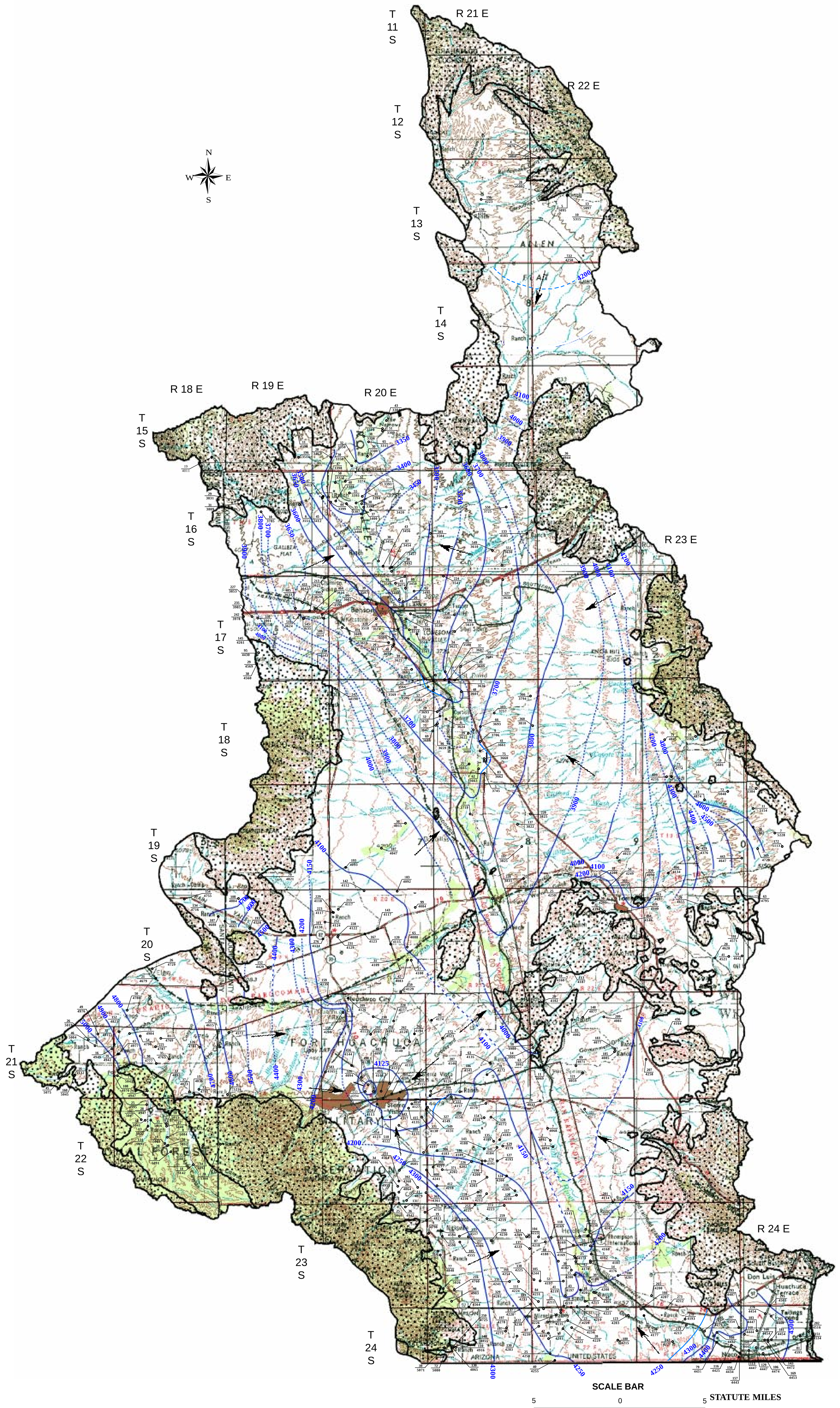

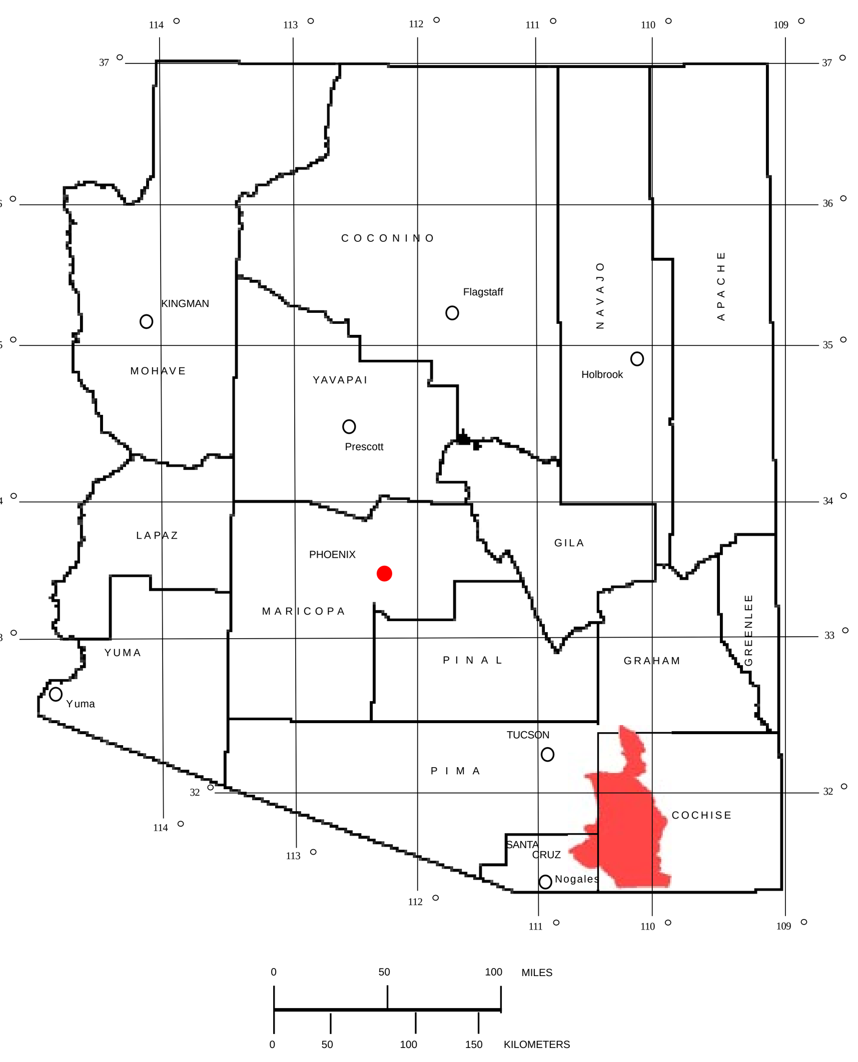

INDEX MAP SHOWING AREA OF REPORT (SHADED)

SCALE BARS

5 0 5 STATUTE MILES

5 0 5 10 KILOMETERS

WATER-LEVEL CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 25 AND 50 FOOT INTERVALS

TRANSVERSE MERCATOR PROJECTION

BLACK NUMBERED LINES INDICATE THE 10,000 METER UNIVERSAL TRANSVERSE MERCATOR GRID, ZONE 12 1977 MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 13 DEGREES (230 MILS) EASTERLY FOR THE CENTER OF THE WEST EDGE 121EASt CENTER OF THE EAST EDGE

LEGEND - EXPLANATION

124 / 4022 — **WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 2001 -2002** - - UPPER NUMBER, 124, IS DEPTH TO WATER IN FEET BELOW LAND SURFACE. LOWER NUMBER, 4022, IS THE ALTITUDE OF THE WATER LEVEL IN FEET ABOVE MEAN SEA LEVEL. DATUM IS REFERENCED TO THE NATIONAL VERTICAL GEODETIC DATUM OF 1929.

ALLUVIAL-FILL DEPOSITS (CONSISTS OF SILT, SAND, CLAY, GRAVEL, AND CONGLOMERATE)

HARDROCK GRANITIC, METAMORPHIC, VOLCANIC OR CONSOLIDATED SEDIMENTARY ROCK - WATER MAY OCCUR IN WEATHERED OR FRACTURED ZONES, JOINT SYSTEMS, OR FLUVIAL DEPOSITS OVERLYING BEDROCK.

BOUNDARY BETWEEN HARDROCK AND ALLUVIUM

4000 — **WATER LEVEL CONTOURS** - SHOWS THE APPROXIMATE ALTITUDE OF THE WATER-LEVEL. THE NUMBER 4000 REPRESENTS 4000 FEET ABOVE MEAN SEA LEVEL. DASHED WHERE INFERRED.

