CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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March 29, 1962

Spring Valley Water Company
940 N. Swan
Tucson, Arizona

Re: Corona de Tucson Area Development,
Pima County, Arizona
Preliminary Groundwater, Hydrology,
Geological-Geophysical Reconnaissance Survey.

Gentlemen:

At the request of your Mr. John Gibbs on 12 March 1962 we were asked to undertake a quick appraisal of the above area in T 16 - 17 S, R 15 - 16 E. After an initial phase was completed, additional work was assigned by Mr. Gibbs on 19 March 1962. Water Development Corporation collaborated in the work in the collection and study of well data shown on the attached plan map, in executing the pump test on the well in Section 13, and in the engineering cost estimate examples as a means to express conclusions regarding our over all estimate of relative groundwater development problems and feasibility in the area. Their separate report and data are attached herewith.

Geophysical work involved a total of 14 days of execution, compilation and interpretation during which four new electrical spreads on three lines were run and tied to a spread-line previously run for Mr. Fiandaca and included herein. Spread and Line locations are shown on the attached plan map and the results on the attached data sheets. A symmetrical colinear dipole-dipole electrode layout, sometimes called Eltran system, was used with a modern induced polarization square wave generator and receiver. Apparent resistivities in units of ohm feet over 2 pi, were obtained on all spreads and are plotted as the main figures on the top half of attached sectional data sheets. Smaller numbers plotted as superscripts to the apparent resistivity values are percent frequency effect of induced polarization and the lower half data sheet values are a combination of apparent resistivity and percent frequency effect. These latter two were obtained on all but lines 2 & 3 where surface ground conditions gave some difficulty with AC

switching. Contouring shown is variable on both a logrithmic and arithmetic interval and is strictly interpretative.

Line 2 was used to correlate results with the better known conditions in the El Paso Gas wells in Section 4, T 16 S, R 15 E. Results show a resistivity decrease with depth to a somewhat more pronounced central low and intervening sharper gradient probably representing a linear resistivity discontinuety more or less parallel to the water table and possibly at or near it such as a clay zone. This general situation is approximately but definitely repeated on Lines 3 and 4, but with a gradual increase in over all resistivity to the south east until the region around Station 1.50S (electrode #5) on spread 1 line 4, where there is a relatively abrupt increase in the deeper resistivities, suggesting a more major change in structure and or lithology with depth in this area. Also, immediately beyond this further southeast is a more sudden and larger increase in the nearer surface resistivities and more radical variations and increases in polarization effects.

Since all of the latter correlate with the poorer indications from the Section 13 well, this zone is interpreted as a probable approximate boundary location of poorer conditions to the southeast and better conditions toward the west and northwest. This information is also supported from magnetic data on the area available to us but not included here, which was used to benefit the work at no additional cost.

Thus, we recommend no initial test well be drilled beyond this area to the southeast and preferably, the first test well be drilled about one mile further northwest as an added factor of safety. Pending results from such a well, then offsetting to the southeast can be best considered at that time. More detailed local interpretations may also be possible following correlation with a reliable log and thorough pump test results from any new well drilled near the geophysical profiles. Also, this should be done in any event, to best evaluate the initial results and potential of any new drilling done.

Respectfully submitted,
HEINRICHS GEOEXPLORATION COMPANY

Walter E. Heinrichs, Jr.
President & General Manager

Registered Professional Engineer (Mining) CERTIFICATE EXPIRES DEC. 31, 19__ WALTER E. HEINRICHS, JR. ARIZONA, U.S.A.

WEH:jh

Enclosures

Water Development Corporation
CONSULTANTS IN GROUND-WATER HYDROLOGY

3938 SANTA BARBARA AVENUE
TUCSON, ARIZONA

PHONE: EAST 6-1133
CABLE: WADEVCO, TUCSON

March 26, 1962

Heinrichs GeoExploration Co.
808 West Grant Road
Tucson, Arizona

Pumping Test, Sec. 13, T.17 S., R.15 E.

Gentlemen:

Basic Data

Enclosed are four copies of the data obtained during the test of the Mt. Fagan Ranch Well located in Sec. 13, T.17 S., R.15 E. Also enclosed are four copies of a graph showing drawdown and recovery versus time.

