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John D. Clark

THE UNIVERSITY OF NEW MEXICO BULLETIN

THE SALINE SPRINGS

OF THE

RIO SALADO

SANDOVAL COUNTY, NEW MEXICO

BY

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THE SALINE SPRINGS OF THE RIO SALADO, SANDOVAL COUNTY, NEW MEXICO

In the northwestern part of New Mexico is a region of uplift known as the Jemez Plateau. Mount Pelado, or "Baldy," which rises to an elevation of 11,200 feet, is the culminating point of the plateau, this peak being part of the rim of an old volcano. The southern part of the plateau is bounded on the west by the Rio Puerco and on the east by the Rio Grande, but very close to the western part of the uplift near Ojo del Espiritu Santo[1] there rises a stream known as the Rio Salado which flows south, and then east, joining the Jemez River, the latter flowing east to the Rio Grande, and forming a southern boundary of the region.

Springs[2] are numerous on the plateau and on its flanks; the Sulfurs, near Mount Pelado, with their hot acid water; the Soda Dam Springs, further south in the Canyon San Diego; the Jemez Hot Springs, on the Jemez River; the Indian Springs; and then along the Rio Salado at the southwest of the uplift, the San Ysidro Springs and the Phillips Springs.

H N. Herrick[3] describes the geological conditions along the Rio Salado, as follows: "All along the western base of the Nacimiento Mountains (the western part of the Jemez uplift), are exposures of the Red Beds with thick bands of gypsum and gypsiferous shales high in salines. The Rio Salado, which is a tributary of the Rio Jemez, is

1. Location shown on map opposite page 472, Bull. 381, U. S. G. S. "The Coal Field Between San Mateo and Cuba, New Mexico," 1908.

2. "A preliminary study of the waters of the Jemez Plateau, New Mexico," Arspach and Kelley, Bulletin University of New Mexico no. 71, 1913.

3. A chapter in "Gypsum deposits of the United States," Adams and others, U. S. G. S. Bull. 223, Ser. A, Economic Geology, 30, 1904.

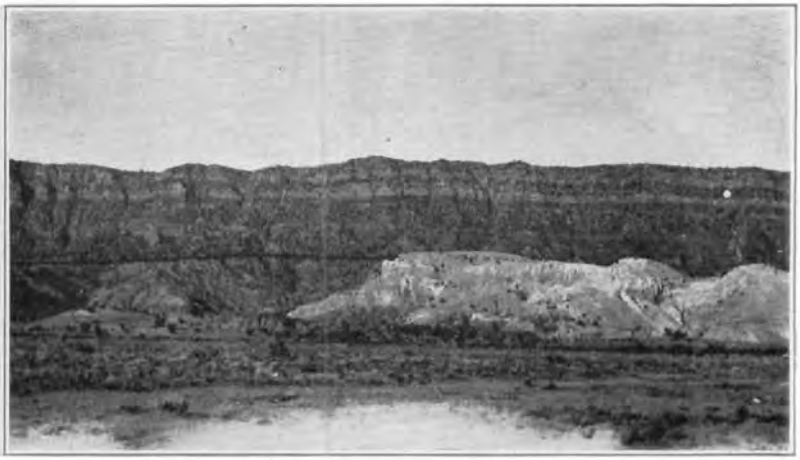

Figure 1. Red beds and gypsum. Photo taken from Albuquerque-Cuba highway. A mile to the north, up the canyon, is the natural swimming pool.

so salty that its water is unfit for domestic use. It derives its salt from the formations along the western base of the Nacimiento Mountains, and carries a great part of the salt and alkalies deposited by the Rio Grande on the flats along its valley above the mouth of the Puerco." The structure of the country north and west of the Rio Salado is shown by contour and in cross section by Gardner[4]

The region covered by this paper is one of rugged beauty, and because of the unusual geological features to be seen there, will undoubtedly be visited by large numbers of people as the locality becomes more widely known. It is favorably located as an attraction for tourists, being less than a two hours' drive from Albuquerque over the State highway to Cuba.

Figure 1 of the accompanying photographs shows the red beds above gypsum, as mentioned by Herrick. This

4. Bull. 341, U. S. G. S., "The Coal Field between Gallina and Raton Spring, New Mexico in the San Juan Coal Region," p. 336, 1907.

Figure 2. Dry bed of the Rio Salado. Solid gypsum above the stratification.

Figure 3. Dry bed of Rio Salado. Gypsum above the stratification.

photograph was taken from the highway. Figures 2 and 3 show bedded stream deposits along the side of the Rio

Figure 4. Solid bank of gypsum in bed of Rio Salado.

