Section 19 - West Colorado River Basin
Groundwater

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Section 19

West Colorado River Basin - Utah State Water Plan

Groundwater

19.1 Introduction [24]

Surface water occurs in readily discernible drainage basins, while groundwater occurs in aquifers that are hidden from view. The boundaries of an aquifer may outcrop at the surface or be deeply buried. At any given location, the land surface may be underlain by several aquifers. Each aquifer may have a different chemical quality and different hydraulic potential. Each aquifer may be recharged in a different location and flow in a different direction. Groundwater divides do not necessarily coincide with surface water divides. For these reasons, the development and management of groundwater is more complicated than that of surface water.

Development of the groundwater resources in the West Colorado River Basin to date has been minor. This is due to several reasons: 1) The general absence throughout the basin of productive and easily developed alluvial aquifers; 2) the unfractured consolidated aquifers generally have hydraulic properties that are not conducive to large-scale groundwater development; 3) the quality of the groundwater in some parts of the area is unsuitable for domestic, municipal, and/or agricultural uses; and 4) the economics of drilling and pumping water from deeply buried consolidated aquifers is not economical for many uses.

In order to adequately address the highly diverse hydrogeology in the West Colorado River Basin, the discussion of groundwater and aquifers is divided into smaller basins. Each of these smaller basin subdivisions has unique aspects to its groundwater setting.19

19.2 Aquifer Characteristics [36, 37, 39,, 49, 50]

From Table 19-1 it is evident that the most productive aquifers within the basin consist of alluvium, basaltic lava flows, and Mesozoic and Paleozoic aged sedimentary formations of limestone and sandstone.

While groundwater is not a major source of water in the West Colorado River Basin, locally it is very important. In some communities it is the sole source of culinary-grade water.

Unconsolidated, valley-fill materials have traditionally been the best producers of groundwater in Utah. About 98 percent of the wells in Utah are completed in unconsolidated deposits. In the West Colorado River Basin, however, the occurrence of unconsolidated deposits is limited. The unconsolidated deposits, where present, are composed of alluvium and lacustrine deposits consisting of gravel, sand, clay and silt.

Alluvial aquifers are generally characterized by high transmissivities (up to 14,000 feet per year) and high storage coefficients (up to 20 percent). They are often thin and thus frequently connected to surface water sources and, therefore, subject to contamination. In most areas of the West Colorado River Basin the unconsolidated aquifers are thin and found in the bottoms of canyons, in stream valleys, and as discontinuous caps on terraces. These deposits are rarely more than 20 to 50 feet thick.

Due to the lack of alluvial aquifers in much of this basin, the only other groundwater that could be developed is from consolidated or bedrock aquifers. The best producing consolidated aquifers are volcanic basalt flows and sandstone formations.

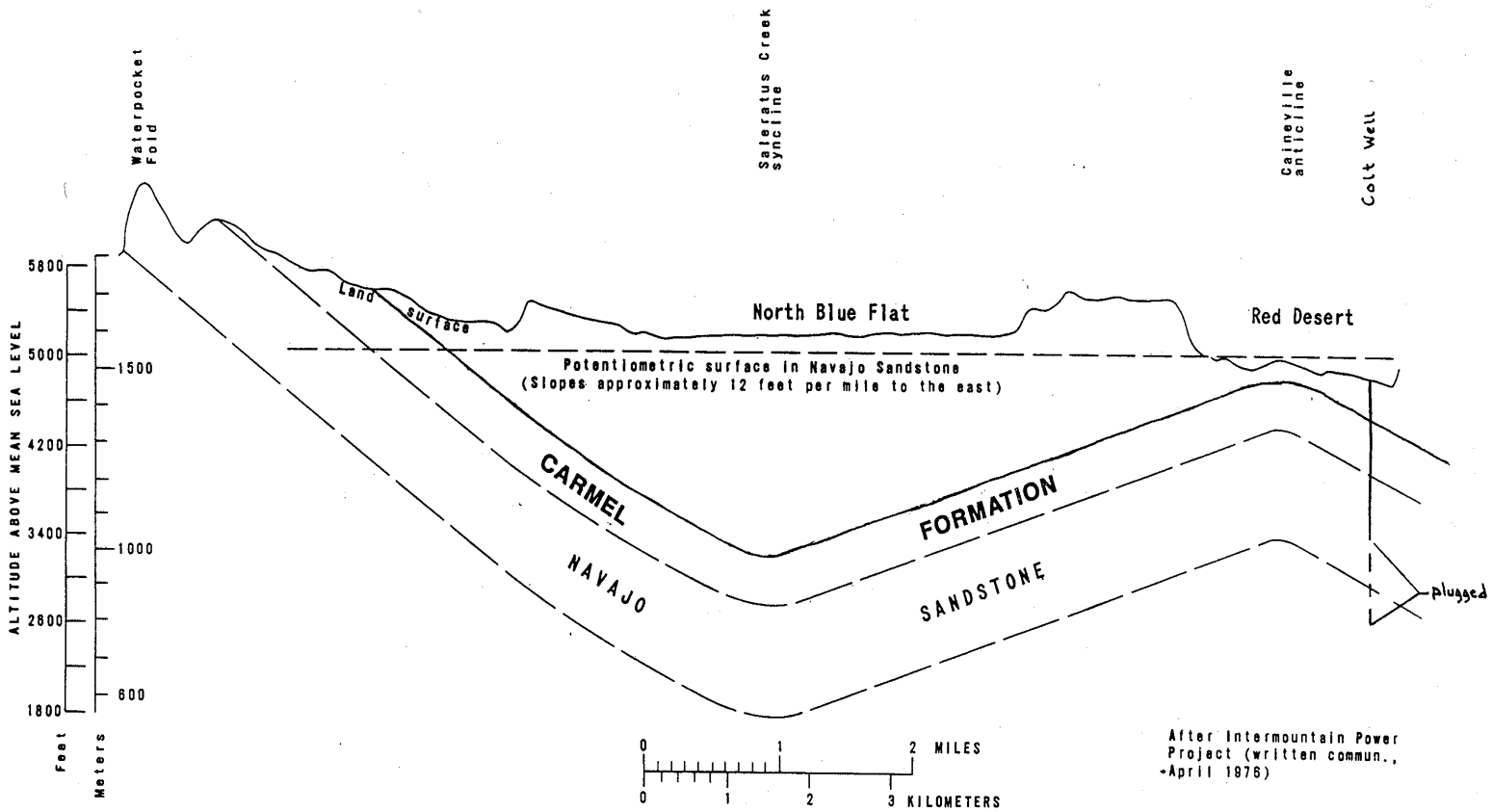
Table 19-1 Characteristics of Selected Aquifers		
Formation	Permeability (ft/d)	Transmissivity $(ft/d)^2$
Alluvium	0.5 to 500	200 to 14,000
Basalt Flows	0.5 to 500	50 to 14,000
Flagstaff	0.5 to 500	nd
North Horn	0.5 to 5	nd
Price River	5 to 500	nd
Entrada	0.5 to 50	5 to 200
Navajo	0.5 to 50	1 to 14,000
Wingate	0.5 to 50	nd
Kaibab	0.5 to 50	nd
Coconino	0.5 to 50	10
Source: Schlotthauer & others, Tables 9 & 10, 1981.		

The Entrada Sandstone, the Navajo Sandstone, the Wingate Sandstone, and the Coconino Sandstone, including its equivalents in the Cutler Formation, have been found to yield water to springs or wells in sufficient quantity and quality to be useful. Of these, the Navajo Sandstone aquifer has been the most studied.

