INTRODUCTION

The Douglas basin encompasses about 950 square miles of Cochise County in southeastern Arizona. It lies within the Mexican Highland section of the Basin and Range physiographic province (Fenneman, 1931, p. 379-380). The basin is typical of the alluvium-filled valleys separated by elongated fault-block mountain ranges characteristic of this province. The Douglas basin is part of the larger Sulphur Springs Valley, a northwest-trending structural trough that includes the Willcox basin to the north. The Douglas and Willcox groundwater basins are separated by a string of small hills which also forms a partial surface-drainage divide between the two basins. The Douglas basin is further separated from the Willcox and San Bernardino basins on the east by the Swisshelm, Pedregosa and Perilla Mountains. The Dragoon and Mule Mountains bound the basin on the west. Although the groundwater basin extends south into The Republic of Mexico, the southern extent of this study is the International Boundary. Altitudes in the study area range from 7,370 feet in the Mule Mountains to 3,909 feet at the International Boundary near where Whitewater Draw crosses into Mexico.

Whitewater Draw is the principal watercourse in the Douglas basin and also drains a small portion of the Willcox basin. The source of this mostly ephemeral stream is in the Chiricahua Mountains in the Willcox basin. After entering the Douglas basin, the draw becomes indistinct at a point northeast of the Town of Elfrida. It begins again as an arroyo about 2 miles south of Elfrida and continues south to the International Boundary (Waters, 1986, p. 1). The southern reach of Whitewater Draw developed during the late nineteenth century (Waters, 1986, p. 1), probably as a consequence of extreme overgrazing by cattle. Forbes (1913, p. 215) mentions that most of Sulphur Springs Valley was originally grass covered but had been heavily overgrazed for at least 40 years prior to 1913. After crossing the International Boundary Whitewater Draw becomes the Rio de Agua Prieta, which flows into the Rio de Bavispe, a tributary of the Rio Yaqui. The Rio Yaqui eventually drains into the Gulf of California (Bureau of Agricultural Economics, 1940, p. 8 , 53). Perennial streamflow was reported in the final 2-mile reach of Whitewater Draw north of the International Boundary prior to 1952 (Coates and Cushman, 1955, p. 8-9). However, subsequent data collected by the U.S. Geological Survey show this stretch to be intermittent since 1952 (Anderson and White, 1979 p. 415). Total annual discharge of Whitewater Draw, measured 1.5 miles north of the International Boundary, averages about 6,730 acre-feet (U.S. Geological Survey, 1989, p. 611).

Average annual precipitation in the Douglas basin ranges from approximately 11 inches at the Town of McNeal to 14 inches at the City of Douglas. The average daily maximum temperature at Douglas is approximately 79°F, and the average daily minimum is approximately 44°F (Sellers and others, 1985, pp. 88, 112, 113). The highest recorded temperature at Douglas is 108°F, which occurred in June of 1973. The lowest recorded temperature is 2°F, which occurred in December of 1978 (Sellers and others, 1985, p. 100, 103).

Groundwater withdrawals in the basin have been primarily for agriculture, with a small portion for industrial, stock and domestic use. Total pumpage was less than 5,000 acre-feet per year prior to 1939. Annual pumpage in the basin (fig. 1) increased steadily from the mid 1940's to the mid 1970's and peaked at 138,000 acre-feet in 1974 (Mann and English, 1980, sheet 1). About 14,000 acres of the basin was irrigated in 1951 (Coates, 1952, p. 191). Irrigated land was estimated to be between 40,000 and 50,000 acres by 1965 (White and Childers, 1967, p. 14). Total irrigated acreage was estimated at 38,000 acres in 1978 (Mann and English, 1980, sheet 1). Annual pumpage in the basin in 1990 was estimated at about 43,000 acre-feet (Arizona Department of Water Resources, 1993, from data reported by well owners for 1990).

In order to prohibit the expansion of land irrigated with groundwater, the Arizona Legislature designated approximately 540 square miles of the Douglas basin as an irrigation non-expansion area (INA) in 1980. This same area had been designated the Douglas Critical Groundwater Area in 1965. As stipulated in the 1948 Arizona Critical Groundwater Code (Arizona Session Laws, Sixth Special Session, 1948, chapter 5), the drilling of new irrigation wells was prohibited in such an area. However, the 1948 Code and its amendments did not prohibit additional land from being irrigated from existing legally drilled wells (State v. Anway, 1960).

According to the Arizona Groundwater Management Act of 1980, only land which had been irrigated at any time from January 1, 1975, to January 1, 1980, in the area now designated as the Douglas INA, may be irrigated. In any one year a user may irrigate only the highest number of acres previously irrigated in any one year during the time of January 1, 1975, to January 1, 1980. All users of non-exempt wells in the INA are required to use a water-measuring device and report annual pumpage to the Arizona Department of Water Resources. Non-exempt wells include all wells with pump capacities greater than 35 gallons per minute (gal/min) and certain others used for commercial purposes.