Salado. Solid banks of gypsum are to be seen above these strata. Figure 4 again shows a bank of gypsum at the side of the Rio Salado. Figure 5 shows a small gorge in solid gypsum, through which the Salado flows, and Figure 6 is that of a photograph taken from the lower opening of that gypsum gorge, the heavy black area in the upper left being gypsum.

As existing maps of the district being described by this paper do not give sufficient detail to make them desirable

Figure 5. Gorge which Rio Salado has cut thru a solid bank of gypsum.

of reproduction, the author prepared a diagram of the district, which, for the purposes of this paper, makes correlation of the subject matter easier than would an actual map. This diagram is shown as Figure 7.

During the early part of 1926, exploration was begun on the Ojo del Espiritu Santo Grant, north of the Rio Salado, at a place marked "Plugged Well" on the diagram. The exploration had for its purpose the seeking of natural

Figure 6. Photo taken looking out of gorge in gypsum. The heavy black area is a gypsum wall.

gas. Water used in the steam boiler of the well rig, was secured from a spring located at the foot of a "crater" (travertine cone) about a mile east, (see Figures 8 and 9), the water flowing by gravity through a pipe to the boilers. By April 17th, the well had gone down 550 feet, its log being as follows:

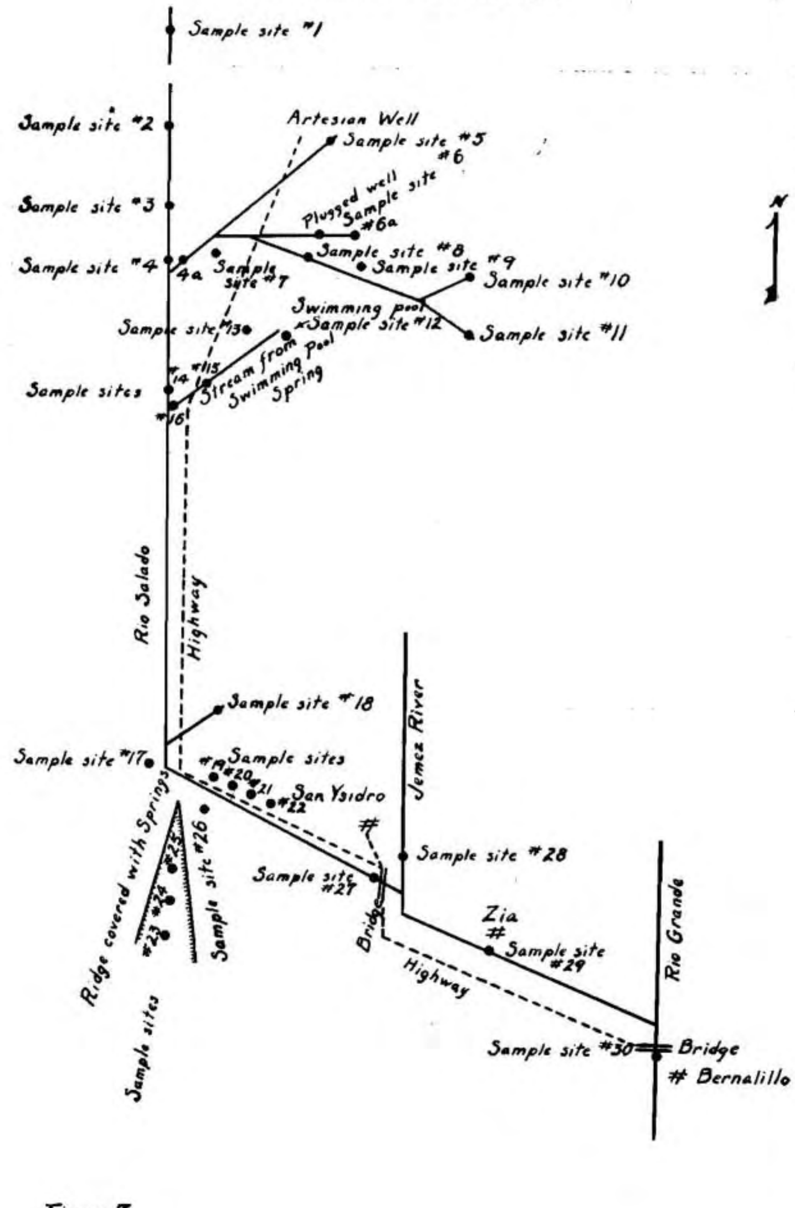
Sample site #1
Sample site #2
Sample site #3
Sample site #4
4a
Artesian Well
Sample site #5
Sample site #6
Plugged well
Sample #6a
Sample site #7
Sample site #8
Sample site #9
Sample site #10
Sample site #11
Swimming pool
Sample site #12
Sample site #13
Sample sites #14 #15 #16
Stream from Swimming Pool Spring
Rio Salado
Highway
Sample site #18
Sample site #17
Sample sites #19 #20 #21 #22
San Ysidro
Ridge covered with Springs
Sample sites #23 #24 #25
Sample site #26
Sample site #27
Bridge
Jemez River
Sample site #28
Zia
Sample site #29
Highway
Rio Grande
Sample site #30
Bridge
Bernalillo
N

Figure 7.