Groundwater in these consolidated formations is unconfined in locations nearest areas of recharge. Confined conditions, however, are the most common. It is estimated that confined conditions occur in about 90 percent of the area within the basin which is underlain by sedimentary rocks. Artesian conditions exist where the confined aquifers are pressurized, such as the Red Desert area north of Caineville (see Figure 19-1). In the Colt well, the top of the Navajo Sandstone was encountered at 710 feet below ground while the artesian water level stood at 178 feet above ground.

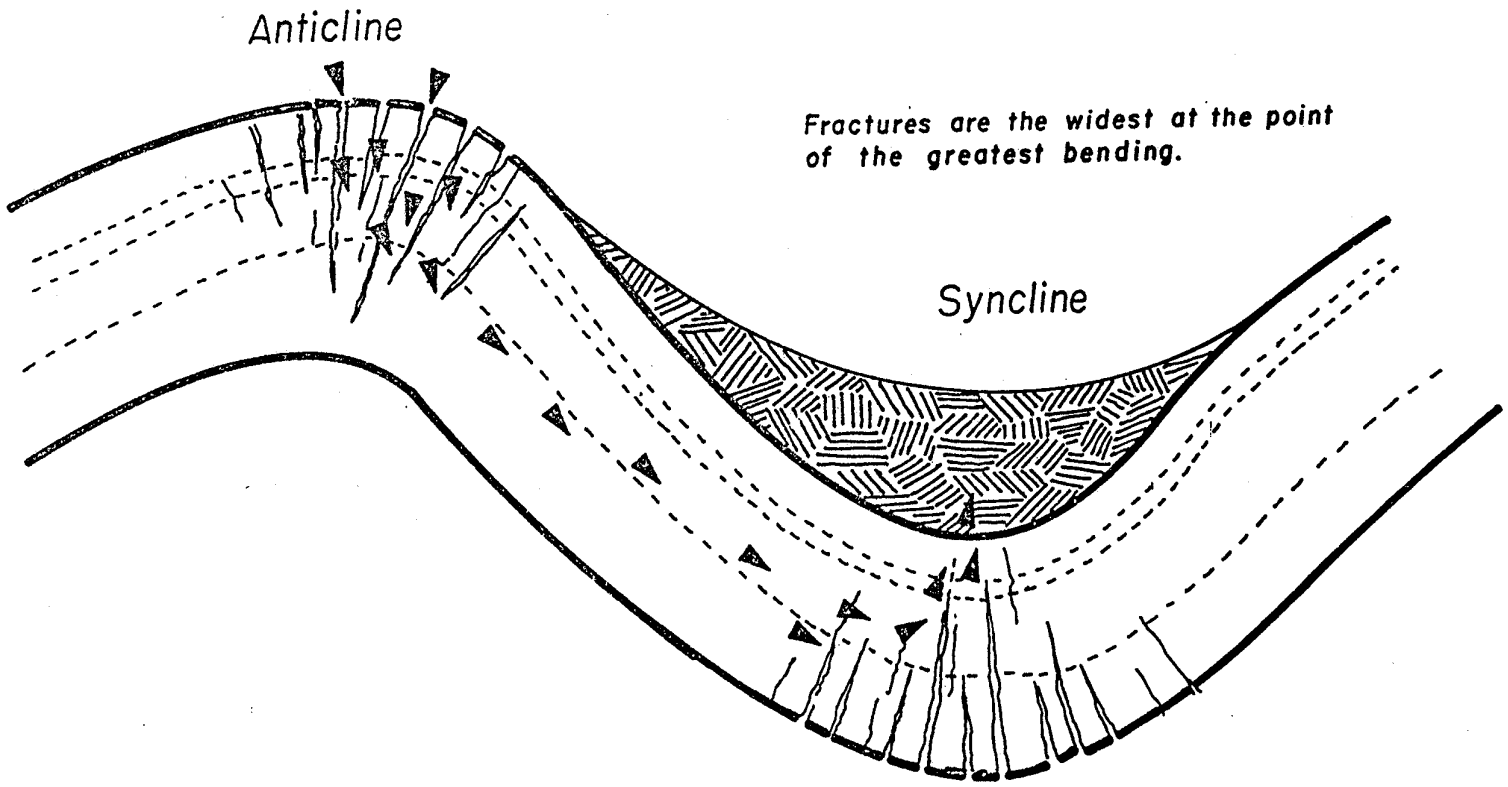
The circulation of groundwater in these consolidated aquifers is affected by folding and faulting, which locally will either enhance groundwater movement by fracturing (See Figure 19-2) or impair groundwater movement by offsetting aquifers, as across Joes Valley. Fracturing also, locally, enhances interformational leakage which affects water quality.

The Navajo Sandstone aquifer underlies most of the West Colorado River Basin and ranges from 400 to 1,600 feet in thickness. It is cross-bedded, massive, and made up of very fine to fine-grained, poorly to well-cemented sand. Between 1971 and 1974, extensive studies of the Navajo Sandstone aquifer were carried out by the Intermountain Consumers Power Association and then by the Intermountain Power Project. These studies were made during planning for the construction of a coal-fired electrical generation plant in the area north of Caineville. From these studies came the following characteristics of the Navajo Sandstone aquifer. The unfractured sandstone as an aquifer is characterized as homogeneous and isotropic. However, geologic mapping and the results of extensive well tests indicate that the Navajo Sandstone is frequently fractured so that the overall permeability is increased and the formation can be



Generalized east-west section showing folding of the Navajo Sandstone.

Figure 19-1



Graphic illustration of stress concentrations in folded rocks

Figure 19-2

considered heterogeneous and probably anisotropic on a regional scale. The average hydraulic conductivity is about 0.5 ft per day. Transmissivity, calculated from a 30-day pump test, averaged 1,500 feet per day. Under artesian conditions, a generalized value for Storage Coefficient is 0.001 and the value for Specific Yield is estimated to be between 5 and 10 percent.

Table 19-2 summarizes the storage characteristics of the Navajo Sandstone for those groundwater basins where studies by the U.S. Geological Survey have been conducted.

19.3 Groundwater Basins

As shown on Figure 19-3, the West Colorado River Basin consists of five groundwater basins which, although connected by surface flows, are geologically separate. Due to the sparse population and lack of industrial development, no detailed studies have been conducted in any of these basins, with the exception of the Intermountain Power Project study in the Red Desert north of Caineville. Only very general information needed to determine the simplest groundwater budgets has been gathered.

19.3.1 Castle Valley Groundwater Basin [13, 21, 33, 35, 42, 60]

Castle Valley has been eroded into the thick, Mesozoic aged Mancos Shale formation (see Figure 19-4-A). It is understood that geologic conditions in this area of Emery and Carbon counties are mostly unfavorable for producing groundwater from wells, especially of the quality and quantity that would be required for a municipal supply. The highest producing wells and springs which occur in this basin have been developed outside of Castle Valley in the neighboring Wasatch Plateau, where the sandstone and limestone beds of the Flagstaff (T_1 in Figure 19-4-A), North Horn (TK), and Price River (uppermost K_3) formations have yielded water. The main Jurassic/Triassic age aquifers (Entrada J_1, Navajo, and Wingate Sandstones JTR) are all too deeply buried to be considered as economically feasible groundwater targets.

Not enough data have been gathered in this groundwater basin to determine a groundwater budget. Table 19-3 indicates there are 488 wells (see Figure 19-5) and 2,930 springs (see Figure 19-6) whose water rights status is categorized as either perfected or approved. In this basin for the 15-year period 1979 through 1993, an average 10 percent of total municipal water supplies was groundwater (see Table 19-4). A total of 648 acre-feet was produced from springs, while 4,079 acre-feet was produced from wells during this time period.