GEOLOGY

According to Drewes (1980, map), the mountains surrounding the Douglas basin consist primarily of sedimentary and igneous rocks, with local outcrops of metamorphic rocks. The sedimentary rocks that occur in the eastern Mule Mountains range in age from Cambrian to Upper Cretaceous and include shale, sandstone, siltstone and limestone of the Bisbee Group and Bisbee Formation. Sedimentary rocks found in the Swisshelm and Perilla Mountains also include those of the Cretaceous age Bisbee Group or Formation. Older limestones of Lower Permian to Cambrian age are found in the Swisshelm Mountains. Igneous rocks in the basin consist primarily of rhyolitic volcanics and granites. The rhyolitic rocks are Miocene and Upper Oligocene in age and are found throughout the Perilla and Pedregosa Mountains. Other volcanic rocks include Tertiary andesite and dacite breccia found in the Perilla Mountains. The granite and related crystalline intrusive rocks are mostly Jurassic in age and crop out mainly in the Dragoon Mountains. Other outcrops in the Dragoon Mountains include older Precambrian and younger Mid-Tertiary granitoid rocks. Outcrops of granitic rocks are also found in the Swisshelm Mountains.

The valley fill of the Douglas basin can be divided into upper and lower alluvial deposits. The upper alluvial deposits consist of gravel, sand and silt of Holocene to Miocene age with a maximum thickness of about 1,000 feet (Drewes, 1980, map). The lower alluvial deposits consist of conglomerate, gravel and sand of Pliocene and Miocene age derived from the underlying or nearby rhyolitic rocks. These deposits occur below the upper alluvial deposits at depths beginning at about 650 feet (Drewes, 1980, map). The log of an oil exploration drill hole in sec. 5, T. 21 S., R. 25 E. indicates a thickness of the lower alluvial deposits of about 2,200 feet. Total depth of this hole is 5,450 feet. Pediments of varying thickness occur discontinuously around the edges of the basin where depth to bedrock is relatively shallow. The pediments appear to be wider on the east side.

Well logs show a basalt flow or flows up to several hundred feet thick beginning at varying depths between 120 and 500 feet below land surface, west of the Perilla Mountains, in the southeast corner of the study area. Lynch (1973, p. 14) believes this basalt is older and unrelated to the Pleistocene to Pliocene Bernardino basalts of the Bernardino volcanic field in the adjacent basin east of the mountains.

GROUNDWATER OCCURRENCE

The principal water-bearing unit in the Douglas basin is the unconsolidated to poorly consolidated upper alluvial deposits. The water-bearing zones in this unit are unconfined to semi-confined and, for the most part, are interconnected to form a single groundwater reservoir (Coates, 1952, p. 189). It is also probable that fully confined conditions occur locally. Water-level measurements in 1990 in the upper alluvial deposits (excluding perched-water zones) ranged from 38 feet below land surface near Whitewater Draw at Double Adobe in sec. 34, T. 22 S., R. 26 E., to 399 feet below land surface at the base of the Dragoon Mountains in sec. 10, T. 20 S., R. 25 E. Small-perched water zones occur locally in the upper alluvial deposits and measured water levels in 1990 were as shallow as 17 feet below land surface. For example, shallow water-level measurements from 1990 show that a perched-water zone occurs at Douglas above the basalt. Clay lenses of low permeability lying above the basalt in the upper alluvial deposits likely allowed for the formation of this perched-water zone. Discharge measurements performed on large-capacity wells by the U.S. Geological Survey throughout the basin over the past 30 years were as high as 1,600 gal/min, but most were less than 1,000 gal/min.

Water-level measurements made in 1990, west of Whitewater Draw, in the southern part of the basin, showed that the water table deepened steadily to the mapped hardrock at the base of the mountains. Some anomalies exist. Water-level measurements made in 1990, east of Whitewater Draw showed that the water table deepened to a maximum of 295 feet below land surface as distance from the draw increased. However, before reaching the edge of the basin, water levels became substantially shallow. This phenomenon was first described by Coates (1952, p. 189) and was believed to be due to much broader pediment development on the east side of the basin as compared to smaller and isolated pediments on the west. Hydrograph R (sheet 2) is from a well on the eastern pediment. Logs of wells on the east side of the basin suggest the pediment to be several miles wide near the southern edge of the Swisshelm Mountains and extending south for 15 miles or more. Few logs are available to confirm the lack of pediment development on the west side of the basin. However, one log does show basin fill to a depth of 305 feet right at the contact between the mapped hardrock of the Dragoon Mountains and the valley fill. Hydrograph G is from a well in this area. The log of a another well 1.5 miles east of the Dragoon Mountains shows basin fill to a depth of 450 feet without encountering bedrock.