W.B.H.

Figure 8. Travertine cone inside of which there is a "crater." A good sized spring in the fore ground furnished boiler water for drilling the first artesian well. The spring ceased to flow when the well was completed.

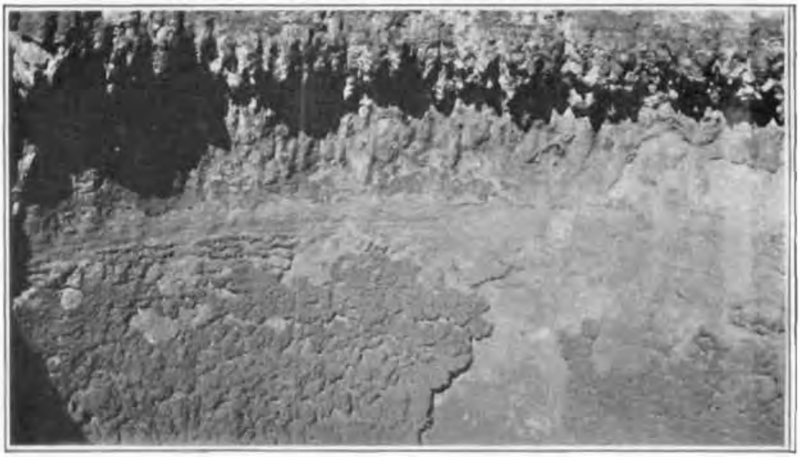

Figure 9. Wall of "crater" inside of cone shown in Figure 8. This "crater" is about 100 feet deep and of about the same diameter. Many similar formations are in this vicinity.

"January 28, 1926. Spudded in.

Set 35 feet 15 inch pipe and got water at 15 feet.

From top to 315 Red Soft. Cave at 255 to 315 feet; set 12 in. pipe at 235 .

From 315 feet to 348 pink-Will not cave. Set 361 feet of 10 in. pipe.

From 348 to 360 blue shale. Will not cave.

From 360 to 385 Red bed-hard-will not cave.

From 385 to 390 Hard sand cap.

From 390 to 420 Sand Water that flowed.

Had cave at 400 feet and set 415 feet of 8 in. pipe.

From 420 to 445 Red-bed-mixed with blue shale.

From 445 to 550 White sand water bearing sand.

The 12 in. pipe lacked 126 feet of being through the Red bed. 12 in. pipe can be put through the red beds without under reaming, and water can be cased off with 10 in. pipe and then have 10 in. hole until more water is struck. (As to geologists report).

Water flowed out of 8 in. hole 3 feet above casing.

After 8 in. pipe was pulled water flowed 18 in. above casing.

Drilled by Hitchcock and Dickason"

The water from this well was hot, (accurate record was not kept, but the temperature was over 100 degrees F.), and strongly saline as is shown by an analysis made June 4, 1926.

Water from first artesian well (marked "Plugged Well" on diagram). Parts per million.

Silica	24.0
Ferric and aluminum oxides	11.0
Calcium	419.0
Magnesium	68.0
Sodium	3461.0
Potassium	103.0
Sulfates (SO_4)	3703.0
Chlorine (Cl_2)	2705.0

Carbonates (CO_3)	none
Bicarbonates (HCO_3)	1525.0
Total solids by evaporation	11,274.0

When this volume of hot water, heavily charged with sodium chloride and sodium bicarbonate, was encountered, this well was abandoned, and another was started about two miles further north. This is shown in Figure 10.

