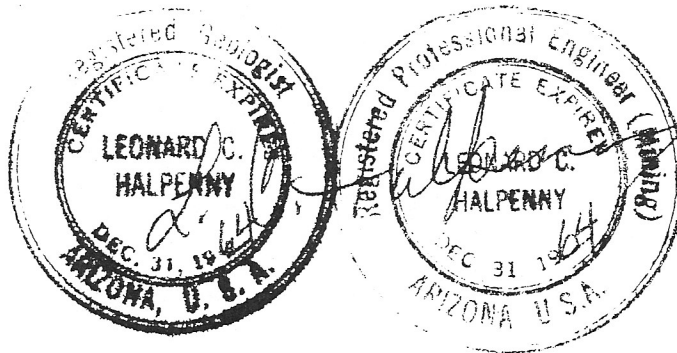


WATER DEVELOPMENT CORPORATION  
TUCSON, ARIZONA

GROUND-WATER SUPPLY OF PATAGONIA  
AREA, SANTA CRUZ COUNTY,  
ARIZONA

By

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N. E. Dausinger



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# GROUND-WATER SUPPLY OF PATAGONIA AREA, SANTA CRUZ COUNTY, ARIZONA

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## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

The data collected and analyzed during the investigation described in this report led the authors to develop the following conclusions:

1. The only feasible place to develop a ground-water supply for the community is in the inner valley near the confluence of Harshaw and Sonoita Creeks.
2. The quality of the ground water is satisfactory for public use.
3. The hydrologic studies indicate that the ground-water reservoir is capable of supplying the needs of the Town and the agricultural lands indefinitely.
4. The most direct method of obtaining a water supply is to purchase Well No. 5 cced if this is feasible. If this is not feasible, an alternate site for drilling a new well is shown on the map, Plate 1.
5. The hydraulic character of the aquifer is such that operation of a municipal well would not affect water levels in irrigation wells and vice versa, except that perhaps 5 feet of seasonal fluctuation of all water levels can be expected to occur if and when all the bottom lands are placed under cultivation and irrigated.

### Recommendations

The recommended procedure in developing a ground-water supply is as follows:

1. If feasible, purchase Well No. 5 cccd and install a pump.
2. Alternatively, acquire a site at the location shown on Plate 1, and drill a well 150 feet deep with a diameter of 12 to 16 inches.



## INTRODUCTION

The Town of Patagonia is in eastern Santa Cruz County at the confluence of Harshaw Creek with Sonoita Creek (see Pl. 1). The 1964 population is about 700, and there is no community water system. There are many wells of small yield in the town, each serving one or more families. The problem of pollution of these individual water supplies has been described by Beard (1963, p. 2) <sup>1/</sup> as follows:

"Each home has an individual sewage-disposal system. The effluent from these separate systems increases the danger of pollution of the ground water. The Arizona State Health Department has recommended that because of this, any development of the ground water supply for a municipal water system should not be downstream from the Town."

In his report, Mr. Beard (op. cit.) has demonstrated that development of a community water supply is warranted and is economically feasible. It was found that a well with a capacity of 250 gpm (gallons per minute) would adequately supply the Town for several years. The existence of a suitable aquifer immediately upstream from Patagonia, in the vicinity of the confluence of Harshaw and Sonoita Creeks was known. The remaining questions were the determination of the adequacy of this aquifer to supply 250 gpm for municipal use for at least 40 years, and the selection of a well site.

Accordingly, on behalf of the Town of Patagonia, Mr. Beard requested that the ground-water supply of the Patagonia area be investigated by Water Development Corporation to review the feasibility of developing a ground-water supply for municipal use. The assignment was undertaken on September 14, 1964. This report contains the results of the investigation.

### Data Collection and Field Work

An initial investigation of the area had been made by Halpenny and Greene (1959), during and following which several test holes and wells were drilled in Sec. 5, T. 22 S., R. 16 E., by Mr. R. B. Ensign (see map (Pl. 1), and well records, (Appendix)). Copies of all the available data relating to the area were kindly supplied by Mr. Ensign (well records, water analyses, and aerial photographs) and by Mr. Beard (base maps and water analyses). Additional data were obtained from the U. S. Geological Survey, including a report on a reconnaissance investigation made by Feth (1954).

<sup>1/</sup> See "References Cited", at end of report.

Field work was done by Halpenny, Greene, and Dausinger, during field trips on September 13, October 7, and October 9, 1964. This work consisted of reviewing well locations, measuring water levels, collecting a water sample from the High School well, and making a supplemental geologic reconnaissance.

#### Acknowledgments

The splendid cooperation of Messrs. Ensign and Beard expedited the work substantially and is gratefully acknowledged. Others who provided assistance were Mr. Robert Lenon, Town Engineer, and Mr. Don Hartranft.

## TOPOGRAPHY AND DRAINAGE

Sonoita Creek rises about 10 miles north of Patagonia, between the Santa Rita Mountains on the west and the Canelo Hills on the east. The creek flows south as far as Patagonia, and thence southwest for about another 20 miles to where it joins the Santa Cruz River about 10 miles north of Nogales. The Patagonia Mountains lie directly south of Patagonia. Harshaw Creek drains the north and west sides of these mountains and part of the west side of the Canelo Hills. The drainage area of Sonoita Creek at Patagonia is about 180 square miles.

The valley drained by Sonoita Creek is about 12 to 20 miles wide. The highest peaks in the region are Mt. Wrightson (9,445 ft) in the Santa Rita Mountains, and Red Mountain (6,341 ft) in the Patagonia Mountains. Gradients of side washes in the vicinity of Patagonia are 200 to 300 feet per mile, and the gradient of Sonoita Creek is about 50 feet per mile. The altitude at Patagonia is about 4,080 feet.

Sonoita Creek has incised a narrow inner valley along its course. The floor of this inner valley is about 100 feet lower than the floor of the main valley. The width of the inner valley is about  $\frac{3}{8}$  mile. It extends up Sonoita Creek for about 8 miles and up Harshaw Creek about  $1\frac{1}{4}$  miles.

## GEOLOGY AND ITS RELATION TO GROUND-WATER SUPPLIES

The geology of the region surrounding Patagonia is extremely complex. The most comprehensive description is given in Schrader (1915). The only place within a radius of 5 miles from Patagonia where a well of 250 gpm capacity is known to be possible is in the inner valley of Sonoita and Harshaw Creeks near their confluence. Accordingly, the discussion of geology in this report is limited to the locality immediately upstream from Patagonia.

### Recent Alluvium

The floor of the inner valley is underlain by alluvium of Recent age, consisting of unconsolidated soil, silt, sand, and gravel. The thickness of this material ranges from less than 10 feet along Harshaw Creek, about 1-1/2 miles east of Patagonia, to about 100 feet along the east side of Sonoita Creek about 1/4 mile upstream from the mouth of Harshaw Creek. At the northern edge of Sec. 5 (see Pl. 1) the thickness of alluvium is 30 feet close to the creek and is about 50 feet close to the east edge of the inner valley.

