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HYDROGEOLOGIC STUDY OF THE
FURNACE CREEK AREA,
DEATH VALLEY NATIONAL MONUMENT
CALIFORNIA

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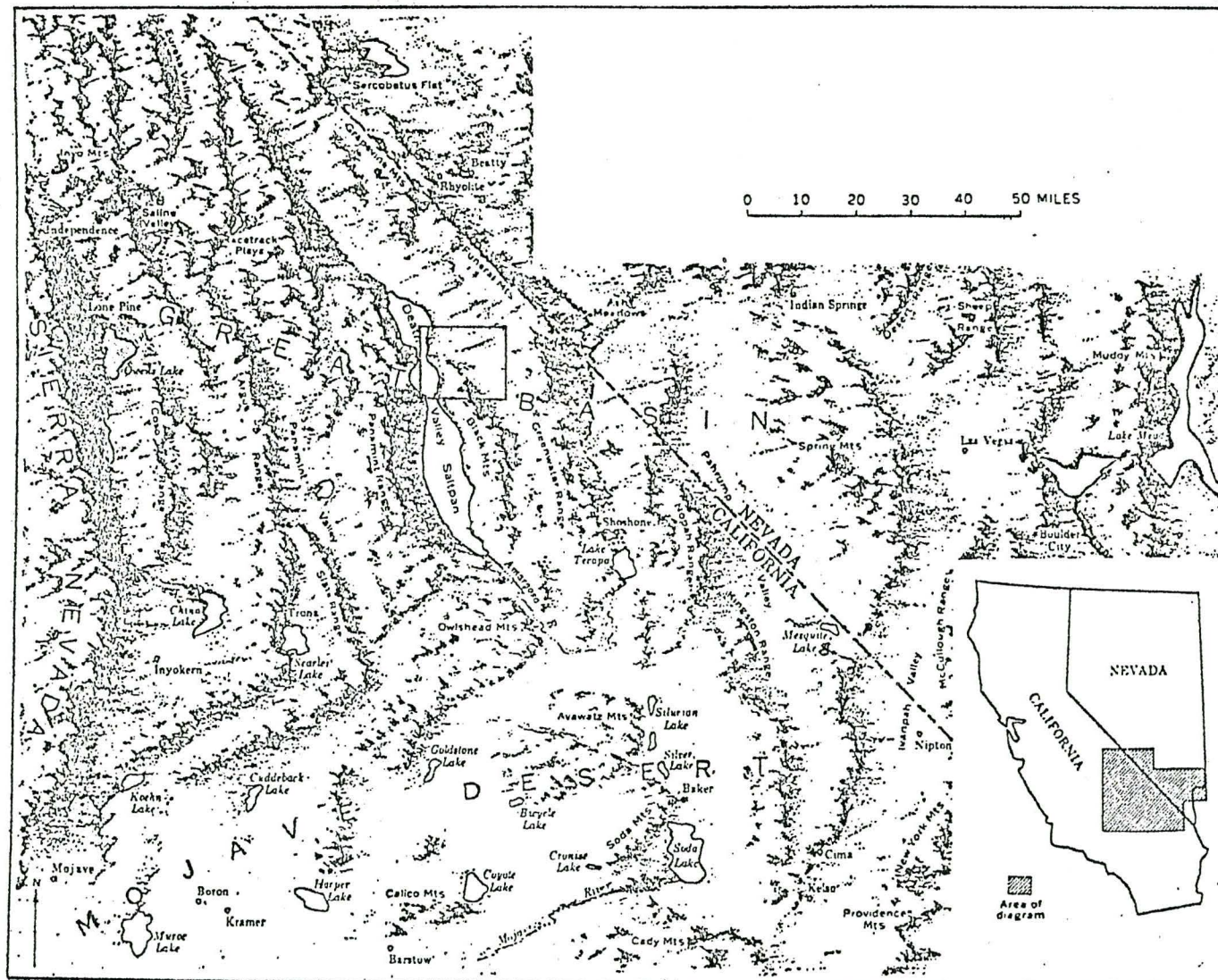
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ABSTRACT-Based on meteorological and geological data, the amount of precipitation that falls within the watershed of the Furnace Creek Wash is insufficient to account for the discharges of several spring groups in the area. In order for the National Park Service to meet the growing demands for potable water in the Furnace Creek area, expansion of its current collection and distribution systems is taking place. Numerous studies were conducted and a test well was drilled prior to the expansion to determine the recharge areas and the characteristics of the aquifers in the system. Apparently, no significant depletion of the groundwater will take place as long as the collection system remains gravity-fed, with no pumping taking place. The groundwater collected would have been ultimately lost to Furnace Creek Wash Fan and from there to the Death Valley salt pan or to the phreatophytes on the surface of the fan. The locations of the principal recharge areas were delineated, as were man-made changes in the drainage system itself. These man-made changes have resulted in reactions by the hydrologic characteristics present in Furnace Creek Wash and on the fan. However, the spring groups in the area derive their recharge primarily from outside of the Death Valley hydrologic basin.

