CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

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AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

April 10, 1967

J. H. C.
APR 13 1967

W.E.S.
APR 19 1967

TO: J. H. COURTRIGHT

FROM: N. P. WHALEY

GROUND WATER IN THE SANTA CRUZ VALLEY SOUTH OF TUCSON - MISCELLANEOUS NOTES OF INTEREST

Recently a number of miscellaneous items pertaining to ground water in the Santa Cruz Valley south of Tucson have come to my attention. These are described below in a series of informal notes. Copies are being transmitted to Mr. Snedden and Mr. Meen.

Last fall three new water wells were drilled for Pima Mining Company in Sec. 2, T17S, R13E. This location is approximately one mile south of the Mission Unit well field. A copy of Report Number 233 of the Department of Agricultural Engineering, University of Arizona, Progress Report on Study of Water in the Santa Cruz Valley, Arizona, is attached. If plates I and II of Appendix B are studied the potential significance of these new wells can be appreciated. Plate I shows ground water contours which define the surface of the water table. The movement of water is presumed to be in the direction of steepest slope, at right angles to these contours. Plate II depicts changes which have occurred from spring of 1961 to 1965. The new Pima Mining Company wells penetrate the margin of the already existing cone of depression created by the Mission Unit wells.

Drillers' logs for two of the new wells are also attached. No information on the third one, which is located in the extreme NE corner of the section, is available at the time.

Well No. 8 (SE 1/4, SE 1/4, NE 1/4, Sec. 2, T17S, R13E) was test pumped at 4,400 gpm with a 99 ft. drawdown. Water was reported to be very soft, low in dissolved salts, and to have a temperature of ever 90°F (duration of test unknown).

Mr. R. J. Shaw of the Agricultural Experiment Station stated that during the pumping test of well No. 7 a 12 ft. column of water was supported in the manometer while using a 10 inch discharge pipe equipped with an 8 inch orifice. Under these conditions he would not estimate discharge.

The Duval Corporation is planning to have a new water well drilled along the south line of Sec. 10, T18S, R13E. Drilling to be done on an open contract with an intention of going to 1,100± ft.

Lane-Texas is drilling a new well for the Anaconda Company. It is located just west of the river and approximately a mile south of the highway crossing between Sahuarita and Continental. This should place it somewhere in Sec. 36, T17S, R13E. This well is to be finished as a 20 inch hole to somewhere between 1200-1500 ft.

N. P. Whaley

N. P. WHALEY

NPW/mcg
Attachments
cc: TASnedden w/attachments
RBMeen w/attachments

Copies to TAS, RBM, ACH, SIB

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

March 2, 1967

TO: J. H. COURTRIGHT

FROM: N. P. WHALEY

CONSIDERATIONS RE WATER SOURCE FOR WELLS ON FORMER ORO VERDE FARM LAND

The following considerations would seem to apply to any classification of the water source for wells on the former Oro Verde farm land south of Tucson.

The advisability of making a classification based on a distinction between the terms "subflow" and "percolating water" was suggested in a January 25 memorandum from Mr. A. C. Hall to Mr. R. B. Meen (copy attached).

Any attempt to classify ground water based on a distinction between the terms "subflow" and "percolating waters" involves more interpretation of legal terminology than scientific knowledge. The following brief analysis of a few rules of law and the attempt to arrive at some seemingly reasonable basis for classification of the groundwater source will perhaps bring out a few of the problems involved.

The practice of most courts has been to differentiate sharply between the occurrence of underground or subsurface water in actual and supposed subsurface water courses ("underground streams" with "subflow") and as "percolating water."

Generally so-called riparian or appropriative rights to subsurface water can be upheld only if its occurrence as a subsurface water course "with ascertainable bed and banks" can be established.

"Percolating water," subject to enumerable legal definitions which would be unsatisfactory in a technical sense, is now generally recognized as being the same thing as "ground water" and the legislature of Arizona adopted the following definition of percolating water in A.R.S., section 45-301:

> "Ground water" means water under the surface of the earth regardless of the geologic structure in which it is standing or moving. It does not include water flowing in underground streams with ascertainable bed and banks." /Emphasis added/

Apparently the presumption is that water beneath the surface of the earth is percolating, and the burden rests upon the person, or persons, claiming an appropriation to prove that the water moves in a definable channel; that is, that the "stream" has ascertainable bed and banks.

If these conditions cannot be met the water is regarded as "percolating" and, while not subject to appropriation, it is subject to a doctrine of "reasonable use." Under this doctrine the owner of the ground is recognized as having license to the use of the water withdrawn from it, but with implication of a quasi-public trust incident to that license. As long as withdrawals are incidental to the beneficial enjoyment of the land from which they were made the owner of that land has unlimited use of the water. Other withdrawals. . .either for non-beneficial use which is incidental to the use of the property, or for use off the property are not, however, necessarily illegal, and they do not necessarily subject the landowner so using the ground water to liability. It is only when a neighbor's water supply is detrimentally affected by such non-beneficial use or use off the property that a neighboring landowner can interfere with the unlimited withdrawal of groundwater by the owner of contiguous land.

If this question of distinguishing between "subflow" and "percolating waters" is considered from a technical or scientific point of view there is no problem. That a need for such a classification exists when free (i.e., unconfined) ground water in granular, pervious material is under consideration points out the fact that our present legal classification of underground water and many of the past rulings of the courts are based on erroneous hydrologic concepts.

We are dealing with alluvium (i.e., texturally granular, pervious material) and the only water which can be diverted and pumped from such a medium is "ground water" which occurs below the water table in the zone of saturation. Modern hydrologists generally speak only of ground-water "movement" in such a medium, and while "percolation" (not "percolating water") has been defined in a technical sense, the term "subflow" is not recognized.

For the sake of recording it, percolation has been variously defined as:

> "Movement under hydrostatic pressure, of water through the interstices of the rock or soil, except movement through large openings such as caves." (Meinzer, 1923, p. 42)
>
> And again as:
>
> ". . .curvilinear flow around the grains and through the interconnected pores of saturated pervious materials." (Tolman, C. F. and Stipp, Amy C., 1941, p. 884)

The technical meaning of the term percolation, although now somewhat obsolete itself, should not be confused with the legal usage of "percolating waters" as distinguished from flow in subsurface water courses. In alluvial materials "subsurface streams," "percolating waters," and "artesian waters," as defined by lawyers, all move by percolation in interconnected, interstitial openings.

From a technical or scientific standpoint the former Oro Verde farmland should have free or unconfined groundwater moving below the water table under the property (moving by percolation if one wishes to state it in such a manner) and "subflow" cannot be considered. . .not being recognized under the existing ephemeral stream - alluvium regime of that area.

Classification from a legal standpoint would appear to be a question to be resolved by ASARCO's attorneys. One point might be considered: This, expressed by Tolman and Stipp (1941, p. 897), is "In the legal sense, 'underflow, subflow, or undercurrent of a surface stream' is considered as 'those waters which slowly find their way through the soil, sand, and gravel constituting the beds of streams, or the lands under and adjacent to the streams which are themselves a part of subsurface streams.' By strict application of the conditions given. . .subflow could be considered only as the groundwater mound or ridge in contact with an influent stream of the ground water adjacent to an effluent stream."

While these authors go on to point out a number of scientific fallacies in both this definition and a consequent test to be applied to determine whether or not ground water constitutes "subflow," it might be well to keep in mind the fact that the 1957 issue of the Tucson, Arizona 15 minute quadrangle locates the Santa Cruz River channel less than half a mile to the west of the land involved and last year's floods could well have shifted the channel even closer.

As far-fetched as any "subflow" classification might seem from a scientific point of view (considering an ephemeral, influent stream), it would seem that it would be in line to ask Mr. W. A. Evans what he had in mind and why he feels that a distinction between "subflow" and "percolating waters" will be important in the general area south of Tucson.

If there is to be a forthcoming extension of the already confused legal perception of ground water, we cannot be expected to make a valid classification for that extension when we are only able to function within the present framework of ideas.

N. P. Whaley

N. P. WHALEY

NPW/mcg
Attachment

R E F E R E N C E S

Meinzer, Oscar E., 1923, Outline of ground-water hydrology, with definitions: U. S. Geol. Survey Water - Supply Paper 494, p. 71

Tolman, 1937, Ground Water, McGraw - Hill Book Company Inc., New York and London.

Tolman, C. F., and Stipp, Amy C., 1941, "Analysis of Legal Concepts of Subflow and Percolating Waters," Amer. Soc. Civil Engineers, Paper No. 2116, reprinted from TRANSACTIONS, vol. 106, p. 882.

Wilmer, Mark, 1966, "Legal Aspects of Wastewater Reuse." Arizona Water and Pollution Control Association Bulletin, vol XXVI, No. 1, pp. 53-61.

NPW
1-31-67
NPW

MIS-5.4.4

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

January 25, 1967

J. H. C.

JAN 25 1967

Memorandum for Mr. R. B. Meen

EX ORO VERDE FARM LAND - WATER SOURCE

At Mr. William A. Evans' suggestion, Mr. Burt Apker of the former's office telephoned me this morning regarding the above noted property.

Looking into the future, Mr. Evans is concerned that sooner or later a distinction will be made within the State, and particularly within the general area south of Tucson, between what he terms "sub-flow" and "percolating water."

In brief, Mr. Evans envisions percolating waters as those which may be taken where found. On the other hand, he feels that waters of the sub-flow catagory are subject to appropriation when so formally requested.

Stated in other terms, if our engineers and geologists are reasonably sure that the water supply falls under the percolating classification, neither Mr. Evans nor Mr. Apker thinks there is any particular danger to losing this supply through any legal action. They do feel that, should there be any uncertainty on the part of those persons, and that it might be successfully argued by other interested parties that the flow in question is sub-flow, the right to the water might be successfully contested.

Mr. Evans has suggested that our engineers devote serious thought to the matter. He further counsels that consideration be given to making a formal application for the anticipated water requirements on the theory that the supply is of sub-flow origin. Should this request appropriation be granted, insurance would thereby be provided. If the request were denied, premised upon the reason that the waters are not sub-flow but of percolating origin, Mr. Evans feels that such a decision would then protect the supply from any danger of future encroachment.

I asked Mr. Apker to thank Mr. Evans for this advice, and assured them that it would have our attention.

A. C. HALL

ACH:cmr

A. A. McDANIEL
WELL AND MACHINE COMPANY INC.
2838 RUTHRAUFF ROAD
TUCSON, ARIZONA

Sec. 2 3dd

December 20, 1966

Log of Well Drilled For: No. 8

Pima Mining Company
Sahuarita, Arizona

Well Number: 8

Location: D17 13 2 add

T. 17S, R. 13E

Formation:

From:		To:	
0'	to	15'	Soil
15'	to	30'	Sand & Gravel
30'	to	65'	Dirty Sand & Gravel
65'	to	200'	Sandy Clay
200'	to	230'	Sandy Clay Gravel & Water
230'	to	235'	Gravel & Water
235'	to	255'	Clay
255'	to	260'	Gravel & Water
260'	to	280'	Clay
280'	to	305'	Cemented Sand & Gravel
305'	to	320'	Clay
320'	to	345'	Sandy Clay & Gravel - Water
345'	to	350'	Gravel & Water
350'	to	365'	Clay
365'	to	420'	Sandy Clay & Gravel - Water
420'	to	425'	Clay
425'	to	520'	Sandy Clay & Gravel - Water
520'	to	545'	Clay
545'	to	560'	Sandy Clay & Gravel - Water
560'	to	573'	Cemented Sand & Gravel
573'	to	583'	Rocky Gravel & Water
583'	to	620'	Sandy Clay & Gravel - Water
620'	to	630'	Sand & Water
630'	to	640'	Clay
640'	to	660'	Sand Gravel & Water
660'	to	690'	Sandy Clay Rock
690'	to	705'	Cemented Sand & Gravel
705'	to	735'	Sand Gravel & Water
735'	to	760'	Sandy Clay & Gravel - Water
760'	to	790'	Sand Gravel & Water
790'	to	820'	Clay & Gravel
820'	to	835'	Sand Gravel & Water
835'	to	860'	Clay & Gravel

PHONE: 887-2170

DRILLING CONTRACTORS

A. A. McDANIEL
WELL AND MACHINE COMPANY INC.
2838 RUTHRAUFF ROAD
TUCSON, ARIZONA

Log Of Well Drilled For :

Pima Mining Company

Continued

860'	to	870'	Sand Gravel & Water
870'	to	880'	Sandy Clay & Gravel - Water
880'	to	940'	Clay- some gravel
940'	to	960'	Sandy Clay & Gravel - Water
960'	to	965'	Clay
965'	to	980'	Sandy Clay & Gravel - Water
980'	to	995'	Clay & Gravel
995'	to	1000'	Rocky Sand Gravel & Water
1000'	to	1025'	Muddy Sand & Gravel -Water
1025'	to	1040'	Muddy Sand & Water
1040'	to	1080'	Clay & Gravel
1080'	to	1095'	Sand & Water
1095'	to	1120'	Clay & Gravel - Water
1120'	to	1140'	Sand & Gravel - Water
1140'	to	1153'	Hard Conglomerate - 13'+ ?

Total Depth: 1153'

Casing: 1151' of 20" OD by .312" wall API Linepipe

Perforations: Milled Slot, 1/4" by 3" cuts from 940' to 1146'

Static Water Level: 190'

Driller: George W Gibson

A A McDaniel Well & Machine Co.Inc.

By: ___

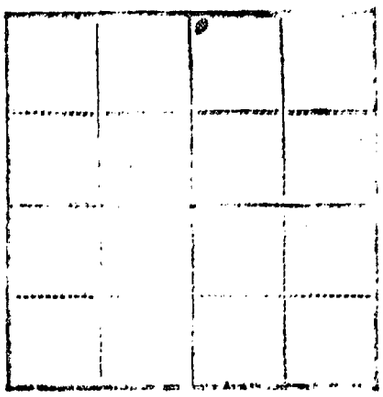
PHONE: 887-2170

DRILLING CONTRACTORS

A. A. McDANIEL
WELL AND MACHINE COMPANY, INC
2838 RUTHRAUFF ROAD
TUCSON, ARIZONA

October 10, 1963

Sec. 2



T. 17S, R. 13E

Log of Well Drilled For:
Pima Mining Co.
PO Box 7267
Tucson, Arizona #1

Location: D(17-13)2abb

Formation:

From:		To:	
0'	to	5'	Sandy Soil
5'	to	100'	Clay & Gravel
100'	to	135'	Clay
135'	to	225'	Clay & Gravel
225'	to	235'	Muddy Gravel & Water
235'	to	270'	Clay
270'	to	286'	Gravel & Water
286'	to	305'	Clay & Gravel
305'	to	310'	Gravel & Water
310'	to	325'	Muddy Gravel & Water
325'	to	350'	Sandy Clay (sticky)
350'	to	410'	Clay & Gravel
410'	to	445'	Clay
445'	to	465'	Sand Gravel & Water
465'	to	505'	Clay
505'	to	540'	Sand Gravel & Water
540'	to	580'	Clay & Gravel
580'	to	600'	Sandy Clay
600'	to	625'	Sand Gravel & Water
625'	to	650'	Hard Conglomerate — 25'
650'	to	660'	Clay & Gravel
660'	to	668'	Sand Gravel & Water
668'	to	680'	Clay
680'	to	700'	Sand Gravel & Water
700'	to	725'	Clay & Gravel
725'	to	745'	Sand Gravel & Water
745'	to	748'	Hard Conglomerate — 3'
748'	to	760'	Sand Gravel & Water
760'	to	775'	Clay & Gravel
775'	to	780'	Hard Conglomerate
780'	to	810'	Clay & Gravel
810'	to	820'	Gravel & Water
820'	to	845'	Clay & Gravel
845'	to	853'	Sand Gravel & Water
853'	to	885'	Sandy Clay
885'	to	906'	Clay & Gravel
906'	to	920'	Gravel & Water
920'	to	950'	Clay & Gravel
950'	to	960'	Green Volcanic Flow Material
Total Depth		960'	

Continued..

PHONE: 887-2170

DRILLING CONTRACTORS

A. A. McDANIEL
WELL AND MACHINE COMPANY, INC.
2838 RUTHRAUFF ROAD
TUCSON, ARIZONA

Log of Well Drilled For:
Elna Mining Co.

Casing: 952' of 20" OD by .312 Wall API Linepipe

Perforations: Milled Slots, 1/4" by 3" cuts from 159' to 960'

Surface Casing: 203' of 24" OD

Static Water Level: 216'

Driller: George W Gibson

A A McDaniel Well & Machine Co. Inc.