The sounder indicated the static water level to be 702 ft. This measurement was later corrected to 707.5 ft. by measuring the sounder line with a steel tape. All other water level measurements were then corrected accordingly.

The pump used during the test was a Jensen Jack operating at a rate of 20 strokes per minute. The depth at which the pump cylinder was set is not known.

The discharge rate increased gradually during the test from about 12 gpm (gallons per minute) to about 14 gpm. Small fluctuations in discharge are due to the type of pump used. Drawdown increased steadily for ONE HOUR until the water level reached 731.1 ft. at which point it leveled off. The well was pumped an additional one hour and ten minutes at the same rate with no further increase in drawdown and was then shut off. Recovery was measured for one hour and eighteen minutes at which time the well had recovered to within 3.5 ft. of initial static water level.

The log of the well indicates that the zone from which water is produced is between depths of 725 and 742 ft. below land surface. This zone is described in the log as clay and gravel. From 742 to 947 ft. the log describes the material as cemented gravel, hard.

Conclusions based on the pumping test

A total of 1,720 gallons was produced during the 129 minutes that the water issued from the well. From these data, the average weighted discharge during the period of pumping was 13.35 gpm. During the period of pumping the drawdown was 23.6 ft. Dividing the discharge by the water-level decline gives a mean specific capacity of 0.57 gpm per ft. From these data it is possible to estimate what the discharge would be if the water level were drawn down to the bottom of the producing zone, 742 ft. Under such circumstances the total drawdown would be 34.5 ft., and the discharge to be expected is 19.6 gpm.

If practically all of the water is coming from the interval 725-742 ft., the maximum yield obtainable from the well is about 20 gpm. If water is also being yielded from the cemented gravel (742-947 ft.) at the same rate as from the interval 725-742 ft., the theoretical discharge at various levels is as follows:

Pumping level (ft.)	Theoretical discharge (gpm)
800	53
850	82
900	110

It is of the utmost importance to realize that the actual data indicate an uppermost yield of about 20 gpm from the well, and that extrapolation of the data to a greater yield as given above is based on an assumption which is not supportable by general knowledge of the geology of the region--such assumption being that the cemented gravel between 742 and 947 ft. might yield water at the same rate as the uncemented material between 725 and 742 ft. The tabulation given in the preceding paragraph clearly indicates that under no circumstances could a 500 gpm well be anticipated in the immediate vicinity of the well that was tested.

Further undesirable considerations are the very limited storage of water in a saturated water bearing formation only 17 ft. thick and the mutual interference effect of pumping twenty-five wells constructed within a small area in such an aquifer.

For the reasons given herein I am firmly of the opinion that it would be economically undesirable to attempt to develop a water supply of 500 gpm within the three sections 12, 13, and 14. Under conditions indicated by the results from the test, twenty-five wells would be needed (500 gpm divided by 20 gpm per well).

Conclusions relating to site for test hole

1. Considering only the available well data, ground-water conditions improve westward and northwestward from the well in Sec. 13.

2. Considering geophysical data and well data, I would recommend that a test well be drilled no farther east or south than the NE 1/4 Sec. 3, T.17 S., R.15 E. If a test well is drilled at that location, I would suggest that the maximum depth be 800 ft., that the diameter be at least 8 inches and preferably 10 inches to accomodate a pump, and that the casing should be perforated opposite all water-bearing material encountered below the water table. It is anticipated that the water table will be at a depth of 460 to 480 ft. below land surface. A well at this location, after thorough development, can be expected to yield at least 25 gpm. The upper limit of yield is not likely to be more than 100 gpm.

Estimated cost of developing 500 gpm.

In order to evaluate the economic aspects of developing the required water supply of 500 gpm at different places in the area, I made some estimates of capital investment cost (Table 1). An assured supply can be developed in the vicinity of Sec. 10, T.16 S., R.15 E., at a capital cost of the order of $175,000. Likewise, an assured supply can be developed locally, at a capital cost in excess of $230,000. If favorable conditions are encountered as a result of drilling a test well in Sec. 3, T.17 S., R.15 E., it appears that a supply can be developed at a cost of $100,000 to $120,000.