Artesian conditions were reported to occur locally in the upper alluvial deposits throughout the Douglas basin in 1952. However, by that time the artesian pressure in these wells had declined locally due to heavy pumping and was considered insufficient to lift water to the surface (Coates and Cushman, 1955, p. 23-24, 27-28). Artesian conditions may still occur in the upper alluvial deposits and at greater depths in the lower alluvial deposits. For example, in sec. 5, T. 22 S., R. 27 E., a 4,440-foot deep flowing well observed in 1990 is probably unaffected by pumping in the upper alluvial deposits.

Recharge of groundwater in the upper alluvial deposits of the Douglas basin occurs mainly in washes along the mountain fronts. Very little recharge is attributable to direct rainfall on the valley floor and/or seepage from irrigation (Coates and Cushman, 1955 p. 25, 28-29). Prior to development, total annual recharge to the groundwater reservoir of the basin was estimated to be about 22,000 acre-feet (Freethey and Anderson, 1986, sheet 3). A small amount of additional recharge occurs as inflow from the Willcox basin as a result of surface water infiltrating the alluvium of Turkey Creek and moving as groundwater into the Douglas basin northeast of the Squaretop Hills (Coates and Cushman, 1955, p. 26). Predevelopment groundwater flow out of the study area across the International Boundary was estimated to be between 1,000 and 5,000 acre-feet per year by Freethey and Anderson (1986, sheet 3).

Several wells drilled in the igneous rocks of the Dragoon Mountains yield water. Most water levels measured in 1990 from wells in this area ranged from 8 feet to 55 feet below land surface. However, a few wells had measured water levels in excess of 200 feet below land surface. A single well in sec. 18, T. 21 S., R. 28 E., was drilled into the sedimentary rocks of the Swisshelm Mountains. The log of this well indicates water-bearing limestone at 70 and 205 feet below land surface. A static water level of 133 feet below land surface was measured in 1990. In the Perilla Mountains the log from a well drilled in 1981 in sec. 10, T. 23 S., R. 28 E., shows water-bearing limestone starting at 70 feet below land surface and a reported static water level of 45 feet below land surface. Wells in the surrounding mountains of the Douglas basin are primarily for small-capacity domestic and stock use.

Basalt flows are generally highly anisotropic with respect to groundwater flow. Horizontal water movement often parallels the dip of the flow with vertical movement limited to cracks or joints that typically form in basalt flows as they cool and shrink (Fetter, 1988, p. 110). Because of this heterogeneous, anisotropic nature of basalt, heavy localized pumping, perched-water zone and lack of data south of the International Boundary, contouring data depicting the surface of the regional aquifer in the area in and around Douglas was difficult. This was not the first time such difficulties have hampered investigators. Coates and Cushman (1955, p. 27) had difficulty distinguishing static water levels in artesian wells from those in water-table wells in the Douglas area on map 1. These difficulties are reflected in the abrupt termination of the contours near the edge of the basalt flow area near Douglas. Also, several wells in and around Douglas had static water-level altitudes over 100 feet lower than the nearest contours on the map. Most of these are City of Douglas water-production wells or former Phelps Dodge industrial-use wells that penetrate the basalt and were not used to determine the final placement of the contour lines.

Springs were reported to be common in the surrounding mountains prior to 1941 and subsequent development of the Douglas basin (Coates and Cushman, 1955, p. 32-33). However, by 1952 springs were not as prevalent and yielded less water than previously reported by longtime residents of the Douglas basin (Coates and Cushman, 1955, p. 32-33). Mountain springs are likely to still occur and have been recorded by the U.S. Geological Survey. However, this study did not actively seek to inventory springs and none were noted in the study area.

WATER-LEVEL CHANGES

The U.S. Geologic Survey measured static water levels in over 200 wells in 1966 and 68 wells in 1978 in the Douglas basin. For this study, over 700 static water-level measurements were made by the Basic Data Section of the Arizona Department of Water Resources. Comparison of these data showed that with very few exceptions, static water levels have declined throughout the basin since 1966. Overall, declines since 1966 are greatest in the northern part of the basin and decrease southward toward the International Boundary. However, considerable declines have been noted in the area around Douglas but seem more localized than in the north and may be kept small in areal extent by the presence of the basalt (map 3, sheet 3). Twenty-nine of the wells in which static water levels were measured by the U.S. Geological Survey in 1978 were remeasured during this study. Static water levels have continued to decline in 15 wells. Ten of the wells showed rises in the static water level and four remained relatively constant. No overall trend was noted in these remeasured wells and each seem to reflect local conditions only.