Water quality has not be studied sufficiently in this groundwater basin to allow a detailed discussion. In general, the thick Mancos Shale (K_2) and other coal bearing bedrock units (Castlegate Sandstone, Blackhawk Formation, and Star Point Sandstone of K_3) have produced water of poor quality. Some concern has been expressed about coal mining activities and the effect it has on water quality. See Policy Issues and Recommendations, Section 19.5, for discussion of this issue. Better quality water is found in the overlying Tertiary and uppermost Cretaceous beds (Flagstaff, North Horn, and Price River formations).

19.3.2 San Rafael Swell Groundwater Basin [21, 35, 38]

The San Rafael Swell is a broad, asymmetrical upwarp which is about 70 miles long and 30 miles wide (see Figure 19-4-B). Its asymmetry comes in part from the fact that strata on the west side have a shallow westerly dip of 2 ° to 6 °, while strata on the east side, by contrast, dip steeply to the east from 45° to 85°. Mesozoic and Paleozoic rocks are exposed on the flanks of the swell where they can receive recharge (see Figure 19-4-B).

All the formations in the geologic section contain some water, but only five are considered to be major aquifers because of their large areal extent, their thickness, and their potential for locally large yields to individual wells. These five are the Entrada (J_1), Navajo and Wingate Sandstones (JTR), the Coconino Sandstone P_1, and the limestone units of Mississippian age (M_1) (see Figure 19-4-B). Due to economic constraints of drilling deep bedrock wells, the most shallow and accessible sandstone units, the Entrada and the Navajo, have become the most common targets for groundwater development.

Table 19-2
Estimated Storage Characteristics of Navajo Sandstone[1]

Groundwater Basin	Average Thickness (feet)	Area (square miles)	Percent Saturated	Estimated Effective Porosity [3] (percent)	Volume of Groundwater in transient storage [4] (millions of acre-feet)	Assumed Specific Yield [5] (percent)	Water [2] in Transient Storage Assuming Complete Drainage (millions of acre-feet)	Water in Upper 100 Feet of Aquifer (millions of acre-feet)
San Rafael Swell	412	2,300	87	18	94	9	42 [2]	12
Lower Dirty Devil River	800	2,580	75	20	198	9	89 [2]	11
Kaiparowits Plateau	1,600	2,150	83	25	434	10	190 [2]	11

[1] Information gathered and published by the U. S. Geological Survey. (Technical Publication #s 78, 68, 81)
[2] The values stated for water recoverable from storage are calculated based on hydrologic theory. Actual recoverable amounts would be less because of various physical limitations, including depth to aquifer, well spacing and well yields, and various economic, legal and environmental constraints such as land ownership.
[3] Effective porosity is defined as the volume of void spaces through which water can travel in a rock or sediment divided by the total volume of the rock or sediment.
[4] Transient storage is the amount of water which is moving through an aquifer, analogous to the “active storage” of a surface reservoir and does not include isolated water or “dead storage”.
[5] Specific yield is the ratio of the volume of water that will drain under the influence of gravity to the volume of saturated rock. This groundwater may not be economically or legally recoverable.