Table 2 shows the range of magnitude of annual consumption of electric power required to pump 500 gpm. It is interesting to note that total hydraulic head, including delivery pressure and friction loss in the delivery pipeline, is almost the same no matter where the wells are drilled. The greatest and least annual power consumption vary from the median by less than 2 percent.

Very truly yours

Leonard C. Halpenny

Leonard C. Halpenny

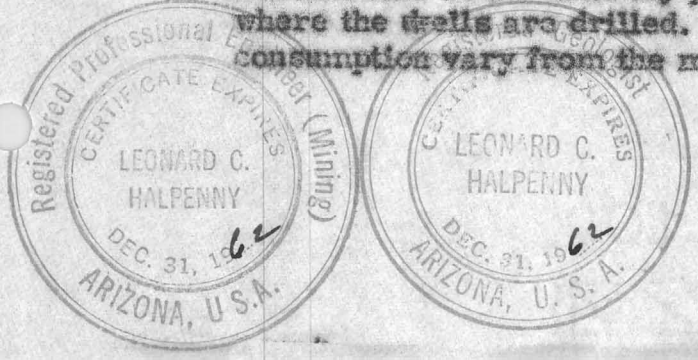


TABLE 1

Comparison of systems required to obtain water from different sites for delivery to SE corner Sec. 11, T.17 S., R.15 E.

Item	Locally developed supply	Supply centered at Sec. 34, T.16 S., R.15 E.	Supply centered at Sec. 28, T.16 S., R. 15 E.	Supply centered at Sec. 10, T.16 S., R.15 E.
Yield of wells, gpm	20	100 ?	100?	250
Number of wells	25	5	5	2
Average depth of wells, ft.	750	650	600	520
Length of pipe line, mi.	1	3	4	6.5
Estimated cost of pumps, each	$1,000	$2,000	$1,500	$2,000
CAPITAL COST				
Wells, @ $10/ft.	$188,000	$32,500	$30,000	$10,400
Pumps	25,000	10,000	7,500	4,000
Pipe line	25,000	75,000	100,000	162,500
Total	$238,000	$117,500	$137,500	$176,900

TABLE 2

Total lift and power required to deliver water from different sites to SE corner, Sec. 11, T.17 S., R.15 E.

Item	Locally developed supply	Supply centered at Sec. 34, T.16 S., R.15 E.	Supply centered at Sec. 28, T.16 S., R.15 E.	Supply centered at Sec. 10, T.16 S., R.15 E.
Static water level, ft.	705	430	340	370
Drawdown, ft.	35	100	80	20
Average rise in land surface from site to point of use, ft.	20	140	240	220
Friction loss in pipeline from site to point of use, ft.	20*	80**	100**	170**
Head to provide delivery pressure, ft.	100	100	100	100
TOTAL HEAD, ft.	860	850	860	880
Total kwh per year, @ 65% efficiency	1,092,000	1,080,000	1,092,000	1,118,000

* Estimated friction loss in gathering lines.

** Friction loss when delivering 500 gpm in a 5-inch line.

TEST DATA -- MT. FAGAN RANCH WELL

Date	Hour	Water Level (ft.)	Drawdown (ft.)	Discharge (gallons per minute)	Remarks
3-23-62	8:45 a.m.	*707.5	--	--	Static water level
	8:52	--	--	--	Pump on, start of drawdown period
	8:53	--	--	--	Water from discharge pipe
	8:55	--	--	11.8	
	8:56	713.1	5.6	--	
	8:57	714.6	7.1	--	
	8:58	715.6	8.1	--	
	8:59	716.7	9.2	--	
	9:00	717.7	10.2	--	
	9:02	718.9	11.4	--	
	9:04	720.3	12.8	--	
	9:06	721.9	14.4	13.0	
	9:08	722.9	15.4	--	
	9:10	723.4	15.9	--	
	9:15	725.0	17.5	--	
	9:20	726.3	18.8	13.0	
	9:25	727.6	20.1	--	
	9:30	728.5	21.0	--	
	9:35	729.7	22.2	--	
	9:45	730.9	23.4	13.4	
	9:55	731.1	23.6	--	
	10:00	731.1	23.6	13.2	
	10:10	731.1	23.6	--	
	10:20	731.1	23.6	13.5	
	10:30	731.1	23.6	--	
	10:45	731.1	23.6	14.0	
	11:00	731.1	23.6	13.7	
	11:02				Pump off