Static water-level measurements taken in 1990 of wells completed in and below the basalt flow around Douglas showed a decline of 27 feet since 1978 in sec. 5, T. 24 S., R. 27 E., and a decline of 71 feet since 1966 in sec. 6, T. 24 S., R. 28 E. However, these measurements only reflect the differences between two water-level measurements and do not show any recent trends. Water levels in this area may have declined more than is indicated and the 1987 shutdown of the copper smelter operated by the Phelps Dodge Corporation west of Douglas may have allowed them to recover. Phelps Dodge Corporation pumped approximately 1,600 acre-feet per year since 1967, but abandoned all their production wells in the area in late 1980's. The City of Douglas has continued pumpage at a fairly constant rate of about 3,000 acre-feet per year since 1966. In their study, Coates and Cushman (1955, p. 27, 28) noted a steepening of the water-table gradient in this area attributable to locally heavy municipal and industrial pumpage. Sustained heavy pumpage has resulted in the continuing decline of water levels, and of the water-level altitudes suggesting a groundwater depression has formed in the area around Douglas. Although no corroborating data are available from the Republic of Mexico, a reversal of groundwater flow may have resulted so that the movement is now from south to north across the International Boundary. Water levels in the wells completed above the basalt showed a maximum decline of 8 feet since 1978 in one well (hydrograph V, sheet 2) and little or no change in others.

Groundwater depressions due to extensive groundwater withdrawal in the northern part of the Douglas basin were first discussed by White and Childers (1967, p. 13). Their study was based on water-level measurements made in the spring of 1966 and showed that gradients of the water-level altitudes were less uniform and steeper near the edges of the basin fill than had previously been mapped. In 1978 Mann and English (1980, sheet 2) noted a decline of water levels north of Elfrida since 1966 great enough to reverse the direction of groundwater flow from southward to northward. As a consequence of continued pumping in this area, a large groundwater depression has formed and groundwater is now flowing toward it from all sides. Although some wells north of Elfrida currently show that water levels have risen 5 feet since 1978 (hydrographs C and D, sheet 2), others have declined 12 and 16 feet (hydrographs E and F, sheet 2, respectively) during the same period. The groundwater resumes its general southward movement south of Elfrida.

WATER QUALITY

Water-quality samples collected and analyzed from 1986-91 showed the groundwater in the Douglas basin to be of good to excellent chemical quality. In 1977-78 the U.S. Geological Survey collected water-quality samples for detailed chemical analysis from seven wells. Four of these wells were resampled for this study, and an additional 33 wells were sampled for the first time. The analysis of one of the resampled wells was disregarded due to the possible misidentification of the well. Of the three remaining wells, one in sec. 9, T. 21 S., R. 26 E., showed significant changes in water chemistry; most notable was a fourfold increase in fluoride. Wells to the west of this one also have very high values of fluoride and suggests that perhaps water is being drawn eastward from this area.

Two wells exceeded the maximum contaminant level (MCL) for nitrate of 37 sampled for detailed chemical analysis,. These two wells are located in sec. 3, T. 19 S., R. 26 E., and sec. 25, T.20 S., R. 26 E. Another well located in sec. 7, T. 19 S., R. 26 E., exceeded the lower MCL for arsenic. The MCL is an enforceable standard set by the U.S. Environmental Protection Agency for drinking water. Water providers must comply with these standards. Private individual domestic wells are exempt from state and federal regulation on water quality but should use MCLs as guidelines for safe drinking water. In Arizona the MCL for nitrate (expressed as N) is 10 milligrams per liter (mg/L) and either 0.05 or 0.10 mg/L for arsenic, depending on the number of year-round residents a water system serves (Arizona Department of Environmental Quality, 1991, p. 26).

More than 100 samples from throughout the basin were analyzed for specific conductance and fluoride. Specific-conductance values ranged from 210 to 2,380 microsiemens per centimeter (µS/cm) and averaged around 500 µS/cm. Dissolved-solids concentration may be approximated by multiplying specific-conductance values by 0.6, the approximate ratio of dissolved solids in mg/L to specific conductance in µS/cm (Table 1). The secondary maximum contaminant level (SCML) for total dissolved solids is 500 mg/L, or about 833 µS/cm (U.S. Environmental Protection Agency, 1988, p. 14). SCMLs are primarily used as guidelines and are generally not enforced by states. SCMLs are associated with the aesthetic quality of the water such as taste, odor and color. Water samples with contaminant levels above the SCML do not necessarily pose a health risk. Dissolved-solids concentrations increased southward along Whitewater Draw but remained fairly constant throughout the basin away from the draw. Only one well located near the edge of the basin in sec. 8, T. 23 S., R. 25 E., at the base of the Mule mountains had an exceedingly high dissolved-solids content. Values for fluoride ranged from 0.2 to 15 mg/L and averaged around 2.0 mg/L. Fluoride levels were found to be significantly higher in the northern part of the basin with the highest values occurring in T. 21 N., R. 26 E. The MCL for fluoride in Arizona is either 4.0 or 6.0 mg/l depending on the number of year-round residents that a water system serves (Arizona Department of Environmental Quality, 1991, p. 26).

SELECTED REFERENCES

Anderson, T. W. and White, N. D., 1979, Statistical summaries of Arizona streamflow data: U. S. Geological Survey Water-Resources Investigations 79-5, 416 p., 1 fig., 2 tables.