The log of this second or upper well (marked "Artesian Well" on diagram) as of January 10, 1927 is as follows:

Soil	Soft	Brown	0 to 15 feet
Quicksand	Soft	Brown	15 to 20 feet
Shale	Soft	Red	20 to 418 feet
Sand	Hard	Gray	418 to 475 feet
Shale	Soft	White	475 to 590 feet
Sand	Hard	Gray	490 to 565 feet
Shale	Soft	White	565 to 600 feet
Sand	Hard	Gray	600 to 615 feet
Sand	Hard	Brown	615 to 645 feet
Sand	Hard	Gray	645 to 665 feet
Sand	Hard	Brown	665 to 675 feet
Shale	Soft	Brown	675 to 690 feet
Sand	Hard	Brown	690 to 700 feet
Sand	Hard	Gray	700 to 715 feet
Lime	Hard	Gray	715 to 730 feet
Sandy Lime	Hard	Gray	730 to 800 feet
Shale	Soft	Red	800 to 870 feet
Sand	Soft	Yellow	870 to 900 feet
Sand	Hard	Red	900 to 1090 feet
Sand	Hard	Gray	1090 to 1100 feet
Sandy shale	Soft	Red	1100 to 1500 feet
Sand	Hard	Red	1500 to 1515 feet
Granite wash	Hard	Brown	1515 to 1525 feet
Shale	Soft	Red	1525 to 1535 feet
Granite wash	Hard	Brown	1535 to 1600 feet
Shale	Soft	Red	1600 to 1640 feet
Sand	Hard	Red	1640 to 1650 feet

Figure 10. Artesian well. Flow about 5.5 cubic feet per second. Temperature of water 123° F. The water appears white because it is so heavily charged with the gas, carbon dioxide.

Conglomerate	Soft	Red	1650 to 1755 feet
Granite shell	Hard	Brown	1755 to 1760 feet
Sand	Hard	Red	1760 to 1780 feet
Shale	Soft	Red	1780 to 1870 feet
Sand	Hard	Red	1870 to 1875 feet
Conglomerate	Soft	Red	1875 to 1880 feet
Lime	Hard	Gray	1880 to 1890 feet
Shale & Gypsum	Soft	Red	1890 to 1915 feet
Sand	Soft	Brown	1915 to 1940 feet
Sandy shale	Soft	Red	1940 to 1980 feet
Conglomerate	Soft	Red	1980 to 2000 feet
Shale	Soft	Red	2000 to 2008 feet

The well was cased as follows:

To 21 feet with 15½ inch casing
To 436 feet with 12½ inch casing
To 940 feet with 8¼ inch casing
To 1810 feet with 6¼ inch casing
To 1905 feet with 5 inch casing

Several flows of hot water were encountered, as follows:

Depth	Temperature	Formation at depth of water
425 feet	108 F.	Hard gray sand
490 feet	108 F.	Between hard gray sand and soft white shale
550 feet	112 F.	Hard gray sand
610 feet	116 F.	Hard gray sand
910 feet	124 F.	Hard red sand
1060 feet	124 F.	Hard red sand
1570 feet	124 F.	Hard brown granite wash
1760 feet	142 F.	Hard red sand
1920 feet	142 F.	Soft brown sand

When valves were closed at the top of the casing a pressure gauge indicated a pressure of 25 pounds per square inch.

The drilling of this second well was discontinued and exploration for natural gas abandoned.

During the early part of 1927, the first well was plugged with a mixture of Portland cement and sand, but before this could be repeated on the second well, very considerable corroding of the casing had taken place, and water was coming to the surface, outside of the casing. At this time the combined flow from the well had a temperature of 123 degrees F., had a very, very faint odor of hydrogen sulfide, and discharged a quantity of carbon dioxide, which was estimated to be one-third of the total volume of the flow. A weir erected near the well in the summer of 1927 showed a flow of approximately 5.5 cubic feet of water a second.

A number of measurements of the volume of water coming from the well were made by different people, and a number of partial analyses were made of the water. Different strata delivered different volumes of water. As is shown above, the temperatures varied. The total mineral content of the water varied also. However, the figures for the mineral matter were between 11,000 and 12,000 parts per million, and, as the casing corroded, the total solid matter in the flow, as noted from time to time, became more uniform, and around 11,600 parts per million.

In August of 1927, a California concern, engaged in the business of plugging wells, sent an expert to this artesian well to shut off this flow of water by using a method which had been shown upon investigation to have worked very successfully in many other places.

A tube of galvanized iron, eight inches in diameter, was charged as follows from bottom to top: blasting gelatine; 80% dynamite; quick setting Portland cement mixed with large lathe turnings; 80% dynamite; and, finally, blasting gelatine. The tube was lowered into the well by means of a cable and sank because of a railroad rail attached to the bottom. At a depth of about 350 feet, both upper and lower charges were fired almost, but not exactly, simultaneously. The cement, compressed between the two explosions set to a plug, and for a few moments it appeared that the water had been shut off. Then pieces of the red shale from the sides of the hole began to come to the surface, and within an hour the well was flowing as usual.