INTRODUCTION-The Furnace Creek Wash area of Death Valley National Monument, California is located on the east side of the Death Valley hydrologic basin, slightly above sea level. The Furnace Creek Wash watershed lies in between the Funeral Mountains and the Black Mountains, and drains most of facing slopes from both ranges (Figure 1). The Furnace Creek Fault Zone, the principal geologic structure in the region, controls many of the features present in the wash area.

Death Valley lies within the Basin and Range Province of the southwest United States. Each mountain range is a fault block, bounded on one side or the other, often on both, by faults. The mountains have been uplifted, and the intervening valleys lowered. A good example of this can be seen at Wildrose Graben. This type of structure would indicate crustal expansion in the Death Valley region of an ongoing nature. Combined with very recent fault movements as shown by the many fresh fault scarps present on alluvial fans descending from the Panamint Mountains and on Furnace Creek Wash Fan itself, the nature of Death Valley is changing very rapidly, on a geologic time scale.

Figure 1:



Location Map of the Death Valley Area. Area enclosed by square denotes subject area.
(from Hunt & others, 1966)

ENVIRONMENTAL CONDITIONS--Death Valley, aside from its extremely low elevation, is noted for the high summer temperatures experienced on the valley floor. The year-round average temperature at Furnace Creek Ranch is 75.3°F. The average maximum is 90.3°F; the average low is 60.2°F. Some highs have been recorded above 130°F during the summer months (data from U. S. Weather Bureau climatic summaries; Hunt & others, 1966).

Along with the high temperatures of the area, high wind velocities are known to occur as evidenced by numerous locations of ventifacts, deflation areas (Devil's Cornfield may be an example of this), vast areas of desert pavement, and sand dunes. As a result of these, and other environmental conditions, evaporation rates on the salt pan are extremely high. Measured pan evaporation rates over most of the basin are more than 120 inches per year. Summertime rates are very high, occasionally reaching above 1 inch per day, depending on temperature, humidity, and wind direction and velocity (measured rates are from a standard Weather Bureau evaporation pan; Hunt & others, 1966).

Precipitation in the Valley itself is controlled by the Panamint Range via rain shadow (the region of diminished rainfall on the lee side of a mountain range, where the annual rainfall is noticeably less than on the windward side). As a result, rainfall is dramatically lessened in the Valley and averages only 1.85 inches per year (National Park Service records; Figure 2).

Usually, the rain comes in very intense, short duration thunderstorms. This type of rainfall is typical of arid regions. It also favors high runoff values and high erosional rates. Little water enters the groundwater systems present until the runoff reaches the apexes of the large alluvial fans coming into Death Valley. In these "recharge zones," some of the runoff enters the alluvial fans' groundwater systems and moves downslope to the salt pan. This provides the necessary groundwater to maintain the phreatophyte growth occurring near the bases of some of the fans. Some plants near the salt pan have developed remarkably high