### Pleistocene Terrace Gravels

Partially consolidated to unconsolidated alluvium consisting of conglomerate, gravel, sand, silt, and clay, comprises the materials at the land surface of the broad main valley. The maximum thickness of these materials is 75 to 100 feet, based on observations in road cuts along State Highway 82 north of Patagonia. Feth (op. cit., p. 3) assigns a Pleistocene age to this unit. He describes it as follows:

"The gravels of the lower terrace are considered to be, at least in part of local origin. This is indicated by the abundance of volcanic materials in the fragments of pebble and cobble size, and especially by the marked red color of the terrace deposits near the base of Red Mountain, which contrasts with the buff and tan colors of the terrace materials at the same levels elsewhere in the valley. The red pigment appears very strongly in the silt-size materials adjacent to Red Mountain. The effect is more striking when seen from across the valley than when the observer is on the red terraces themselves.

"It appears probable that some beds in the gravel potentially are good aquifers, as the degree of cementation is slight and, in some beds, sorting is good. However, gullying of the gravels to the present level of Sonoita Creek makes it unlikely that any water is long trapped in the alluvium above the level of Sonoita Creek. Only the materials extending below the bottom-land levels can be considered potentially water-bearing. They no doubt serve to conduct runoff from mountain canyons underground."

Evidence as to whether or not the Pleistocene terrace gravels underlie Recent alluvium in Sec. 5 is inconclusive. If this unit does underlie Recent alluvium in Sec. 5, the occurrence is only in a belt about 500 feet wide against the east edge of the inner valley.

#### Pleistocene (?) Alluvium

In many road cuts along State Highway 82 north of Patagonia, a grayish to reddish fairly dense conglomeratic unit can be seen underlying the Pleistocene terrace gravels. This material was termed agglomerate by Feth (op. cit., p. 5), but additional field work indicates that the term "agglomerate" is too restrictive to describe the unit adequately. Accordingly in this report the authors use the term Pleistocene (?) alluvium to designate the unit.

The contact between the Pleistocene (?) alluvium and the overlying terrace gravels is unconformable. The Pleistocene (?) alluvium directly underlies the Recent alluvium along the west side of the inner valley of Sonoita Creek, and is exposed in the hills along the east side. It was identified at various depths in different wells in Sec. 5 as follows:

Well No.	Depth to Pleistocene (?) alluvium (ft)
5 acaa	25
5 bdaaa	45
5 bdaab	70
5 bdabd	44
5 bdba	36
5 caca	65 or 105
5 caccd	prob. 115
5 ccad	138 (?)
5 cccd	95
5 cdca	80

The Pleistocene (?) alluvium is extremely heterogeneous, although fine-grained materials predominate. Examination of the well logs (Table 2) indicates the existence of clay, clay with gravel, some sandy zones, and one layer of water-bearing tuff 3 feet thick.

### Structure

The drilling done to date in the inner valley indicates that the structural relations in the inner valley are complicated. The straight alignment of Sonoita Creek for several miles implies the existence of a fault trending south along the creek.

A major structural pattern in the region trends northwest. Apparently there are a series of northwest-trending faults that cut across Sonoita Creek. One of these, upthrown on the southwest side, follows the wash that enters Sonoita Creek from the northwest in the NW 1/4 SW 1/4 Sec. 5. Andesite crops out on the west side of this wash about 1/4 mile upstream from the mouth, but on the east side terrace gravel and Pleistocene (?) alluvium were found. At this point the throw of the fault was estimated to be 75 to 80 feet based on topographic features shown on aerial photographs and the U. S. G. S. quadrangle map. It is possible that this fault extends southeastward beneath the inner valley, on the downstream side of Well No. 5 ccad.

Another northwest-trending fault, upthrown on the southwest side, may cut across the inner valley between Well No. 7 aabc and the old railroad bridge. Andesite crops out in the bed of the creek near the bridge and in a road cut on Harshaw Creek road in the NW 1/4 NE 1/4 Sec. 7.

### Summary of Units Underlying the Inner Valley

The subsurface relations along the west side of the inner valley of Sonoita Creek in Sec. 5 are clear, but they are obscure along the east side. Along the west side, Recent alluvium clearly lies on top of Pleistocene (?) alluvium, with the contact at a depth of 35 to 40 feet. Well yields are low because the water table is about at the contact and because the Pleistocene (?) alluvium is dense and yields little water.

Along the east side of the inner valley the subsurface relations are obscure. In 1959, geophysical equipment was used without success in an attempt to clarify the situation.

By 1964 much additional data had been accumulated. The material below a depth of 50 feet (the logical bottom of the Recent alluvium) is extremely transmissible in comparison with the west side. Nevertheless, no continuous belt of relatively high transmissibility exists. In the vicinity of Well No. 5 bdaaa the coefficient is about 10,000 gpd/ft (gallons per day per foot). About 3/8 mile downstream at Well No. 5 caca it is less, estimated as about 8,000 gpd/ft. Only 1/8 mile farther downstream it increases to 100,000 gpd/ft at Well No. 5 caccc, and this condition prevails as far as Well No. 5 ccad. From there, the coefficient decreases to about 15,000 gpd/ft at Well No. 5 cccd and increases to perhaps 50,000 gpd/ft in the vicinity of Well No. 7 aabc.

On the basis of present knowledge, it is evident that the deepest part of the inner valley lies along the east side. Apparently successive cross faults have slightly uplifted the downstream beds, producing deeper pockets of transmissible material or fractured zones in the vicinity of the faults. This hypothesis fits the facts as known.

## GROUND-WATER RESOURCES

### Occurrence

Within the area covered by this report ground water, in quantities considered to be adequate for irrigation purposes or for a municipal supply, occurs in the Recent alluvium and in the underlying materials where they are poorly cemented or have been shattered or fractured as a result of faulting.

The present depth to the water table (1963-1964) ranges from about 41 feet at Well No. 5 bdaaa to 44 feet at Well No. 5 cccd. The depth increases east along Harshaw Creek, and is 55 feet at Well No. 8 baca. Depth to water in Well No. 5 bdaaa was 40.9 feet in October 1959 when the well was drilled, 37.3 feet in November 1960, 38.4 feet in December 1961, and 40.2 feet in August 1963. Thus, for the period 1959 through 1963 there has been no net decline in the water table. Estimated depth to the water table at the alternate site selected for the City well is about 40 feet.

Yields of irrigation wells which have been drilled in the inner valley vary widely, ranging from a maximum of 1,300 gpm at Well No. 5 ccad, down to yields so low that the wells were abandoned for irrigation purposes. This indicates that in addition to the variable thickness of material, there is also a great variation in the percentage of silt and clay mixed with the sand and gravel.

### Movement

The direction of ground-water movement is downstream in a southerly direction along Sonoita Creek to the Sonoita-Harshaw confluence where it joins with the underflow of Harshaw Creek from the east. The combined underflow of both creeks then moves southwest along Sonoita Creek past the town of Patagonia.