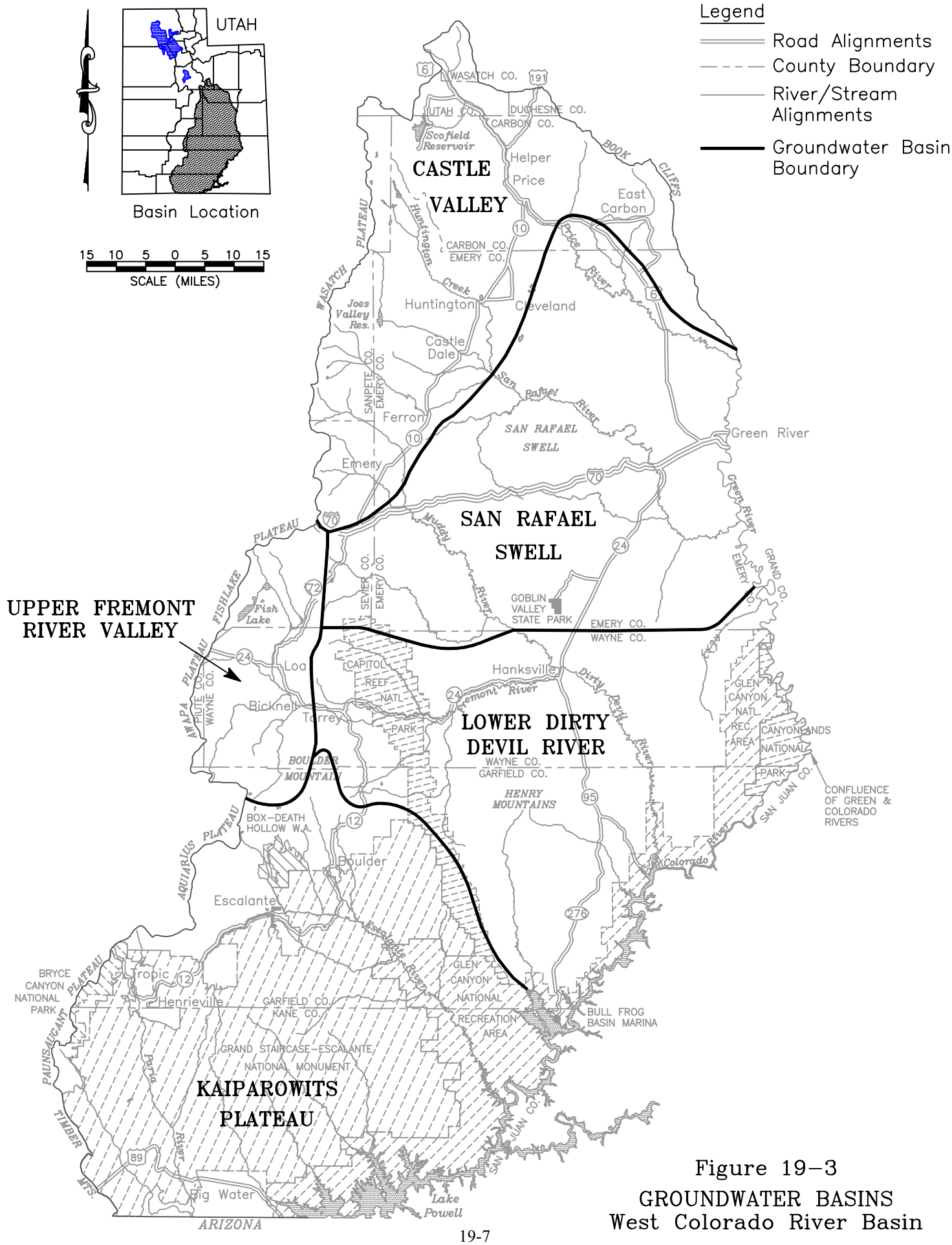


Figure 19–3
GROUNDWATER BASINS
West Colorado River Basin

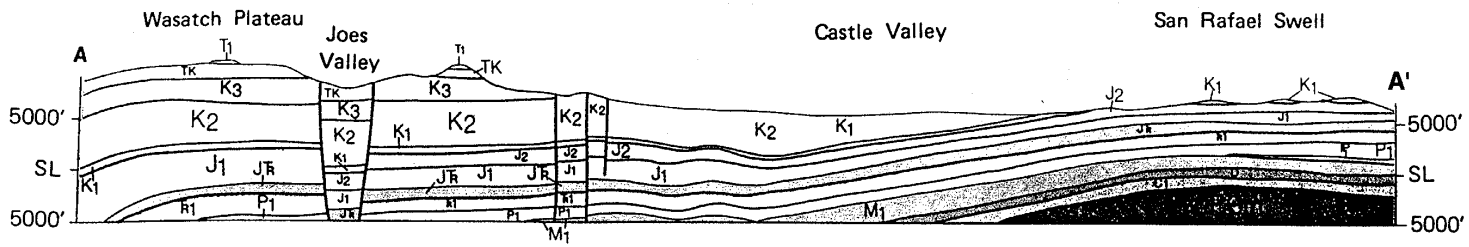


Figure 19 - A

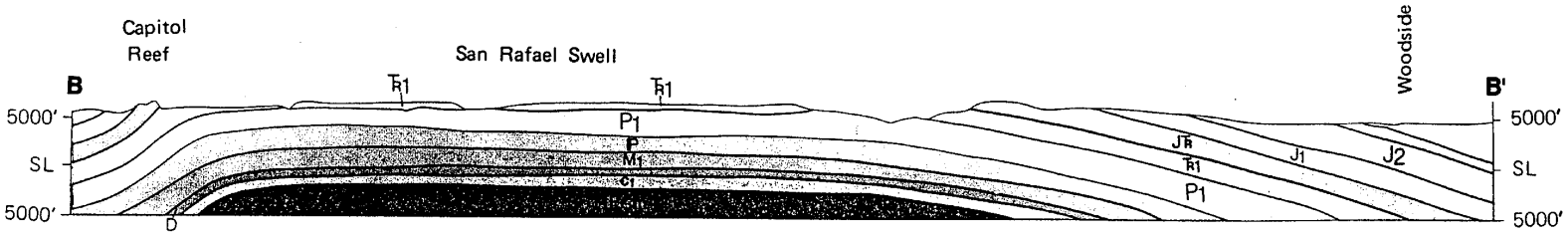


Figure 19 - B

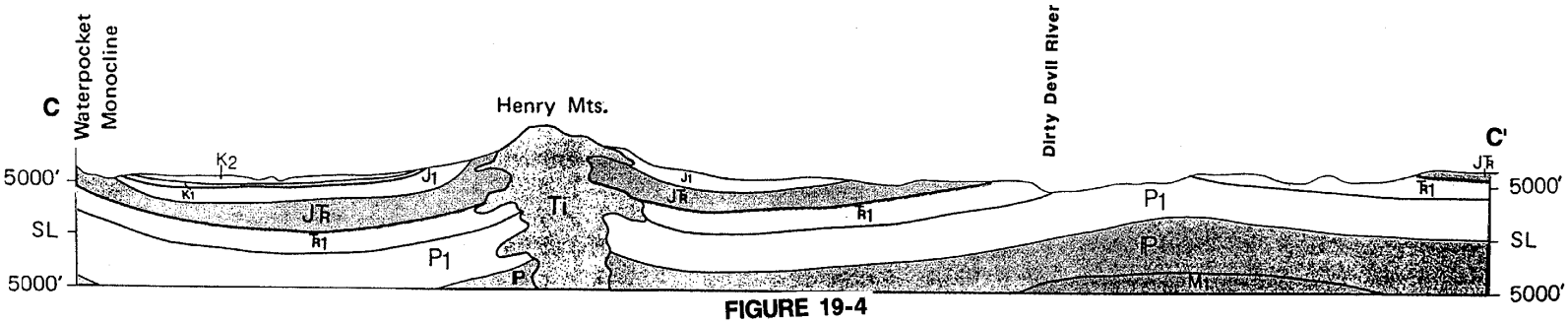


Figure 19 – C

FIGURE 19-4
GEOLOGIC CROSS SECTIONS
(LOCATIONS ON FIGURE 19-3)

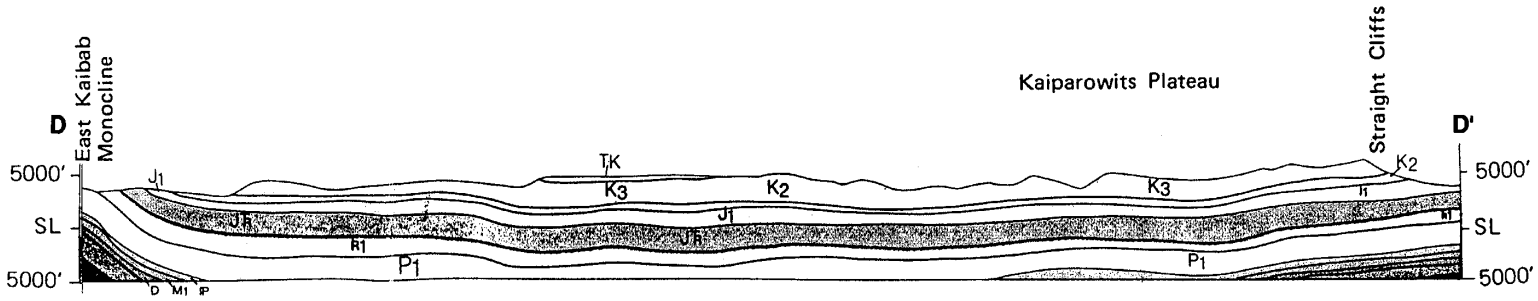


Figure 19 - D

Geologic Legend for Cross-sections

Tertiary
- T_1 - Flagstaff Formation
- TK - North Horn & Canaan Peak Formations

Cretaceous
- K_3 - Price River Fm., Castlegate Sandstone, Blackhawk Formation, Star Point Sandstone
- K_2 - Mancos Shale
- K_1 - Dakota Sandstone & Cedar Mtn. or Burro Canyon Fm.

Jurassic
- J_2 - Morrison Formation
- J_1 - Bluff Sandstone, Summerville Formation, Curtis Formation, Entrada Sandstone, Carmel Formation
- JR - Navajo Sandstone, Kayenta Formation, Wingate Sandstone

Triassic
- R_1 - Moenkopi Formation

Permian
- P_1 - Cutler Group

Pennsylvanian
- P - Hermosa Group

Mississippian
- M_1 - Redwall Lms.

Devonian
- D - Ouray Lms., Elbert Fm., McCracken Ss., Aneth Fm.

Cambrian
- C_1 - Tapeats Qtzt.

FIGURE 19-4
Continued

Table 19-3
Springs and Wells by Basin

Groundwater Basins	Springs	Wells
Castle Valley	2,930	488
San Rafael Swell	294	109
Upper Fremont River Valley	499	100
Lower Dirty Devil River	479	301
Kaiparowits Plateau	698	388
Total	4,900	1,386

Source: Division of Water Rights.

Table 19-4
Groundwater Contribution to Municipal Supply
1979-1993

Groundwater Basins	Total Municipal Supply 1979-1993 (ac-ft)	Groundwater Source		Groundwater Percentage of Total Municipal Supply
		Springs (ac-ft)	Wells (ac-ft)	
Castle Valley	7,000	648	80	10
San Rafael Swell	6,265	0	0	0
Upper Fremont River Valley	5,720	4,938	782	100
Lower Dirty Devil River	4,673	3,560	1,113	100
Kaiparowits Plateau	12,496	9,218	3,278	100
Total	36,404	18,364	5,253	310

Source: Division of Water Rights.