ANNUAL PRECIPITATION FURNACE CREEK RANCH, 1941 to 1976

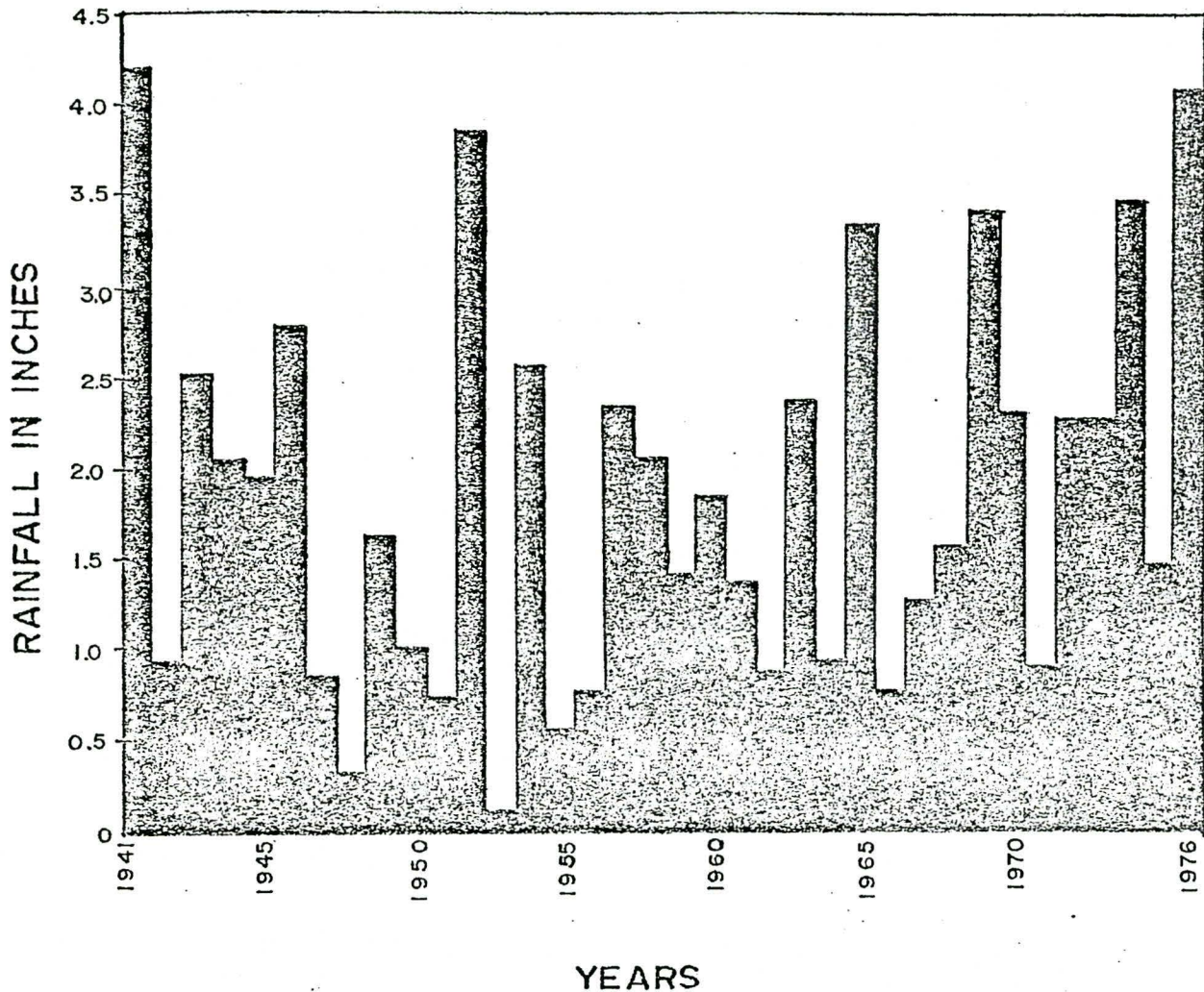


Figure 2:

(From National Park
Service Records)

salt tolerances due to continual changes in the environment.

As indicated by the data presented in Figure 2, the basin goes through "wet and dry" cycles. More precipitation has fallen during the latter half of the period of measurement than during the first half. This will have a small effect on the groundwater in the area. However, the source of the majority of the water

issuing at the springs into the salt pan of Death Valley is derived from outside of the basin. Therefore, any variations in the amount of rainfall in the areas of recharge to the springs in Death Valley will result in greater changes in the discharges of the springs.

DESCRIPTION-Within the area being studied are two major spring groups, Travertine and Texas Springs. Another spring group that probably derives its waters from the same source, but surfaces under different conditions, is Nevares Springs. It will be discussed only briefly as to its similar characteristics to the other two spring groups.

The springs issuing forth in the Furnace Creek area are related as to their chemical composition, temperature, and quality. The waters from all three springs are alkaline. All three are also thermal, the average temperature being approximately 90°F. at the groundwater collection facilities.

The springs are located within the Furnace Creek Fault Zone. The Furnace Creek Fault and its splays are acting as subsurface dams and are the responsible agents for the locations of the springs. Old travertine mounds that were once the site of active springs can be found at many locations throughout the Furnace Creek area. Texas and Travertine Springs also rest on a northwest plunging syncline between the Funeral Mountains and the Black Mountains. This structure would help to furnish a means of bringing water to ground surface.