By:_____

DATA ON WELLS AND PUMP IRRIGATION

AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA

AGRICULTURAL EXPERIMENT STATION
TUCSON, ARIZONA

NAME: Rima Mine #7 ADDRESS: .....

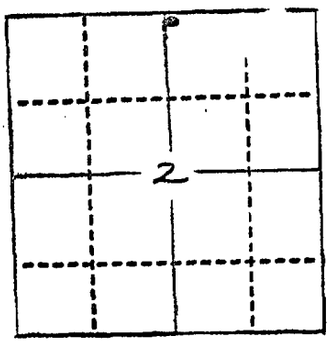
WELL: Location a & b Sec. 2, Twp. 17 S, R. 13 E

Use, domestic, stock, or irrigation Industrial acres

Type Drilled Casing 20'

Perforations .....

Drilled by A.A. McDaniel Date: 1966



LOG

FROM	TO	MATERIAL	FROM	TO	MATERIAL
Feet 0	Feet		Feet	Feet	
				960	To Hard Rock

WATER LEVEL: Depth from surface when drilled 185 feet. Date .....

Present depth to water ..... feet. Date .....

Notes on fluctuation of water level .....

.....

PUMP: Make ..... Type ..... Size .....

Diam. of bowls ..... Number of stages .....

Diam. of column ..... Diam. discharge ..... Diam. suction .....

Rated capacity in G. P. M. ..... at ..... feet head, at ..... R. P. M.

Amount of discharge ..... G. P. M. measured by means of .....

Drawdown ..... feet when pumping ..... G. P. M. Total lift ..... feet

ENGINE OR MOTOR: Make ..... Type ..... Size ..... H. P.

Drive: direct-connected ..... belted ....., or geared .....

Fuel consumption or power input .....

Description of installation .....

.....

Date: ..... (Signed) .....

SEE OTHER SIDE FOR MISCELLANEOUS DATA

Report Number 233

PROGRESS REPORT

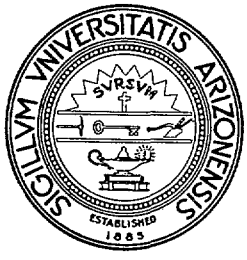
ON STUDY OF

WATER IN THE SANTA CRUZ VALLEY

ARIZONA

by

W. G. Matlock, H. C. Schwalen and R. J. Shaw



DEPARTMENT OF AGRICULTURAL ENGINEERING
Agricultural Experiment Station

THE UNIVERSITY OF ARIZONA
Tucson

September 1965

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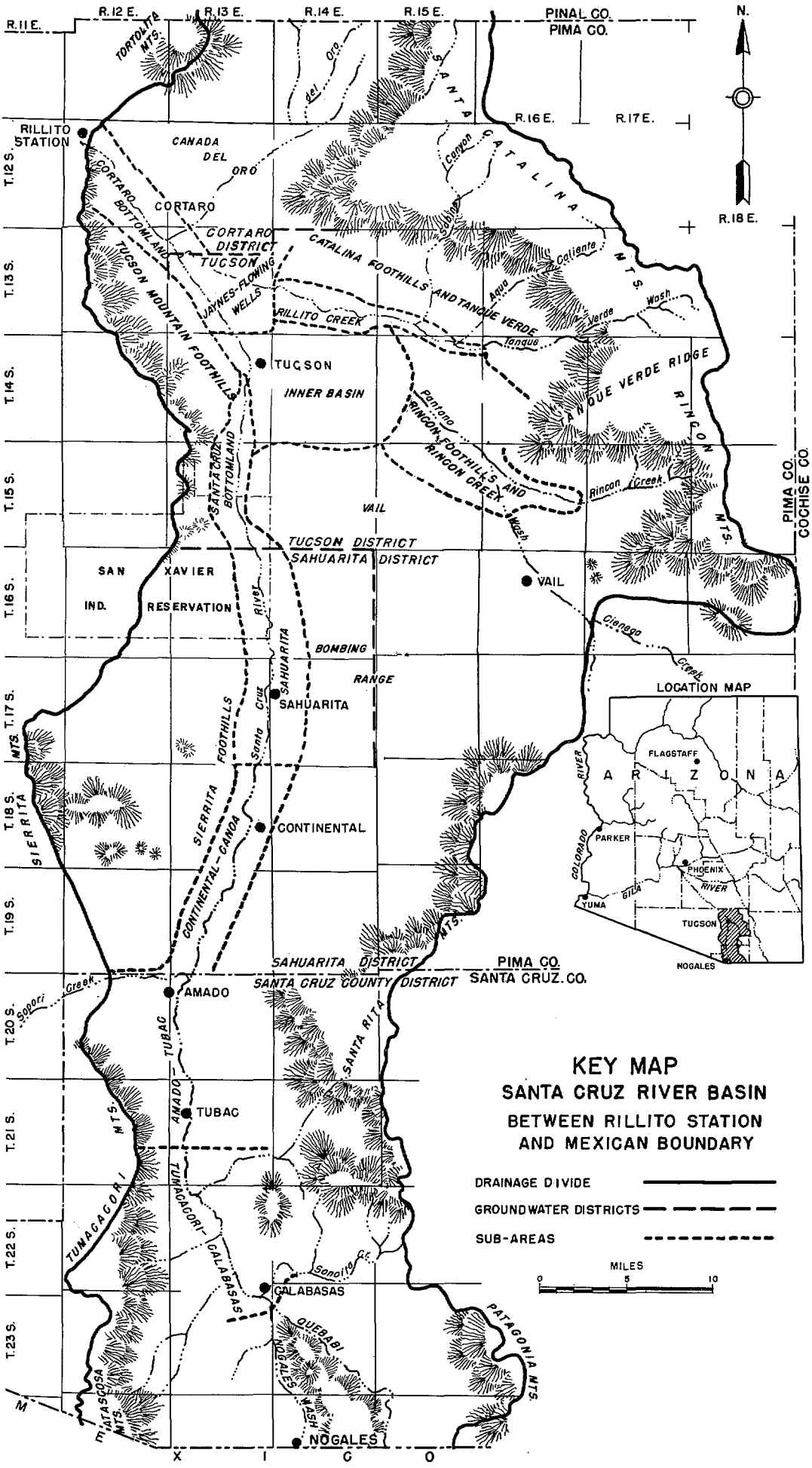
ACKNOWLEDGEMENTS

Continued financial support from Pima County and the City of Tucson has made possible the extensive water-level measuring program and the collection of hydrologic data in the Santa Cruz Valley by the Agricultural Engineering Department of the University of Arizona. Their assistance is gratefully acknowledged.

The well drillers of the area are also given special thanks for making available for public use their records and the results of their experience. They have collected and interpreted many formation samples, and, at the request of the Department, have often made special tests while drilling.

In addition many property owners have granted access to their wells and furnished information concerning them to assist in the progress of this work.


R.11E.
R.12E.
R.13E.
R.14E.
R.15E.
R.16E.
R.17E.
R.18E.
PINAL CO.
PIMA CO.
N.
T.12S.
T.13S.
T.14S.
T.15S.
T.16S.
T.17S.
T.18S.
T.19S.
T.20S.
T.21S.
T.22S.
T.23S.
TORTOLITA MTS.
SANTA CATALINA MTS.
RILLITO STATION
CANADA DEL ORO
CORTARO
CORTARO BOTTOMLAND
CORTARO DISTRICT
TUCSON
TUCSON MOUNTAIN FOOTHILLS
JAYNES-FLOWING WELLS
RILLITO CREEK
CATALINA FOOTHILLS AND TANQUE VERDE
Canyon
Subwash
Agua Caliente
Tanque Verde Wash
Tanque
TANQUE VERDE RIDGE
RINCON MTS.
TUCSON
INNER BASIN
Pantano
RINCON FOOTHILLS AND RINCON CREEK
Rincon Creek
Wash
VAIL
SANTA CRUZ BOTTOMLAND
TUCSON DISTRICT
SAHUARITA DISTRICT
SAN XAVIER IND. RESERVATION
VAIL
Cienega Creek
BOMBING RANGE
SAHUARITA
SIERRITA MTS.
FOOTHILLS
Santa Cruz River
CONTINENTAL
SIERRITA
CONTINENTAL-CANOA
SAHUARITA DISTRICT
SANTA CRUZ COUNTY DISTRICT
PIMA CO.
SANTA CRUZ CO.
AMADO
Sopori Creek
TUBAC
AMADO-TUBAC
SANTA RITA MTS.
TUMACACORI MTS.
TUMACACORI
CALABASAS
Sonoita Cr.
QUERABI
NOGALES WASH
PATAGONIA MTS.
PATAGONIA MTS.
NOGALES
LOCATION MAP
FLAGSTAFF
ARIZONA
PARKER
PHOENIX
YUMA
TUCSON
NOGALES
COLORADO RIVER
GILA RIVER
KEY MAP
SANTA CRUZ RIVER BASIN
BETWEEN RILLITO STATION AND MEXICAN BOUNDARY
DRAINAGE DIVIDE
GROUNDWATER DISTRICTS
SUB-AREAS
MILES
0
5
10

INTRODUCTION

The City of Tucson and the adjacent urban, industrial, and farming areas are completely dependent for their water supply on a groundwater reservoir. With continued growth in population and consequent increased pumping of water causing rapid decreases in water levels, an intensive study of the groundwater system is imperative. A groundwater investigation of this area was initiated in 1905 (1)* and has been continuous since that time. The scope of the project was expanded and intensified in 1946 through a cooperative agreement for financing with Pima County and the City of Tucson and further expanded in 1961 to include a program of special tests and measurements for determination of the hydraulic characteristics of the groundwater aquifer. The Key Map, frontispiece, shows the drainage area and location of the Santa Cruz River Basin.

The results of groundwater studies up to the Spring of 1961 have been previously published in Agricultural Experiment Station Bulletin 288, Water in the Santa Cruz Valley, (2) and Report 205, (3) a progress report supplementing Bulletin 288. In those publications results of studies covering the period of the previous 55 years were given.

The purpose of this report is to summarize the results of studies which have been conducted since the publication in 1961 of Report 205. As a further supplement to Bulletin 288, no attempt is made to report or enlarge on those sections dealing with the physiography and general hydrology of the groundwater basin.

---

*Numbers in parenthesis refer to REFERENCES.

Because it is impractical to publish annually the results of the investigations, they are presented in this report in the form of a 4-year summary with water level records, groundwater contour maps and water level change maps.

All well and water level information is on open file and available for reference by the public. Logs of several thousand wells are included in the Department files.

WATER LEVEL MEASUREMENTS

Depths to water are measured annually in over 1,500 wells in the Santa Cruz Valley to determine the changes in water level which have taken place during the previous year. To be consistent from year to year the individual well measurements are made on approximately the same date each year. Winter or spring measurements are considered most suitable since they show the position of the water table after a period of reducing pumping draft when area-wide drawdown as a result of pumping is at a minimum.

The water level measurements for a large number of wells in the Santa Cruz Valley are listed in tables in Bulletin 288 and Report 205. From the total number of wells, about 500 wells which are considered typical and representative of the areas in which they are located have been selected for inclusion in Table III, Appendix A. Where many water level records are available, wells were selected on the basis of about one well per square mile. Where possible the following information relative to each well has

been included in the table: (1) location of well by section, township and range; (2) depth of well in feet; (3) elevation above sea level of measuring point--usually at approximate ground surface; (4) depth to water and first year water level measurement was made; (5) depths to water in 1940, 1950, 1956, 1961, and 1965.

WELL NUMBERING SYSTEM

The wells are listed under their respective townships and ranges in the numerical order of the section in which they are located. The location of wells within the sections is indicated by letter and number to the nearest 10-acre subdivision as shown in Figure 1 according to the system used by the Arizona State Land Department and the U.S. Geological Survey.

The land survey in Arizona is based on the Gila and Salt River Meridian and Base line, which divide the state into four quadrants designated counterclockwise by capital letters A, B, C, D (Figure 1). The first number of a well indicates the township, the second the range, and the third the section in which the well is located. The lower case letters a, b, c, d, assigned in a counterclockwise direction indicate the location within the section. The first letter indicates a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. In the example shown well no. (D-3-5) 17 dda places the well in the NE 1/4 SE 1/4 SE 1/4 of section 17, Township 3 South, Range 5 East. Where more than one well is located within a 10-acre tract consecutive numbers beginning with 1 are added as suffixes.

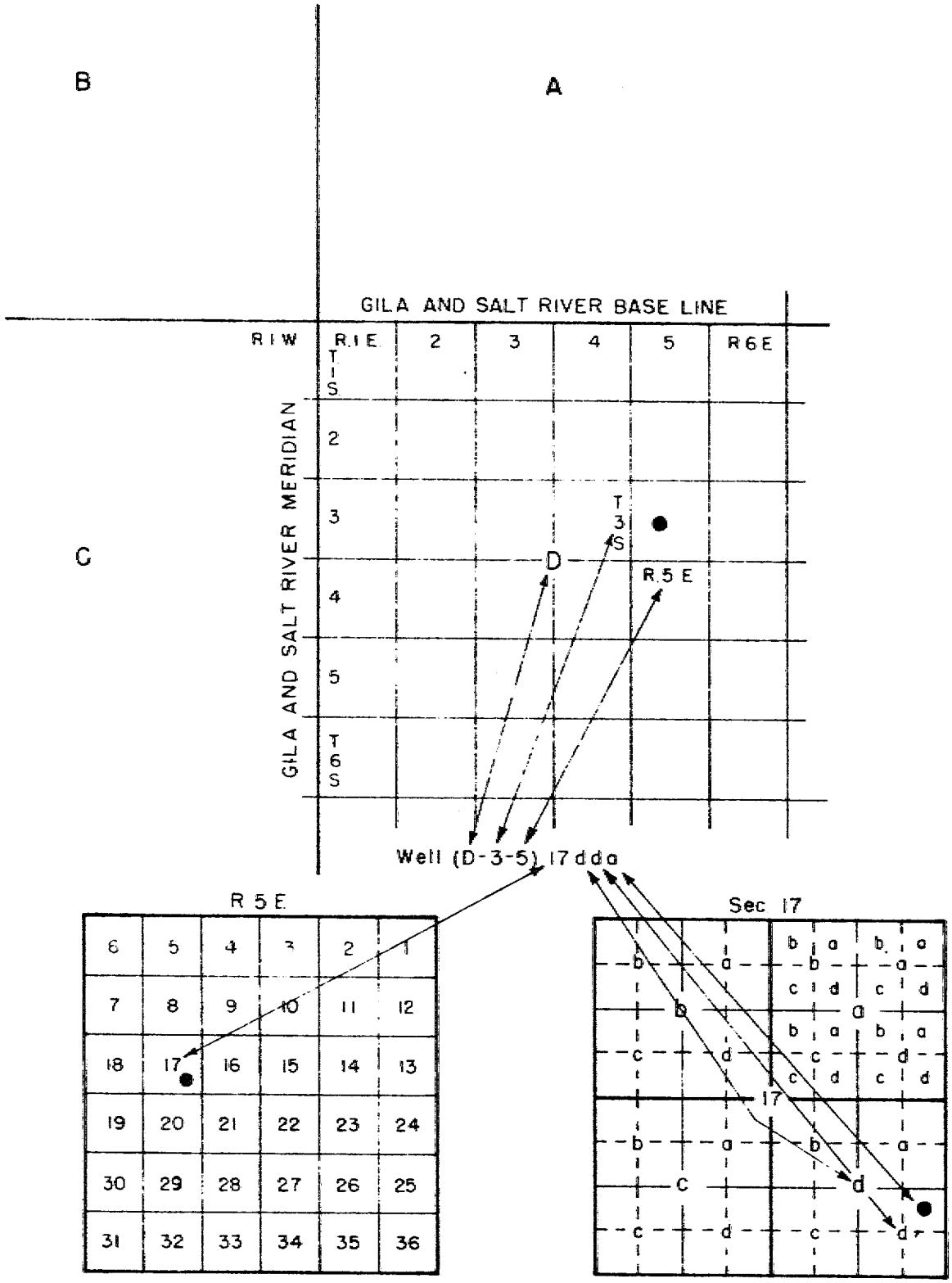


Figure 1 Example of well-numbering system

GROUNDWATER CONTOURS AND WATER LEVEL CHANGES

Groundwater contour maps have been drawn from the information obtained by water level measurements made in the Spring of 1965. The map shown in Plate I, Appendix B, covers that portion of the Santa Cruz Basin for which information is available between Rillito Station and the Pima--Santa Cruz County line. The map for the Santa Cruz County portion of the basin is given in Plate IV, Appendix B.