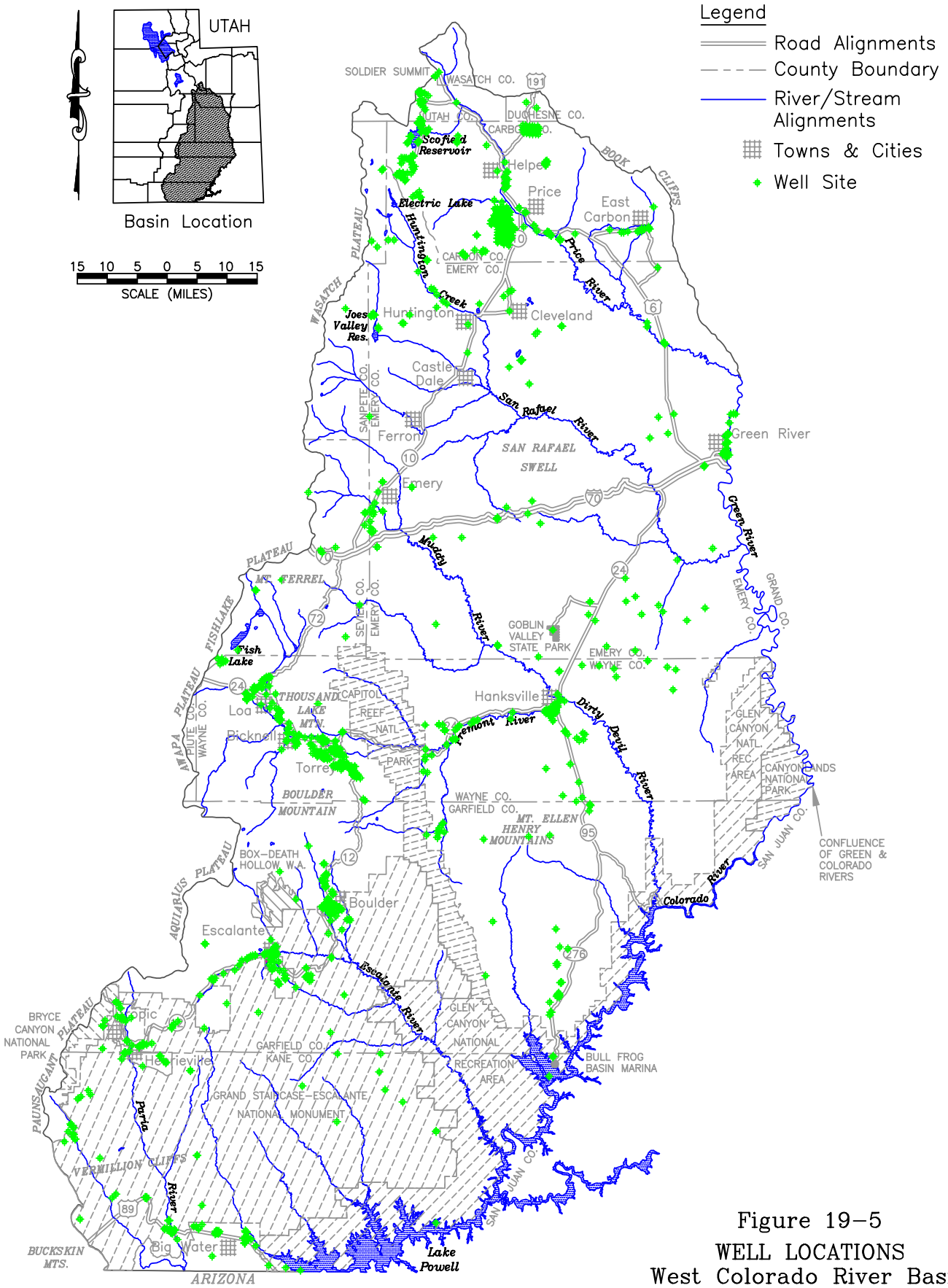


Figure 19–5
WELL LOCATIONS
West Colorado River Basin

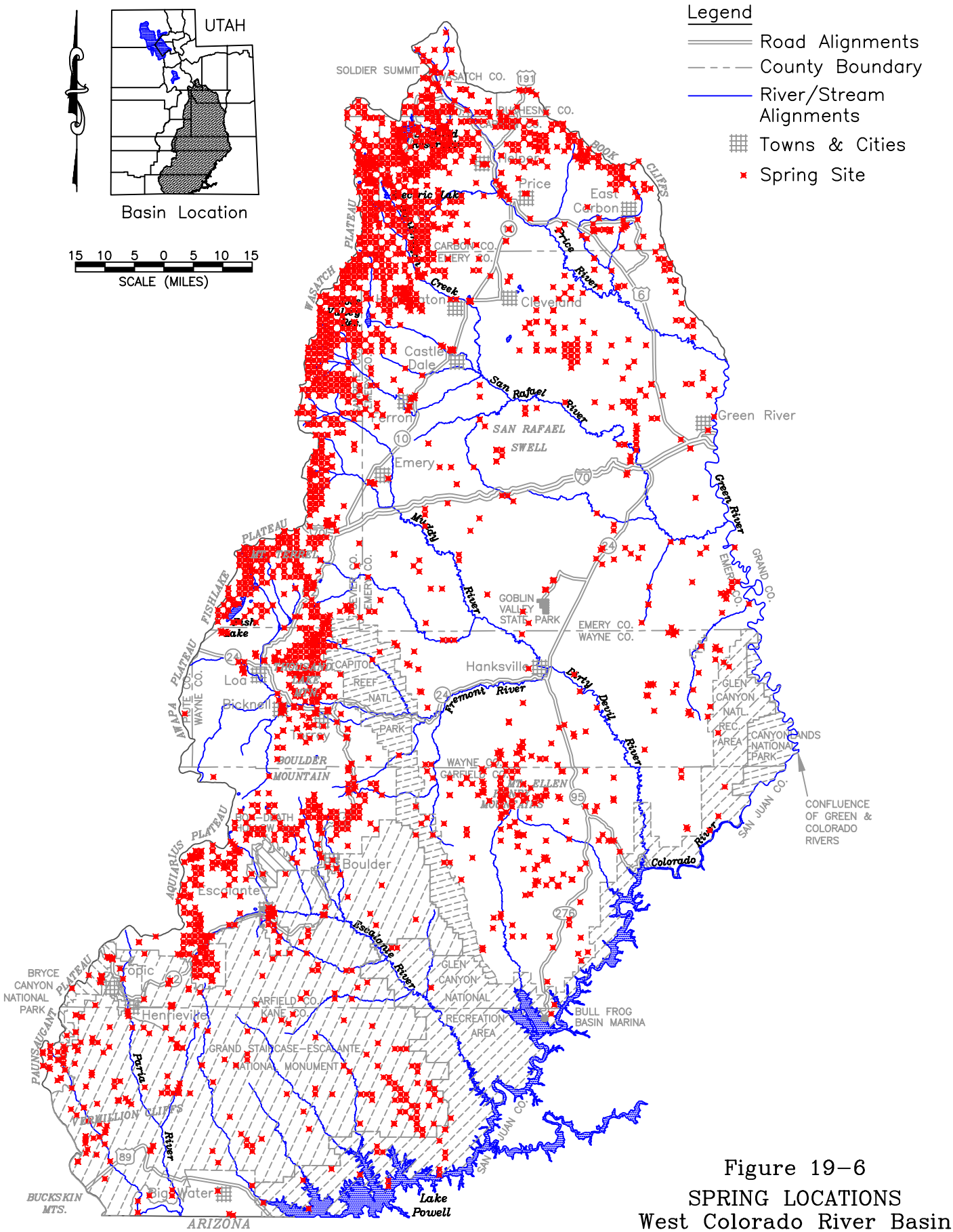


Figure 19–6
SPRING LOCATIONS
West Colorado River Basin

Table 19-5 Groundwater Budget of the San Rafael Basin		
Component	Long-Term Average (ac-ft per year)	
	Navajo Sandstone	Basin Total
Recharge		
Precipitation	3,000	10,000
Recharge from Stream Loss (not known)	--	--
Subsurface Inflow (not known)	--	--
Total	3,000	10,000
Discharge (figured for Navajo Sandstone only)		
To Gaining Streams	2,000	Moderate Amount
Evapotranspiration + Springs	400	Majority
Subsurface Outflow	600	Minor Amount
Total	3,000	10,000

Table 19-5 shows the groundwater budget from the 1984 USGS study. Table 19-3 indicates that located within this basin are 109 wells (see Figure 19-5) and 294 springs (see Figure 19-6) whose water rights status is categorized as either perfected or approved. For the 15-year period from 1979 through 1993, none of the municipal supply was supplemented by groundwater (see Table 19-4), although there is a well at Goblin Valley State Park which supplies water from the Navajo Sandstone to park visitors. The average population during this time period was 1,136, all located in the town of Green River.