Of the two, Travertine Springs are the largest group with a combined flow of 1.9 cfs (cubic feet per second). The National Park Service, however, takes its freshwater supplies from Texas Spring, whose flow is 0.5 cfs (Pistrang & Kunkel, 1957). Total flow from the Furnace Creek Wash area, including Nevares Springs, is estimated to be 5.6 cfs (excluding unknown underflow to Death Valley saltpan). This rate is about 2,500 gallons per minute, or about 4,000 acre-feet per year. These rates, when measured, seemed to be constant. However, small variations were observed by Hunt & others, 1966, and were attributed to changes in barometric pressure. This phenomenon lends credence to the thought that the

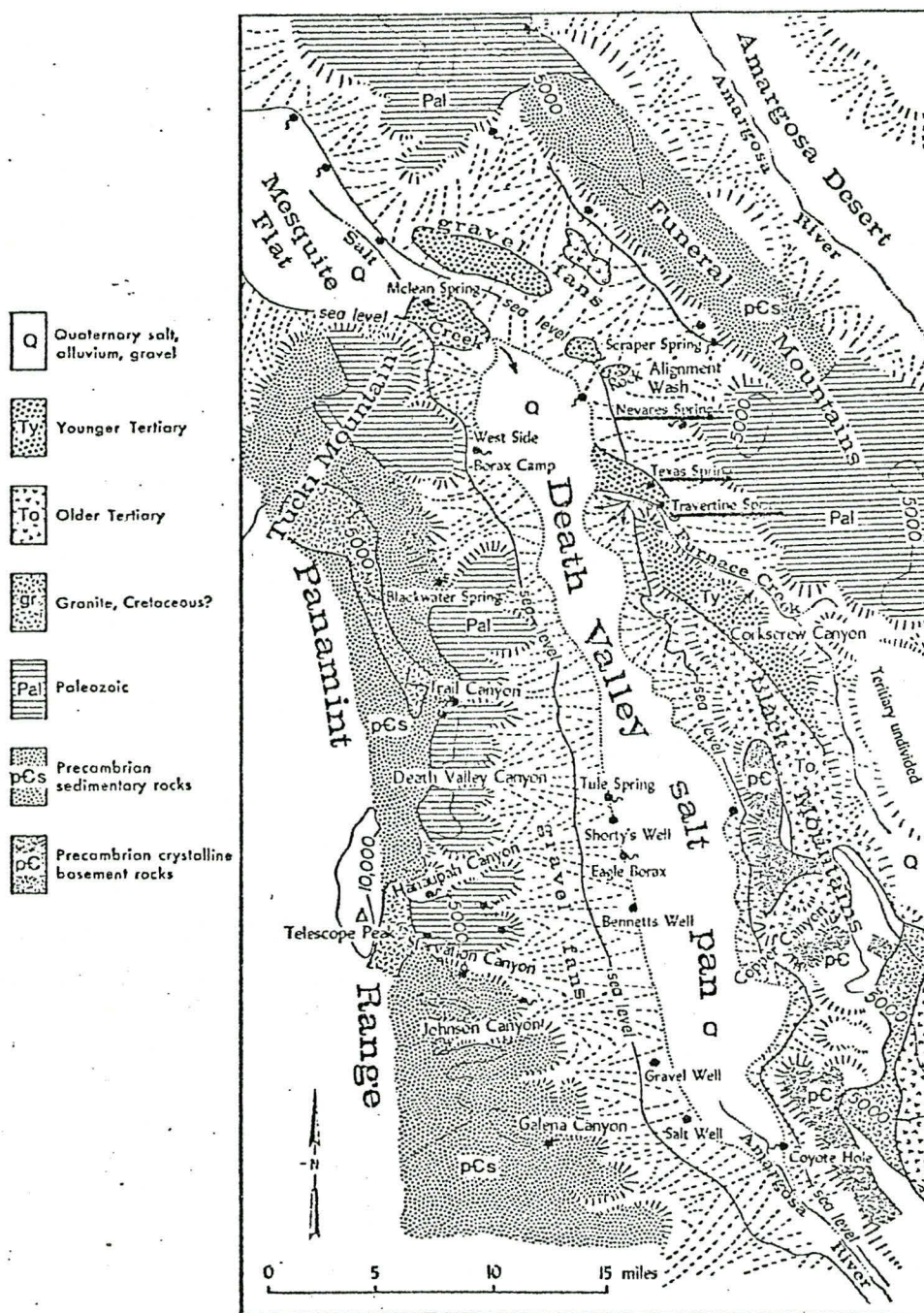
water is under artesian pressure.

The water at all three springs is drinkable, though hard and somewhat high in fluorine (see Figure 4, Page 8). The water from Nevares Springs provides for the needs of the Park Service's housing units at Cow Creek. The water from Travertine Springs is diverted for irrigation use at the Furnace Creek Inn. The principal discharge point of Texas Spring is from a horizontal tunnel approximately 100 meters long that has been dug into the side of a hill. It apparently intersects the water table. The groundwater percolates into collecting trays and is transported by gravity down to the Furnace Creek Inn and to the Park Service facilities. All of the water collected and distributed is by gravity flow.