The writer was present when the attempt was made to plug the well, and, having some years before made an investigation of the waters of the Jemez Canyon, he became interested in the situation and raised the question as to whether it was really wise to shut off the water. Water for livestock was no longer available along the Rio Salado very frequently, as, since recent filling of its bed from excessive erosion, the river flowed underground most of the time. Opinion prevailed, when the well first flowed, that livestock would not drink water so heavily charged with salt and soda. Observation was, however, confined to the vicinity of the well, and here the animals would not drink the water, as it was later shown, not because it was saline, but because it was hot. Out of sight from the well, and from the highway, sheep and cattle were drinking the water regularly.

If the well should be allowed to flow, it furnished a stream of water some ten miles long, which was available as drinking water for livestock. This was excellent. On the other hand, this water flowed into the Jemez and the Jemez into the Rio Grande, and, while no Jemez river water for irrigation was taken from the stream below the Salado, the Rio Grande furnished irrigating water all along its course. For years it had been known that ranchers at Corrales, some seven miles below where the Jemez joins the Rio Grande, avoided irrigating after heavy showers had fallen along the Rio Salado. The Indians at Zia, (spelled in several different ways), in recent years avoided Rio Salado contamination by taking irrigation water from the Jemez above the Salado.

Concerning Rio Salado contamination we have word printed in 1894[5] "Sia is situated upon an elevation at the base of which flows the Jemez river. The Rio Salado empties into the Jemez some four miles above Sia and so impregnates the waters of the Jemez with salt that, while it is at all times most unpalatable, in the summer season when the river is drained above, the water becomes undrinkable, and yet it is this or nothing with the Sia." The results of avoidance of Jemez water below the Salado are pointed out in the same report. "Through the Sia have considerable irrigable land they have but a meager supply of water, this being due to the fact that, after the Mexican towns above them and the Pueblo of Jemez have drawn upon the waters of the Jemez river, little is left for the Sia, and, in order to have any success with their crops, they must curtail the area to be cultivated."

What might be the effect on the water of the Rio Grande if the convenience of water for stock was taken advantage of, and the artesian well allowed to flow? This

5. Matilda Coxe Stevenson, in the 11th Annual Report. Bureau of Ethnology, 1889-91. p. 10.

is what the writer undertook to determine. Investigation led to examination of the country for miles around the well, and, during this investigation, hundreds of small openings in the earth were noted, from which saline water came forth.

The investigation itself and the conclusions as they grew can probably be made most clear by a discussion of the places marked "Sample Sites" on the diagram.

Sample Site no. 1	Rio Salado above "The Bancos"
September 3, 1927	Water running on surface. Total solids, 2,192 p.p.m. Water largely charged with gypsum.
Sample Site no. 2	Rio Salado about two miles above junction with stream from artesian well
June 14, 1928	4,987 p. p. m. total solids. Water running on surface.
Sample Site no. 3	Rio Salado about one mile above junction with stream from artesian well
October 2, 1927	6,188 p. p. m. total solids. Water running on surface.
June 14, 1928	4,978 p. p. m. total solids. Water running on surface.
Sample Site no. 4	A pool about 100 yards long in the bed of the Rio Salado, at the junction with, but above, the stream from artesian well.
October 2, 1927	14,812 p. p. m. total solids.
Sample Site no. 4a	Same as no. 4, except sample taken 100 yards up the stream coming from the artesian well
October 2, 1927	12,912 p. p. m. total solids.
Sample Site no. 5	The Artesian Well
August 31, 1927	11,542 p. p. m. total solids.
October 2, 1927	11,654 p. p. m. total solids.

January 14, 1928	11,654 p. p. m. total solids-123° F.
February 22, 1928	11,608 p. p. m. total solids-123° F.
April 29, 1928	11,708 p. p. m. total solids.
June 14, 1928	11,608 p. p. m. total solids.
February 23, 1929	11,644 p. p. m. total solids-123° F.
September 29.1929	11,496 p. p. m. total solids.
Sample Site no. 6	The Plugged Well
January 14, 1928	20,312 p. p. m. total solids.

After the first artesian well was drilled, the spring, from which boiler water had been secured for drilling, went completely dry (See Figure 8). After this well was plugged, many small springs reappeared up the hillside close by the well.

Sample Site no. 6a	Spring up arroyo from plugged well.
March 18, 1928	27,926 p. p. m. total solids.

This spring started to flow after the well had been plugged. Sheep tracks at the spring indicated that animals had been there for water. This is the saltiest water the writer has known animals to drink. Other similar springs were beginning to reappear, down the arrayo from the plugged well.