An estimated 87 percent of the Navajo Sandstone in this groundwater basin is saturated. Based on the figures in Table 19-2, there is 11.5 million acre-feet of water in the upper reaches of the Navajo Sandstone. It is not presently known how much of this resources is economically and legally recoverable.

The water budget shows the bedrock aquifers are full and overflowing. The water in storage is so large in comparison to recharge and discharge that substantial additional groundwater could be developed with a carefully planned system of wells without significantly affecting surface flow, spring discharge or existing water rights.

In this basin, consolidated bedrock aquifers are most likely to contain fresh water nearest their outcrop areas, where recharge takes place. Known occurrences of fresh water in the Navajo Sandstone include outcrop areas east and west of the San Rafael Swell, but also at depth in a broad area extending from the east edge of the Swell to the Green River. In most other areas, water in the Navajo shows some degradation by mixing with more saline water from overlying and/or underlying formations through interformational leakage.

19.3.3 Upper Fremont River Valley Groundwater Basin [11, 21]

The largest and most productive alluvial aquifers in the West Colorado River Basin are in the upper Fremont River Valley in the vicinity of Loa,

northwestern Wayne County. Here the valley-fill material is as thick as 500 feet. Through well and spring development, groundwater from the unconsolidated aquifers in the upper Fremont Valley has been utilized for drinking water, irrigation, stock watering and fish culturing. Wells and springs in these deposits are found to yield from less than 10 gpm to greater than 1,000 gpm. The other productive aquifer in this basin is the volcanic basalt flows of Rabbit Valley in western Wayne County. Interconnecting columnar joints greatly add to the aquifer's ability to recharge, store, transmit and discharge groundwater. Numerous springs and wells are supplied by the basalt. Pine Creek Spring flows at 17.6 cfs, while some individual wells produce nearly 4.6 cfs. Springs at the head of Spring Creek flow at 10-12 cfs.

Not enough data have been gathered in this basin to determine a groundwater budget. Within this basin are 100 wells (see Figure 19-5) and 499 springs (see Figure 19-6). In this basin, all municipal water supplies come from groundwater (see Table 19-4), 85 percent of it from springs.

Water quality in this basin is generally very good. because the main aquifers are alluvium and basaltic lava flows, neither of which have many soluble minerals which would degrade water quality.

19.3.4 Lower Dirty Devil River Groundwater Basin [21, 35, 37]

The Henry Mountains set in the midst of a large structural basin (see Figure 19-4-C). Folding, faulting, and igneous intrusion are the principal factors that influence the permeability of consolidated rocks in this basin. While the Henry Mountain intrusions are themselves mostly impermeable, their emplacement resulted in extensive fracturing of intruded rocks, thus increasing the permeability of the enveloping sedimentary strata. The USGS studied this area in 1984 and developed a groundwater budget as shown in Table 19-6. There are 301 wells (see Figure

Table 19-6
Groundwater Budget of the Lower Dirty Devil River Basin

Component	Long-Term Average (ac-ft per year)	
	Navajo Sandstone	Basin Total
Recharge		
Precipitation	5,000	34,000
Recharge from Stream Loss (not known)	--	--
Subsurface Inflow (not known)	--	--
Total	5,000	34,000
Discharge		
To gaining streams	--	Moderate Amount
Springs and Wells	--	Very Minor Amount
Evapotranspiration	–	Majority
Subsurface Outflow	--	Minor Amount
Total	5,000	34,000

19-5) and 479 springs here (see Figure 19-6 and Table 19-3). In this basin, 100 percent of municipal water supplies comes from groundwater (see Table 19-4), more than two-thirds from springs. A total of 3,560 acre-feet was produced from springs, while 1,113 acre-feet was produced from wells.

An estimated 75 percent of the Navajo Sandstone in this groundwater basin is saturated. Based on the figures in Table 19-2, there is 11 million acre-feet of water in the upper 100 feet of the Navajo Sandstone. More work needs to be done to determine how much of this is economically and legally recoverable. As in the San Rafael groundwater basin, the water budget for this basin shows that the bedrock aquifers are full and overflowing.

From studies conducted and reported by the USGS, it has been determined that the Navajo Sandstone in this basin contains fresh water over large areas, but locally is degraded by interformational leakage to qualities ranging from slightly saline to briny.

19.3.5 The Kaiparowits Plateau Groundwater Basin [12, 21]

The Kaiparowits Plateau consists of nearly flat-lying sedimentary rocks and overlies the Kaiparowits structural basin, where the down-turned Navajo Sandstone reaches depths at or below sea level (see Figure 19-4-D). The plateau is bounded on the west by the Cockscomb Ridge which is a hogback formed on the East Kaibab Monocline. The monocline dips steeply eastward as much as 86 degrees. The Navajo Sandstone is intensely fractured along this fold. This secondary porosity enables a large percentage of the precipitation in the area to infiltrate as recharge. The Kaiparowits Plateau is bounded on the east by the Straight Cliffs, which is a cuesta formed along the west limb of the Circle Cliffs upwarp. Here the strata has a gentle westward dip.

In 1986 the USGS studied this area and came up with the very general groundwater budget shown in Table 19-7. Within this basin are 388 wells (see Figure 19-5) and 698 springs (see Figure 19-6 and Table 19-3). In this groundwater basin, most of the municipal water supplies come from groundwater (see Table 19-4). An estimated 83 percent of the Navajo Sandstone in this basin is saturated. Based on figures in Table 19-2, there is 10.9 million acre-feet of water in the upper 100 feet of the Navajo Sandstone aquifer. More work needs to be done to determine how much of this is economically and legally recoverable. Again, as in the San Rafael and Upper Fremont groundwater basins, the water budget of this basin shows bedrock aquifers are full and overflowing.

From studies conducted and reported by the USGS, it has been determined that groundwater in the Navajo Sandstone in this basin ranges from fresh to slightly saline. As expected it is freshest in the principal recharge areas (near Boulder Mountain, the Paria Plateau and the western side of the Kaiparowits Plateau) where unconfined conditions exist. In these areas, the Navajo is either at the surface or is overlain by alluvium or dune sand. The water is slightly saline in areas of deepest burial where the formation is completely saturated and is overlain by the Carmel Formation. Areas such as this, where the Navajo aquifer is confined, exist throughout the basin and were identified particularly near the Paria River where it is crossed by U.S. Highway 89 and in the Wahweap Bay area near Lake Powell. In areas dominated by unconfined conditions, the predominant water type is calcium magnesium bicarbonate. In areas of confined conditions, the water type is generally sodium sulfate.