Present domestic use of freshwater in the Furnace Creek area is 0.122 cfs (0.078 cfs which goes to the Park Service). Future domestic use is expected to climb by 1980 to 0.171 cfs (from Death Valley Hotel Co. Ltd., Water Report, April 23, 1962). The estimated dependable flow from Texas Spring alone was 0.85 cfs (personal comm. Mike Fox, NPS). However, these figures are for domestic use only, and do not include the amounts used for irrigation. The NPS has an agreement with the Death Valley Hotel Co., made when the land was purchased for the Monument, to provide the Co. with water at certain amounts by a certain date. The NPS is currently involved in a water development project designed to meet those agreements, and provide a better means of collecting, storing, and distributing the freshwater supplies of the area.

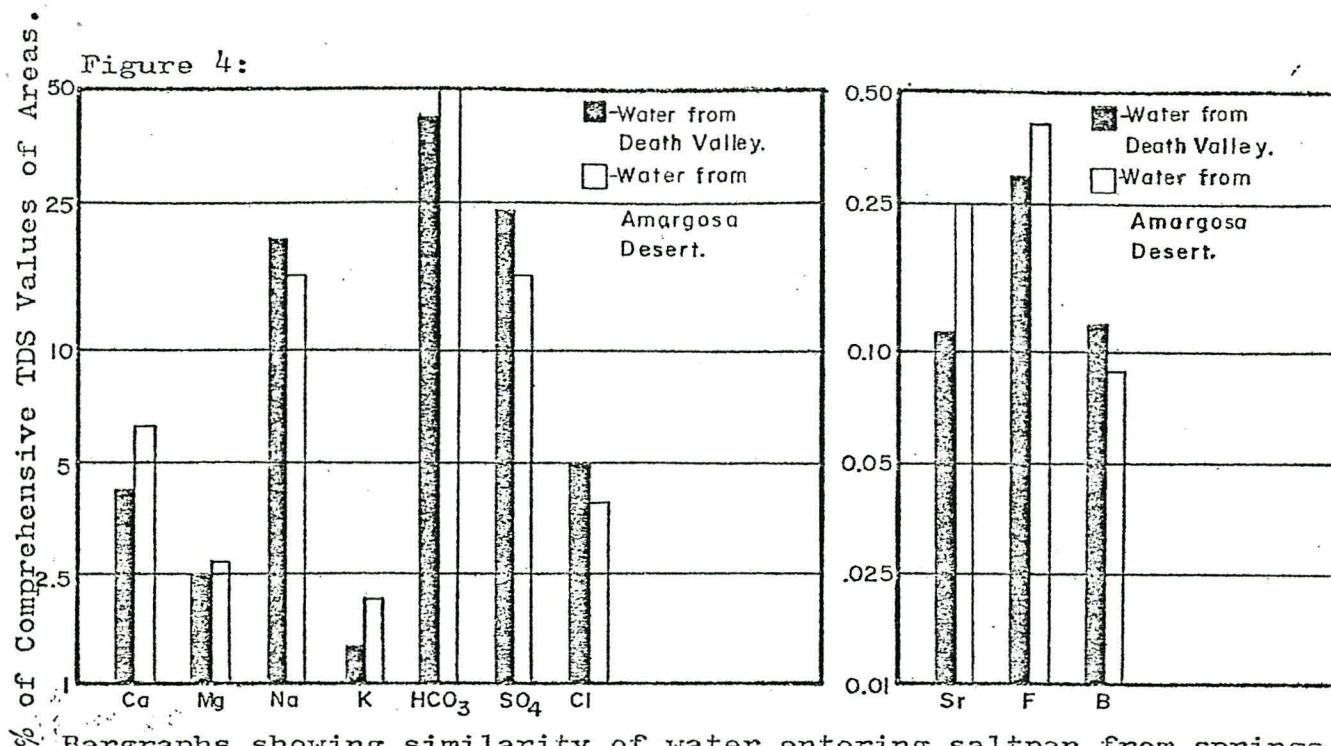
Instead of one collecting point at Texas Spring, four will be used. The current storage capacity of freshwater in the area is one 500,000 gallon tank. Another 2,000,000 gallon tank is to be built. Currently, water being transported from Travertine Springs to Furnace Creek Ranch is conducted by means of an open, lined channel. With the high evaporation rates of the area, much water is lost. Plans call for piping it in the future. The high carbonate content of the groundwater requires that the pipes conducting it be replaced often and this is currently being done (personal comm.