Arizona Department of Environmental Quality, 1991, Public and semi-public water supply system rules, State of Arizona: Department of Environmental Quality, Phoenix, Arizona, 56 p.

Coates, D. R., 1952, Douglas basin, Cochise County, in Ground water in the Gila River basin and adjacent areas, Arizona -- a summary, by L.C. Halpenney and others: U.S. Geological Survey open-file report (unnumbered), p. 187-194.

Coates, D. R. and Cushman, R. L., 1955, Geology and ground-water resources of the Douglas basin, Arizona, with a section on Chemical quality of the groundwater by J. L. Hatchett: U. S. Geological Survey Water-Supply Paper 1354, 56 p., 8 figs.

Drewes, Harald, 1980, Tectonic map of southeast Arizona: U. S. Geological Survey Miscellaneous Investigations Series Map I-1109, 2 sheets.

Fenneman, N. M., 1931, Physiography of the western United States: McGraw-Hill Book Co., Inc., New York and London, 534 p.

Fetter, C. W., 1988, Applied hydrogeology (second edition): Merrill Publishing Co., Columbus, Ohio, 592 p.

Forbes, R. H., 1913, Agriculture of Sulphur Spring Valley, Arizona: University of Arizona, Agricultural Experiment Station Bulletin 72, p. 214-224.

Freethey, G. W. and Anderson, T. W., 1986, Predevelopment hydrologic conditions in the alluvial basins of Arizona and adjacent parts of New Mexico: U. S. Geological Survey Hydrologic Investigations Atlas HA-664, 3 sheets.

Lynch, D. J., 1973, Reconnaissance geology of the Bernardino volcanic field, Cochise County, Arizona: Tucson, Arizona, University of Arizona, unpublished M.S. thesis, 101 p.

Mann, L. J. and English, C. S., 1980, Maps showing ground-water conditions in the Douglas basin area, Cochise County, Arizona--1978: U. S. Geological Survey Open-file Report 80-700, 3 sheets.

Sellers, W. D., Hill, R. H., and Sanderson-Rae, Margaret, eds., 1985, Arizona climate,the first hundred years, 1885-1985: Institute of Atmospheric Physics, University of Arizona Press, Tucson, Arizona, 143 p., 3 figs., 18 tables.

State v. Anway, 1960, 87 Ariz. 206, 349 P.2d 744.

U. S. Bureau of Agricultural Economics, Division of Land Economics, Water Utilization Section, 1940, Water facilities area plan for Whitewater Draw watershed, Cochise County, Arizona: Water facilities plan number 5, 105 p.

U. S. Environmental Protection Agency, 1988, The Safe Drinking Water Act - a pocket guide to the requirements for operators of small water systems: U. S. Environmental Protection Agency, Region 9, San Francisco, California, 37 p., appendix.

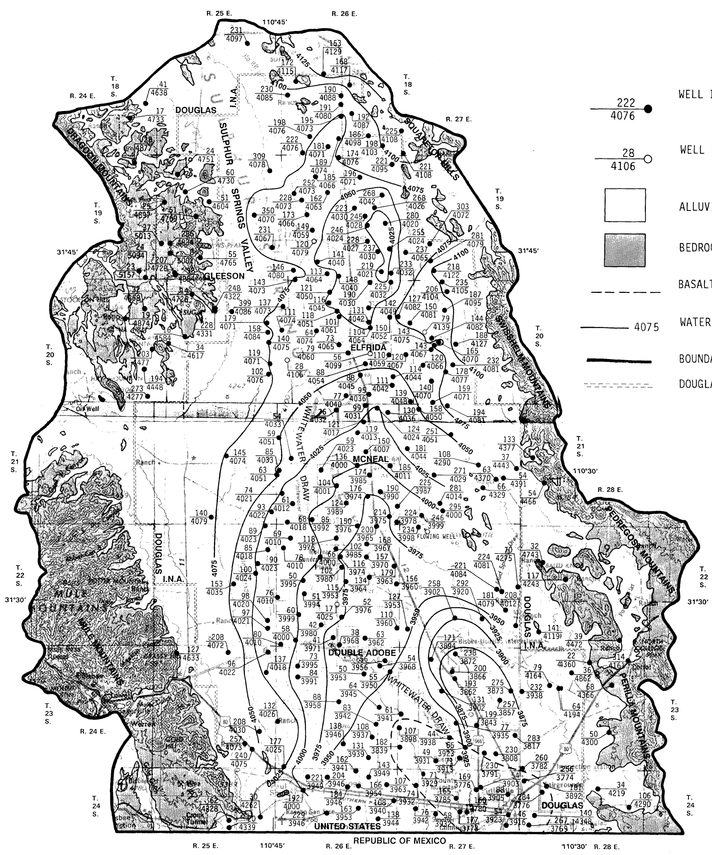
U. S. Geological Survey, 1989, Basin characteristics and streamflow statistics in Arizona as of 1989: U. S. Geological Survey Water-Resources Investigations Report 91-4041, 612 p.