TEST DATA -- MT. FAGAN RANCH WELL

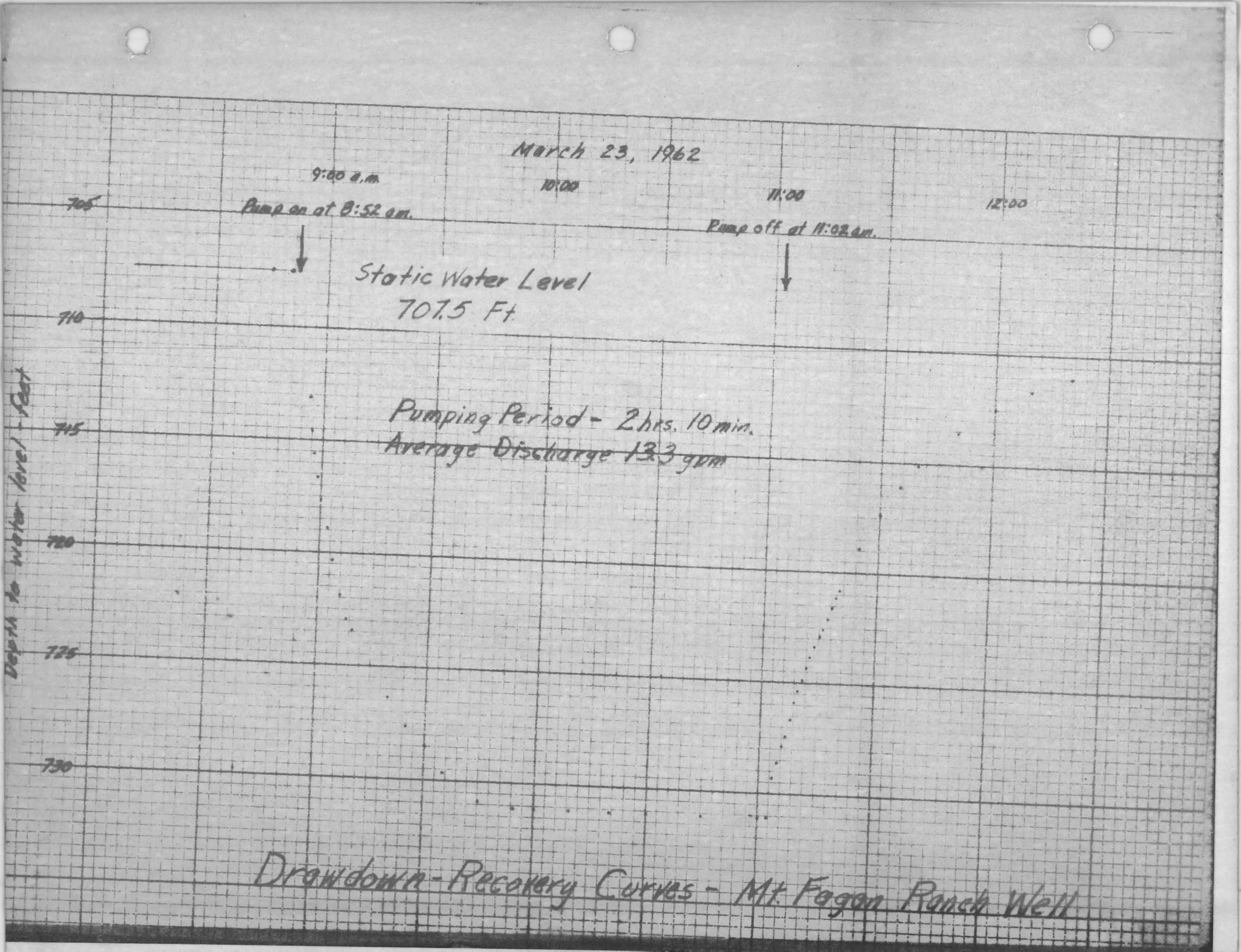
RECOVERY PERIOD

Date	Hour	Water Level	Residual Drawdown	Remarks
3-23-62	11:02 a.m.	731.1	23.6	
	11:04	729.3	21.8	
	11:05	728.6	21.1	
	11:06	727.8	20.3	
	11:07	727.4	19.9	
	11:08	726.7	19.2	
	11:09	725.9	18.4	
	11:10	725.4	17.9	
	11:11	724.9	17.4	
	11:12	724.3	16.8	
	11:13	723.8	16.3	
	11:14	723.4	15.9	
	11:15	722.9	15.4	
	11:16	722.6	15.1	
	11:17	722.1	14.6	
	11:18	721.6	14.1	
	11:19	721.2	13.7	
	11:20	720.8	13.3	
	11:25	718.9	11.4	
	11:30	717.4	9.9	
	11:35	716.1	8.6	
	11:40	715.2	7.7	
	11:50	713.6	6.1	