Sample Site no. 7	Pool in bed of intermittent stream, which flows into stream from Artesian well.
October 2, 1927	16,292 p. p. m. total solids.
Sample Site no. 8	Damp swampy flat bed of stream flowing into arrayo from plugged well.
March 18, 1928	26,192 p. p. m. total solids.
Sample Site no. 9	Small spring on hillside near Site no. 8.
April 29, 1928	11,448 p. p. m. total solids.
Sample Sites no. 10 and no. 11	Two small springs well up on hillside near old "craters."
April 29, 1928	15,938 p. p. m. and 11,206 p. p. m. total solids.

Sheep were drinking this water. Near these springs is an old "crater" spring which appears to have ceased to flow within a matter of a few months. Its walls are perpendicular. The water level is now about 25 feet below the rim. See Figures 11 and 12. These "craters" are travertine cones—a part of the group of some 40 Phillip's Springs.[6]

Sample Site no. 12 Swimming Pool (See Figure 13)
February 22, 1928 7,174 p. p. m. total solids.

This is an old "crater" spring which has remained full of water in spite of the flow from the artesian well. It appears to receive its water on an entirely different side of a fault line from the springs mentioned above.

Sample Site no. 13 Large spring on north side of the canyon from Swimming Pool.
February 22, 1928 11,398 p. p. m. total solids.

On the same side of the canyon but nearer the main highway is another spring whose mouth is not that of a "crater," but rather that of a geyser. J. Wick Miller of San Ysidro says that before the wells were drilled, water stood in this spring to within a few feet of the top. It is now some twenty feet down to water. Mr. Miller says he has dropped sounding lines in the water to a depth of about 80 feet.

Sample Site no. 14 Rio Salado above junction with a stream from Swimming Pool Canyon.
September 3, 1927 12,486 p. p. m. total solids.
Sample Site no. 15 Stream from Swimming Pool Canyon at highway.
January 14, 1928 6,842 p. p. m. total solids.
Sample Site no. 16 Stream from Swimming Pool Canyon near junction with Rio Salado.

6. Auspach and Kelley, Bulletin University of New Mexico no. 71, p. 4., 1913.

Figure 11. Another "crater." Water, which recently flowed over the top, now stands some 25 feet below the rim.

Figure 12. Inside wall of "crater" shown in Figure 11. These little-known "crater" springs are only about a two hour drive from Albuquerque, N. M.

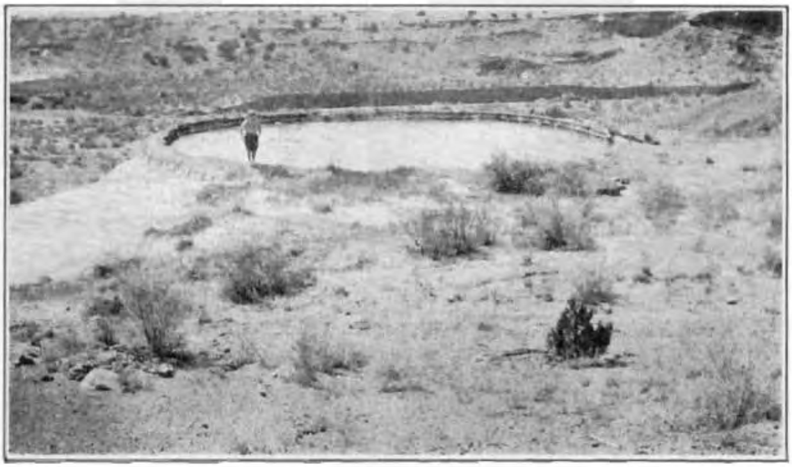

Figure 13. Natural swimming pool.

Figure 14. Travertine ridge south of Rio Salado. Small, old "crater" spring in center. X indicates "crater" now forming. Arrow points to the Cuchillo, a ridge of solid gypsum.

September 3, 1927	9,786 p. p. m. total solids.

This stream was about 20% the volume of the Salado.

Sample Site no. 17,	Spring on south side of Salado at base of Cuchillo ridge .(See Figure 14).
March 18, 1928	2,404 p. p. m. total solids.

Where the Albuquerque-Cuba highway makes a turn to the north along the Rio Salado there is a prominent gypsum ridge on the south of the stream. The spring here seems to be caused by water following this ridge, coming to the surface near the river. The water is nearly saturated with gypsum. This ridge is west of sample sites 23, 24, and 25 of the diagram.

Sample Site no. 18	A small intermittent stream close to highway-seeps along the stream.
March 18, 1928	19,226 p. p. m. total solids.
Sample Site nos. 19, 20, 21, and 22	These are some of the larger of the San Ysidro Springs which are on each side of the highway. They are cold.
February 22, 1928	7,376; 6,363; 6,082; and 6,320 p. p. m. total solids respectively.
Sample Sites no. 23, 24, and 25	Travertine ridge south of Rio Salado. (See Figure 14).