The groundwater contours define the surface of the water table, and movement of water is presumed to be in the direction of the steepest slope, at right angles to the contours. The sources of the groundwater and the general direction of water movement through the basin are thus indicated by the contours.

The general character of the groundwater contour maps has changed very little since the first maps were prepared in 1947. However, changing water levels cause a shift in the location of contours. In areas of marked lowering the slope or gradient of the water table has increased, and changes in the contours show increased flow into these areas.

Estimates of depths to water may be made by subtracting the elevation of the water table at any point from the ground surface elevation at that point. Elevations between contours must be obtained by interpolation. Surface contours as shown have been traced from U.S. Geological Survey topographic maps.

The changes in groundwater levels for the periods 1961-1965 and 1947-1965 are shown by lines of equal lowering on the water level change maps in Appendix B. The maps for the part of the basin in Pima County are on Plates II and III, and those for Santa Cruz County on Plates V and VI.

The groundwater basin has been somewhat arbitrarily divided into districts and sub-areas on the basis of aquifer characteristics and patterns of water use for the purpose of describing conditions in individual areas within the basin. For assistance to the reader in studying the discussion which follows, reference should be made to the Key Map, frontispiece, which shows the districts and sub-areas, and Plates I-III, Appendix B, for areas in Pima County, and to the Key Map and Plates IV-VI, Appendix B, for those in Santa Cruz County.

CORTARO - CANADA DEL ORO DISTRICT

This district consists of that part of the groundwater basin lying north of Rillito Creek between the Santa Catalina Mountains on the east and the Tucson Mountains on the west, and south and east of the Tortolita Mountains. Hydrographs of wells representative of this district are shown in Figure 2.

Cortaro Bottomland Area

This area occupies the bottomland along the Santa Cruz River from the junction of Rillito Creek to the north end of the Tucson Mountains at Rillito Station. Since 1921 about 21,000 acre-feet have been pumped annually

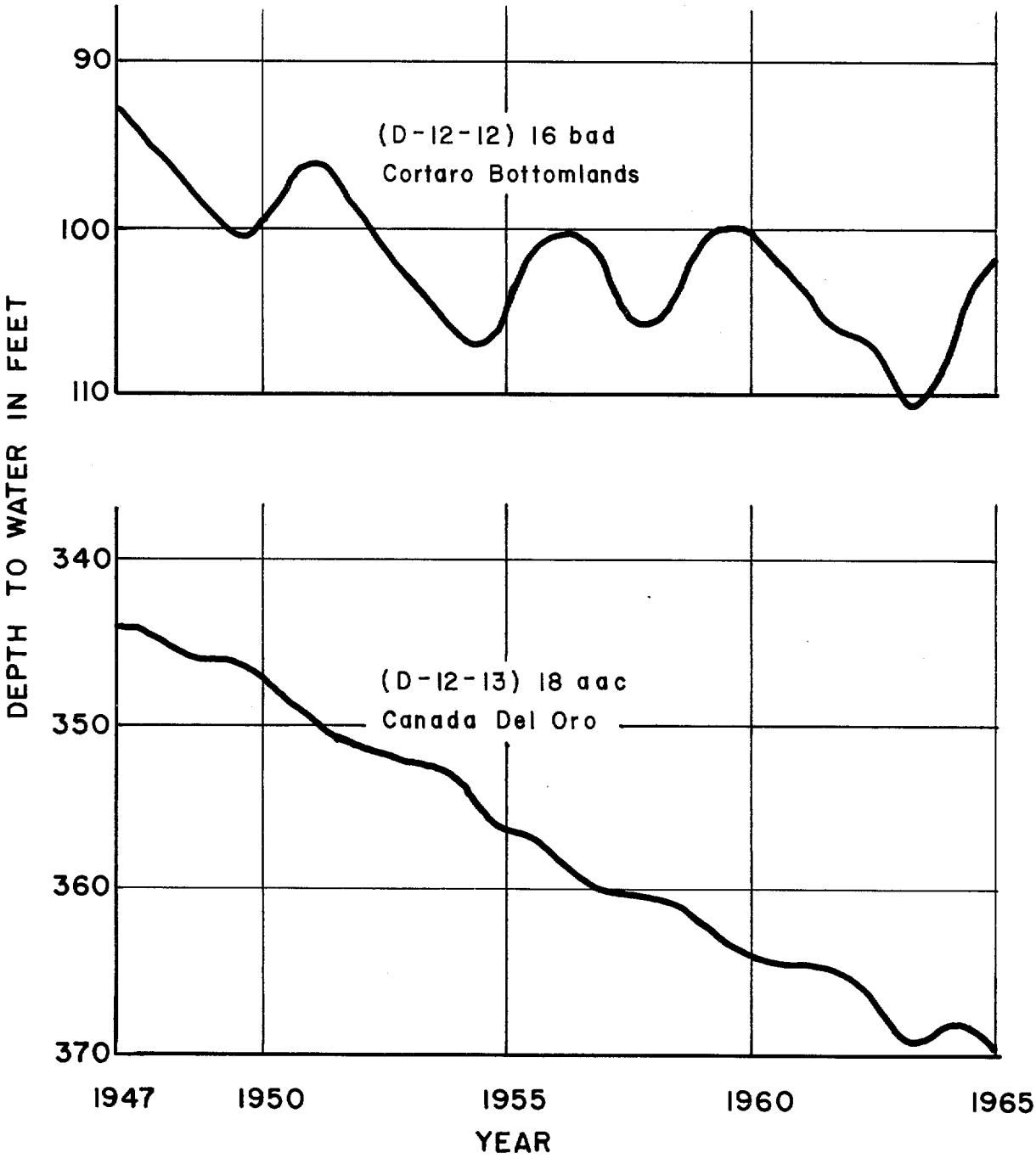


FIGURE 2. HYDROGRAPHS OF REPRESENTATIVE WELLS IN CORTARO - CANADA DEL ORO DISTRICT

with most of the water conveyed by canal to the Marana area for irrigation. Since 1955 lands within the area have been irrigated in part with treated effluent from the City of Tucson sewage disposal plant. Sewage effluent has increased from about 17,000 AF in 1961 to over 20,000 AF in 1964 (4). The average for the 4-year period has been 18,700 AF per year of which about 2600 acre-feet has been used for irrigation on the City Farm and a small amount at the plant site. The remaining 16,100 acre-feet per year has been available for irrigation in the Cortaro area, although part of it has been discharged into the Santa Cruz River channel when it could not be fused for irrigation.

Groundwater recharge in this area is from infiltration of flood flows in the Santa Cruz River and the deep percolation losses from sewage effluent used for irrigation or diverted into the river channel. Continuous underdrainage from the valley slopes also provides some recharge to the trough of the valley.

In the 4-year period 1961-1965 a rise in the water table has occurred in most of this area resulting from slightly decreased pumping and higher than average flood and sewage flows. Lowering of from 10 to 15 feet has occurred in the 18-year period 1947-1965.

Canada del Oro Area

This area occupies the valley slopes between the Cortaro bottomland and the Tortolita Mountains on the north and the Santa Catalina Mountains on

the east. The principal source of recharge in the area is infiltration from flood flow in the Canada del Oro channel.

Water level records are available for the past 26 years during which depths to water have shown a consistent and continuous downward trend. The lowering in the past four years has been at the rate of about 2 feet per year in the eastern portion of the area. The lowering has been from 1 to 2 feet per year in the Canada del Oro drainage below the Oracle Road crossing.

In the 18-year period, 1947-1965, water levels have fallen as much as 35 feet with an average of from 1 to 2 feet annually.

Water pumped in this area is mainly for irrigation and recreation (2 golf courses and a man-made lake), but domestic use is increasing rapidly with the population. A dam which has been built on the Canada del Oro channel will have some effect on water levels by removing part of the natural recharge.

TUCSON DISTRICT

The broad central part of the Santa Cruz Valley in the center of which Tucson is located has been designated as the Tucson District. It extends from the Tucson Mountains on the west to the Rincon Mountains on the east and from the Santa Catalina Mountains on the north as far south as Sahuarita Butte. It also includes a portion of the valley slopes southeast of the city. Within this district population growth has been most rapid with a corresponding increase in pumping draft for domestic water supplies

taking place. Hydrographs of representative wells in this district are given in Figure 3.

Tucson Mountains Foothills Area

This is the area north of "A" Mountain between Silverbell Road and the east slopes of the Tucson Mountains. Water supplies for suburban development are principally from individually owned small domestic water company or City of Tucson wells of limited capacity. Additional water is supplied to the area from the municipal system. Some problems have arisen where water levels have dropped below the top of the relatively impervious buried pediment or older formations.

Water levels in most of this area show little change in the 4-year period, 1961-1965, but losses of up to 5 feet have occurred at the south end. In the 18-year period, 1947-1965, losses range from about 10 feet at the north end to over 50 feet at the south end of the area. These losses are not caused so much by increased water use in the area but, rather, by increased underflow into the adjacent lower areas.

Jaynes - Flowing Wells Area

This area lies northwest of the City of Tucson between the Santa Cruz River and Rillito Creek in a section where most pumping was originally for irrigation use. Pumping for irrigation has become negligible, and with urban development of the area the pumping of groundwater has been reduced. Lowering of up to 10 feet has taken place in the 4-year period, 1961-1965,

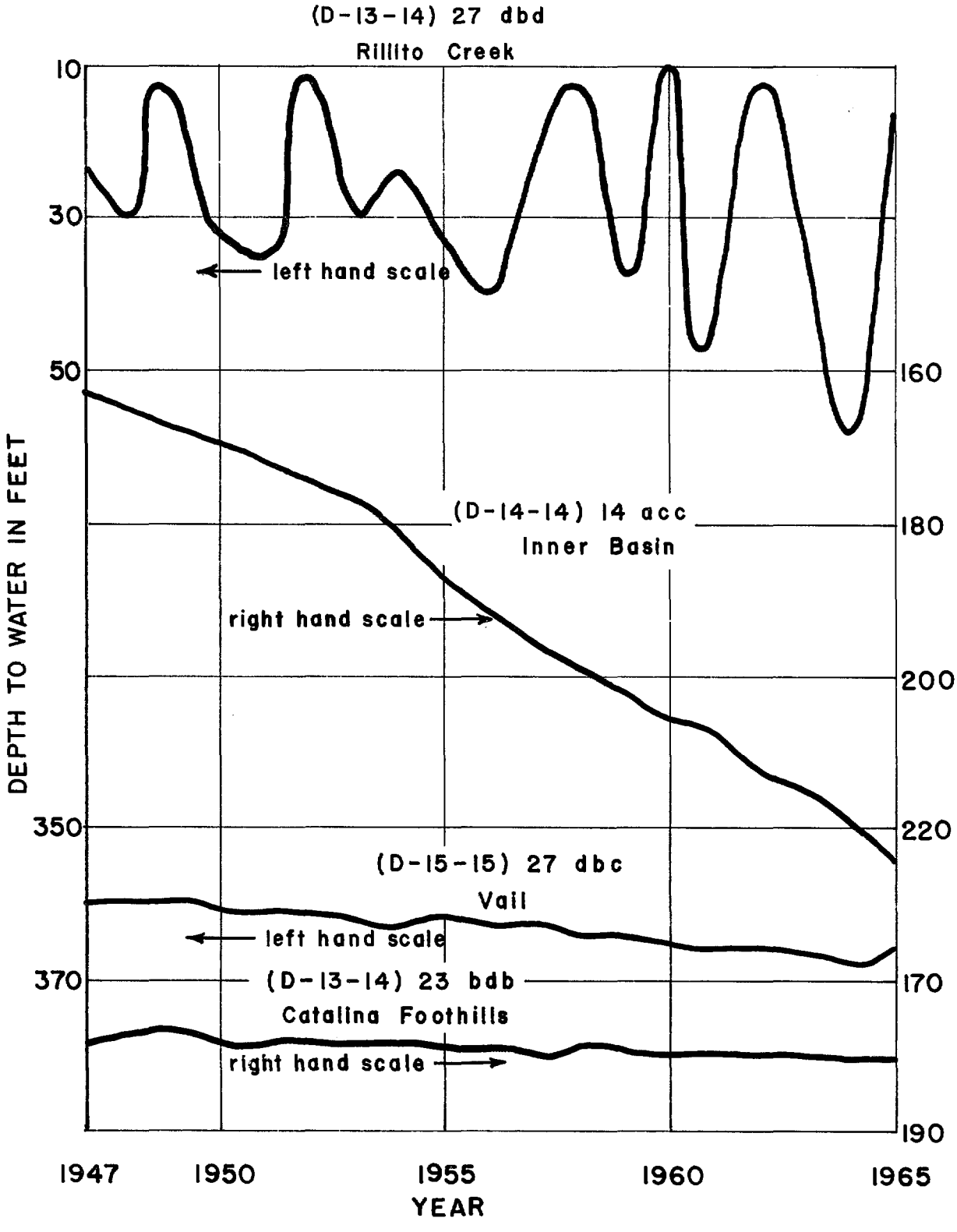


FIGURE 3 HYDROGRAPHS OF REPRESENTATIVE WELLS IN TUCSON DISTRICT

with the least lowering at the northeast corner and the greater lowering in the southeast portion of the area. In the period from 1947-1965 lowering was from 25 to 50 feet, similarly distributed.

Catalina Foothills and Tanque Verde Area

This area includes most of the Catalina Foothills north of Rillito Creek and the lands along Tanque Verde Wash in Range 16 East. Wells of limited capacity or dry holes may be expected in the Catalina Foothills area which is almost entirely underlain by the comparatively impervious Pantano formation. (2) Water levels in wells in the Tanque Verde part of the area tend to fluctuate with the demand and recharge from stream flow, some responding much more rapidly than others to the changes.

In the 4-year period, 1961-1965, portions along Tanque Verde and Agua Caliente Washes showed a rise in water level as did the section near the rise in the Rillito Creek Area. Other wells showed losses of up to 45 feet. A large part of the area shows no change in water level for the 18-year period, 1947-1965. Underdrainage to adjacent areas has caused lowering of about 10 feet in some portions of this area.

Rincon Foothills and Rincon Creek Area

This area includes Rincon Creek and the foothill slopes extending westward from Tanque Verde Ridge to the boundary of the Inner Basin Area. In the foothill portion of the area pumping has been limited and lowering has been caused principally by underdrainage.

In the 4-year period, 1961-1965, there has been little change near the mountains but farther out in the valley losses up to 10 feet have occurred. During the period from 1947-1965 lowering of up to 30 feet has taken place.

The water levels in Rincon Creek valley tend to fluctuate with flow in the creek channel. No net change occurred in this valley during the period, 1961-1965, and a net gain is shown for the 18-year period, 1947 to 1965.

Rillito Creek Area

This area consists of the bottomlands of Rillito Creek east of First Avenue and the lower reaches of Sabino Canyon and Tanque Verde Wash together with adjacent lands to the south. In this area the stream channels of Rillito Creek and its tributaries constitute the most effective natural recharge area in the entire Tucson District. Wide fluctuations in water levels occur, with lowering during dry periods and rapid recovery during periods with flow in the channels. Losses of 5 to 10 feet were common in the western portion of the area during the 4-year period, 1961-1965, but in the vicinity of Swan Road a rise of 25 feet was noted. The eastern portion also showed a rise of up to 5 feet during this period.

For the 18-year period, 1947-1965, a rise of 10 feet is evident for the section near Swan Road, but lowering of up to 40 feet occurred in the western portion and in the adjacent lands to the south of the river channel. Part of these losses are caused by increased pumpage in the area and part by increased underflow to the Inner Basin Area.

Inner Basin Area

The City of Tucson and some of the adjacent metropolitan area overlie an inner groundwater basin within the larger Santa Cruz Valley basin. The eastern and southern boundaries of the inner basin are marked by a region of more closely spaced groundwater level contours (See Plate I). The northern and western boundaries are formed by the Santa Cruz River and Rillito Creek bottomlands. Pumping within this area is mainly for municipal and industrial use with the major part of the pumping for the City of Tucson coming from this area.

Water table lowering of from 10 to 25 feet has occurred in the period, 1961-1965, with the maximum lowering in the vicinity of 22nd street and Wilmot Road. Lowering of 40 to 70 feet has taken place during the 18-year period, 1947-1965, at an average rate of 2 to 4 feet per year.

Santa Cruz Bottomland Area

This area occupies the bottomland of the Santa Cruz River and immediately adjacent lands between "A" Mountain and Sahuarita Butte. Water in this area is used for irrigation, and, in addition, the City of Tucson Southside Well Farm is located in the center of the area, just east of the river.

During the 4-year period, 1961-1965, water levels dropped from 5 to 10 feet with maximum lowering at the south end of the area. Lowering of from 20 to 40 feet has taken place in the 18-year period, 1947-1965.