### Discharge

Discharge of ground water from the area occurs in the form of water pumped by wells for domestic and irrigation use plus natural discharge as surface flow out of the area, and evapotranspiration by plants.



## Ground-Water Pumpage

At the present time there are approximately 90 acres of land immediately upstream from Patagonia being irrigated with ground water. Based on a net consumptive use of 2.0 acre-feet per acre per year the total amount of water used is 180 acre-feet per year. Another 20 acres could go into cultivation in the future, which would raise the total annual requirement for irrigation to 220 acre-feet. Ground-water pumpage for domestic use is estimated to be 150 gpd (gallons per day) per person. With a present population of 700 people (Beard, op. cit., p. 2) this pumpage amounts to 105,000 gpd or about 118 acre-feet per year. Combined with irrigation use, this gives an eventual total of 338 acre feet per year of ground water pumped.

## Natural Losses

Natural losses in the area were studied by Halpenny and Greene (1959, p. 7) and described as follows:

"Studies of streamflow measurements made by the U. S. Geological Survey on Sonoita Creek downstream from Patagonia indicate that a year-round average of 7 cfs (cubic feet per second) of underflow rises to the surface at and downstream from the Patagonia Narrows. This quantity does not include flood flows but does include an adjustment for consumptive use by plants above the gaging station."

Most of this flow issues from the Recent alluvium, with possibly a small portion consisting of deeper ground water being brought to the surface along faults or formation contacts. In terms of the present usage for domestic and irrigation purposes, this 7 cfs amounts to 5,050 acre feet per year, or about 15 times the calculated annual requirement for the Patagonia area.

## Recharge

Recharge to the alluvial material in the Patagonia area is furnished by stream flow during the rainy seasons. Studies of streamflow measurements made by the U. S. Geological Survey at the gaging station downstream from Patagonia, based on 28 years of record, show that average annual flood flows at this station amount to 1,880 acre-feet. The principal period of flood runoff is the summer rainy

season and runoff occurs every summer. The net result of this flow is to provide a perennial source of replenishment to the alluvium immediately upstream from the Town of Patagonia. Evidence of this is verified by the lack of decline in water levels in the area.

### Hydraulic Properties

The hydraulic properties of the aquifer at one point were determined by means of a pumping test made on Well No. 5 cacc in August of 1959 by personnel of Water Development Corporation and R. B. Ensign (see data in Table 4). Water-level measurements were made on both the pumped well and Well No. 5 cacc. The hydraulic properties determined from the test are described in the Appendix on page 4. To be conservative, for field use a coefficient of transmissibility of 100,000 gpd/ft was used for the vicinity of this well and the coefficient of storage was selected as 20 percent.

Additional tests to determine aquifer characteristics were subsequently made by R. B. Ensign. The data are given in the Appendix.

The coefficient of transmissibility for Well No. 5 cccd, based on the specific capacity, was computed to be 15,000 gpd/ft and the coefficient of storage is estimated to be 20 percent. As this well is near the alternative site selected for the community well, the same figures of transmissibility and storage were assigned and calculations were made to determine the extent of the cone of depression and the resultant effect on nearby wells of pumping the proposed community well in accordance with the projected requirements. Assumptions made were as follows:

Discharge of well	250 gpm
Daily period of operation	7 hrs.
Daily period of recovery	17 hrs.
Coefficient of transmissibility	15,000 gpd/ft
Coefficient of storage	20 percent

The calculations indicated the drawdown at the end of a daily cycle of 7 hours of pumping would be as follows:

<u>Distance from Pumped Well (ft)</u>	<u>Drawdown (ft)</u>
1	19.8
78	1.0
102	.5
124	.25
208	.01

The cumulative effect of this cone would be no greater, because the daily recovery period (17 hrs) is much longer than the daily operating period.

These data indicate that, if a well were constructed for the community at a point midway between Well No. 5 cccd and Well No. 7 aabc, pumping the community well would not affect pumping levels in either of the existing wells. The distance to either well is 800 feet, and the daily cone of depression would not be measurable beyond a distance of about 225 feet.

## QUALITY OF WATER

Sixteen complete water analyses and three partial analyses were available for use in appraising the quality of the ground-water supply. The data are given in Table 3.

The analyses were plotted on trilinear graph paper, using the Piper (1944) method, to consider the character of the various waters. It was found that all but four analyses grouped closely as predominantly Calcium-Magnesium Sulfate waters, termed here "Sulfate type". Two analyses, from Wells No. 6 abdb and No. 6 dcdb, grouped as predominantly Calcium-Magnesium Bicarbonate waters, termed here "Bicarbonate type". Water from Well No. 6 ddba also is of this type. The remaining two analyses, for Wells No. 5 bdaba and No. 5 caca, lay halfway between these two primary groupings. The Bicarbonate-type waters are all from wells tapping Pleistocene (?) alluvium overlain by Pleistocene terrace gravels, and appear to represent ground water moving southeast from the Santa Rita Mountain drainage. The Sulfate-type waters are related to the volcanic rocks on the east side of Sonoita Creek, which are rich in pyritic materials high in sulfate content. Water from the limestones of the Canelo Hills also is high in sulfate.

### Acceptability for Public Use

The total content of dissolved solids of the bulk of the ground water in the area (Sulfate type) ranges from a low of 215 to a high of 1,113 ppm (parts per million). Sulfate content ranges from 94 to 680 ppm; hardness ranges from 144 to 800 ppm. The most highly mineralized of the waters of this group are along Harshaw Creek. With one exception, the waters in the south half of Sec. 5 and the north half of Sec. 7 are acceptable for domestic and public use when the chemical quality is judged by the Standards of the U. S. Public Health Service (1962). The exception is water from Well No. 7 bacd, in which the sulfate content and total dissolved solids content slightly exceed the recommended limits.

Water from Well No. 6 abdb (windmill), Well No. 6 dcdb (U. S. Forest Service well), Well No. 6 ddba (High School well), and Well No. 7 acbc (private well) is considered of excellent chemical quality for domestic and public use. Unfortunately, the yields from none of these wells are large enough to provide for a community water supply.

### Relation of Quality of Water to Geology of Inner Valley

The geochemical study of the water analyses corroborates the observed difference in water-yielding capacity between the west and east sides of the inner valley. The low-yielding Pleistocene (?) alluvium on the west side of Sonoita Creek contains the better-quality water. The materials on the east side of the inner valley, which are more permeable and provide higher well yields, contain the higher-sulfate water. The relationship is most striking between Wells No. 5 bdaba (mixture) and No. 5 bdaaa (Sulfate type), which are only about 280 feet apart.