Waters, M. R., 1986, The geoarchaeology of Whitewater Draw, Arizona: University of Arizona Press, 81 p.

White, N. D., and Childers, Dallas, 1967, Hydrologic conditions in the Douglas basin, Cochise County, Arizona: Arizona State Land Department Water-Resources Report 30, 26 p., 9 figs.

INDEX MAP SHOWING AREA OF REPORT (SHADED)

MAP 1 DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL



EXPLANATION

222 / 4076 — WELL IN WHICH DEPTH TO WATER WAS MEASURED IN January 1990--Upper number, 222, is depth to water, in feet, below land surface. Lower number, 4076, is the altitude of the water level in feet

28 / 4106 — WELL IN WHICH AN ANOMOLOUS DEPTH TO WATER WAS MEASURED IN JANUARY 1990--Upper number, 28, is depth to water, in feet, below land surface. Lower number, 4106, is the altitude of the water level in feet

ALLUVIUM--Consists of semi-consolidated to poorly consolidated sand, silt, clay, and gravel and conglomerate

BEDROCK--Consists of Tertiary volcanics and intrusives, Paleozoic and Mesozoic sedimentary rocks: limestone, sandstone, siltstone, and shale

BASALT FLOW(S)--Dashed line bounds approximate area in which basalt flow or flows occur at varying depths between 120 and 500 feet below land surface

4075 — WATER-LEVEL CONTOUR--Shows approximate altitude of the water level. Contour interval 25 feet. Datum is the National Geodetic Vertical Datum of 1929

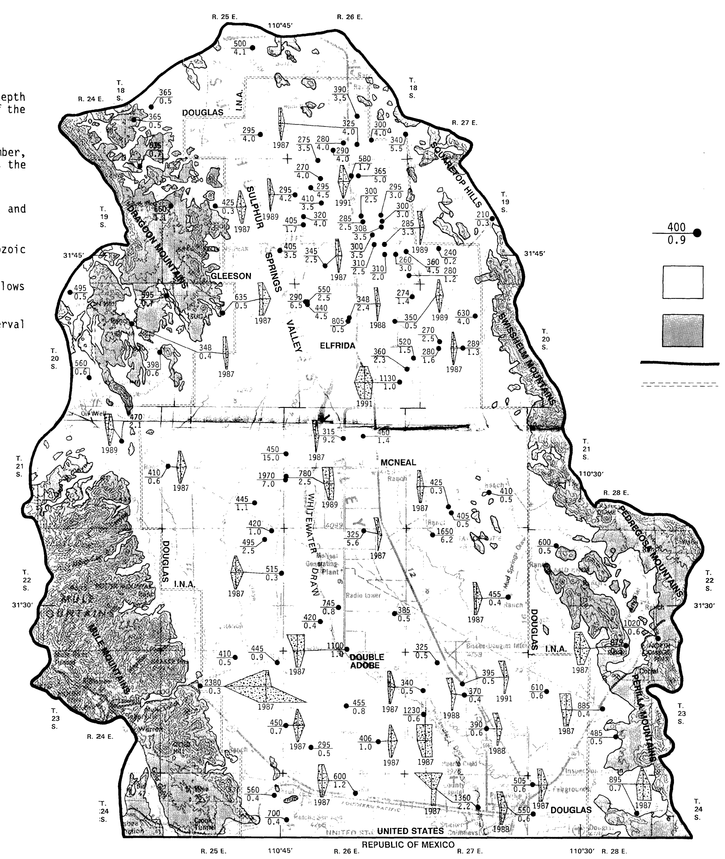
BOUNDARY OF DOUGLAS BASIN

DOUGLAS INA BOUNDARY

MILES / KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929
SCALE 1:250,000

MAP 2 CHEMICAL QUALITY OF WATER



400 / 0.9

ALLUVIUM--Consists of semi-consolidated to poorly consolidated sand, silt, clay, and gravel and shale

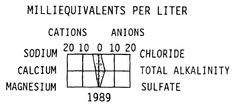
BEDROCK--(Consists of Tertiary volcanics and intrusives, Paleozoic and Mesozoic sedimentary rocks: limestone, sandstone, siltstone, and shale

BOUNDARY (OF DOUGLAS BASIN

BOUNDARY (OF DOUGLAS INA

CHEMICAL QUALITY DIAGRAM--Shows major constituents in milligrams per liter. The diagrams are in a variety of shapes and sizes, providing a means of comparing, correlating, and characterizing similar or dissimilar types of water. 1989, below diagram, indicates year in which sample was collected

MILLIEQUIVALENTS PER LITER



For readers who prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	0.4047	square hectometer
acre-foot	0.001233	cubic hectometer
gallons per minute	0.06309	liters per second