Near where the highway to Cuba makes a turn to the north one may see, across the Salado, a ridge on which the water from many springs is glistening. This ridge runs north and south, and has hundred of tiny springs and many old "craters" upon it. Near its north end are some springs. (See Figures 14 and 15).

November 6, 1927	12,418; 11,230 and 9,518 p. p. m. total solids respectively.
April 25, 1929	9,582 & 11,516 p. p. m. total solids.
Sample Site no. 26	A rain pool near sites nos. 23, 24, and 25.

Figure 15. Looking north down the travertine ridge. Saline matter from dozens of small springs and seepages, which will reach the Rio Salado when the next hard rain washes the ridge.

On the surface, at least, the water from the springs of the travertine ridge does not reach the Salado, but evaporates. (See Figure 15). Each rain picks up the mineral matter deposited by the springs and carries it to the river. Even diluted with rain water, the concentration of this transported spring deposited is high.

November 12, 1927	(shortly after a rain storm) 7,698 p. p. m. total solids.
Sample Site no. 27	Rio Salado at Bridge near San Ysidro.
October 2, 1927	5,118 p. p. m. total solids.
November 6, 1927	11,836 p. p. m. total solids.
January 14, 1928	11,220 p. p. m. total solids.
February 22, 1928	12,612 p. p. total solids.
April 29, 1928	21,720 p. p. m. total solids.
July 20, 1928	5,924 p. p. m. total solids.
August 25, 1928	2,762 p. p. m. total solids.*
February 23, 1929	12,816 p. p. m. total solids.
April 25, 1929	16,436 p. p. m. total solids.
September 29, 1929	9,836 p. p. m. total solids.

(* See also "cloud burst conditions".)

These figures show the concentration of mineral matter which the Rio Salado, ordinarily a very small stream, throws into the Jemez River. Under "Sample Site no. 28" may be noted the mineral content of the Jemez before this addition to it has been made, and under "Sample Site no. 29", one can note the effect of the addition.

Sample Site no. 28	Jemez River at San Ysidro.
November 6, 1927	536 p. p. m. total solids.
January 14, 1928	544 p. p. m. total solids.
February 22, 1928	508 p. p. m. total solids.
March 18, 1928	518 p. p. m. total solids.
June 14, 1928	944 p. p. m. total solids.*
July 20, 1928	484 p. p. m. total solids.
August 25, 1928	1,1182 p. p. m. total solids.
April 25, 1929	328 p. p. m. total solids.
September 29, 1929	280 p. p. m. total solids.

(* River very low, being taken out above for irrigation.)

Sample Site no. 29	Jemez River at Indian village of Zia.
January 14, 1928	1,598 p. p. m. total solids.
February 22, 1928	1,604 p. p. m. total solids.
March 18, 1928	1,688 p. p. m. total solids.
May 5, 1928	650 p. p. m. total solids.
June 14, 1928	4,898 p. p. m. total solids.*
July 20, 1928	1,730 p. p. m. total solids.

(* Jemez being used up above for irrigation.)

August 25, 1928	5,348 p. p. m. total solids.*
April 25, 1929	646 p. p. m. total solids.
September 29, 1929	824 p. p. m. total solids.

(* See also "cloud burst conditions".)

Sample Site no. 30	Rio Grande at Bernalillo Bridge.
February 22, 1928	304 p. p. m. total solids.
March 18, 1928	350 p. p. m. total solids.
April 29, 1928	282 p. p. m. total solids.
June 14, 1928	202 p. p. m. total solids.

July 1928	1,486 p. p. m. total solids.*
July 20, 1928	2,550 p. p. m. total solids**
August 25, 1928	536 p. p. m. total solids.
February 23, 1929	286 p. p. m. total solids.
April 25, 1929	176 p. p. m. total solids.
September 29, 1929	274 p. p. m. total solids.

(* See also "cloud burst conditions".)
(** See also "cloud burst conditions.")

Figure 16. Blocks of travertine left as erosion remnants on the travertine ridge south of the Rio Salado. Hundreds of such giants form the east side of the ridge.