The fact that water from Well No. 5 caca also is a mixture is considered significant. Subsurface materials in the vicinity of this well yield water less readily than upstream (Well No. 5 bdaaa) or downstream (Wells No. 5 caccc and No. 5 ccad). The authors consider that the geochemical data support a hypothesis that the most permeable zones represent fracturing associated with faulting in the Pleistocene (?) alluvium or deeper pockets of more transmissible material, and that the more abundant supply of Sulfate-type water circulates freely therein.

## WATER SUPPLY FOR TOWN OF PATAGONIA

### Adequacy of Ground-Water Supply

As discussed in the chapter of this report entitled "Ground-Water Resources", the aquifer of the inner valley of Sonoita Creek is considered adequate to supply the needs of the community indefinitely, even if the remaining bottom land is placed in cultivation and irrigated. Owing to the relatively high annual rainfall in the region, substantial replenishment of the ground-water reservoir by recharge from flood runoff will occur even in relatively dry years.

It is considered likely that in the future the community will expand into the present agricultural land, which can be expected to reduce the net annual consumption of water.

One word of caution is offered, however. If, in the future, it becomes necessary to export water from the community and suburban environs for any reason, it may become necessary to increase recharge to the area. This could be done by constructing a flood-detaining reservoir on Harshaw or Sonoita Creek, so designed as to release flood runoff slowly over a period of several days.

### Specific Well Sites

#### Well No. 5 cccd

The authors consider that the most conservative method of obtaining a water supply for the Town would be to purchase Well No. 5 cccd from the present owner if this is feasible. The well has already been drilled, developed, and tested. It is more than capable of yielding the required 250 gpm, and the quality of the water is satisfactory. No danger of pollution is apparent.

#### Alternative Site

If it is not feasible to purchase Well No. 5 cccd, a site for a well to be drilled by the Town is shown on Plate 1, midway between Wells No. 5 cccd and No. 7 aabc. The recommended depth is 150 feet. The recommended minimum casing diameter is 12 inches, and 16 inches is preferred.

If a new well is drilled, the specific site preferably should be on a direct line between the two existing wells, as shown on Plate 1. The risk of encountering less permeable materials increases westward, and the risk of encountering more highly mineralized water increases eastward. If it becomes necessary to deviate more than 150 feet either side of a direct line, the recommendation is made that a 6-inch diameter test hole should be drilled first.

As was discussed in a preceding section of this report, the effect on water levels in nearby wells of constructing and operating the community well at the recommended site will be negligible.

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A P P E N D I X

DATA ON WELLS IN PATAGONIA AREA

## EXPLANATION OF WELL NUMBERING SYSTEM

The well numbering system used in this report is in accordance with the system used by the Bureau of Land Management, the U. S. Geological Survey, the State Land Department and the State Health Department. All wells listed in this report are in Township 22 South, Range 16 East. The well number indicates the section within the township in which the well is located and the lowercase letters indicate the well location within the section. Each section is broken into four quadrants of 160 acres each which are designated counterclockwise by the letters a, b, c, and d. Thus the letter a represents the northeast 160 acres, b the northwest 160 acres, c the southwest 160 acres, and d the southeast 160 acres. Each 160 acre quadrant is then broken into 4 quadrants of 40 acres in the same manner each of which is then subdivided into quadrants of 10 acres each and so on down to the smallest subdivision used in this report which represents an area of 0.625 acres. For this report most well locations are shown only to the nearest 2-1/2-acre tract, in which case the section number is followed by 4 lowercase letters. In the example shown in Figure 1, Well No. 5 acaa designates the well as being in the NE 1/4 NE 1/4 SW 1/4 NE 1/4 Sec. 5.

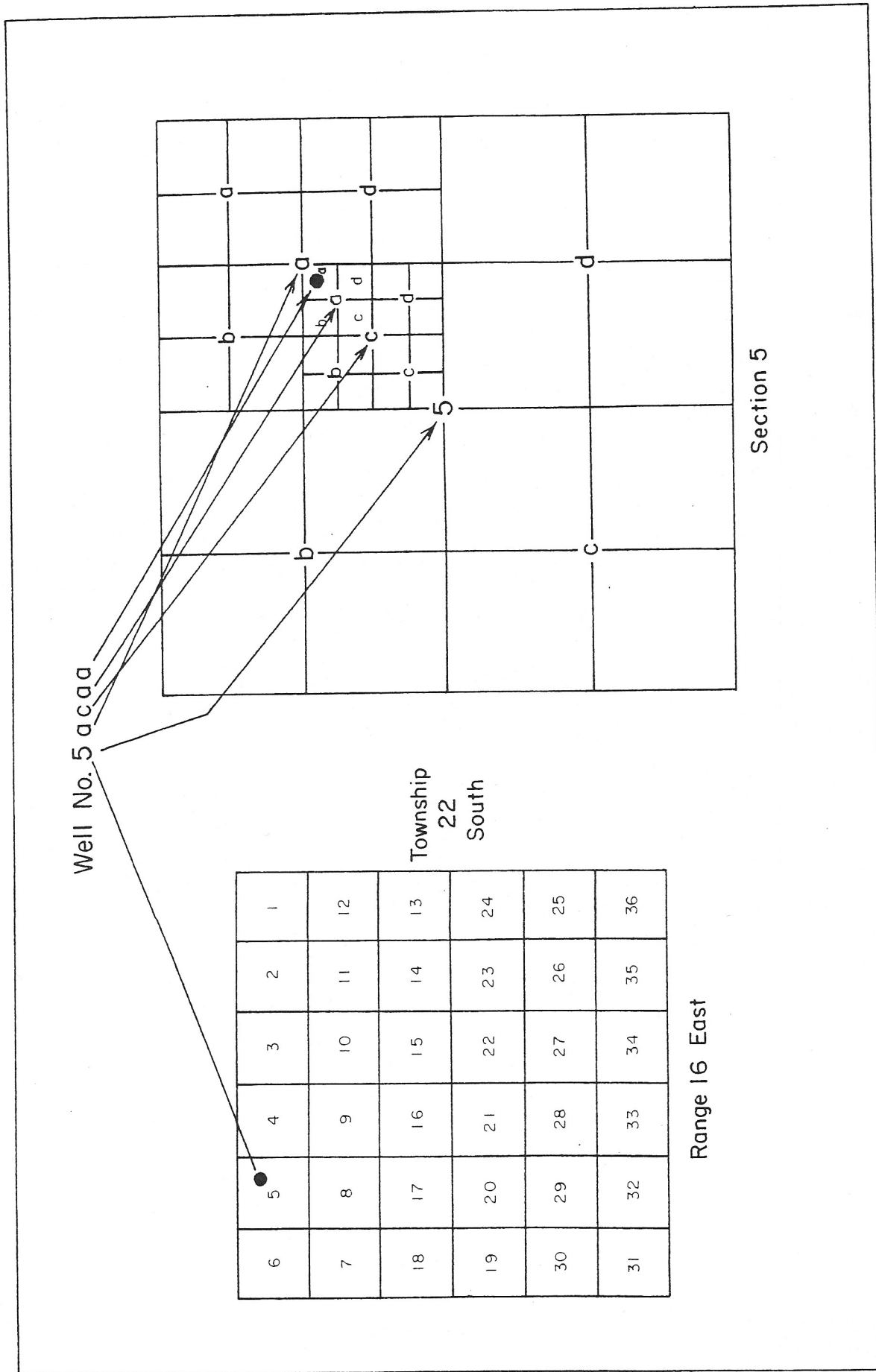


Figure 1. - Sketch showing well-numbering system.