	12:00	712.5	5.0	
	12:10	711.7	4.2	
	12:20	711.0	3.5	Measurements discontinued

Water sample taken

Water temperature 84°F

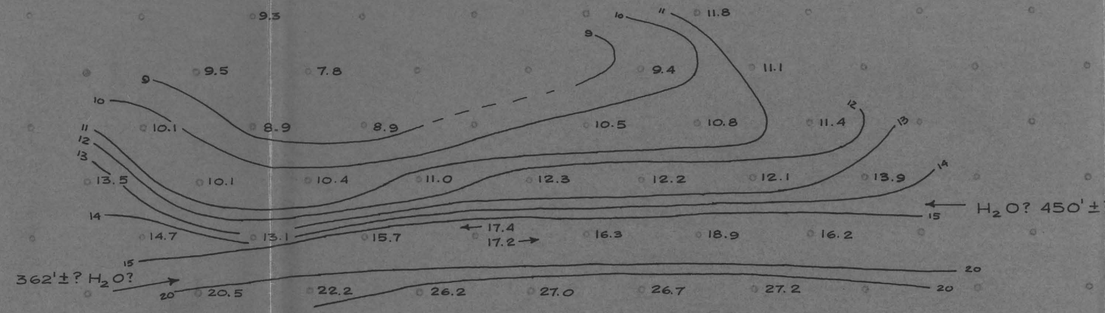
* Measuring point 3/4 inch bolt hole approximately 1 ft. above general land surface.

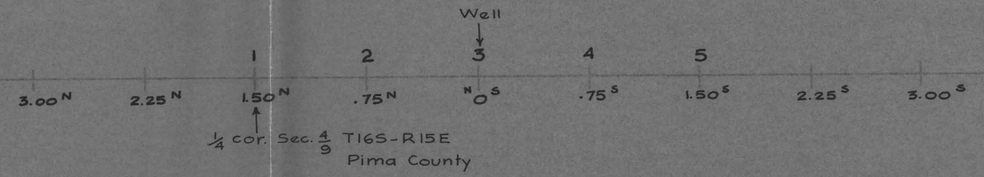


Drawdown - Recovery Curves - Mt. Fagan Ranch Well

Separation or Depth Point

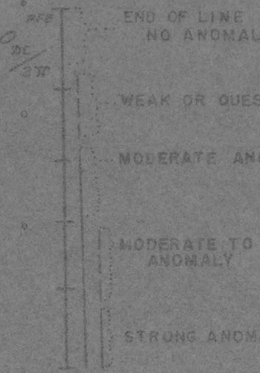
Apparent Resistivity (Ohm feet)
Superscript numbers indicate Percent Frequency Effect





Line bearing N 58° W
S 58° E

Metallic Conduction Factor (Apparent)