Vail Area

This is the area south and east of the Inner Basin Area and includes the wide valley slopes southeast of Tucson. Development of this area has been limited with consequently small water demand. Industrial wells along the Tucson-Benson Highway and a subdivision and golf course southwest of Vail are the principal water users.

Most of the area shows little change in groundwater levels for the period, 1961-1965, but losses of up to 5 feet have occurred along the northern and western boundaries. Lowering of 5 to 10 feet has occurred in the period from 1947 to 1965.

SAHUARITA DISTRICT

The district includes the farming lands on the Santa Cruz River bottomlands and the adjacent valley slopes between Sahuarita Butte and the Pima-Santa Cruz County line. Hydrographs of wells representative of this district are shown in Figure 4.

Sahuarita Area

This area is comprised of the farming lands along the Santa Cruz River between Sahuarita Butte and the north end of the Canoa Land Grant. The pumping draft is principally for agricultural use with an irrigated acreage of about 7000 acres in 1964. Pumping in this area by the City of Tucson and for milling low grade copper ore can be expected to increase in the years ahead. Groundwater levels have fallen more than 10 feet over

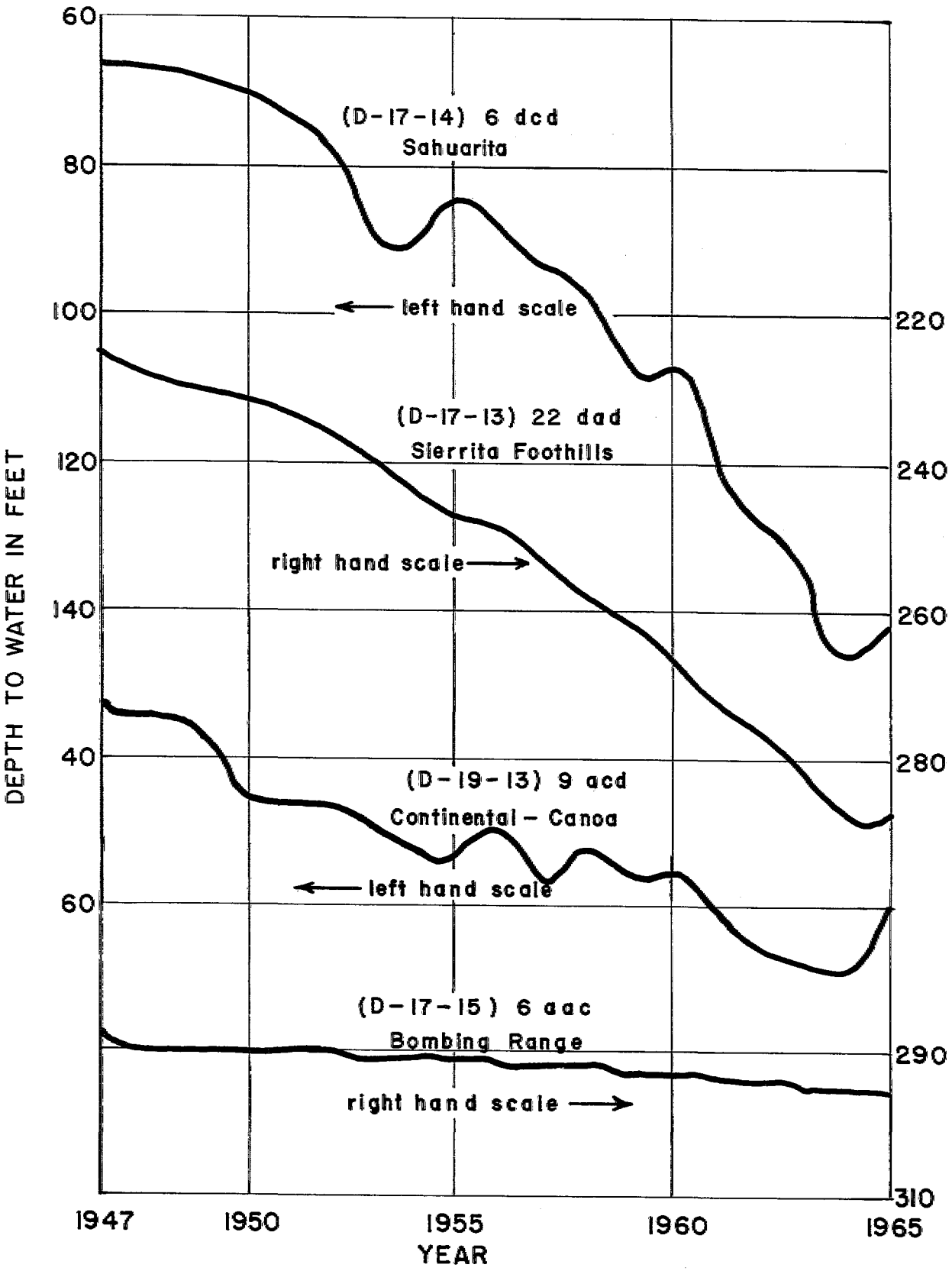


FIGURE 4. HYDROGRAPHS OF REPRESENTATIVE WELLS IN SAHUARITA DISTRICT

the entire area during the 1961-1965 period. Locally losses of up to 30 or 35 feet have occurred. During the 18-year period, 1947-1965, losses of over 30 feet in groundwater levels were general in the area with local losses up to 70 feet.

Subsidence or sinking of the surface of the ground has been noted around several wells in the Sahuarita Area (See Figure 5). The protrusion of well casings above the level at which they were originally set suggests that the compaction causing subsidence is distributed throughout the zone penetrated by the well.

The causes of subsidence are not completely known, but in an area of interfingering sand or gravel aquifers and clay aquicludes, such as exist in the Santa Cruz Valley, compaction of the clay material following water withdrawal is a probable cause.

Sierrita Foothill Area

This area is located on the alluvial valley slopes between the Santa Cruz bottomland and the east side of the Sierrita Mountains. Much of the upper part of the area is underlain by the buried rock pediment extending out from the base of the mountains. Water levels in this upper part of the area are either controlled by the depth to the pediment or by the character of the rock formations and have not been affected by pumping in the valley. The remainder of the area with a width of about 3 miles along the bottomland on the west side overlies the deep alluvial filled portion of the valley. The

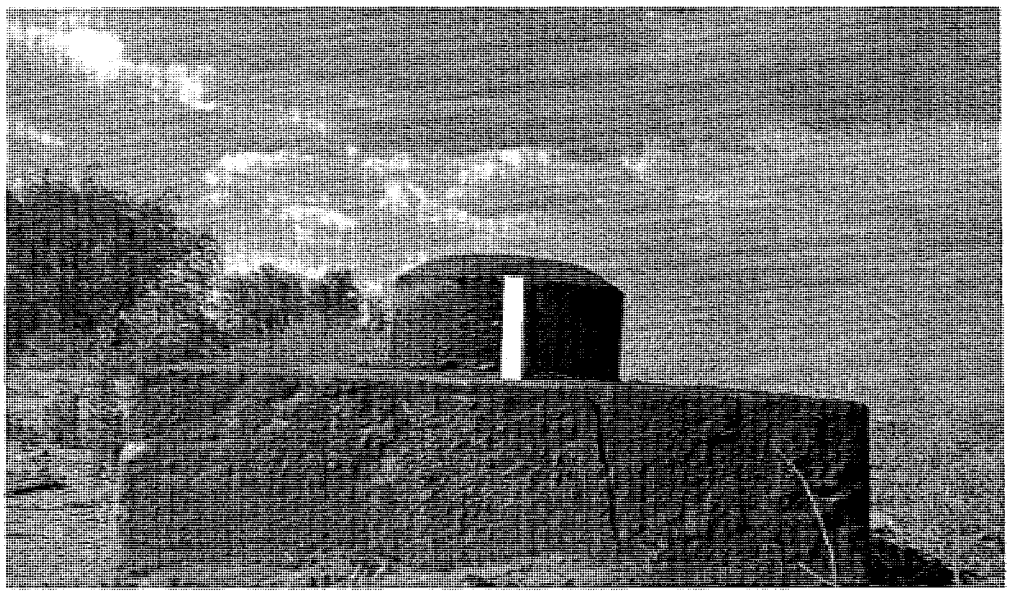


Figure 5. Protrusion of well casing in Sahuarita Area shows subsidence of 6 inches.

water table here responds to the changes in pumping draft and recharge from the Santa Cruz River the same as in the Sahuarita Area, but to a more limited extent.

In the 4-year period, 1961-1965, minor losses have occurred over the entire area with maximums of about 10 feet along the east side. This loss is caused principally by underdrainage into the Sahuarita area. Heavy pumping along Pima Mine Road has resulted in lowering of 35 feet. During the period from 1947-1965 losses of 15 to 60 feet have taken place, again with the greater loss along the east side adjoining the Sahuarita Area.

Bombing Range Area

This area lies east of the Sahuarita Area on the valley slopes extending out from the Santa Rita Mountains. Few wells are located in this area, and pumping demand is limited. Losses in water level in this area are caused principally by underflow to the north and to the adjacent Sahuarita Area. Losses of up to 5 feet occurred in the 4-year period, 1961-1965, and up to 10 feet in the 18-year period, 1947-1965. The rapid lowering of water levels in the Sahuarita Area will continue to affect the Bombing Range Area.

Continental - Canoa Area

This area includes the Canoa Land Grant and the bottomlands extending about 1 mile south to the Pima-Santa Cruz County line. Pumping draft is mainly for agricultural use, and there has been no major change in the irrigated acreage of about 5000 acres in the past few years. Losses in the area

during the 1961-1965 period ranged from no change at the county line to 15 feet at the lower end near Continental. From 1947-1965 losses of 10 feet occurred at the upper end with losses of 70 feet at the lower end adjoining the Sahuarita Area.

SANTA CRUZ COUNTY DISTRICT

This district is comprised of the narrow bottomlands along the Santa Cruz River from the Pima County line to the Mexican boundary. Also included are similar lands on the tributaries, Nogales Wash and Sopori Creek. Hydrographs of representative wells in this district are given in Figure 6.

Amado - Tubac Area

This area is between the Pima County line and Tumacacori Mission, with the lower part of the Sopori Creek bottomland also included. Little change in pumping draft has occurred along the Santa Cruz River during the period 1961-1965 and most of the area showed a slight gain in water levels for this period with only the extreme lower end registering a loss of 5 feet. Along Sopori Creek losses of up to 10 feet took place in a small area while one mile upstream there was a gain of 10 feet in water level. The loss at the lower end is attributed to increased pumpage for irrigation.

During the 18-year period, 1947-1965, losses of 5 to 10 feet occurred along the Santa Cruz River with losses from 10 to 25 feet in Sopori Creek. The losses are partly caused by the increased underdrainage downstream, but along Sopori Creek most of the loss resulted from increased irrigation use.

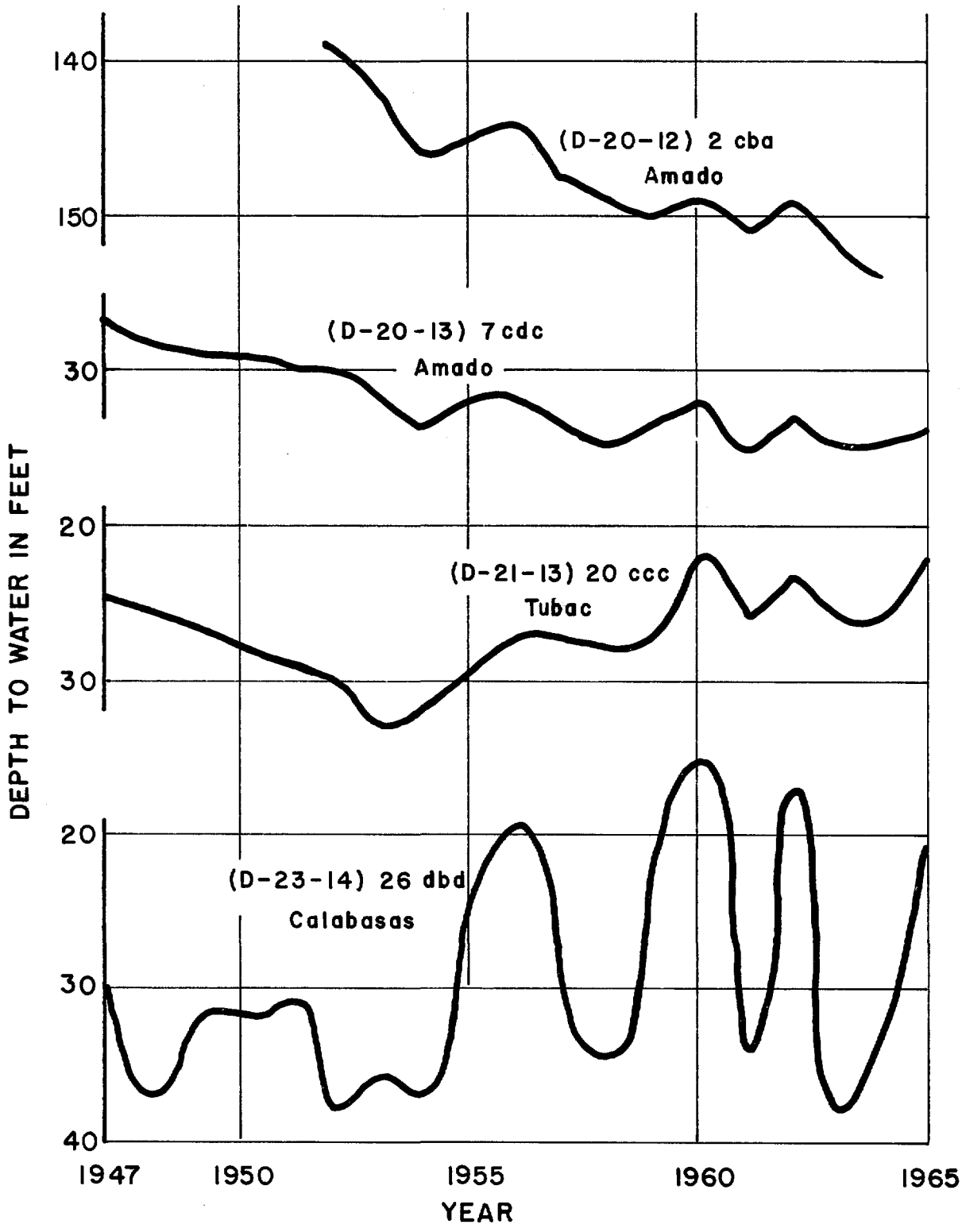


FIGURE 6 HYDROGRAPHS OF REPRESENTATIVE WELLS IN SANTA CRUZ COUNTY DISTRICT

Tumacacori - Calabasas Area

From Tumacacori Mission this area extends south along the Santa Cruz River to the mouth of Nogales Wash. The groundwater basin is shallow and of limited capacity, but is composed of uniform coarse materials with high permeability, particularly in the Calabasas area. Because of the limited storage capacity and rapid underdrainage downstream, wide fluctuations in the water levels occur in this portion of the area. The basin at Calabasas frequently fills to the level of the streambed following prolonged runoff in the channel.

During the 4-year period, 1961-1965, water levels have shown a loss of 5 feet in the middle of the area but a gain of 10 feet at Calabasas. From 1947-1965 the lower end of the area shows a loss of up to 5 feet while a 30 foot rise occurred at Calabasas. This change is attributed to the fluctuating nature of the water table and the abnormally low level of the 1947 measurement.

Nogales Wash - Quebabi Area

The narrow, shallow alluvial fill along the Santa Cruz River from near Calabasas to the International Boundary is called the Quebabi area. A similar area occurs along Nogales Wash between Calabasas and the City of Nogales. In general, both of these areas are subject only to minor changes annually. An exception is the area on the Santa Cruz River near the City of Nogales pumping plant where fluctuations of more than 20 feet occur between wet and dry years. Most parts of the area had only minor changes in water

levels for either the 4-year or 18-year periods although a rise of 18 feet is shown at the City pumping plant. This apparent rise is caused by the exceptionally low water level in 1947 and does not represent a permanent change.

GROUNDWATER USE IN TUCSON AND SAHUARITA DISTRICTS

Water use in the Tucson and Sahuarita Districts has been classified under the following headings: municipal, irrigation, industrial, recreation (golf courses, etc.), and schools. The use by native vegetation or phreatophytes in the shallower water areas has also been included in the total.