## DATA ON WELLS IN PATAGONIA AREA

Basic well data have been tabulated insofar as possible, as shown in Tables 1-4 inclusive. Supplemental data which are difficult to express in tabulated form are presented here for some of the wells.

### 5 acaa

Drilled for W. B. Milar by A. A. McDaniel. The bottom of the 8-inch casing is set at 493 feet, perforated from 5 to 490 feet. Observations of drawdown in this well made when testing Well No. 5 bdaaa are given in Table 4. The wells are about 1,100 feet apart.

### 5 bdaaa

Drilled for R. B. Ensign by A. A. McDaniel. Twelve-inch casing set at 51 feet. Equipped with turbine pump. Capacity was tested on Nov. 7, 1960. Pumped at rate of 150 gpm, 11:03 a.m. until 12:55 p.m.; measured recovery until 1:15; surged to improve yield until 2:00 p.m.; pumped 138 gpm until 3:41 p.m. (see data in Table 4). Observed effect on water levels in Wells 5 acaa and 5 bdaab.

### 5 bdaab

Drilled for R. B. Ensign by A. A. McDaniel. Twelve-inch casing set at 60 feet. Unsuccessful as a production well and eventually abandoned. Bail tested Sept. 26, 1959; pulled 57 bailers of 15 gallons each between 1:29 and 2:02 p.m.; effect on water level shown in Table 4. See Table 4 also for measurements made on Nov. 7, 1960, when testing Well 5 bdaaa. Distance between wells is about 175 feet.

### 5 bdaba

This is an old domestic well that is no longer in use. It was deepened in 1959 by 5 feet to a total depth of 105 feet and the 6-inch casing was reset at 105 feet. The driller described the zone from 100 to 105 feet as "Light clay, gravel". The well was tested on Sept. 26, 1959, at 7 gpm from 3:42 until 5:31 p.m., and on Sept. 29, 1959, at 15 gpm from 4:20 until 7:40 p.m. The resulting water-level measurements are given in Table 4.

5 bdabd

Drilled for R. B. Ensign by A. A. McDaniel. Unsuccessful as a producer; abandoned.

5 bdba

Drilled for R. B. Ensign by A. A. McDaniel. Unsuccessful as a producer; abandoned.

5 caca

Drilled for R. B. Ensign by A. A. McDaniel. Cased with 12-inch to 65 feet; perforated 45 to 62 feet. Tested Nov. 12, 1960: Pumped at an average of 78 gpm from 10:00 to 10:55 a.m.; measured recovery until 11:35; surged to improve yield until 12:20; measurements are given in Table 4. On Nov. 14, 1960, Well 5 caccc was tested at 1,000 gpm; measurements on Well 5 caca are given in Table 4. Also see Table 4 for measurements in June 1963, when Well 5 caccc was pumping 1,200 gpm and Well 5 cbcd was pumping 600 gpm steadily for several days. The distance from Well 5 caca to Well 5 caccc is about 650 feet; to Well 5 cbcd is about 1,250 feet.

5 caccc

Drilled sometime between 1949 and 1958. The reported depth is 97 feet; the casing diameter is 12 inches. This is the best well in Sec. 5. In 1964 it was equipped with a 1,200 gpm turbine pump with bowls set at 80 feet. It surges occasionally, and the safe maximum yield is considered to be about 800 gpm. The well was tested Aug. 10, 1959, at which time observations were also made in Well 5 caccd, which is 39 feet distant. The pump was operated from 9:58 a.m. until 4:01 p.m. in a step drawdown test at 192 gpm, 342 gpm, and 384 gpm. The coefficient of transmissibility was calculated from the data and, from recovery on the pumped well, was 212,000 gallons per day per foot. Using data from the observation well, the coefficient was 101,000 gallons per day per foot and the coefficient of storage was calculated as 30 percent. The coefficients selected for field use are 100,000 gallons per day per foot for transmissibility and 20 percent for storage.

The well was again tested on Nov. 14, 1960, when the pump was operated from 12:55 until 3:45 p.m. at an average of about 1,000 gpm. Observation wells used were 5 caccd (39 feet distant), 5 caca (650 feet distant), and 5 ccad (700 feet distant).

From May 25 through June 1, 1963 the well was operated continuously at 600 gpm and Well 5 ccad was simultaneously operated at 1,200 gpm. On June 1 the two pumps were switched.

All water-level data are given in Table 4.

#### 5 caccd

This is a 6-inch well, cased to total depth, and equipped with a windmill. Water-level measurements as given in Table 4 relate mainly to the pumping history of Well 5 cacc as described for that well.

#### 5 ccad

Drilled for R. B. Ensign by A. A. McDaniel. Cased with 12-inch to 98.5 feet, perforated from 40 to 90 feet. Tested on Nov. 9, 1961; discharge was 1,025 gpm from 10:11 to 10:16 a.m. and 1,300 gpm from 10:16 a.m. until 4:00 p.m. Well 5 cacc was used as an observation well. Also, when Well 5 cacc was tested on Nov. 14, 1960, measurements were made in Well 5 ccad. This is the second-best well in Sec. 5. See Table 4 for measurements of water level.

#### 5 cccd

Drilled for R. B. Ensign by A. A. McDaniel. Cased with 16-inch to 101 feet; perforated 35 to 96 feet. Tested July 16, 1963: Began test at 8:50 a.m. at 450 gpm; reduced discharge to 420 gpm at 10:00 a.m.; to 400 gpm at 10:30, to 384 gpm at 10:45, to 365 gpm at 11:00, to 355 gpm at 11:15; to 345 gpm at 11:30, and to 338 gpm at 11:45. Continued at 338 gpm until 1:20 p.m. Water-level measurements are in Table 4.