C.I. = LOGARITHMIC

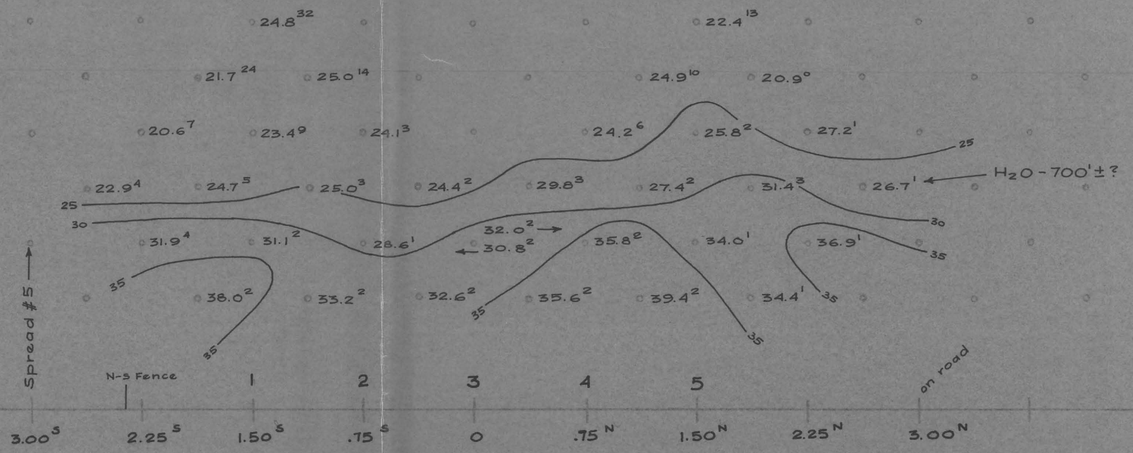
( ) INDICATES QUESTIONABLE DATA

M.C.F.

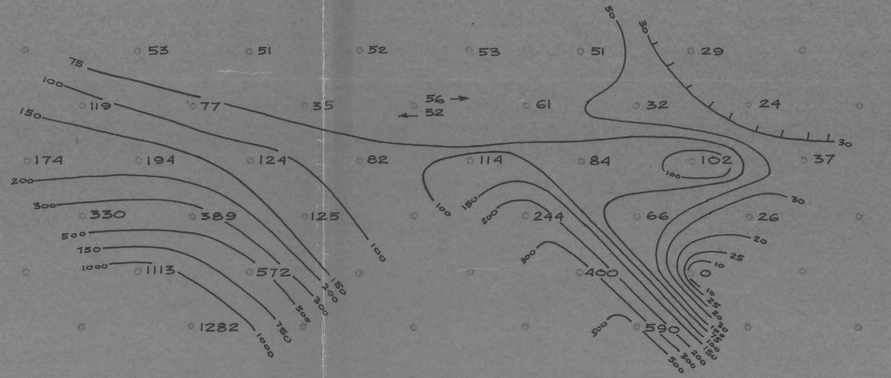
SECTIONAL DATA SHEET
CORONA DE TUCSON PROJECT
for
Spring Valley Water Company
LINE No. 2
INDUCED POLARIZATION SURVEY
HEINRICHS GEOEXPLORATION COMPANY
SCALE 1" = 750'
DATE March 1962

Separation or Depth Point

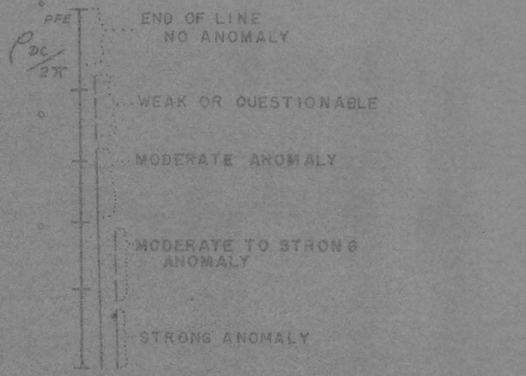
Apparent Resistivity (Ohm feet)
Superscript numbers indicate Percent Frequency Effect



Metallic Conduction Factor (Apparent)