Municipal and irrigation use comprise the major part of the total pumping draft. Municipal use has been determined from the City of Tucson pumping records and estimates based on population. Irrigation consumptive use has been computed from a survey of irrigated crop acreage on the basis of the following consumptive use per acre factors: 3.5 acre-feet for cotton, 2.5 acre-feet for grain and sorghum, 4.5 acre-feet for alfalfa, 2.5 acre-feet for lettuce, and 3.5 acre-feet for pasture and miscellaneous use. Water use for other purposes has been determined from pump records and computed or estimated where records were not available.

The annual pumping draft for these classifications of use and average annual use for the 4-year period 1961-1965 are given in Table I. Water use in the Tucson and Sahuarita Districts continues to increase in all classifications except irrigation and loss by phreatophytes. Municipal use decreased

in 1964 because of much greater than average rainfall during the year particularly in the normally high use season. Irrigation is decreasing as more land is taken out of production for urban development. In 1964 irrigation use was further decreased by the unusually large rainfall. The use by phreatophytes has decreased because the falling water table along the Santa Cruz River has resulted in greatly reduced phreatophytic growth.

Table I. GROUNDWATER USE IN TUCSON AND SAHUARITA DISTRICTS

Use	1961	1962	1963	1964	Average
	(All figures in acre-feet)				
Municipal	51,000	53,000	54,000	52,000	52,500
Irrigation	56,000	51,000	51,000	40,000	49,500
Industrial	13,000	16,000	17,000	17,000	15,600
Recreation	2,500	2,800	3,400	4,000	3,200
Schools	1,100	1,200	1,500	1,600	1,400
Phreatophytes	3,500	3,200	2,900	2,500	3,100
TOTAL	127,100	127,200	129,800	117,100	125,300

Water use in the Tucson District can be expected to increase during the coming years as the population increases. Population increases in the Sahuarita District will result in decreased irrigation use, but the growing mining activity will probably use the water saved in converting land from irrigation to municipal use.

GROUNDWATER STORAGE LOSS AND RECHARGE IN TUCSON AND SAHUARITA DISTRICTS

A study of the volume of aquifer material which is unwatered by the removal of water at a rate greater than the natural recharge can be used to determine the average recharge to the system and the average specific yield of the aquifer materials. Specific yield is the volume of water, expressed as a percent of total volume, removed when a given volume of aquifer material is drained. If specific yield and the boundaries of a groundwater basin are known, the total volume of water in storage can be computed. Average recharge defines the ultimate limit of water withdrawal from the basin without continual lowering of water levels.

The hydrologic equation for a groundwater basin with subsurface inflow equal to subsurface outflow would be:

water withdrawn = recharge + storage change

$$W = R + S \times V$$

Where:

W = average annual total of all water pumped from the basin in acre-feet

R = average annual recharge in acre-feet

S = specific yield in percent

V = volume unwatered in acre-feet

If the underflow into the Tucson Basin at the south end of the basin is assumed to be equal to the underflow out at the northwest corner, this equation can be used. When neither recharge or specific yield are known,

the equation cannot be solved. However, assumptions of the value of either of the unknowns will produce corresponding values of the other.

The volumetric unwatering in the Tucson and Sahuarita Districts has been computed from Plate II for the 4-year period, 1961-1965. This unwatering represents the depletion in groundwater reservoir storage resulting primarily from over-pumping within the basin.

Unwatering and water use for the 1961-1965 period were:

Average annual use	125,300 acre-feet
Average annual unwatering	462,000 acre-feet

The hydrologic budget equation for this period is then

$$125{,}300 = (R) + 462{,}000\ (S)$$

In values of specific yield (S) are assumed, corresponding values of recharge (R) can be computed with the results as shown in Table II.

Table II. RELATIONSHIP BETWEEN ASSUMED SPECIFIC YIELD AND COMPUTED RECHARGE FOR 1961-1965 PERIOD IN TUCSON AND SAHUARITA DISTRICTS

Assumed Specific Yield (S)	Computed Average Annual Recharge (R)
10 percent	79,000 acre-feet
11	74,000
12	70,000
13	65,000
14	60,000
15	56,000

A specific yield range of 10 to 15 percent is in agreement with other studies; but the average annual recharge of 56,000 to 79,000 acre-feet is somewhat higher than previously computed values. (3) However, runoff in the stream channels was higher than average for the study period, and since groundwater recharge occurs principally from the infiltration of flood flows in the stream channels, the range of recharge values seems reasonable.

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4. Dye, E. O., Personal communication.

APPENDIX A

Table III. REPRESENTATIVE WELLS WITH LOCATION, DEPTH, MEASURING POINT ELEVATION, AND INITIAL, 1940, 1950, 1956, 1961, and 1965 WATER LEVELS

Section	Depth in feet	Meas. Point elev.	Depth to water in feet from measuring point (approx. ground surface) First Record Year	First Record Depth	1940	1950	1956	1961	1965
PINAL COUNTY									
Township 8 South, Range 12 East									
7 add	180	-	1965	103.2	-	-	-	-	103.2
9 cac	-	-	1962	435.6	-	-	-	-	438.7
20 acc	350	-	1965	(200.0)	-	-	-	-	(200.0)
22 daa	630	-	1964	176.3	-	-	-	-	-
25 ddc	210	-	1964	41.7	-	-	-	-	-
35 bcc	31	-	1964	17.5	-	-	-	-	-
35 bcc	31	-	1964	19.2	-	-	-	-	-
Township 9 South, Range 13 East									
7 acd	-	-	1964	41.7	-	-	-	-	-
8 dbd	-	-	1962	34.4	-	-	-	-	42.8
8 dbc	249	-	1964	47.7	-	-	-	-	42.8
13 add	-	3510	1964	332.2	-	-	-	-	327.2
14 cba	-	-	1964	370.0	-	-	-	-	370.0
Township 9 South, Range 14 East									
20 aad	-	3560	1962	517.6	-	-	-	-	516.7

Table III.--continued

Section	Depth in feet	Meas. Point elev.	First Record Year	First Record Depth	Depth to water in feet from measuring point (approx. ground surface) 1940	1950	1956	1961	1965
				Township 10 South, Range 12 East					
25 bcc	490	3354	1947	406	-	-	-	-	402.2
				Township 10 South, Range 13 East					
6 dbc	-	3403	1959	431.8	-	-	-	431.6	431.7
17 abb	455	3411	1958	441.3	-	-	-	441.5	440.9
18 ddc	920	3311	1962	334.9	-	-	-	-	345.9
19 aac	-	3303	1957	333.9	-	-	-	335.1	(337.7)
23 acc	804	3449	1963	457.3	-	-	-	-	456.6
25 cca	287	3201	1954	208.8	-	-	209.2	195.1	204.0
27 cbc	361	3318	1954	347.6	-	-	348.2	346.9	343.3
29 dcd	407	3273	1954	317.6	-	-	315.5	315.8	316.0
32 cca	314	3166	1965	224.0	-	-	-	-	224.0
				PIMA COUNTY					
				Township 11 South, Range 12 East					
32 dbd	382	2139	1961	193.9	-	-	-	193.9	200.1
34 ddc	490	2392	1952	369.2	-	-	373.5	376.3	377.4
36 cdb	551	2592	1931	470	-	478.5	482.9	486.9	489.9
				Township 11 South, Range 13 East					
33 daa	608	2814	1948	564.6	-	-	559.4	567.7	568.6
34 dbc	578	2817	1950	517.3	-	517.3	525.0	530.1	534.7
36 bbb	-	2903	1949	439.4	-	439.0	447.2	450.9	(452.0)

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
Township 11 South, Range 14 East									
2 bdc	-	3127	1954	166.2	-	-	166.2	150.3	161.6
2 cac	-	3041	1941	13.8	-	-	92.2	68.5	78.4
4 ccb	310	3127	1954	220.0	-	-	216.5	217.7	218.0
10 aad	324	3009	1954	63.3	-	-	-	67.9	84.2
16 bcd	400	3034	1961	215.6	-	-	-	215.6	210.6
22 bab	-	2921	1940	93.4	93.4	-	106.8	103.2	105.9
26 bbb	228	2961	1940	161.7	-	-	-	148.5	167.5
28 abd	202	2845	1934	147.0	-	-	168.3	166.7	171.9
28 caa	200	2811	1945	138.0	-	-	157.8	160.7	159.9
30 ccd	314	2744	1953	205.0	-	-	204.2	206.1	207.1
31 acc	466	2703	1953	174.6	-	-	172.9	174.0	176.1
32 ccc	-	2663	1948	120.6	-	127.5	134.9	136.8	145.8
34 cca	99	2719	1953	58.8	-	-	67.1	70.3	67.6
Township 12 South, Range 12 East									
1 ccd	-	2472	1947	363.3	-	365.7	370.8	374.6	377.3
5 bdb	188	2061	1928	105.0	111.0	129.9	138.9	144.3	147.4
8 bbb	300	2060	1948	169.2	-	174.8	185.1	-	194.4
8 dbd	261	2071	1919	38.0	80.4	103.5	104.8	109.7	107.7
11 dac	397	2377	1955	295.0	-	-	300.8	304.2	307.4
13 dbb	400	2315	1958	287.4	-	-	-	283.8	287.4
14 ada	300	2343	1932	246.6	249.3	265.4	272.3	277.5	278.5
15 dbd	249	2192	1924	113.4	-	164.0	166.5	170.5	170.2
16 baa	300	2087	1919	28.0	74.7	98.8	100.0	105.3	102.0
17 daa	416	2086	1920	28.5	70.6	97.5	97.3	101.2	98.1

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	Depth to water in feet from measuring point (approx. ground surface) 1940	1950	1956	1961	1965
			Township 12 South, Range 12 East, cont.						
20 aad	386	2099	1920	31.0	71.8	98.6	98.2	102.2	100.3
21 bab	242	2100	1919	28.0	71.6	99.8	101.1	102.6	100.3
22 ddb	316	2133	1924	36.0	72.3	93.9	93.3	96.6	93.4
25 cac	238	2172	1942	78.8	-	89.7	90.6	94.9	93.5
26 dba	248	2159	1923	40.6	71.2	90.8	90.6	93.9	92.0
27 cbb	160	2132	1919	35.0	79.6	104.8	103.0	107.0	103.5
28 ddd	158	2168	1920	68.0	114.7	141.6	140.1	144.3	141.5
29 bdd	250	2158	1948	139.8	-	144.6	143.7	-	145.5
33 aca	230	2206	1935	150.3	160.3	180.3	185.6	187.9	190.1
34 dac	138	2197	1936	111.0	-	129.9	-	135.5	130.2
35 bcd	-	2157	1949	83.1	-	83.5	82.9	85.6	81.1
36 cdc	347	2177	1920	22.5	54.9	75.1	74.7	78.0	77.2
			Township 12 South, Range 13 East						
2 abb	501	2809	1930	423.0	-	-	436.6	441.4	443.3
5 cdb	570	2640	1955	462.0	-	-	462.0	(467.0)	470.4
8 daa	-	2620	1938	405.5	-	416.5	425.1	432.5	438.6
14 cda	206	2456	1930	138.4	-	158.7	167.7	176.8	182.3
15 cda	-	2418	1954	193.2	-	-	193.0	201.1	205.1
16 cda	400	2521	1932	311.9	317.3	328.5	340.1	347.7	352.1
17 dda	430	2515	1938	322.9	324.8	336.5	347.7	356.7	359.8
21 bbd	-	2485	1953	312.2	-	-	316.9	323.9	328.9
22 bbb	268	2424	1936	194.4	197.3	207.5	219.2	227.0	232.0
23 dda	380	2546	1946	286.2	-	274.0	288.0	293.6	300.3

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
			Township 12 South, Range 13 East, cont.						
24 abd	470	2619	1950	309.7	-	309.7	320.1	328.3	334.7
26 caa	375	2516	1956	288.5	-	-	288.5	297.1	305.0
27 ddd	345	2496	1932	258.5	263.7	274.6	287.3	296.5	304.1
28 ada	486	2351	1954	172.3	-	-	172.0	179.6	187.1
30 daa	237	2340	1931	139.4	197.3	215.4	222.6	229.1	230.3
31 bca	-	2241	1956	136.4	-	-	136.4	142.8	142.3
32 cbb	352	2321	1938	169.6	172.4	194.1	200.4	207.6	208.1
33 aba	354	2419	1947	232.7	-	238.1	252.9	259.6	266.2
35 dda	450	2529	1932	279.6	286.1	297.0	309.5	321.5	329.5
36 dcc	500	2608	1947	369.5	-	374.7	-	398.9	406.7
			Township 12 South, Range 14 East						
3 bba	-	2711	1953	29.4	-	-	66.9	68.5	7.6
4 abb	-	2694	1953	49.3	-	-	64.9	70.6	38.6
5 cdc	193	2625	1940	100.5	100.5	108.8	98.1	100.3	115.8
7 acb	130	2587	1906	110.0	-	-	154.0	153.3	160.0
33 cbc	200	3063	1955	134.4	-	-	135.1	137.3	137.3
			Township 13 South, Range 12 East						
1 dac	201	2187	1923	21.1	42.8	65.3	67.6	74.1	68.4
2 dab	164	2228	1947	118.7	-	119.7	119.8	120.4	119.8
3 abc	-	2251	1949	102.7	-	103.4	106.8	110.3	111.8
4 aac	345	2298	1953	214.1	-	-	216.8	223.8	225.3
9 add	-	2373	1964	49.1	-	-	-	-	42.0

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
			Township 13 South, Range 12 East, cont.						
10 dda	366	2447	1945	295.0	-	-	-	298.8	319.4
11 bab	285	2316	1950	-	-	193.1	196.5	203.5	203.7
12 bab	187	2218	1930	70.0	74.7	95.5	97.7	104.1	99.8
24 bda	285	2391	1931	196.7	-	-	225.1	238.0	238.5
			Township 13 South, Range 13 East						
1 aac	500	2602	1954	381.2	-	-	385.2	397.9	397.8
2 bda	360	2482	1947	256.1	-	260.3	274.8	286.2	295.9
3 dcc	239	2377	1945	170.4	-	180.2	196.0	206.0	211.2
5 bbd	294	2246	1944	101.0	-	115.5	121.9	129.4	129.4
6 bba	355	2210	1919	51.4	74.1	96.9	100.7	107.8	106.4
7 caa	203	2206	1960	70.0	-	-	-	75.9	72.9
8 cdd	120	2235	1946	59.9	-	71.9	81.5	90.3	89.9
9 bcd	253	2250	1919	44.0	60.3	86.4	96.1	105.1	106.2
10 baa	-	2360	1933	144.1	149.9	163.3	182.8	191.3	(197.0)
11 bbb	310	2412	1949	200.0	-	203.2	222.2	233.5	245.3
12 bca	-	2465	1929	215.2	221.1	237.5	258.1	268.4	275.9
13 bba	242	2379	1948	142.9	-	151.9	174.6	184.2	191.8
14 ddb	270	2307	1947	61.2	-	78.4	96.1	102.0	110.1
15 dac	-	2279	1934	39.0	44.5	-	-	94.6	99.3
16 aaa	158	2262	1948	58.5	-	-	84.5	94.4	99.0

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	Depth to water in feet from measuring point (approx. ground surface) 1940	1950	1956	1961	1965
			Township 13 South, Range 13 East, cont.						
17 dad	96	2247	1938	39.8	41.3	67.7	81.2	90.8	92.7
18 aca	120	2230	1947	60.8	-	72.1	80.0	89.3	87.6
19 ddd	228	2348	1947	156.7	-	169.7	184.4	194.3	187.5
20 ddc	-	2259	1947	55.7	-	68.7	86.7	96.9	98.4
21 dac	-	2264	1952	70.8	-	-	77.3	89.3	91.9
22 dac	220	2312	1947	72.4	-	-	104.8	116.8	121.0
23 adb	-	2301	1960	95.5	-	-	-	91.2	99.7
24 bdd	-	2314	1946	45.1	-	63.4	81.4	84.9	93.8
25 aad	-	2346	1949	62.6	-	64.8	83.4	88.7	95.5
26 bbb	200	2318	1946	73.4	-	-	104.5	114.3	121.6
28 aac	154	2271	1947	43.1	-	54.9	77.3	88.1	91.3
29 dda	200	2336	1931	104.9	-	128.9	151.3	161.1	169.9
30 bcc	-	2426	1958	258.4	-	-	-	267.3	270.4
31 bbb	300	2438	1948	232.9	-	236.8	253.1	266.5	268.3
32 ccc	302	2468	1948	216.9	-	-	224.2	227.1	231.4
33 dac	175	2298	1946	34.2	-	49.8	71.8	81.8	90.1
34 aad	234	2309	1948	52.3	-	64.3	78.6	87.1	97.3
35 ccb	500	2316	1948	53.4	-	58.0	79.4	88.8	95.0
36 acb	157	2352	1946	57.2	-	70.6	90.6	95.6	(103.5)