Figure 3:



Geologic map of Death Valley Region showing locations of wells and springs.
(from Hunt, 1975)

Figure 4:



Bargraphs showing similarity of water entering saltpan from springs north of Furnace Creek and water from springs in Amargosa Desert (from Hunt & others, 1966).

RESULTS IN Mg/l	1. Travertine Springs	2. Texas Spring	3. Nevares Springs	
			A	B
SiO ₂	43	25	32	---
Ca	26	35	43	42
Mg	22	20	21	22
Na	145	155	145	138
K	11	12	11	12
HCO ₃	321	348	350	317
CO ₃	---	0	0	0
SO ₄	158	160	174	173
Cl	39	43	36	34
F	3.0	2.0	2.8	2.9
B	0	1.0	---	1.2
NO ₃	0	0	0	1.8
Sums of Determined Constituents	605	599	637	583
pH	8.05	7.9	7.9	7.9

3A. Upper springs.
3B. Lower springs.

Analyses of waters from Travertine, Texas, and Nevares Springs.

1. Analysis by U.S. Geol. Survey.
 2. Analysis by Calif. Dept. of Water Resources.
 3. A. Analysis of sample collected by R.C. Scott & analyzed by U.S.G.S.
B. Analysis by Calif. Dept. of Public Health.
- (from Hunt & others, 1966)

Mike Fox, NPS; and Virgil Olson, Chief Naturalist, Death Valley National Monument).

CHARACTERISTICS OF THE SPRINGS AND RELATED AREAS-The quantity of water discharging at the three springs is quite large, considering the size and aridity of the drainage basin in which the springs are located. Early studies indicated that sufficient recharge took place within the Furnace Creek Wash area to account for the measured flows at the springs. Later studies tend to look outside the drainage basin for areas of recharge. The remainder of this paper will look into possible areas of recharge, how the structure of this area relates to the recharge, how the rocks in the area itself affect the springs and groundwater flow, and what, if any, are the effects on the groundwater equilibrium in the area of the Park Service's withdrawal of water from the springs.

ROCK TYPES IN FURNACE CREEK AREA-Rocks of the basement complex form the Funeral Mountains in the eastern part of the area. These rocks consist mostly of dolomite and quartzite of Cambrian age, which have been intensively folded and faulted (Pistrang & Kunkel, 1957). The formation aggregating more than 15,000 feet in thickness is very important to the hydrology of the Furnace Creek Wash area for they allow groundwater to move through topographic divides by means of conduits along cracks and fissures. Thus, the area has a recharge source outside of the watershed basin itself (Hunt & others, 1966).

Some questions could be raised as to the availability of open conduits in the Funeral Mountains. In carbonate rocks, solution of the rock itself is more active above the water level as water moves in the vadose zone (Emmons, 1940). The climate in the Pleistocene was much wetter than it is today and would, therefore, recharge the water table in the Funeral Mountains to a higher level. This would slow or stop the solution process by stagnating the groundwater. Yet, the solution process could continue in the phreatic zone, if new water is being conducted through the Funerals from the higher Amargosa Desert to the lower Furnace Creek Area. Also, if the dolomite in the formations was originally a fairly

pure limestone and was changed to dolomite without the addition of carbon dioxide, a shrinkage of about 12% takes place. This would open up fissures in the rock and allow a greater permeability to develop (Emmons, 1940).

The Furnace Creek Formation is a Pliocene (3-12 my) formation, consisting mostly of light-colored, soft, silty lake beds with intercalated conglomerate and volcanic layers (Hunt & others, 1966). These rocks are exposed in Death Valley at the north end of the Black Mountains and underlie the gravel on the fans north of Furnace Creek Wash. These beds contain borax in considerable quantities and have been extensively prospected and mined in certain areas. The upper surface of the sedimentary layers of this formation when exposed to weathering develops into a soft, fluffy deposit which will not allow water to percolate through. Other areas of this formation are covered by desert pavement and favor runoff. No, or very little, recharge takes place where this formation is exposed. Within the formation are conglomerate and sand lenses that will transmit groundwater downslope (Hunt & others, 1966).