Line bearing N 25° E - S 25° W

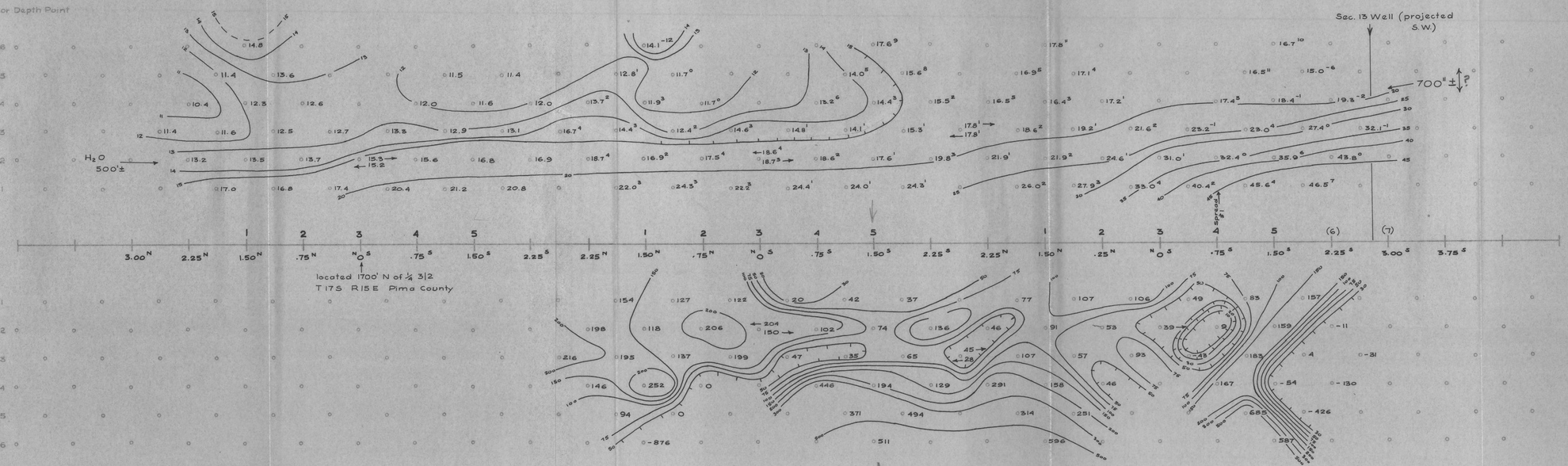


O.L. = LOGARITHMIC

(( )) INDICATES QUESTIONABLE DATA

M.C.F.

SECTIONAL DATA SHEET
CORONA DE TUCSON PROJECT
for
Spring Valley Water Company
LINE No. 1
INDUCED POLARIZATION SURVEY
HEINRICHS GEOEXPLORATION COMPANY
SCALE 1" = 750'
DATE March 1962



INTERPRETATION LEGEND

- End of line no anomaly
- ? Very weak & questionable
- Weak or questionable
- Moderate anomaly
- Moderate to strong anomaly
- Strong anomaly

C.I. = Logarithmic

(( )) indicates questionable data

M.C.F.