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
Township 13 South, Range 14 East									
18 cbc	300	2369	1960	132.2	-	-	-	129.9	138.1
19 dda	163	2345	1908	8.0	27.0	36.9	53.7	56.2	66.3
20 cbb	216	2344	1954	50.6	-	-	57.0	55.6	64.8
23 bbd	243	2625	1947	177.5	-	178.2	179.3	180.1	179.9
25 cdd	100	2440	1950	14.1	-	14.1	-	12.7	5.0
26 dca	41	2426	1946	19.3	-	20.5	23.6	40.0	12.2
27 dda	240	2410	1946	25.4	-	31.1	39.8	47.5	15.6
28 cbd	128	2389	1946	38.4	-	47.2	59.9	69.3	76.9
29 aad	94	2366	1946	24.9	-	33.3	43.6	46.5	55.8
30 abb	134	2348	1946	36.8	-	51.0	68.5	70.8	79.6
31 aca	-	2381	1950	-	-	67.7	83.3	87.1	97.1
32 bda	319	2400	1952	67.2	-	-	79.4	86.4	97.7
33 ccc	271	2426	1952	82.1	-	-	93.6	102.3	110.8
34 cad	239	2442	1949	71.0	-	73.4	88.2	99.2	110.3
35 bad	215	2430	1947	36.3	-	40.8	52.5	61.0	50.1
36 bbd	244	2454	1948	46.1	-	48.2	56.1	73.0	75.7
Township 13 South, Range 15 East									
7 bbc	-	2954	1960	-	-	-	-	129.2	(128.0)
16 abc	-	2880	1960	-	-	-	-	18.7	18.7
17 bca	112	2688	1947	78.8	-	-	84.0	74.2	94.0
19 cdd	304	2624	1930	146.5	-	148.4	152.3	148.4	150.1
20 abd	134	2598	1947	47.7	-	52.2	57.6	55.8	59.4

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	Depth to water in feet from measuring point (approx. ground surface) First Record Year	Depth	1940	1950	1956	1961	1965
			Township 13 South, Range 15 East, cont.						
21 ddb	-	2596	1951	74.4	-	-	88.4	76.5	73.6
26 dca	405	2640	1964	230.0	-	-	-	-	222.7
27 baa	62	2571	1930	42.8	-	50.9	54.3	51.9	53.4
28 cbd	-	2555	1955	68.9	-	-	70.3	70.5	69.0
29 acb	202	2584	1948	102.0	-	104.4	105.3	105.1	105.7
30 ddc	65	2476	1946	13.4	-	-	16.5	17.5	13.3
31 aaa	-	2477	1959	16.7	-	-	-	17.2	13.5
32 baa	60	2489	1946	17.5	-	20.3	20.8	20.3	11.8
33 baa	-	2510	1946	13.1	-	13.3	21.4	22.7	11.9
34 cda	160	2535	1947	21.8	-	22.9	24.0	23.0	25.5
35 bdd	300	2626	1948	96.3	-	98.5	100.6	94.9	102.9
36 abb	600	2659	1949	90.6	-	90.7	90.7	90.5	90.3
			Township 13 South, Range 16 East						
18 ddb	-	2787	1961	25.3	-	-	-	6.2	6.2
19 dbc	-	2690	1960	19.4	-	-	-	32.5	23.0
20 bcb	210	2718	1964	121.5	-	-	-	-	92.2
29 ccd	402	2735	1949	180.5	-	142.7	148.1	150.7	147.1
			Township 14 South, Range 13 East						
1 bcb	302	2372	1954	101.3	-	-	102.6	110.4	121.2
2 cdc	400	2333	1913	28.3	-	49.3	68.8	83.7	92.2
3 cab	588	2333	1956	85.4	-	-	85.4	97.4	110.0
4 acb	151	2358	1931	85.2	-	102.7	126.3	138.0	144.0
10 dac	120	2345	1933	40.0	-	-	77.0	91.2	99.1

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
			Township 14 South, Range 13 East, cont.						
11 bbc	230	2335	1946	45.6	-	55.1	73.1	87.6	95.1
12 cdc	315	2384	1947	52.1	-	58.4	66.9	71.0	71.7
13 cbc	274	2367	1950	30.8	-	30.8	34.6	38.8	47.4
22 ada	164	2377	1929	9.2	-	31.4	30.9	36.5	44.6
23 acc	-	2374	1947	22.4	-	28.3	30.0	32.3	42.9
24 daa	300	2440	1949	85.2	-	89.0	100.3	109.8	124.7
25 daa	500	2461	1929	61.4	-	-	93.5	103.9	114.3
26 ccd	63	2409	1913	22.0	29.5	46.5	43.0	54.1	62.4
27 ada	220	2399	1914	11.1	-	40.5	38.0	46.3	53.5
34 adc	-	2419	1913	22.3	32.1	-	48.3	59.4	66.1
35 cac	476	2422	1931	30.0	32.8	51.4	46.3	62.2	67.9
36 bad	260	2466	1949	87.4	-	90.7	90.4	102.2	111.7
			Township 14 South, Range 14 East						
1 adc	157	2521	1946	106.2	-	111.0	123.6	142.2	162.9
2 acd	300	2484	1952	96.2	-	-	106.7	122.2	134.8
3 adc	232	2471	1949	91.2	-	94.6	109.0	122.2	134.5
4 acb	325	2459	1955	112.0	-	-	114.0	126.6	134.7
5 ddc	240	2469	1939	105.0	-	129.3	141.0	150.6	155.7
6 bdd	266	2434	1924	102.0	105.0	123.3	136.1	144.1	157.0
7 bda	282	2424	1915	74.5	88.4	109.4	124.8	135.8	144.8
8 baa	-	2473	1930	113.5	-	152.0	154.3	167.3	167.0
9 bcb	-	2484	1946	124.5	-	135.2	149.2	157.9	163.2
10 cba	323	2509	1951	138.3	-	-	147.5	165.1	172.4

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
			Township 14 South, Range 14 East, cont.						
11 ccb	320	2524	1950	132.8	-	132.8	151.6	-	179.2
12 bdc	260	2542	1950	137.1	-	137.1	153.7	171.0	186.3
13 cdb	357	2579	1955	183.5	-	-	189.2	208.6	228.5
14 acc	-	2570	1946	165.4	-	170.0	191.9	207.0	224.2
15 dba	307	2538	1954	157.9	-	-	166.2	183.6	201.6
16 aad	308	2515	1931	118.5	121.3	135.5	153.8	174.6	179.5
17 aab	280	2475	1946	105.8	-	118.2	132.2	145.7	156.6
18 adb	350	2429	1947	(81.0)	-	94.9	107.2	122.0	140.0
19 bdd	315	2453	1949	101.8	-	100.8	111.0	111.3	113.4
20 dbd	320	2490	1949	106.9	-	108.0	129.0	147.2	157.3
21 bcd	250	2500	1954	136.3	-	-	133.9	149.9	163.6
21 caa	-	2514	1955	142.7	-	-	142.1	159.5	171.7
22 bdc	-	2539	1948	134.0	-	-	159.9	178.0	194.5
23 aaa	536	2587	1950	175.5	-	175.5	195.9	214.6	243.1
24 caa	550	2619	1954	202.8	-	-	215.0	244.1	266.5
25 cba	400	2640	1945	204.9	-	211.1	222.7	241.3	258.7
28 ddb	381	2564	1956	166.3	-	-	166.3	183.2	201.8
29 bdd	490	2511	1953	127.7	-	-	134.4	136.1	164.6
30 dbc	545	2488	1950	93.3	-	93.3	106.8	112.4	117.7
31 aba	-	2499	1958	99.0	-	-	-	105.4	107.6
32 daa	300	2555	1951	125.0	-	-	-	-	143.4
34 bbb	405	2583	1957	174.7	-	-	-	195.7	216.6
35 aaa	401	2643	1945	204.3	-	205.6	219.1	237.0	256.7
36 cca	500	2663	1961	244.9	-	-	-	244.9	265.9

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	Depth to water in feet from measuring point (approx. ground surface) 1940	1950	1956	1961	1965
			Township 14 South, Range 15 East						
1 add	-	2600	1946	22.3	-	30.5	26.6	28.7	15.3
2 bda	-	2566	1954	41.1	-	41.9	41.9	39.4	40.5
3 cab	361	2564	1947	(62.1)	-	(63.2)	(65.3)	(65.5)	69.3
4 cca	-	2579	1947	86.1	-	90.7	88.9	89.5	92.5
5 aac	103	2549	1947	64.5	-	66.6	67.4	68.4	68.3
6 bbb	143	2492	1946	72.6	-	78.1	91.3	106.8	120.7
7 bba	355	2561	1952	149.6	-	-	159.5	178.2	(191.0)
8 dcc	270	2583	1943	149.3	-	155.3	166.0	-	209.9
9 baa	220	2589	1947	91.7	-	93.9	95.7	96.8	102.2
10 aac	240	2633	1947	113.2	-	-	-	116.2	119.0
12 bcb	-	2641	1946	106.2	-	110.9	113.3	114.6	113.6
13 ccb	320	2851	1952	312.4	-	-	314.5	316.5	318.9
14 acc	-	2768	1946	232.3	-	235.7	238.6	243.6	241.3
15 bab	457	2751	1962	244.4	-	-	-	-	255.6
16 bdd	557	2650	1961	217.6	-	-	-	217.6	248.5
16 ada	304	2659	1948	169.5	-	171.3	-	179.1	189.6
17 add	-	2600	1946	160.9	-	164.9	174.2	192.5	212.6
18 cda	340	2621	1952	199.1	-	-	213.5	238.4	266.0
19 bbd	350	2636	1956	222.9	-	-	222.9	234.6	279.6
20 bab	-	2648	1948	(222.5)	-	(225.0)	(233.0)	(254.0)	271.3
21 cda	385	2656	1943	177.6	-	175.2	179.9	205.1	206.2
22 bbd	350	2707	1955	205.0	-	-	205.6	209.5	221.8
23 cbd	343	2805	1950	-	-	268.5	272.7	276.8	279.2

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	Depth to water in feet from measuring point (approx. ground surface)						
			First Record						
			Year	Depth	1940	1950	1956	1961	1965
Township 14 South, Range 15 East, cont.									
24 aaa	449	2929	1953	386.7	-	-	387.1	391.7	393.2
25 bac	444	2906	1946	358.5	-	351.0	362.6	358.4	388.7
26 aba	422	2860	1946	307.0	-	310.0	314.6	318.1	321.6
28 cbb	501	2726	1949	(288.0)	-	(231.1)	(245.0)	(254.6)	270.2
29 cbb	550	2701	1955	244.2	-	-	249.8	276.5	275.5
32 bbb	550	2719	1954	253.0	-	-	259.5	276.4	284.3
34 bdb	385	2734	1953	200.5	-	-	195.9	204.0	214.2
35 aac	-	2849	1951	279.9	-	-	283.6	285.4	293.1
36 bbc	406	2883	1947	311.0	-	-	319.4	-	327.2
36 ada	323	2948	1947	224.0	-	227.6	230.3	233.3	232.0
Township 14 South, Range 16 East									
4 ddd	335	2672	1946	18.8	-	29.7	23.6	31.8	7.2
5 dbb	83	2639	1948	16.0	-	14.1	11.7	15.9	8.2
6 bdc	-	2608	1953	21.0	-	-	24.1	24.5	14.5
6 daa	-	2626	1952	7.9	-	-	19.9	19.9	7.2
6 ccd	96	2637	1954	62.9	-	-	62.8	63.4	58.9
7 cdc	-	2844	1953	270.0	-	-	271.2	270.9	271.7
8 aab	70	-	1961	23.1	-	-	-	23.1	9.2
10 aad	165	-	1964	63.5	-	-	-	-	-
17 bcc	550	2807	1964	128.2	-	-	-	-	-
18 abc	341	2829	1955	255.5	-	-	256.0	256.4	257.0

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
Township 14 South, Range 16 East, cont.									
18 cba	507	2919	1956	368.0	-	-	368.0	373.2	371.4
19 bdc	-	2969	1946	220.7	-	-	-	-	229.4
31 bbc	312	2974	1946	255.6	-	256.6	260.0	261.1	262.0
Township 15 South, Range 13 East									
1 caa	-	2490	1949	65.4	-	68.3	71.0	81.0	78.9
2 cca	-	2444	1931	30.4	31.3	50.5	52.7	71.5	82.2
3 add	142	2439	1946	40.2	-	-	53.1	67.5	78.3
10 dbb	141	2463	1946	39.3	-	46.8	48.0	37.7	79.8
11 aac	150	2481	1953	54.8	-	-	54.8	80.0	99.7
12 aca	56	2503	1946	51.8	-	55.1	58.3	65.0	67.1
13 add	130	2548	1952	69.9	-	-	-	76.3	78.6
14 dcb	-	2505	1947	54.3	-	-	56.9	59.4	60.3
15 aca	-	2476	1953	56.3	-	-	40.1	76.6	85.8
16 ccd	-	2520	1959	69.0	-	-	-	71.3	73.4
20 cdc	-	2537	1952	75.8	-	-	-	82.0	-
21 caa	-	2509	1932	44.9	46.9	50.1	55.0	60.2	69.4
22 adc	44	2501	1932	29.5	33.4	36.7	35.4	37.8	38.9
23 cca	-	2505	1960	57.4	-	-	-	63.7	79.0
25 ccc	-	2555	1959	42.3	-	-	-	44.9	58.2
26 bcc	-	2502	1935	9.2	9.9	13.3	11.6	16.2	44.4
27 abb	45	2519	1933	22.5	26.9	31.0	32.8	39.2	(44.9)
34 cad	-	2570	1946	53.0	-	58.3	60.3	67.0	76.4
35 ccb	128	2549	1933	20.0	25.3	-	-	45.3	52.1

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	Depth to water in feet from measuring point (approx. ground surface) First Record Year	First Record Depth	1940	1950	1956	1961	1965
Township 15 South, Range 14 East									
2 cac	2500	2673	1960	284.3	-	-	-	284.2	302.2
2 acb	-	2666	1949	179.3	-	179.8	184.6	194.0	206.0
3 bdb	1140	2615	1956	148.0	-	-	148.0	215.0	243.5
4 ccb	-	2591	1946	107.2	-	107.6	111.1	116.1	121.0
5 aab	1220	2558	1960	116.8	-	-	-	117.9	-
5 abd	151	2555	1946	96.0	-	97.4	101.5	108.1	(110.0)
6 dcc	100	2538	1946	73.7	-	74.6	77.2	84.1	87.3
7 cac	-	2540	1954	72.5	-	-	73.3	82.8	90.4
9 ccc	-	2613	1953	111.4	-	-	112.2	114.5	(115.0)
10 dba	300	2653	1952	140.0	-	-	-	150.2	(156.0)
15 ddc	-	2691	1946	165.4	-	-	163.6	166.3	168.8
17 cda	-	2561	1946	73.3	-	-	87.9	88.3	98.0
18 cbd	250	2673	1948	78.0	-	73.4	76.9	79.4	86.6
19 baa	310	2573	1948	78.0	-	75.9	83.5	96.7	103.4
27 cac	180	2684	1947	139.8	-	-	141.4	143.4	(144.0)
30 add	504	2602	1954	86.6	-	-	81.5	84.8	92.8
31 ccb	-	2582	1947	39.1	-	41.6	-	52.0	73.0
34 bba	200	2690	1955	143.9	-	-	145.8	147.4	150.6
Township 15 South, Range 15 East									
1 acd	-	2806	1959	194.8	-	-	-	196.2	196.5
1 aac	-	2809	1949	72.7	-	73.3	68.2	77.0	75.4
6 bbb	492	2717	1951	244.5	-	-	257.9	273.4	283.7
6 ddc	407	2754	1951	238.7	-	-	242.6	248.3	253.8
7 dca	290	2762	1952	233.0	-	-	234.2	238.1	241.5