TABLE 1

## RECORDS OF WELLS IN PA

Well No.	Depth (ft)	Year Drilled	Water Level		Date of Measurement	Gallons per Minute (a)	D
			Depth Below Meas. Point (ft)	Altitude of Water Table (ft)			
5 aaaa	500	1959	43.14	4,136	11-7-60	10 E	
5 bdaaa	160	1959	40.87	4,081	10-19-59	138 M	
5 bdaab	150	1959	39.89	4,081	9-26-59	6 M	
5 bdaba	110	pre-49	38.00	4,080	7-28-59	15 M	
5 bdabd	73	1959	35.04	4,080	10-19-59	--	
5 bdba	51	1959	--	--	--	--	
5 caca	143	1959	27.05	4,069	10-7-64	78 M	
5 caacc	97	--	45.07	4,048	7-28-59	1,000 M	
5 caacd	170	1948	45.19	4,048	8-10-59	5 E	
5 ccad	145	1959	40	4,038	11-59	1,300 M	
5 cccd	105	1965	46.55	4,033	9-13-64	338 M	
5 cdca	103	1959	--	--	--	--	
6 abdb	--	pre-59	23.53	4,123	7-28-59	5 E	
6 dbd	196	pre-49	47.27	4,039	7-28-59	3 M	
6 ddba	--	pre-59	56	4,020	1949	10 E	
7 aabc	--	pre-59	41.54	4,032	9-29-59	600 R	
7 aacd	--	pre-59	44.00	4,032	9-29-59	5 E	
7 aadd	65	pre-49	38.00	4,039	8-25-49	--	
7 abcd	--	pre-59	38.86	4,027	9-29-59	--	
7 acba	--	pre-49	62.45	4,029	8-23-49	--	
7 acbc	--	pre-63	--	--	--	--	
7 baed	--	pre-59	--	--	--	--	
8 baca	--	1961	54.65	4,052	10-7-64	--	
8 baed	--	1961	--	--	--	--	
8 bbcc	83	pre-49	42.32	4,038	8-24-49	--	

(a) E, estimated; M, measured; R, reported.

(b) Discharge in gallons per minute divided by drawdown in feet; E, estimated.

(c) D, domestic; I, irrigation; S, livestock; A, abandoned test hole; U, not in use.

TABLE 1 cont.

AGONIA AREA

Specific Capacity (b) gpm/ft	Date of Meas- urement	Use of Water (c)	Log Avail- able (See Table 2)	Water Anal- ysis (See Table 3)	Water Level Meas. (See Table 4)
--	1959	D	Yes	No	Yes
4.5	11-7-60	D	Yes	Yes	Yes
.08	9-26-59	A	Yes	Yes	Yes
10	9-29-59	U	Part	Yes	Yes
--	--	A	Yes	No	No
--	--	A	Yes	No	No
1.4	11-12-60	D	Yes	Yes	Yes
100	8-10-59	I	No	Yes	Yes
--	8-10-59	D	Yes	Yes	Yes
130	1964	I	Yes	Yes	Yes
9	7-11-63	I, U	Yes	Yes	Yes
--	--	A	Yes	No	No
--	1959	S	No	Yes	No
--	1949	D	Yes	Yes	No
--	1959	D	No	Yes	No
--	1959	I	No	Yes	No
--	1959	D	No	No	No
--	--	D	No	No	No
--	--	D	No	No	No
--	--	D	No	No	No
--	--	D	No	Yes	No
--	--	D	No	Yes	No
--	--	D, U	No	Yes	No
--	--	D	No	Yes	No
--	--	D	No	No	No



TABLE 2  
LOGS OF WELLS IN PATAGONIA AREA

Material	Thickness (ft)	Depth (ft)
<u>5 acaa</u>		
Sandy soil	10	10
Soft clay, gravel	15	25
Hard clay, gravel, some H <sub>2</sub> O at 53'	28	53
Soft clay	22	75
Layers of clay and sandstone, H <sub>2</sub> O	50	125
Soft clay, gravel	160	285
Sticky clay	10	295
Clay, gravel	20	315
Sticky clay	110	425
Clay, gravel	60	485
Soft clay, gravel	10	495
Hard rock (rhyolite)	5	500
TOTAL DEPTH		500
<u>5 bdaaa</u>		
Dirt	10	10
Red clay	16	26
Clay, gravel	9	35
Loose gravel, seep at 45'	10	45
Tight gravel, clay	10	55
Tight conglomerate	50	105
Tight sandy clay	10	115
Tight clay, gravel	45	160
TOTAL DEPTH		160
<u>5 bdaab</u>		
Dirt	14	14
Loose gravel	41	55
Tight gravel, clay	20	75
Tight clay, sand	60	135
Tight clay, gravel	15	150
TOTAL DEPTH		150

TABLE 2  
LOGS OF WELLS IN PATAGONIA AREA  
continued.

Material	Thickness (ft)	Depth (ft)
<u>5 bdabd</u>		
Tight dirt	8	8
Clay, gravel	29	37
Loose gravel, dry	3	40
Tight gravel, clay, seep at 44'	22	62
Very tight gravel, clay	11	73
TOTAL DEPTH		73
<u>5 bdba</u>		
Sand	4	4
Gravel	10	14
Light clay, gravel	6	20
Red clay	17	37
Tight clay, gravel	14	51
TOTAL DEPTH		51
<u>5 caca</u>		
Dirt	25	25
Gravel, clay	22	47
Loose gravel and water	18	65
Red clay, gravel	40	105
Tight clay, gravel	38	143
TOTAL DEPTH		143
<u>5 caccd</u>		
Clay	54	54
Sand	28	82
Red clay, hard to drill	33	115
No record	45	160
Gray tuff, water bearing	3	163
No record	7	170
TOTAL DEPTH		170

TABLE 2  
LOGS OF WELLS IN PATAGONIA AREA  
continued.

Material	Thickness (ft)	Depth (ft)
<u>5 ccad</u>		
Dirt	9	9
Red clay	26	35
Tight gravel, clay	7	42
Gravel and water	32	74
Light clay, sand	64	138
Tight clay, gravel	7	145
TOTAL DEPTH		145
<u>5 cccd</u>		
Soil	15	15
Conglomerate	30	45
Sand and gravel, water	10	55
Muddy sand and gravel, water	30	85
Yellow clay with gravel	5	90
Yellow clay	5	95
Red clay with gravel	5	100
Yellow clay	5	105
TOTAL DEPTH		105
<u>5 cdca</u>		
Dirt	6	6
Red clay, gravel	74	80
Tight clay, gravel	23	103
TOTAL DEPTH		103
<u>6 dcdb</u>		
Valley fill	52	52
Sand and gravel	6	58
Shale	116	174
Blue shale	22	196
TOTAL DEPTH		196

TABLE 3

## ANALYSES OF WATER SAMPLES FROM

(Parts per million except Specific Con-  
ductance is sum of determined ions with Bicarbonate)

Well No.	Analyzed By	Date of Collection	Tem- pera- ture (°F)	Specific conduct- ance (micro- mhos at 25° C)	Cal- cium (Ca)	Mag- ne- sium (Mg)	Phos- phorus (P)
5 bdaaa	State Health Dept.	7-9-63	73	1,050	156	24	
5 bdaab	Wadevco	9-23-59	--	700	--	--	
5 bdaba	Univ. of Ariz.	9-26-59	66	875	92	9	
5 bdabd	Wadevco	10-7-59	68	860	--	--	
5 caca	State Health Dept.	7-9-63	--	1,650	76	12	
5 cacco	Univ. of Ariz.	8-10-59	66	810	155	17	
5 cacco	State Health Dept.	7-9-63	--	1,150	124	22	
5 caccd	U. S. Geol. Surv.	6-17-49	69	829	131	27	
5 ccad	State Health Dept.	7-9-63	--	--	112	24	
5 cccd	do.	8-21-63	--	1,250	116	25	
6 abdb	do.	7-9-63	--	2,125	53	10	
6 dcdb	U. S. Geol. Surv.	6-17-49	69	437	43	2	
6 ddba	Wadevco	10-7-64	--	405	--	--	
7 aabc	State Health Dept.	8-30-63	--	1,260	52	26	
7 acbc	do.	7-9-63	--	--	45	8	
7 bacd	do.	do.	--	--	140	29	
8 baca	Univ. of Ariz.	9-30-61	--	1,150	124	71	
8 bacd	State Health Dept.	2-15-63	--	--	206	52	
8 bacd	do.	7-9-63	--	660	236	50	

# TABLE 3 cont.

## WELLS IN PATAGONIA AREA

Distance. Dissolved solids  
expressed as Carbonates.)