DISCUSSION

From near San Ysidro to the artesian well the formations adjoining or near the highway on the north and west are travertine. This deposit is probably more extensive than the deposit at Mammoth Hot Springs in Yellowstone Park. The remains of ancient springs are to be seen everywhere, and hundreds of small openings from which salt water now flows or seeps, occur in this vicinity. Of this vast deposit Kirk Bryan[7] of the U. S. Geological Survey and of Harvard says, "The rise of salty water at this locality must be very ancient, as the gravel of the Pleistocene terraces is cemented whereas elsewhere it is not. When hot water reached the surface, it deposited its calcium carbonate, but the sodium salts remaining in solution went into the Rio Salado. This is exactly what is happening today." When a "crater" formed, water rose to a certain height, and then its hydrostatic pressure caused the water to burst forth atthe base of the cone. There is every evidence that the volume of water coming to the surface in this locality is less than it used to be, yet it became apparent, soon after this study was started, that it was inevitable that saline water should go to the Rio Salado. If the springs flowed freely, the flow reached the river. If they flowed but slightly, the water evaporated and the saline matter reached the river when the rains came. If the well flowed, many of the springs did not flow, and while the flow from the well was a constant contribution of saline matter, it was diluted regularly as it reached the Jemez. If the springs flowed more and the well less, then the addition of saline matter was irregular and in high concentration.

Opportunity to test this surmise came in the summer of 1928 when the Rio Grande at Albuquerque, had, because

7. Private communication.

of drought, ceased to flow. Original notes on this read as follows: "I chose a time when the Rio Grande had practically ceased to flow because of lack of rainfall in late June and early July, yet just after the July rains had started. A very heavy rain had just fallen locally in the Rio Salado country so that the Rio Grande was made up largely of water coming from this district. On July 20th the Rio Grande, at the Bernalillo bridge, had a total solid content of 2550 parts per million, or about 10 times its usual mineral content. The Jemez at Zia had only 1730 parts per million, the general washings from the Rio Salado country having passed down stream."

Cloudburst Conditions:

Late in the morning of August 25th, 1928 the writer drove to San Ysidro. A thunderstorm of moderate proportion had just gone across the lower end of the valley of the Rio Salado and up the Jemez. The volume of water in the Rio Salado was only a little more than usual. A sample of water from the Jemez at San Ysidro showed what the storm had washed into the Jemez, its concentration being 1,182 parts per million, probably much of this coming from dried deposits around the Indian Springs.

In the afternoon a second storm, this time of cloudburst intensity, broke in the valley of the Salado and went east along the highlands to the south. The whole of the lower Rio Salado valley was washed thoroly and when the writer reached the bridge, the Salado was in full flood from bank to bank. A sample of water taken showed 2762 parts per million. The writer then drove at high speed toward Zia, arriving there ahead of the flood, and awaited the coming of the water. When the flood arrived, and the stream, normally a few feet wide, was over two hundred yards wide, a sample was taken. This represented the washings from the whole spring district of the Rio Salado. It ran 5348 parts per million. This compares with 2762 parts back at the bridge. Even with great dilution from rain water the accumulated spring deposits gave this very large concentration of mineral matter. That evening, after dark, the Rio Grande had a mineral content of 536 parts per million, the great bulk of the mineral matter having gone south.

Conclusions:

The saline matter in the waters of the Rio Salado valley cannot be prevented from getting into the Rio Grande. If the artesian well flows and serves live stock, (and now concrete dipping vats have been set up at the well), the contamination will be constant but slight. If the well is not allowed to flow, the mineral matter will come to the surface thru the springs, and in time of rain, will be added to the river in much greater concentration. There is full confirmation that the long established practice of the Corralles ranchers of avoiding irrigating after showers have fallen in the Rio Salado valley, which is indicated in the Rio Grande by reddish material from these beds, is most reasonable.

Addition Observations:

Many have remarked that such a well of hot mineral water should be put to practical use. It has been suggested that a health resort could be established at the well. This is feasible. A crude bath has already been set up.

It would take 35 tons of average coal per day to heat the water coming from the well in twenty four hours. It has been suggested that the heat of the water should be saved.

Many have noted that the "Russian thistle" close to the well is many times larger than is the same plant a little distant from the water. In both cases the plants get only rain water for their roots but those near the flow have more heat, and are exposed to more carbon dioxide. Carbon dioxide has been shown[8] to have a remarkable effect in increasing plant growth. The writer is of the opinion that a green house could be set up near the well; that the water could flow thru the house in troughs, furnishing heat, and liberating carbon dioxide; and that condensation of water vapor from the roof would furnish plenty of moisture for plant growth, in summer and in winter.

It is also within the range of commercial possibility that the carbon dioxide coming from the well might be used for the manufacture of "dry ice."

8. Chamberlain and Browne, "Chemistry in Agriculture", Chemical Foundation, Inc. New York City.

Figure 18. Aqueduct over the Jemez river. This permits water taken from the Jemez, above the Salado, to be used on Zia Indian land, south of the Jemez.