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
			Township 15 South, Range 15 East, cont.						
8 dbb	314	2799	1947	257.5	-	257.9	261.0	264.8	268.6
15 dbb	426	2899	1951	325.9	-	-	328.0	331.1	334.1
18 dca	417	2787	1952	234.6	-	-	235.3	238.3	240.8
24 bbb	518	2964	1959	361.3	-	-	-	361.3	363.8
25 cda	1480	3027	1947	398.0	-	399.4	403.7	406.9	409.9
27 dbc	404	2941	1913	364.0	-	360.2	362.3	365.5	367.1
33 aad	-	2918	1960	343.4	-	-	-	343.7	345.6
36 cdb	905	3050	1964	426.3	-	-	-	-	423.8
			Township 15 South, Range 16 East						
5 ccc	205	2935	1950	186.7	-	186.7	190.1	187.5	185.9
6 aac	-	2990	1947	234.7	-	247.1	249.5	254.2	248.6
7 dba	158	2861	1946	92.9	-	-	111.2	104.2	103.9
8 bca	-	2869	1954	117.1	-	-	117.9	109.7	109.8
14 dcc	255	2993	1955	64.1	-	-	58.0	60.4	46.4
15 dda	200	2985	1953	55.9	-	-	58.9	59.2	52.9
16 ccb	-	2942	1951	171.3	-	-	175.5	160.0	161.1
17 acd	309	2898	1954	138.0	-	-	140.9	125.3	128.2
18 aac	361	2887	1946	123.0	-	132.4	-	126.3	(126.0)
19 acb	400	2935	1961	243.1	-	-	-	243.1	240.7
21 aab	-	2957	1951	177.4	-	-	182.9	172.0	169.2
22 abc	225	2971	1949	97.6	-	96.9	97.1	87.4	94.9
22 bbb	300	2990	1950	200.0	-	200.0	208.2	193.8	195.4
23 baa	225	2998	1959	64.0	-	-	-	69.0	56.5
27 ada	504	3145	1963	345.8	-	-	-	-	345.1

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	Depth to water in feet from measuring point (approx. ground surface) First Record Year	First Record Depth	1940	1950	1956	1961	1965
Township 15 South, Range 16 East, cont.									
33 cba	-	3038	1959	342.1	-	-	-	342.6	344.2
Township 16 South, Range 13 East									
2 bbb	232	2544	1934	19.7	24.3	32.4	36.4	44.2	50.6
2 bdc	180	2570	1934	31.7	34.0	41.8	42.0	49.0	55.5
3 caa	106	2610	1947	80.6	-	83.7	85.7	90.7	96.6
14 aaa	-	2613	1947	56.6	-	58.8	62.7	74.2	79.2
34 aaa	-	2812	1960	221.4	-	-	-	229.2	268.7
36 ddd	275	2677	1944	62.2	-	63.7	72.3	105.8	115.6
Township 16 South, Range 14 East									
4 baa	335	2673	1963	128.3	-	-	-	-	131.2
5 cad	160	2655	1950	102.5	-	102.5	104.8	114.8	130.8
6 bbc	126	2588	1946	40.8	-	43.0	46.0	61.0	75.2
7 cdd	230	2608	1951	48.4	-	-	49.5	62.7	75.5
17 bcc	360	2542	1955	75.7	-	-	76.6	92.6	109.5
18 acd	113	2621	1953	53.7	-	-	55.3	70.8	85.7
19 ccd	260	2640	1942	57.7	-	60.5	64.8	90.8	95.0
20 ccc	447	2648	1951	66.9	-	-	71.3	97.4	106.8
25 cba	-	2806	1946	192.3	-	193.1	195.2	197.8	200.2
29 dba	190	2682	1947	83.9	-	86.8	99.0	114.1	127.2

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
Township 16 South, Range 14 East, cont.									
30 dcc	-	2656	1943	65.3	-	65.3	73.8	105.6	(101.0)
31 bdc	-	2673	1953	70.4	-	-	74.8	108.1	103.6
32 cda	253	2672	1947	(63.0)	-	67.7	81.8	94.0	124.1
Township 16 South, Range 15 East									
4 dda	505	2953	1953	355.6	-	-	350.5	361.6	374.9
22 bcc	-	2991	1946	370.8	-	366.2	368.4	369.6	373.5
34 aaa	703	3075	1963	442.9	-	-	-	-	444.0
36 caa	620	3200	1927	562.0	-	560.1	559.7	561.8	562.3
Township 16 South, Range 16 East									
9 dcd	-	3233	1959	561.9	-	-	-	556.7	556.8
14 dcd	308	3241	1959	62.5	-	-	-	69.6	59.6
21 bda	630	3258	1946	577.0	-	577.0	582.1	600.1	583.3
27 aba	878	3367	1959	300.1	-	-	-	340.2	404.0
36 abb	700	2539	1961	145.4	-	-	-	145.4	-
Township 17 South, Range 13 East									
1 cdc	311	2743	1953	109.9	-	-	118.3	133.3	156.5
11 dca	445	2806	1957	169.6	-	-	-	180.5	201.0
12 adc	320	2709	1951	83.2	-	-	83.0	108.7	122.0
13 bad	190	2732	1946	76.4	-	84.9	-	119.1	130.1
21 bdb	452	3147	1947	422.7	-	422.2	424.6	430.9	425.0

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
			Township 17 South, Range 13 East, cont.						
23 bcb	-	2898	1957	222.3	-	-	-	236.8	257.1
24 bad	134	2750	1947	71.2	-	76.3	91.6	108.0	124.8
25 bdd	230	2756	1949	63.9	-	59.6	71.6	101.3	119.8
26 acd	230	2830	1947	126.0	-	129.5	145.6	164.6	180.3
27 bcd	462	3035	1950	325.0	-	325.0	343.1	363.4	383.7
34 ddb	500	2965	1960	286.7	-	-	-	288.8	302.6
35 ddd	76	2795	1946	66.8	-	68.3	89.7	114.0	135.4
36 dcd	175	2782	1947	60.8	-	58.4	76.2	101.9	108.9
			Township 17 South, Range 14 East						
5 aba	168	2681	1949	75.6	-	76.6	90.7	102.7	(98.0)
6 dcd	307	2690	1930	44.3	52.8	64.6	74.6	93.1	107.2
7 ccc	312	2705	1951	60.8	-	-	70.8	99.5	109.0
8 cad	-	2718	1948	58.3	-	96.6	114.3	125.3	158.3
17 dcc	-	2753	1953	80.9	-	-	93.1	122.2	(112.0)
18 adc	-	2712	1958	84.0	-	-	-	104.1	127.0
19 cbd	388	2738	1930	35.3	35.3	39.5	54.4	94.7	117.0
28 bdd	-	2849	1953	197.0	-	-	166.5	182.8	192.5
29 cbd	-	2799	1953	(109.0)	-	-	117.8	149.2	(164.0)
30 aad	248	2788	1952	125.0	-	-	112.7	147.8	161.1
31 bac	220	2770	1942	61.0	-	-	81.8	107.1	121.3

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
Township 17 South, Range 15 East									
2 ddc	849	3200	1962	535.0	-	-	-	-	547.2
6 bba	345	2875	1960	254.0	-	-	-	254.5	256.6
7 cdb	306	2916	1946	255.5	-	255.8	256.8	257.7	258.5
13 bcd	947	3384	1956	701.6	-	-	701.6	-	689.2
Township 18 South, Range 13 East									
1 bdc	-	2794	1917	34.6	46.5	59.2	80.2	104.4	-
2 dcd	295	2823	1950	84.0	-	84.0	102.9	126.1	135.8
7 bbb	275	2822	1952	83.5	-	-	97.9	120.5	128.8
10 dcc	650	2959	1956	220.7	-	-	220.7	247.2	264.6
11 dca	251	2826	1946	56.1	-	68.9	84.6	103.9	113.6
13 bac	216	2829	1918	29.0	42.8	58.4	79.8	99.0	109.7
14 cdb	215	2854	1939	42.8	-	70.4	87.8	104.4	127.3
23 cbb	-	2892	1949	90.0	-	88.2	103.0	117.6	124.5
24 bca	360	2868	1917	40.1	54.4	-	89.7	106.6	122.4
26 bca	395	2871	1920	26.5	36.0	52.4	64.8	79.5	85.9
27 dab	377	2910	1950	84.4	-	84.4	92.8	106.4	112.0
34 abc	266	2911	1917	38.7	50.3	63.8	74.0	85.5	88.6
35 bab	250	2884	1947	41.8	-	46.4	57.2	69.9	74.2
36 bcc	-	2978	1948	128.4	-	130.8	140.1	149.7	161.0

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	Depth to water in feet from measuring point (approx. ground surface)						
			First Record						
			Year	Depth	1940	1950	1956	1961	1965
Township 18 South, Range 14 East									
6 cdd	240	2858	1959	118.9	-	-	-	125.1	127.9
7 bbb	285	2822	1952	83.0	-	-	97.9	120.5	128.8
8 add	410	2973	1948	215.3	-	223.5	234.1	247.0	255.0
8 dad	289	2993	1947	(239.0)	-	241.7	247.6	253.0	259.8
17 ccb	350	3001	1962	253.8	-	-	-	-	254.6
Township 19 South, Range 12 East									
24 ddd	185	3130	1951	167.7	-	-	171.5	177.9	181.8
25 cdd	165	3129	1947	(144.0)	-	147.4	152.2	158.3	(164 +)
28 bdd	425	3330	1964	355.6	-	-	-	-	356.8
30 bbb	-	-	1964	170.7	-	-	-	-	173.3
32 ddd	49	3224	1952	47.7	-	-	44.2	61.2	43.4
36 ddd	-	3068	1951	74.0	-	-	75.3	79.7	75.5
Township 19 South, Range 13 East									
3 bba	246	2928	1912	38.1	48.7	61.4	69.8	80.4	84.7
5 abd	250	3082	1948	193.4	-	196.0	206.6	213.6	220.0
9 acc	-	2938	1931	23.7	28.9	39.4	52.2	61.2	56.5
11 abc	-	2981	1953	104.3	-	-	-	122.5	126.6
16 bdd	155	2938	1931	0.7	7.3	-	-	-	36.9
17 bda	200	3009	1958	87.3	-	-	-	92.6	94.1
20 dba	-	2984	1950	30.5	-	30.5	33.1	-	(42.0)
21 baa	189	2967	1951	33.1	-	-	36.0	-	(47.0)
22 abb	-	3043	1950	119.5	-	-	125.7	133.1	138.3
27 ddb	400	-	1965	-	-	-	-	-	270.3

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
Township 19 South, Range 13 East, cont.									
28 bbb	88	2996	1950	41.8	-	41.8	42.4	50.2	49.8
29 ccc	-	3015	1939	23.5	22.0	36.7	37.1	44.8	45.6
31 dcc	175	3050	1941	41.2	-	48.5	90.5	53.2	53.3
32 bdc	182	3020	1952	32.7	-	-	32.0	35.8	34.6
Township 20 South, Range 12 East									
2 cba	-	3132	1943	132.5	-	139.1	144.2	151.2	(156.0)
3 dbc	247	3151	1946	154.5	-	-	167.7	170.5	180.5
3 bbb	350	3179	1952	181.3	-	-	170.4	183.7	171.6
5 adb	25	3236	1958	22.1	-	-	-	19.3	18.5
7 aaa	65	3290	1958	26.6	-	-	-	25.6	24.2
10 dcd	-	3281	1953	279.5	-	-	283.8	289.2	292.7
12 dbc	-	3131	1964	101.6	-	-	-	-	100.0
13 daa	150	3096	1952	43.4	-	-	44.5	46.8	45.2
24 cba	240	3195	1965	132.2	-	-	-	-	132.2
25 dad	250	3193	1962	98.7	-	-	-	-	95.5
Township 20 South, Range 13 East									
5 bcc	-	3051	1952	42.7	-	-	42.2	45.8	51.1
6 acc	125	3053	1945	41.9	-	46.1	45.5	46.6	49.3
7 cdc	180	3073	1940	21.4	21.4	29.4	31.6	34.6	33.8
18 cda	150	3093	1948	27.0	-	-	-	35.3	34.1
19 cdb	111	3108	1946	35.1	-	28.8	31.9	33.6	32.0

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Depth to water in feet from measuring point (approx. ground surface)						
			Township 20 South, Range 13 East, cont.						
20 cbb	-	3179	1953	106.1	-	-	106.2	108.2	108.0
28 ccb	-	3331	1953	228.1	-	-	229.2	232.7	235.0
30 bba	115	3121	1947	35.0	-	40.1	42.0	43.6	41.0
31 cba	98	3186	1940	70.4	70.4	77.4	80.2	81.2	79.7
32 bcc	81	3147	1940	26.1	26.1	32.4	33.8	33.8	34.2
33 bdb	-	3289	1954	177.7	-	-	179.7	181.3	180.0
			Township 21 South, Range 12 East						
1 add	-	3248	1953	125.3	-	-	128.3	126.6	124.9
12 daa	145	3297	1953	139.9	-	-	135.7	137.6	133.9
13 ada	335	3318	1953	139.9	-	-	138.9	137.3	136.1
24 daa	307	-	1961	190.8	-	-	-	190.8	189.4
			Township 21 South, Range 13 East						
5 dab	-	3231	1953	80.5	-	-	82.9	83.8	81.8
5 ccb	35	3174	1948	24.0	-	26.3	27.1	27.0	24.2
6 bca	-	3228	1940	97.6	97.6	104.5	107.3	107.8	106.3
7 bba	-	3234	1947	82.0	-	85.0	87.4	86.8	85.1
8 cdb	-	3200	1947	26.5	-	28.5	27.9	26.9	24.3
9 bcc	-	3249	1953	78.4	-	-	79.7	78.3	76.8
14 bdc	-	3712	1963	473.4	-	-	-	-	-
17 bdc	-	3206	1950	21.1	-	21.1	-	16.3	13.5
19 aad	-	3222	1939	14.9	12.5	24.4	24.3	-	16.4
20 ccc	-	3240	1939	17.0	19.7	28.2	26.3	26.1	22.9

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	Depth to water in feet from measuring point (approx. ground surface) First Record Year	First Record Depth	1940	1950	1956	1961	1965
			Township 21 South, Range 13 East, cont.						
29 bab	-	3263	1940	35.4	46.2	46.2	-	42.8	(42.0)
30 dbb	60	3263	1940	30.4	36.5	36.5	35.4	31.5	29.6
31 dab	72	3274	1939	11.0	22.5	22.5	20.3	16.8	17.2
32 bcc	81	3284	1940	22.6	-	-	32.4	29.5	(32.0)
			Township 22 South, Range 13 East						
5 dad	-	3313	1953	41.2	-	-	31.3	27.5	28.1
6 dad	120	-	1956	48.6	-	-	48.6	-	42.1
8 abb	-	3309	1929	18.0	19.5	35.2	28.7	25.2	24.7
9 bdd	-	3322	1941	19.0	-	36.0	24.2	21.4	25.6
16 adb	104	3341	1943	27.5	-	32.7	18.7	17.2	25.5
22 aad	-	3364	1948	29.7	-	30.7	10.1	13.5	10.7
26 ccb	70	3396	1934	10.0	4.9	27.2	-	6.1	4.8
27 aaa	81	3382	1939	16.8	11.3	31.3	9.0	12.1	12.8
34 add	-	3411	1952	38.8	-	-	11.8	-	(16.0)
35 ddb	90	3431	1930	20.0	19.0	42.6	11.9	17.2	8.0
36 add	-	3472	1953	64.2	-	-	45.5	46.7	29.3
			Township 23 South, Range 13 East						
1 ddd	83	3458	1939	32.2	13.1	35.2	6.6	21.3	9.5
2 abb	-	3427	1954	49.5	-	-	14.9	17.0	13.1
10 bab	-	3567	1953	225.3	-	-	226.5	223.0	221.2

Table III.--continued

Section	Depth in feet	Meas. Point Elev.	Depth to water in feet from measuring point (approx. ground surface)						
			First Record						
			Year	Depth	1940	1950	1956	1961	1965
Township 23 South, Range 14 East									
16 bcd	-	-	1953	8.5	-	-	6.4	6.0	5.9
17 aac	40	-	1939	16.8	14.5	14.7	14.3	14.7	14.6
19 bcd	23	-	1940	10.7	10.7	12.6	8.6	12.8	16.9
22 dcc	-	-	1940	12.9	12.9	13.3	13.6	19.5	14.0
25 bdc	49	-	1940	26.4	26.4	42.0	22.9	38.4	19.0
26 dbb	-	-	1940	18.6	18.6	31.6	19.1	34.2	25.4
27 abd	-	-	1952	21.5	-	-	12.0	18.5	13.1
30 bad	-	-	1946	19.0	-	18.8	20.1	20.6	20.4
31 acc	-	-	1949	21.8	-	16.6	10.7	12.3	(14.0)
36 bca	75	-	1939	23.8	-	19.2	2.6	27.4	1.3
Township 23 South, Range 15 East									
31 ddd	67	-	1938	13.0	11.5	11.7	10.3	16.5	11.7
Township 24 South, Range 14 East									
5 dac	39	-	1939	31.1	22.2	25.0	19.6	26.8	26.5
8 ddd	-	-	1963	18.8	-	-	-	-	15.5
Township 24 South, Range 15 East									
6 bdd	-	-	1956	6.0	-	-	6.0	8.7	6.5
7 dcc	42	-	1941	10.9	-	9.3	8.8	9.2	9.1
18 abb	45	-	1938	8.5	10.3	11.3	10.6	11.1	10.1