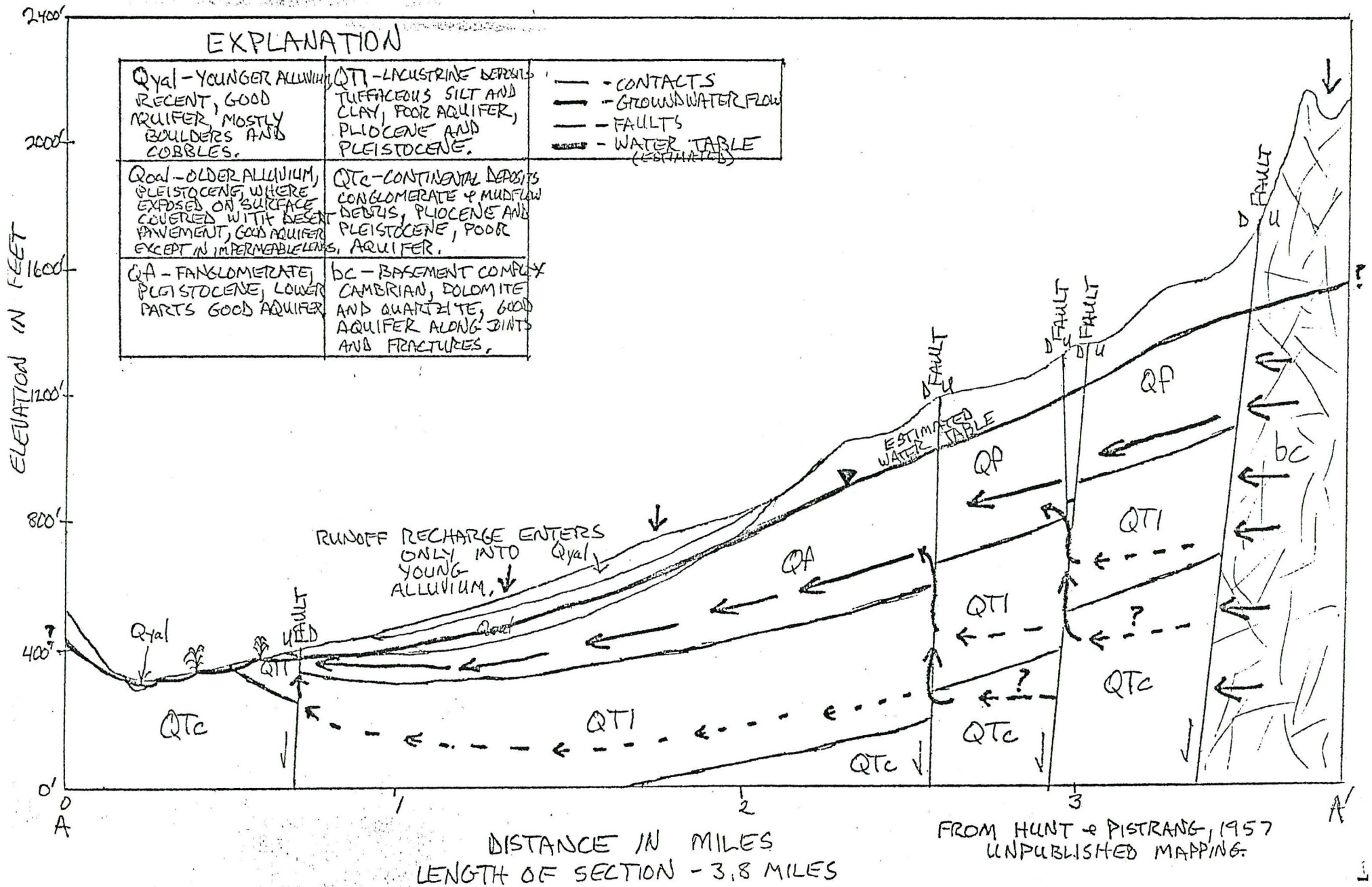
The volcanics of this formation are also found in the areas bordering the Amargosa Desert and the Greenwater Mountains, and are highly permeable. This could lend credence to the theory that groundwater flow is contributed to the Furnace Creek Wash area from Greenwater Valley via the Death Valley-Furnace Creek fault zone.

Resting on the lacustrine beds of the Furnace Creek Formation are gravel beds making up the Funeral Formation. It is a conglomerate about 750 feet thick and is found in the Texas Spring syncline, as well as in other areas of Death Valley. It is fairly well cemented by calcium carbonate, especially downslope from the springs, but it is a good aquifer (see Figure 5, Page 11 & 12). Where it is exposed at the surface, it is covered by desert pavement (Pistrang & Kunkel, 1957). The intermediate aged gravel is also characterized by desert pavement.

The youngest Quaternary gravels consist of the materials lying in present day washes. They comprise the principal areas of recharge during storm runoff. (The following is taken from Pistrang & Kunkel, 1958.) "In May, 1958 the NPS deepened and extended an existing trench

GEOLOGIC CROSS SECTION OF FURNACE CREEK WASH IN VICINITY OF TRAVERTINE SPRINGS.