SECTIONAL DATA SHEET

CORONA DE TUCSON PROJECT

for

Spring Valley Water Company

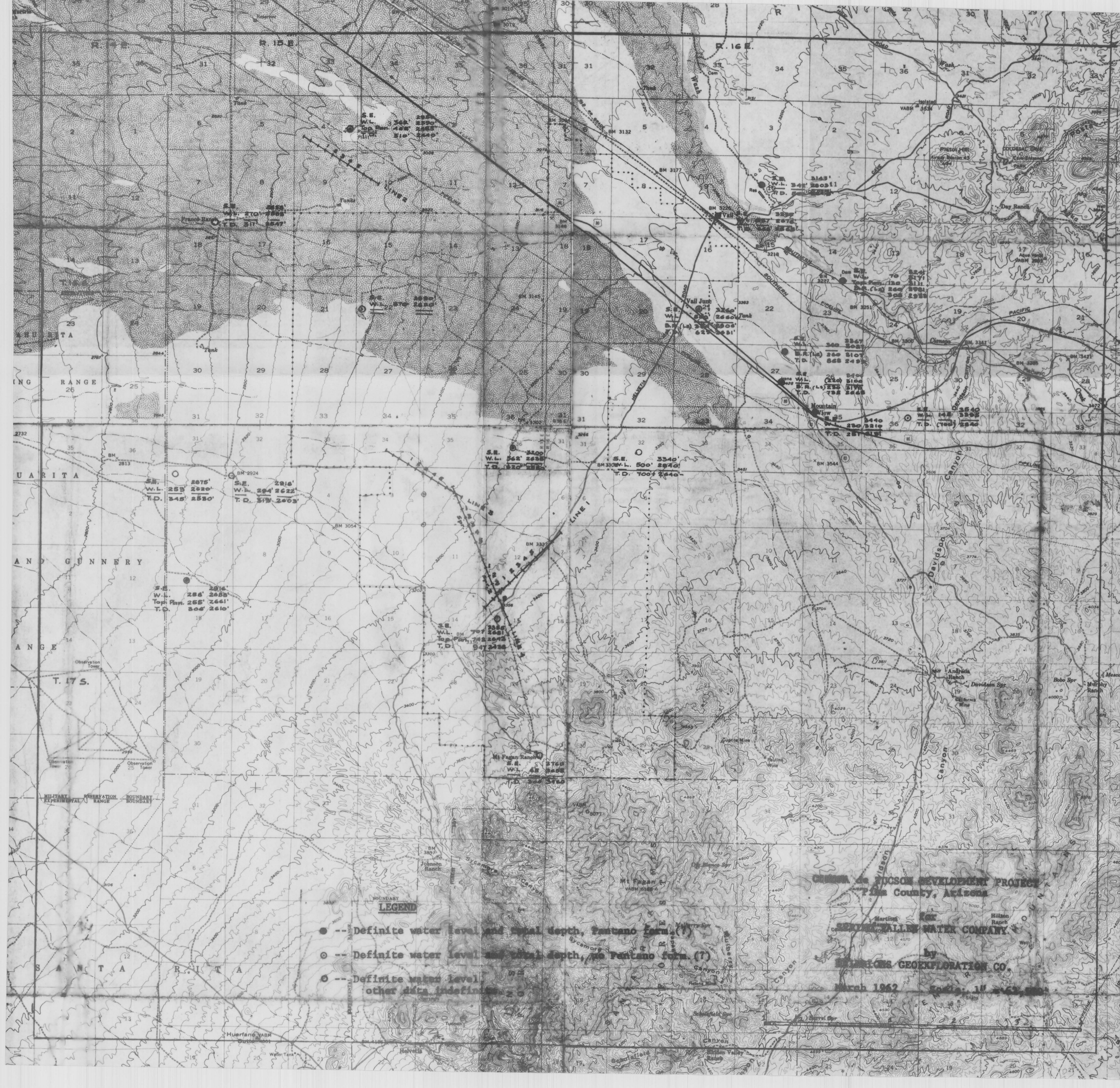
LINE No. 3 & 4

INDUCED POLARIZATION SURVEY

HEINRICHS GEOEXPLORATION CO.

Scale 1" = 750'

Date March 1962



R. 15 E.
R. 16 E.
T. 17 S.
Vail
Vail Junc
Mountain View
Franco Ranch
Pistol Hill
Day Ranch
Andrada Ranch
Davidson Canyon
Mt Fagan Ranch
Mt Fagan
Johnson Ranch
Sycamore Canyon
Mulberry
Observation Tower
LINE 1
LINE 2
SOUTHERN
PACIFIC
Cienega
SANTA RITA
AND GUNNERY
MILITARY RESERVATION BOUNDARY
EXPERIMENTAL RANGE BOUNDARY
LEGEND
● -- Definite water level and total depth, Pantano form.(?)
◎ -- Definite water level and total depth, no Pantano form.(?)
⊙ -- Definite water level, other data indefinite.
CORONA de TUCSON DEVELOPMENT PROJECT
Pima County, Arizona
for
VALLEY WATER COMPANY
by
HEINRICHS GEOEXPLORATION CO.
March 1962