Base from U.S. Geological Survey
1:250,000, Douglas, 1969

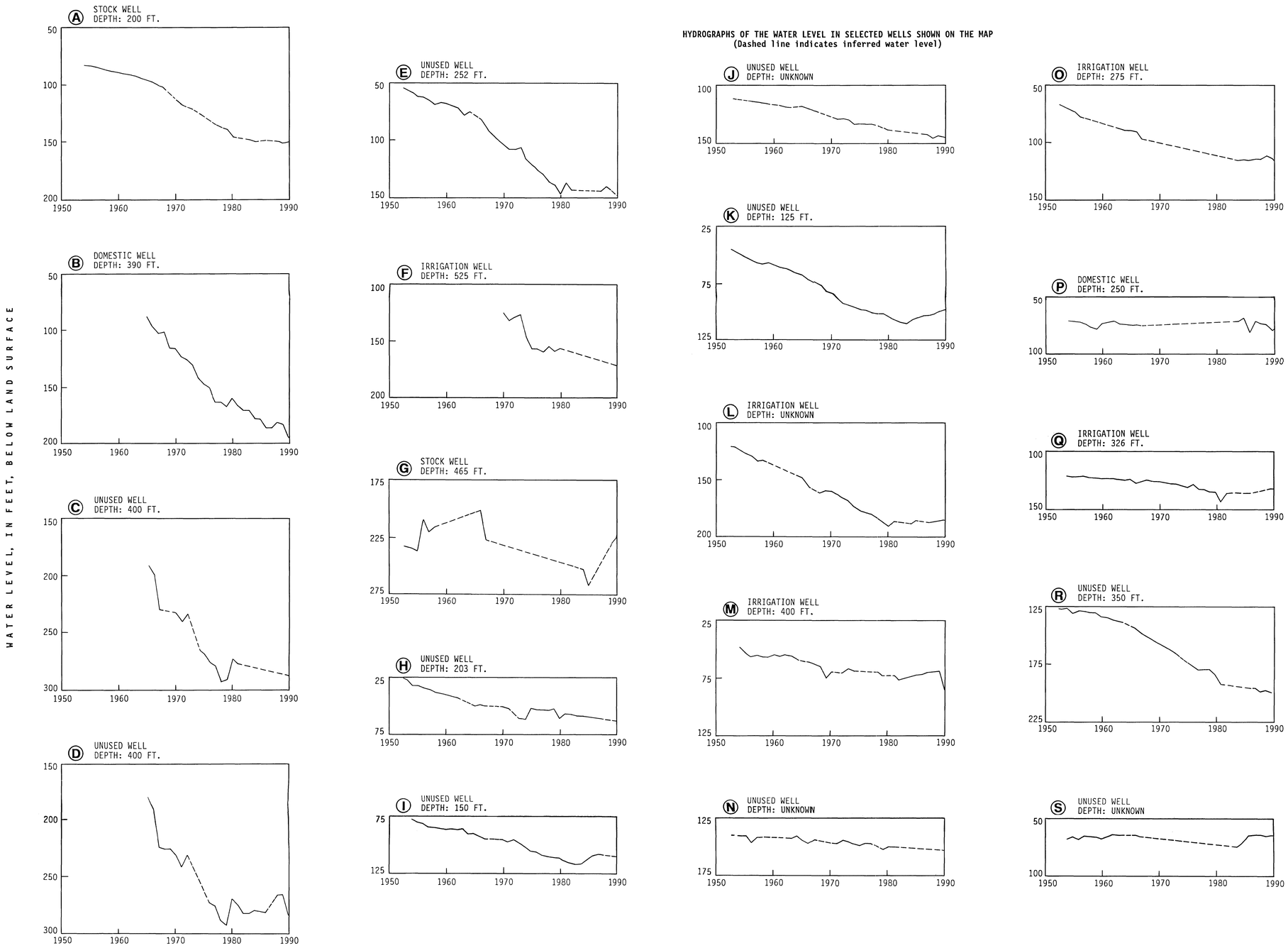
MAPS SHOWING GROUNDWATER CONDITIONS IN THE DOUGLAS BASIN, COCHISE COUNTY, ARIZONA--1990

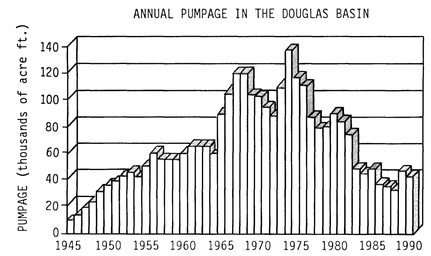
BY

S. J. RASCONA

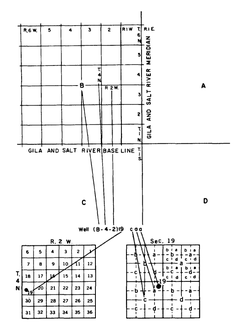
These hydrologic maps are available upon request from the Department of Water Resources, Basic Data Section, 2810 South 24th Street, Suite 122, Phoenix, Arizona, 85034. The hydrologic data on which these maps are based are available, for the most part, in computer-printout form and may be consulted at the Department of Water Resources and at the U.S. Geological Survey offices located at: 375 S. Euclid, Tucson, Arizona, 85719, and 1545 West University, Tempe, Arizona, 85281.