APPENDIX B

GROUNDWATER CONTOURS
TUCSON BASIN
OF
SANTA CRUZ VALLEY
SPRING 1965

GROUNDWATER CONTOURS ——2950——

WATER SURFACE ELEVATION--WELLS 2336

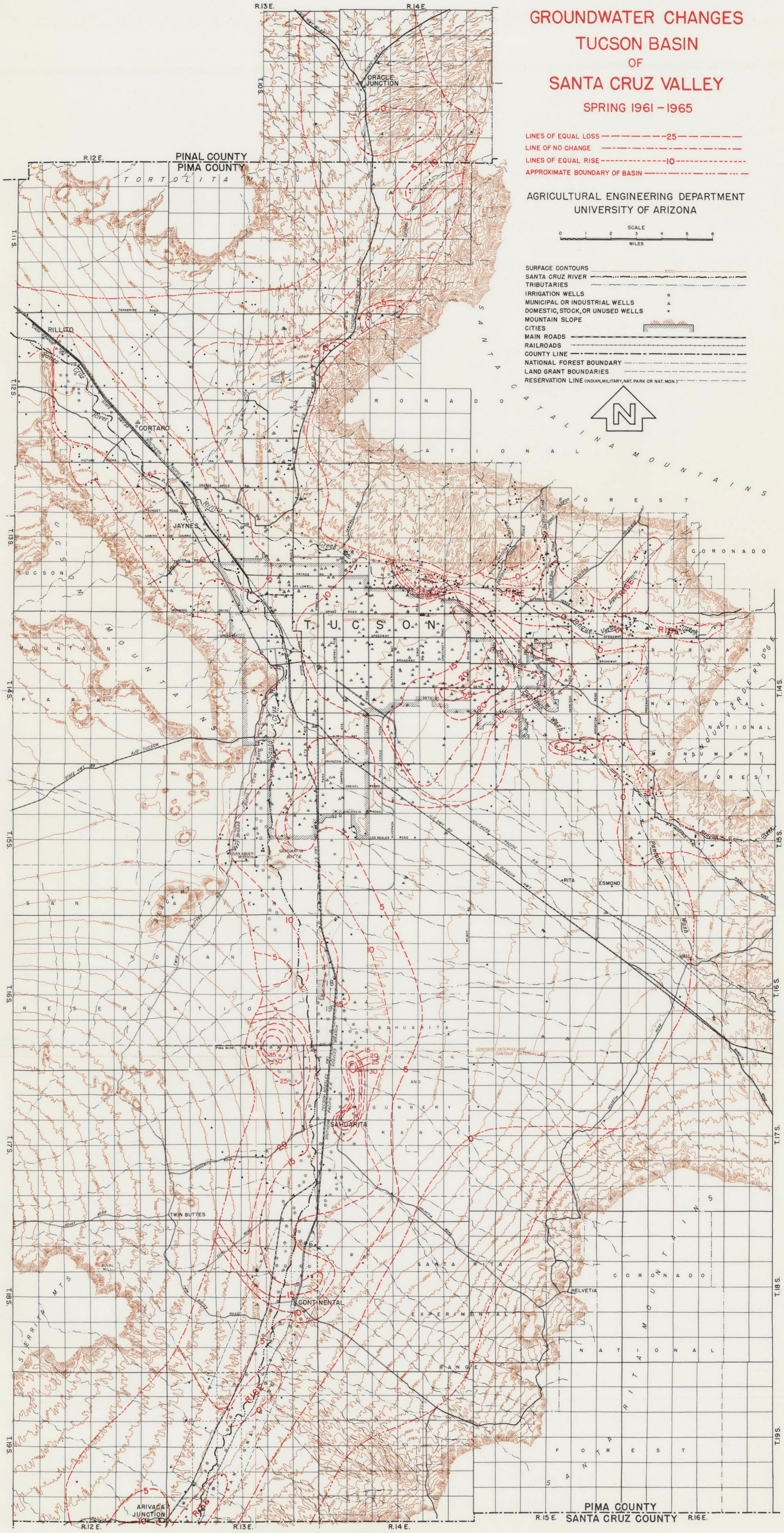
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA

SCALE
0 1 2 3 4 5 6
MILES

SURFACE CONTOURS 3000
SANTA CRUZ RIVER
TRIBUTARIES
IRRIGATION WELLS
MUNICIPAL OR INDUSTRIAL WELLS
DOMESTIC, STOCK, OR UNUSED WELLS
MOUNTAIN SLOPE
CITIES
MAIN ROADS
RAILROADS
COUNTY LINE
NATIONAL FOREST BOUNDARY
LAND GRANT BOUNDARIES
RESERVATION LINE (INDIAN, MILITARY, NAT. PARK OR NAT. MON.)

N

R.12 E. R.13 E. R.14 E. R.15 E. R.16 E.
T.11 S. T.12 S. T.13 S. T.14 S. T.15 S. T.16 S. T.17 S. T.18 S. T.19 S.
PINAL COUNTY
PIMA COUNTY
SANTA CRUZ COUNTY


GROUNDWATER CHANGES
TUCSON BASIN
OF
SANTA CRUZ VALLEY
SPRING 1961 - 1965
LINES OF EQUAL LOSS ——25——
LINE OF NO CHANGE
LINES OF EQUAL RISE ------10------
APPROXIMATE BOUNDARY OF BASIN
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA
SCALE
0 1 2 3 4 5 6
MILES
SURFACE CONTOURS
SANTA CRUZ RIVER
TRIBUTARIES
IRRIGATION WELLS
MUNICIPAL OR INDUSTRIAL WELLS
DOMESTIC, STOCK, OR UNUSED WELLS
MOUNTAIN SLOPE
CITIES
MAIN ROADS
RAILROADS
COUNTY LINE
NATIONAL FOREST BOUNDARY
LAND GRANT BOUNDARIES
RESERVATION LINE (INDIAN, MILITARY, NAT. PARK OR NAT. MON.)
N
R.13 E.
R.14 E.
R.12 E.
R.15 E.
R.16 E.
T.10 S.
T.11 S.
T.12 S.
T.13 S.
T.14 S.
T.15 S.
T.16 S.
T.17 S.
T.18 S.
T.19 S.
PINAL COUNTY
PIMA COUNTY
SANTA CRUZ COUNTY
ORACLE JUNCTION
TORTOLITA MTS.
RILLITO
CORTARO
JAYNES
TUCSON
SANTA CATALINA MOUNTAINS
CORONADO NATIONAL FOREST
TUCSON MOUNTAINS
TUCSON MOUNTAIN PARK
SAGUARO NATIONAL MONUMENT
TANQUE VERDE RV.
SAN XAVIER INDIAN RESERVATION
SAN XAVIER MISSION
RITA
ESMOND
VAIL
SAHUARITA
SAHUARITA BOMBING AND GUNNERY RANGE
TWIN BUTTES
DUVAL MILL
SIERRITA MTS.
SANTA RITA EXPERIMENTAL RANGE
CONTINENTAL
HELVETIA
SANTA RITA MOUNTAINS
CORONADO NATIONAL FOREST
ARIVACA JUNCTION
AJO - TUCSON
SOUTHERN PACIFIC RR
Santa Cruz River
Rillito
Pantano Wash
Tanque Verde Creek
Sabino Canyon
Canada del Oro
TANGERINE ROAD
PRINCE
SPEEDWAY
BROADWAY
GRANT
IRVINGTON
VALENCIA
LOS REALES ROAD
PIMA MINE RD.

GROUNDWATER CHANGES
TUCSON BASIN
OF
SANTA CRUZ VALLEY
SPRING 1947–1965

LINES OF EQUAL LOSS ——20——

LINE OF NO CHANGE

LINES OF EQUAL RISE ——10——

APPROXIMATE BOUNDARY OF BASIN

AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA

SCALE
0 1 2 3 4 5 6
MILES

SURFACE CONTOURS 3000
SANTA CRUZ RIVER
TRIBUTARIES
IRRIGATION WELLS
MUNICIPAL OR INDUSTRIAL WELLS
DOMESTIC, STOCK, OR UNUSED WELLS
MOUNTAIN SLOPE
CITIES
MAIN ROADS
RAILROADS
COUNTY LINE
NATIONAL FOREST BOUNDARY
LAND GRANT BOUNDARIES
RESERVATION LINE (INDIAN, MILITARY, NAT. PARK OR NAT. MON.)

N

R.13 E. R.14 E.
T.10 S.
R.12 E.
PINAL COUNTY
PIMA COUNTY
T.11 S.
T.12 S.
T.13 S.
T.14 S.
T.15 S.
T.16 S.
T.17 S.
T.18 S.
T.19 S.
R.15 E.
R.16 E.
SANTA CRUZ COUNTY
ORACLE JUNCTION
RILLITO
CORTARO
JAYNES
TUCSON
SAHUARITA
RITA
ESMOND
VAIL
HELVETIA
CONTINENTAL
ARIVACA JUNCTION
TWIN BUTTES
SAHUARITA BUTTE
TORTOLITA MTS.
SANTA CATALINA MOUNTAINS
CORONADO NATIONAL FOREST
SAN PEDRO RIVER AND SAGUARO NATIONAL MONUMENT
SAN XAVIER INDIAN RESERVATION
SIERRITA MTS.
SANTA RITA MOUNTAINS
CORONADO NATIONAL FOREST
CONTOUR INTERVAL 100'

GROUNDWATER CONTOURS
UPPER SANTA CRUZ VALLEY
SANTA CRUZ COUNTY

SPRING - 1965

GROUNDWATER CONTOURS ——— 3000 ———
WATER SURFACE ELEVATION WELLS 3345

AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA

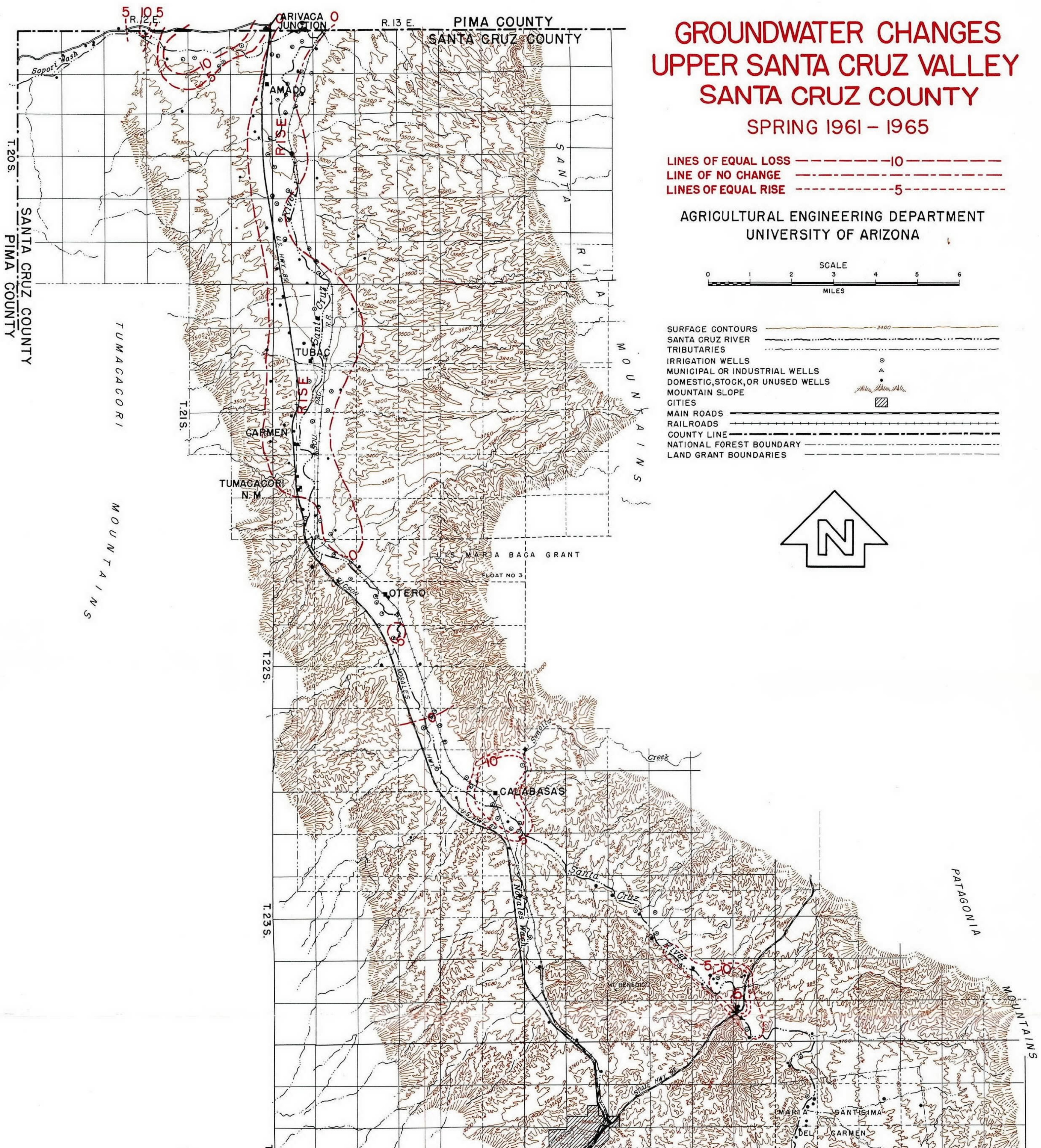
SCALE
0 1 2 3 4 5 6
MILES

SURFACE CONTOURS 3400
SANTA CRUZ RIVER
TRIBUTARIES
IRRIGATION WELLS
MUNICIPAL OR INDUSTRIAL WELLS
DOMESTIC, STOCK, OR UNUSED WELLS
MOUNTAIN SLOPE
CITIES
MAIN ROADS
RAILROADS
COUNTY LINE
NATIONAL FOREST BOUNDARY
LAND GRANT BOUNDARIES

N

CONTOUR INTERVAL 100 FEET
CONTOUR INTERVAL 80 FEET

MEXICO


GROUNDWATER CHANGES
UPPER SANTA CRUZ VALLEY
SANTA CRUZ COUNTY
SPRING 1961 – 1965
LINES OF EQUAL LOSS ———10———
LINE OF NO CHANGE
LINES OF EQUAL RISE - - - - -5- - - - -
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA
SCALE
0 1 2 3 4 5 6
MILES
SURFACE CONTOURS
SANTA CRUZ RIVER
TRIBUTARIES
IRRIGATION WELLS
MUNICIPAL OR INDUSTRIAL WELLS
DOMESTIC, STOCK, OR UNUSED WELLS
MOUNTAIN SLOPE
CITIES
MAIN ROADS
RAILROADS
COUNTY LINE
NATIONAL FOREST BOUNDARY
LAND GRANT BOUNDARIES
N
PIMA COUNTY
SANTA CRUZ COUNTY
ARIVACA JUNCTION
AMADO
TUBAC
CARMEN
TUMACACORI N.M.
OTERO
CALABASAS
NOGALES
LUIS MARIA BACA GRANT
MARIA SANTISIMA DEL CARMEN
SANTA RITA MOUNTAINS
TUMACACORI MOUNTAINS
PATAGONIA MOUNTAINS
RISE
R.12 E.
R.13 E.
R.14 E.
R.15 E.
T.20 S.
T.21 S.
T.22 S.
T.23 S.
T.24 S.
M E X I C O
CONTOUR INTERVAL 100 FEET
CONTOUR INTERVAL 80 FEET

GROUNDWATER CHANGES
UPPER SANTA CRUZ VALLEY
SANTA CRUZ COUNTY

SPRING 1947–1965

LINES OF EQUAL LOSS ——10——
LINE OF NO CHANGE
LINES OF EQUAL RISE ----5----

AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA

SCALE
0 1 2 3 4 5 6
MILES

SURFACE CONTOURS 3400
SANTA CRUZ RIVER
TRIBUTARIES
IRRIGATION WELLS
MUNICIPAL OR INDUSTRIAL WELLS
DOMESTIC, STOCK, OR UNUSED WELLS
MOUNTAIN SLOPE
CITIES
MAIN ROADS
RAILROADS
COUNTY LINE
NATIONAL FOREST BOUNDARY
LAND GRANT BOUNDARIES

N

CONTOUR INTERVAL 100 FEET | CONTOUR INTERVAL 80 FEET

MEXICO