Inundation of Glen Canyon and tributary canyons by Lake Powell has resulted in an increase in the level of the potentiometric surface near the lake. The groundwater system, put out of equilibrium by the lake, has been slow to re-establish the regional gradient back toward Glen Canyon and Lake Powell. A higher potentiometric surface and much flatter groundwater gradient will result from the attainment of equilibrium. Inundation has also caused changes in groundwater chemistry near the lake. This is particularly true where the potentiometric surface has risen above the contact between the Navajo Sandstone and the Carmel Formation. Most affected has been the

Table 19-7 Groundwater Budget of the Kaiparowits Plateau Basin		
Component	Long-Term Average (acre-feet per year)	
	Navajo Sandstone	Basin Total
Recharge		
Precipitation	8,300-16,900	44,000
Recharge from Stream Loss (not known)	--	--
Subsurface Inflow (not known)	--	--
Total	8,300-16,900	44,000
Discharge (figured for Navajo Sandstone only)		
To gaining streams (not known)	--	Moderate Amount
Spring and Seeps	6,600-15,200	Moderate Amount
Wells	1,500	Minor Amount
Evapotranspiration	200	Majority
Subsurface Outflow (not known)	--	Minor Amount
Total	8,300-16,900	44,000

increase in sulfate concentration and decrease in bicarbonate plus carbonate concentration of water in the Navajo Sandstone.

19.4 Case Histories [5, 39]

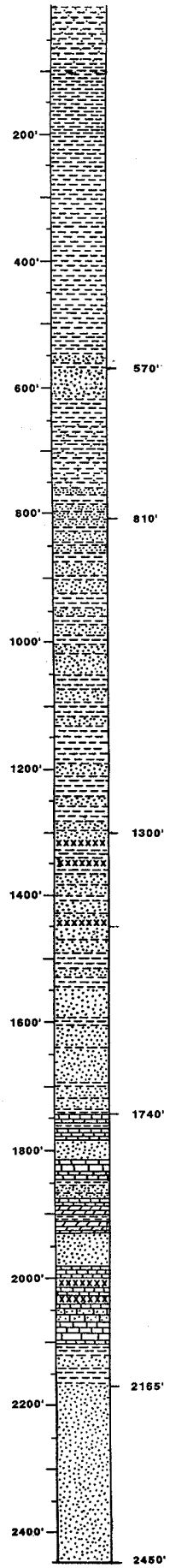
Two wells, both drilled in the time period of 1990 to 1991, are worthy of discussion. They are characteristic of the challenges faced by those who would develop water from the consolidated aquifers in this basin.

The first well, completed in April 1991, targeted the Navajo Sandstone and was drilled in the town of Tropic in Garfield County. The second well, likewise completed in 1991, also targeted the Navajo Sandstone and was drilled near the town of Escalante in Garfield County. Both wells exceeded 2,000 feet in total depth. It was anticipated that each would provide water to their respective communities as public supply wells, but currently only the Escalante well provides culinary water.

The Tropic well, located in the Paria Amphitheater, is collared in the Tropic Shale. The well encounters the following formations before entering the Navajo Sandstone: the Tropic Shale, Dakota Formation, Entrada Sandstone and the Carmel Formation (see Figure 19-7). The Navajo Sandstone was encountered at a depth of 2,165 feet and the well penetrated 285 feet of Navajo before reaching total depth at 2,450 feet. Static water level stood at 911 feet below the collar.

The Tropic well was test pumped at 320 gpm for 24 hours. The water has a total dissolved solids content of 448 mg/l. It exceeds state drinking water standards in arsenic, iron and turbidity (which is a consequence of dissolved iron), and at this time remains unused for culinary purposes.

The Escalante well, located near the western limb of the Escalante anticline, penetrates the Entrada Sandstone, Carmel Formation and Page Sandstone before reaching the Navajo Sandstone (see Figure 19-8).



TROPIC SHALE

Mudstone, sandy and carbonaceous, medium-grey to black, soft to hard, finely laminated, fissile, bentonitic, gypsiferous. Carbonaceous content varies. Weathered into sandy clay to clayey sand in the upper 90 feet.

Incomplete Thickness Tropic Shale--570'

DAKOTA FORMATION

Interbedded Sandstone, light-to medium-grey, friable, very-fine-grained, well-sorted;

Mudstone, medium-grey to black, soft to hard, finely laminated, fissile, carbonaceous, gypsiferous.

Total Thickness Dakota Fm.--240'

ENTRADA FORMATION

Interbedded Sandstone, light-to medium-brown, reddish-brown and light-grey, friable, very-fine-grained, well-sorted;

Mudstone, grey, brown, and reddish-brown, soft to hard, finely laminated.

Total Thickness Entrada Fm.--490'

CARMEL FORMATION

Interbedded Sandstone, light-to medium-brown and reddish-brown, friable, very-fine-grained, well-sorted;

Mudstone, light-to medium-reddish-brown and light-to medium-grey, soft, finely laminated;

Gypsum, mostly white, acicular selenite and massive fine-granular.

Interbedded Limestone, light-grey, hard, brittle, siliceous, medium-to fine-grained;

Dolomite, white to light-grey, hard, brittle, siliceous, fine-grained;

Sandstone, light-brown, friable, very-fine-grained, well-sorted;

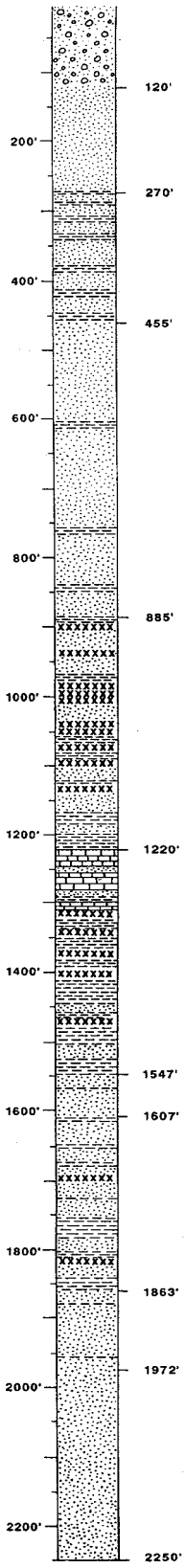
Gypsum, white and light-to medium-grey, massive, sugary textured.

Total Thickness Carmel Fm.--865'

NAVAJO SANDSTONE

Sandstone, white, friable, very-fine-grained and well-sorted.

Figure 19-7. Lithologic log - Tropic culinary well



ALLUVIUM/COLLUVIUM

Sand, generally white to light-brown, coarse-to fine-grained; and
Gravel, to cobble size, mostly well-rounded sandstone, quartzite, chert and siltstone.

ENTRADA FORMATIION

Sandstone, light-to medium-greenish-grey, friable, fine-to very-fine-grained, well-sorted.

Interbedded Sandstone, light-to medium-brown and reddish-brown, friable, fine-to very-fine-grained, well-sorted;
Mudstone and Siltstone, mostly reddish-brown and minor bluish-grey, soft, very-thin-bedded.

Sandstone, reddish-brown, harder, medium-to fine-grained, contains large, angular chips of yellow, orange, grey, and black chert; contains a few thin interbeds of
Mudstone, medium-to dark-reddish-brown, very-thin-bedded to laminated.

Incomplete Thickness Entrada Fm.--765'

CARMEL FORMATION

Interbedded Sandstone, brown to reddish-brown, fine-to very-fine-grained, well-sorted;
Mudstone, mostly reddish-brown with some greenish-grey, soft, very-thin-bedded;
Gypsum, white, grey, green, red, and brown, acicular selenite and massive fine granular.