Figure 5:



12



across Furnace Creek Wash. During the same period...test holes were augered. Bedrock was not penetrated in the center of the wash within...24 feet. Groundwater flow did not occur in the trench in its entire length but was restricted to narrow channels along permeable gravel lenses." This fact would make any estimate of the underflow in Furnace Creek Wash a very questionable statement.

In the 1940's, a man-made diversion of the upper watershed runoff of the Furnace Creek Wash at Zabriskie Point was made to protect the structures farther down the wash. Statements have been made as to the effects on the wash as a result of this diversion (Dzurisin, 1975; Troxel, 1974). The deflection of runoff will affect the fresh groundwater level in the Furnace Creek Fan, but the effects of removing the water reentering the wash at Travertine Springs will have a greater effect over time than the storm runoff. The springs had been supplying a year-round flow of water to the wash before any development was made. This gave a constant freshwater flow into the alluvial fan down the wash. Now with both 80% of the storm runoff removed and the recharging of the springs into the wash stopped, very little water is being drained to the fan. With the added development of the springs planned by the NPS even less underflow will occur accompanied by lower fresh groundwater levels in Furnace Creek Fan. Ultimately, saline water will encroach into the fan replacing the freshwater. This will result in changes in the plant communities on the fan.

TEST WELL-In November, 1958 a test well was drilled for the NPS near Texas Spring and on the axis of the syncline. The well went down 250 feet and was drilled in order to find out more about the formations from which the water at Texas Spring was coming from. A pump test was conducted in order to determine the hydrologic characteristics of the formation.

Concern was noted that the pump test would adversely affect the discharge of the springs, but no effects were noted. From the data provided in Hunt & others, 1966, no determinations concerning transmissivity or storage values of the material encountered in the well could be made. The dissolved solids of the water in the well totaled 569 ppm, with a fluoride content of 1.0 ppm.

Texas and Travertine Springs have a fluoride content ranging from 2.0 to 4.0 ppm, above the State Health Department's safe limit. No reason was found for the high values and apparently nothing is done to treat the water for the high levels.

RECHARGE AREAS-The rainfall occurring in the watershed contributes water to the groundwater system in Furnace Creek Wash. An estimate by Hunt, 1975, sets this amount of recharge at about 50% of the flow issuing at the springs. The rest of the flow must be accounted for outside of the watershed, and indeed, outside of the Death Valley area.

Extending northwesterly for at least 200 miles through the Death Valley region is the Death Valley-Furnace Creek fault zone. It roughly parallels the San Andreas Fault and shows similar right-lateral displacement. The lateral displacement of several miles seems agreed upon, but there is disagreement as to 50 miles (Sharp, 1972). Eagle Mountain presents a structural barrier to groundwater flow in the Amargosa Desert near the southeast end of the fault zone (Hunt & others, 1966). This barrier could provide a lateral movement of groundwater towards the Death Valley area. When the underground flow reaches the fault zone it moves downslope toward the springs (Dudley & Larson, 1976). The composition of the waters from the two areas is similar, but they could have different sources (Hunt & others, 1966). The water, however, from Ash Meadows on the east side of the Funeral Mountains is very much like the water issuing from the springs (Dudley & Larson, 1976).

The water at the springs in the Furnace Creek area is warm, as was noted before. Assuming the thermal gradient in the Death Valley region is about the same as in deep wells in southwestern California, about 35°C per kilometer of depth, the water needed to circulate to a depth of only about 1,500 feet. Ash Meadows is 2,000 feet higher than the Furnace Creek area. Groundwater slowly percolating through an aquifer such as the ones in this area could not retain the high temperatures long enough to reach the surface and would dissipate the heat back into the rocks at higher levels. Providing the rapid transport of the groundwater would be the travertine mounds and conduits so prevalent in the area. This

could account for the high water temperatures found.

SUMMARY-The principal sources of recharge for the springs at Furnace Creek Wash are from Ash Meadows, Green Water Valley, the ponding at Eagle Mountain, and the runoff within the watershed. Perhaps, Pahrump Valley contributes through Ash Meadows, but doubt has been thrown on this theory. Because of the little amount of rainfall within the watershed and the type of rocks on the surface, another source of recharge must occur. This source is Ash Meadows.

As long as the water demands of the NPS do not require pumping of the aquifer in the Texas Spring Syncline, no effects should be felt in the aquifer. Before development the water was either lost to evaporation or reentered the wash and moved again as groundwater down the wash to Furnace Creek Fan and eventually to the Death Valley saltpan.

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