ground and surface water. Study the occurrence of water in existing coal mines and evaluate the effects of mining on the hydrologic system.

Plans for Next Year:

1. Literature survey and search of the files of Federal and State agencies to compile data previously collected in the area that will be useful in this study.

2. Contacting coal and oil companies to obtain drilling data and available hydrologic data, including data on the occurrence of water in existing coal mines.

3. Inventory of wells and springs and collection of samples of surface and ground water for chemical analysis.

4. Determining water-bearing zones in the stratigraphic section using information obtained in (1), (2), and (3).

5. Making seepage measurements along streams to indicate reaches gaining water from or losing water to the ground-water reservoir.

6. Designing a data-collection network to supplement present and past sites for collection of surface-water, ground-water, sediment, water-quality, and precipitation data.

7. Determining the need for test-drilling to obtain ground-water data; and if deemed necessary, design a drilling and testing program and prepare specifications for a contract.

8. Conducting aquifer tests on existing wells to determine hydraulic characteristics of aquifers.