Num and ssium + K)	Elcar- bonate (HCO <sub>3</sub> )	Sul- fate (SO <sub>4</sub> )	Chlo- ride (Cl)	Fluo- ride (F)	Ni- trate (NO <sub>3</sub> )	Dis- solved Solids	Hard- ness as (CaCO <sub>3</sub> )
2	202	330	6	0.5	7	635	490
-	--	--	--	--	--	--	--
6	178	240	8	.8	--	504	268
-	--	--	--	--	--	--	--
8	172	136	8	.4	7	354	240
5	256	285	18	--	--	636	486
2	156	262	9	.5	8	515	400
5	240	243	8	.5	11	554	438
2	140	250	6	.4	9	486	380
2	148	240	6	.5	10	483	395
9	130	6	15	.4	3	225	172
6	205	50	12	.4	1	266	116
-	--	41	15	.3	--	--	34
1	120	225	23	.4	14	460	240
6	74	94	12	.6	3	215	144
3	128	300	12	.8	10	627	470
2	158	468	26	.8	2	881	600
1	248	540	13	1.3	1	966	730
0	300	680	14	1.0	4	1,113	800

TABLE 4

SUPPLEMENTAL WATER-LEVEL MEASUREMENTS  
FROM WELLS IN PATAGONIA AREA

(These measurements are given as depth in feet below measuring point,  
which in most cases was top of casing).

Date	Hour	Depth to Water (ft)	Date	Hour	Depth to Water (ft)
<u>5 acaa</u>			<u>5 bdaaa cont.</u>		
11-7-60	--	43.14	11-7-60	1:07	40.2
	11:25 a	46.3		1:08	39.8
	11:41	47.3		3:53	39.65
	12:04 p	48.05	6-12-61	--	41.9
	12:43	48.75	7-11-61	--	42.4
	1:30	47.9	8-1-61	--	42.4
	3:45	47.1	9-4-61	--	41.7
<u>5 bdaaa</u>			10-2-61	--	42.5
11-7-60	10:55 a	37.3	12-20-61	--	38.4
	11:03	40.3	1-4-62	--	36.2
	11:07	60.0	2-15-62	--	34.9
	11:10	61.73	5-30-63	--	42.6
	11:13	62.9	6-4-63	--	43.45
	11:15	63.75	6-10-63	--	42.6
	11:20	64.9	6-24-63	--	42.55
	11:32	66.75	7-1-63	--	42.5
	11:37	67.2	7-8-63	--	42.4
	11:51	67.5	7-21-63	--	42.2
	12:00	67.63	8-15-63	--	40.2
	12:13 p	68.05	<u>5 bdaab</u>		
	12:40	67.9	9-24-59	3:15 p	52.80
	12:55	68.45		7:03	51.29
	1:00	51.0		7:23	48.89
	1:01	50.5		7:45	47.24
	1:02	49.6		8:00	46.47
	1:03	45.0	9-26-59	12:30 p	44.00
	1:04	43.0		1:25	39.89
	1:05	42.0		2:02	120.00
	1:06	40.7		2:32	89.00

TABLE 4

SUPPLEMENTAL WATER-LEVEL MEASUREMENTS  
FROM WELLS IN PATAGONIA AREA

(These measurements are given as depth in feet below measuring point,  
which in most cases was top of casing).  
continued.

Date	Hour	Depth to Water (ft)	Date	Hour	Depth to Water (ft)
<u>5 bdaab cont.</u>			<u>5 bdaba cont.</u>		
9-26-59	2:52 p	75.0	9-29-59	5:00 p	37.80
	3:10	62.2		5:15	38.15
	3:13	61.8		5:37	38.35
	3:15	59.73		6:00	38.56
	3:18	58.50		6:20	38.66
	3:22	56.93		6:38	38.76
	4:00	46.0		7:40	40.00
	5:00	42.5		8:00	38.40
	5:40	41.37		8:10	38.35
11-7-60	11:00 a	37.9	10-19-59	--	36.67
	11:28	37.95			
	11:45	38.0	<u>5 caca</u>		
	12:09 p	38.45	11-11-60	--	32.45
	12:48	40.95	11-12-60	10:01 a	40.0
	3:48	38.0		10:02	48.0
<u>5 bdaba</u>				10:03	71.0
9-26-59	3:32 p	37.11		10:04	79.0
	3:40	37.12		10:05	82.0
	3:46	37.25		10:06	84.0
	3:56	37.27		10:10	87.2
	4:08	37.32		10:15	88.5
	4:33	37.38		10:20	92.9
	4:56	37.40		10:25	93.5
	5:06	37.50		10:31	94.6
	5:16	37.53		10:45	96.4
	5:28	37.49		10:55	97.2
	5:32	37.44		10:56	75.0
	5:36	37.42		11:00	70.0
	5:45	37.40		11:03	65.0
				11:05	60.0

TABLE 4

SUPPLEMENTAL WATER-LEVEL MEASUREMENTS  
FROM WELLS IN PATAGONIA AREA

(These measurements are given as depth in feet below measuring point,  
which in most cases was top of casing).  
continued.