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS SHOWN ON THE MAP
(Dashed line indicates inferred water level)

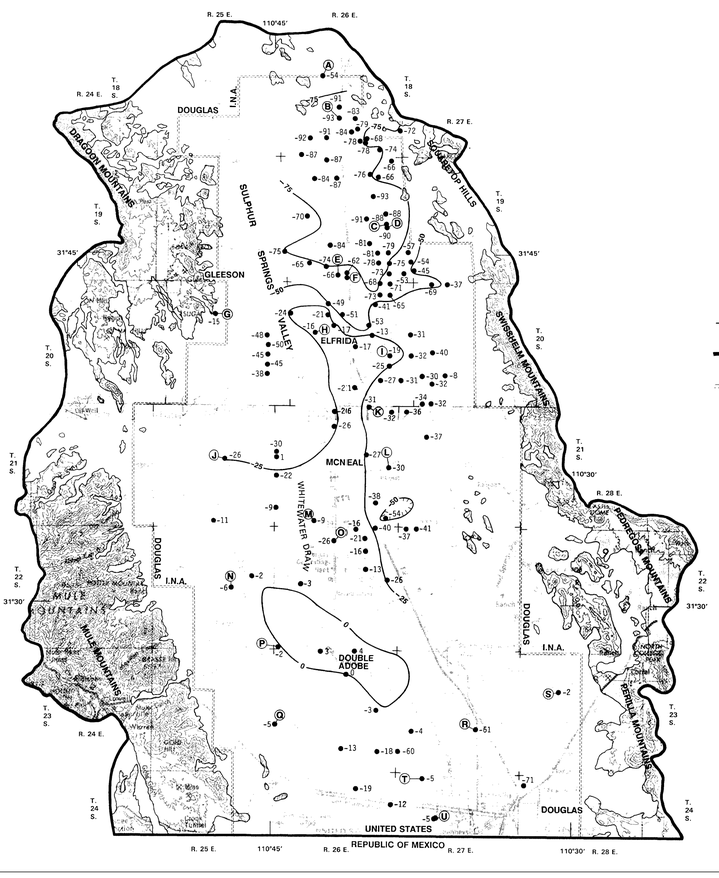




The well numbers used by the Department of Water Resources are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the state into four quadrants. These quadrants are designated counter-clockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters, a, b, c, and d, after the section number, indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counter-clockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (B-4-2)19caa designates the well as being in the NE¼ NE¼ SW¼ sec. 19, T. 4N., R. 2W. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.



MAP 3 CHANGE IN WATER LEVEL IN SELECTED WELLS HYDROGRAPHS OF SELECTED WELLS



EXPLANATION

-91 WELL IN WHICH WATER LEVEL WAS MEASURED IN 1966 AND 1990--Number, -91, is the difference, in feet, between the 1966 and 1990 water levels

A WELL FOR WHICH A HYDROGRAPH DEPICTING CHANGES IN WATER LEVEL IS SHOWN

ALLUVIUM--Consists of semi-consolidated to poorly consolidated sand, silt, clay, and gravel and conglomerate

BEDROCK--Consists of Tertiary volcanics and intrusives, Paleozoic and Mesozoic sedimentary rocks: limestone, sandstone, siltstone, and shale

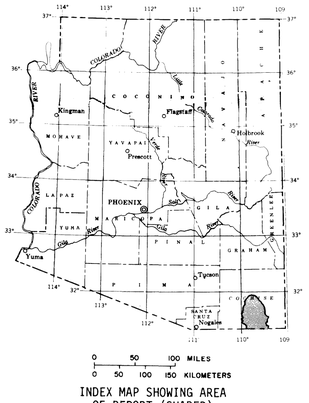
-25 APPROXIMATE LINE OF EQUAL CHANGE IN WATER LEVEL, 1966-1990--Contour interval 25 feet

BOUNDARY OF DOUGLAS BASIN

DOUGLAS INA BOUNDARY

5 0 5 MILES
5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929
SCALE 1:250,000



INDEX MAP SHOWING AREA OF REPORT (SHADED)

Base from U.S. Geological Survey
1:250,000, Douglas, 1969

MAPS SHOWING GROUNDWATER CONDITIONS IN THE DOUGLAS BASIN, COCHISE COUNTY, ARIZONA--1990

BY

S. J. RASCONA

These hydrologic maps are available upon request from the Department of Water Resources, Basic Data Section, 2810 South 24th Street, Suite 122, Phoenix, Arizona, 85034. The hydrologic data on which these maps are based are available, for the most part, in computer-printout form and may be consulted at the Department of Water Resources and at the U.S. Geological Survey offices located at: 375 S. Euclid, Tucson, Arizona, 85719, and 1545 West University, Tempe, Arizona, 85281.