GENERAL GROUNDWATER FLOW DIRECTION

BOUNDARY OF UPPER SAN PEDRO BASIN

FOR READERS WHO PREFER TO USE METRIC UNITS RATHER THAN INCH-FEET UNITS, THE CONVERSION FACTORS FOR THE TERMS USED IN THIS REPORT ARE LISTED BELOW:

ENGLISH UNITS			METRIC UNITS
1	INCH	25.4	MILLIMETERS
1	FOOT	0.3048	METERS
1	MILE	1.609	KILOMETERS
1	SQUARE MILE	2.59	SQUARE KILOMETERS

INTRODUCTION

In December, 2001 and January, 2002 the Arizona Department of Water Resources field staff collected data on groundwater elevations in numerous wells throughout the Upper San Pedro Basin of southeastern Arizona. These data are presented in this report as maps of groundwater elevation contours and changes in water level, including hydrographs of selected wells showing changing water levels over time. The Department previously produced such maps showing groundwater conditions in 1990. These maps were published as Hydrologic Map Series (HMS) 31 in 1997 (Barnes, 1997). In 1990 the Department staff visited 1,075 wells and obtained water level data from 753 of them. In 2001-2002 the Department staff revisited the 753 wells previously measured, as well as obtaining additional measurements from new wells. Hydrographs depicting changes in water levels in specific wells are also presented in this report. Much of the text from Barnes (HMS 31, 1997), remain valid to discuss the hydrology and geology of the basin. That text has been updated where necessary to discuss new geologic information, recent water level data, and to update water use estimates.

GENERAL SETTING

The Upper San Pedro Basin is an intermontaine valley which includes approximately 1,875 square miles in southeast Arizona. The basin is bounded on the west by the Huachuca, Whetstone, and Rincon Mountains, and on the east by the Mule, Dragoon, Little Dragoon and Winchester Mountains. The basin extends approximately 58 miles along the San Pedro River, from the International boundary with the Republic of Mexico on the south, to the Narrows, approximately 11 miles north of Benson. The north sloping, north-to-northwest-trending valley ranges from 6 to 39 miles wide, and is divided into two sub-basins, Allen Flat and Sierra Vista.

The basin is drained by the San Pedro River and its main tributaries, the Babocomari River and Tres Alamos Wash. The San Pedro River flows northward from its headwaters, 25 miles south of the International boundary. The river enters the basin just south of the community of Palominas at an altitude of 4,275 feet, and exits at the Narrows, at an altitude of 3,309 feet, yielding a topographic gradient of nearly 17 feet per mile. Within the Upper San Pedro Basin the San Pedro River could be considered a perennial interrupted watercourse (Meinzer, 1923). The perennial reach runs from just south of Highway 90 to south of Fairbank.

The climate in the Upper San Pedro Basin is semiarid, characterized by hot summers and mild winters (Roeske and Werrell, 1973, p. 9). Rainfall primarily occurs during two peak periods. During the months of December, January and February gentle rains, occasionally of long duration, are typical. Intense, short-duration rainfall resulting from monsoonal thunderstorms make July and August the wettest months of the year. May is the driest month of the year, typically with little or no recorded precipitation. Average annual rainfall ranges from 11 inches at Benson to 15 inches in the area around Fort Huachuca-Sierra Vista, to more than 22 inches at the Coronado National Memorial. Snowfall contributes a minor amount of precipitation in the Upper San Pedro Basin, with a yearly total of 1.5 to 3 inches throughout most of the valley floor, and from 5 to 15 inches in the foothills of the mountains. Much more snow and rainfall occurs in the mountains surrounding the basin. June is the hottest month of the year, and average daytime temperatures range from the mid-to-high 90's°F near Benson to approximately 90°F in the southern part of the basin. The coolest month is January, when average daytime highs range from the low 60's°F near Benson to the high 50's°F in the southern part of the basin. Extremes of 116°F at Benson in June 1904, and -7°F at St. David in December 1978 have been recorded (Sellers and others, 1985, p. 86-93, 112-114, 132, 133).