Date	Hour	Depth to Water (ft)	Date	Hour	Depth to Water (ft)
<u>5 caca, cont.</u>			<u>5 cacco, cont.</u>		
11-12-60	11:10 a	55.0	8-10-59	12:08 p	47.51
	11:15	50.0		12:31	47.59
	11:23	45.0		12:47	47.61
	11:35	40.67		1:04	47.83
	12:20 p	40.40		1:22	47.87
11-14-60	2:30 p	32.83		1:46	47.91
	3:15	32.83		2:04	47.95
5-29-63	--	36.55		2:25	47.97
5-30-63	--	36.15		2:56	48.02
6-1-63	--	35.8		3:25	48.05
6-3-63	--	35.8		3:44	48.07
6-4-63	--	35.9		3:58	48.09
6-10-63	--	36.5		4:04	46.12
10-9-64	--	27.08		4:08	46.03
<u>5 cacco</u>				4:13	45.98
8-10-59	7:15 a	45.19		4:19	45.91
	7:45	45.18		4:25	45.86
	8:04	45.19		4:34	45.82
	9:05	45.19		4:44	45.77
	9:50	45.19		5:06	45.70
	10:12	46.12		5:16	45.67
	10:14	46.14		5:31	45.64
	10:20	46.21		6:04	45.45
	10:34	46.26		6:40	45.47
	10:49	46.35		7:45	45.45
	11:05	46.41	10-19-59	10:00a	44.39
	11:19	46.46	11-9-60	9:30a	36.35
	11:30	47.68		10:45	36.33
	11:44	47.42		3:25p	36.47
				4:20	36.5
			11-14-60	11:00a	36.25



TABLE 4

SUPPLEMENTAL WATER-LEVEL MEASUREMENTS  
FROM WELLS IN PATAGONIA AREA

(These measurements are given as depth in feet below measuring point,  
which in most cases was top of casing).  
continued.

Date	Hour	Depth to Water (ft)	Date	Hour	Depth to Water (ft)
<u>5 ccccc, cont.</u>			<u>5 ccccc, cont.</u>		
11-14-60	12:55 p	36.43	5-29-63	--	60 +
	12:58	39.0	5-30-63	--	60.0
	12:59	40.0	6-1-63	--	60.0
	1:00	40.2	6-2-63	--	70 +
	1:02	40.9	6-3-63	--	70 +
	1:05	41.35	6-4-63	--	52.0
	1:09	41.7	6-5-63	--	49.75
	1:13	43.67	6-6-63	--	58.3
	1:15	44.05	6-10-63	--	49.0
	1:26	44.6	6-24-63	--	50.0
	1:45	44.7	7-1-63	--	48.9
	1:55	45.3	7-21-63	--	46.8
	2:08	45.56	8-15-63	--	44.35
	2:23	45.66	9-3-63	--	42.0
	3:26	46.03	10-5-63	--	41.9
	3:46	37.65			
	3:47	37.55			
6-5-61	--	44.0	<u>5 ccccd</u>		
6-12-61	--	44.0	8-25-49	--	36.87
7-11-61	--	44.9	8-31-49	--	36.75
8-1-61	--	45.2	8-10-59	7:30 a	45.20
9-4-61	--	44.8		7:47	45.19
10-2-61	--	44.3		8:06	45.20
12-20-61	--	42.1		8:35	45.19
1-4-62	--	39.7		9:08	45.19
2-15-62	--	38.1		9:55	45.18
5-25-63	12:01 p	51.0		10:17	45.45
	5:30	56.0		10:37	45.56
5-26-63	--	58.0		10:52	45.62
5-27-63	--	59 +		11:09	45.68
5-28-63	--	59 -		11:23	45.69

TABLE 4

SUPPLEMENTAL WATER-LEVEL MEASUREMENTS  
FROM WELLS IN PATAGONIA AREA

(These measurements are given as depth in feet below measuring point,  
which in most cases was top of casing).  
continued.

Date	Hour	Depth to Water (ft)	Date	Hour	Depth to Water (ft)
<u>5 caced, cont.</u>			<u>5 caced, cont.</u>		
8-10-59	11:32 a	45.86	5-25-63	12:02 p	45.8
	11:49	45.95		5:30	49.1
	12:11 p	46.03	5-26-63	--	49.5
	12:34	46.06	5-27-63	--	50.0
	12:53	46.15	5-28-63	--	50.5
	1:09	46.22	5-29-63	--	51.3
	1:25	46.26	5-30-63	--	50.95
	1:49	46.31	6-1-63	--	50.6
	2:07	46.34	6-2-63	--	50.4
	2:28	46.37	6-3-63	--	50.7
	2:59	46.41	6-4-63	--	47.65
	3:28	46.45	6-5-63	--	47.7
	3:47	46.48	6-6-63	--	52.0
	4:00	46.51	6-10-63	--	47.1
	4:06	46.14	6-24-63	--	46.6
	4:11	46.10	7-1-63	--	46.45
	4:16	46.04	7-8-63	--	51.9
	4:22	45.98	7-21-63	--	45.4
	4:30	45.93	8-15-63	--	42.7
	4:37	45.88	9-3-63	--	40.15
	4:47	45.84	10-5-63	--	40.0
	4:58	45.75	9-30-64	--	37.7
	5:08	45.76	10-7-64	--	41.21
	5:18	45.75			
	5:34	45.70			
	6:07	45.38			
	6:43	45.45			
	7:48	45.48			
11-14-60	1:29 p	37.3			
	1:40	37.4			
	2:07	37.61			
	3:30	38.04			
			<u>5 ccad</u>		
			11-8-60	9:00 a	39.15
				3:05 p	39.25
			11-9-60	9:40 a	39.35
				10:12	42.3
				10:13	45.0
				10:15	45.55

TABLE 4

SUPPLEMENTAL WATER-LEVEL MEASUREMENTS  
FROM WELLS IN PATAGONIA AREA

(These measurements are given as depth in feet below measuring point,  
which in most cases was top of casing).  
continued.

Date	Hour	Depth to Water (ft)	Date	Hour	Depth to Water (ft)
<u>5 ccad, cont.</u>			<u>5 ccad, cont.</u>		
11-9-60	10:16 a	48.6	6-4-63	--	60.2
	10:19	48.9	6-5-63	--	61.55
	10:21	49.15	6-6-63	--	61.55
	10:23	49.1	6-10-63	--	54.85
	10:25	49.4	6-24-63	--	52.5
	10:30	49.0	7-1-63	--	53.4
	10:35	49.35	8-15-63	--	47.1
	10:40	49.4	9-3-63	--	44.4
	11:00	49.7	10-5-63	--	44.85
	11:15	50.0			
	11:30	49.83	<u>5 cccd</u>		
11-14-60	1:25 p	39.66	7-16-63	8:30 a	54.35
	2:00	39.70		9:20	94
	3:23	39.75		10:00	93
6-12-61	--	48.6		10:30	93
7-11-61	--	49.7		10:45	93
8-1-61	--	50.2		11:00	93
9-4-61	--	49.8		11:15	93
10-2-61	--	49.3		11:30	90
12-20-61	--	48.2		11:45	88
1-4-62	--	46.8		12:00 p	88
2-15-62	--	45.3		12:15	88
5-25-63	11:00 a	50.7		12:30	88
	5:30 p	50.85		12:45	88
5-26-63	--	51.3		1:00	88
5-27-63	--	51.85		1:20	88
5-28-63	--	52.25	7-21-63	--	53.9
5-29-63	--	52.7	8-15-63	--	50.2
5-30-63	--	52.95	9-3-63	--	47.5
6-1-63	--	53.35	10-5-63	--	46.2
6-2-63	--	53.2	9-13-64	--	46.55
6-3-63	--	53.25	10-7-64	--	44.25