Interbedded Limestone, light-to medium-grey, very-fine-grained, hard, siliceous;
Sandstone,light-to medium-brown and reddish-brown, friable, medium-to very-fine-grained;
Mudstone, reddish-brown and light-to medium-greenish-grey, soft, very-thin-bedded;
Gypsum, clear and white, acicular selenite and massive fine granular.

Total Thickness Carmel Fm.-Upper Member--662'

PAGE SANDSTONE - THOUSAND POCKETS TONGUE

Sandstone, light-to medium-brown, friable, medium-to very-fine-grained; with very minor Mudstone and Gypsum.

Total Thickness Page Ss.-Thousand Pockets Tongue--60'

CARMEL FORMATION - JUDD HOLLOW TONGUE

Interbedded Sandstone, light-to medium-brown, friable, fine-to very-fine-grained, well-sorted;
Mudstone, reddish-brown and light-to medium-grey and greenish-grey, soft, very-thin-bedded to laminated;
Gypsum, clear and white, acicular selenite.

Total Thickness Carmel Fm.-Judd Hollow Tongue--256'

PAGE SANDSTONE - HARRIS WASH TONGUE

Sandstone, light-to medium-brown, friable, fine-to very-fine-grained, well-sorted, contains angular chips of white, yellow, and orange chert; & minor
Mudstone, reddish-brown and bluish-grey to grey, soft, very-thin-bedded.

Total Thickness Page Ss.-Harris Wash Tongue--109'

NAVAJO SANDSTONE

Sandstone, light-to medium brown, friable, fine-to very-fine grained, well-sorted.

Figure 19-8. Lithologic log - Escalante culinary well

The Navajo Sandstone was encountered at a depth of 1,972 feet and the well penetrated 278 feet of Navajo before reaching total depth at 2,250 feet. Static water level stood at approximately 120 feet below the collar.

The Escalante well was pump-tested in 1998 as part of its resource protection plan. It showed a 575 feet. The water meets all the standards for a culinary source and has a total dissolved solids content of 288 mg/l.

The Escalante well continues to produce potable water, while the Tropic well produced a marginal quality in some categories and exceeded state standards in others. The Escalante well is located much nearer outcrops in recharge areas of the Navajo Sandstone, while the Tropic Well site is far from its recharge area. The Tropic Well is also near the Paunsagunt Fault zone, which may be allowing groundwater to mix and travel between several formations.

The following are accounts of other wells drilled within the West Colorado River Basin:

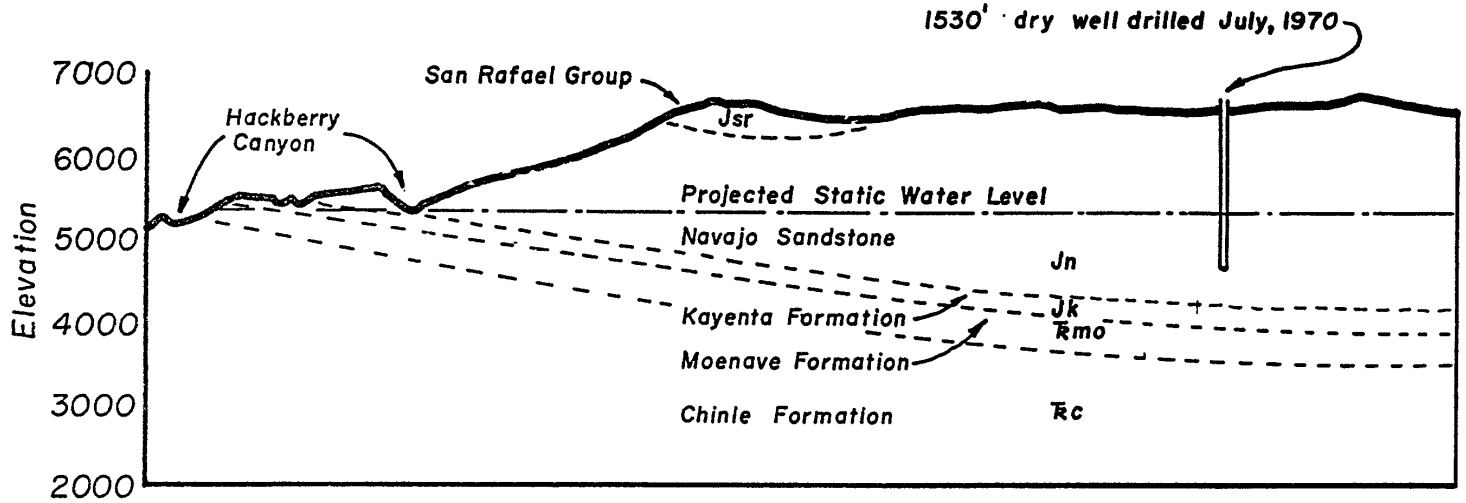
- During construction of Glen Canyon Dam, the Merrit-Chapman Construction Company drilled three wells into the Navajo Sandstone. These were located along the axis of the Kaiparowits Syncline, parallel to the Echo Monoclinal flexure. The wells produced an average of 3 cfs each. Recharge was considered to be from Wahweap Creek which flows along the flexure.
- Near Colton, in the Wasatch Plateau, two wells were drilled into fractured rock of the North Horn Formation. These wells were located for Utah Power and Light Company by Dr. Ray Marsell of the University of Utah. When pumped, these two wells produced a combined total of 5 cfs.
- In January 1971, an 803-foot 16-inch well was drilled approximately five miles upstream from Lake Powell on Wahweap Creek. This well was test pumped at 1,627 gpm for 48 hours with a draw down of 177 feet. The static water level stood at 20 feet below ground.

In sharp contrast to the wells just discussed are the following accounts:

- Five wells, all 10 inches in diameter and ranging from 537 to 675 feet deep, were drilled as municipal supply wells for town sites near Lake Powell. All five wells were drilled into the Navajo Sandstone along the general trend of the Echo Monoclinal flexure and are all within three miles of the well last mentioned above. These wells produced between 5 and 25 gpm, which is typical for wells in non-fractured sandstone aquifers in this region.
- Marathon Oil Company drilled a well in 1970 that was to be used as a water supply. The well was located between Hackberry Canyon and Cottonwood Creek east of the Paria River and about 13 miles southeast of Henrieville, Utah. It had been assumed that the fractured Navajo Sandstone was saturated to an elevation equal to that of several springs that flowed from fracture openings in the two canyons mentioned. It is customary and logical to assume that such springs represent the overflow of the groundwater reservoir. The Marathon well was drilled to a depth of 1,530 feet, which is 500 feet deeper than the previously estimated level of saturation in the area between the canyons (see Figure 19-9). From all indications, this well should have been a good producer of water, but it was abandoned as a dry hole. This clearly indicates the complexity of bedrock aquifers. It also indicates that due to this complexity the usual assumptions or customary procedures may not always be valid.

19.5 Policy Issues and Recommendations

Two issues previously discussed in sections 12 and 7 are presented here.



Hydrographic Profile

Figure 19-9

19.5.1 Monitoring Methane Concentrations in Shallow Groundwater near Price, Utah

Issue - Ongoing and future development of coal-bed methane resources in the vicinity of Price, Utah, could cause migration of methane into near-surface environments. (See Section 12.7.2)

19.5.2 Groundwater Interference from Mining Operations

Issue - Possible groundwater interference by mining operations in Emery County may be affecting local water entity supplies (see Section 7.8). ●