Anglo settlement of the Upper San Pedro Basin was hastened by mining which brought early settlers to the area around Bisbee and Tombstone. The first homesteads were established in the late 1800's. Mormons settled at St. David in 1877, and Camp Huachuca, now Fort Huachuca, was established by the U.S. Army the same year (Barnes and Granger, 1960, p. 40, 49). To supply the needs of the booming mining districts, agriculture became important, resulting in the need for reliable sources of water. Early reports mention that groundwater under artesian pressure was first noted in 1887. Water reportedly flowed for several hours from a fissure caused by a strong earthquake (Lee, 1905, p. 169). There is evidence to support such a claim as an estimated magnitude 7.2 earthquake centered 30 miles southeast of Douglas, caused damage throughout southeastern Arizona in 1887 (Fellows, 1995, p. 1). The first flowing well in the Upper San Pedro Basin, and possibly the first in the state, was drilled in 1892 (Roeske and Werrell, 1973, p. 6). In his 1903 investigation of the valley, W.T. Lee (1905, p. 166) observed that over 200 wells had been drilled between Benson and Fairbank, a distance of only 20 miles.

The major cities, towns and communities in the basin include Sierra Vista, Tombstone, Huachuca City, Fort Huachuca, Benson, St. David, Naco, Pomerene, Hereford, Palominas and Nicksville. Farming, ranching and mining are the notable industries in the basin, with major groundwater users being farmers, the mining industry, and municipalities. In May, 2002 there were approximately 3,000 actively irrigated acres in the Upper San Pedro Basin (Arizona Department of Water Resources, 2003).

GEOLOGY

The Upper San Pedro Basin is an elongated trough formed by the uplift of the surrounding mountain blocks relative to the blocks underlying the valley floor. The resultant mountains are made up mainly of granite, schist, gneiss, volcanics and consolidated sedimentary rocks ranging in age from Precambrian to Tertiary. The structural and, to some degree, the hydrologic system are affected by the Tombstone Hills which jut out into the basin between Tombstone and the San Pedro River. These outcrops are composed of Tertiary granite and volcanics. As the surrounding mountains eroded, the basin subsequently filled with alluvium. The estimated maximum depth to bedrock along the axis of the basin may exceed 6,000 feet in the southern part, and is less than 5,000 feet in the northern part (Oppenheimer and Sumner, 1980, map). Pediments, or shallow bedrock, exist in places beneath the alluvial fill along the mountain fronts (Heindl, 1952, p.70).

Within the elongated trough of basin fill are three deeper troughs with depths of up to 6000 feet below land surface (Drewes,1980, Gettings and Houser, 2000). Gettings and Houser (2000) found three deeper pockets of alluvium in the basin. One lies south of Sierra Vista and west of the San Pedro River, a second lies under and north of the Babocomari River and west of the San Pedro River, and a third lies northwest of Tombstone. Gettings and Houser (2000) also describe a more shallow area of hardrock extending eastward from the Huachuca Mountains, under Sierra Vista toward the San Pedro River. Bedrock is found at relatively shallow depths of 200-500 feet below land surface along this line. This study also found that much of the southern area of the basin under the San Pedro River and to the east of the river was underlain by very shallow alluvium (on the order of 150 to 500 feet). This study is notable because it defines the bedrock as much more shallow than prior studies had indicated, effectively reducing the aquifers estimated total groundwater storage volume.

Unconformably overlying the bedrock is the Pantano (?) Formation. The Pantano (?) Formation is a sedimentary deposit, which has been firmly established as Tertiary, and likely as Miocene in age. This unit is a poorly to moderately indurated conglomerate, with clasts ranging in size from pebbles to boulders. They are composed of granite, limestone and volcanics, embedded in a coarse sandstone matrix (Brown and others, 1966, p. 9-13). Gettings and Houser (2000), indicate that the Pantano (?) Formation probably exceeds 1,000 feet in thickness in some areas near Sierra Vista and Fort Huachuca.
Unconformably overlying the Pantano (?) Formation are the Quaternary and Tertiary (Pliocene) basin-fill deposits. The basin-fill deposits, unlike the Pantano (?) Formation, are post Basin and Range development (Brown and others, 1966, p.15). The lower unit of the basin fill consists of whitish-gray to light-brown lenticular beds of strongly to weakly cemented gravel, sandstone, siltstone and clay. The lower unit can be up to 1,000 feet thick in places, near the center of the basin. The unit grades into coarse-grained beds a few feet thick near the mountain fronts (Roeske and Werrell, 1973, p. 10-11).

The upper unit of the basin fill is characterized by weakly cemented, sometimes compacted beds of reddish-brown to brown sediments of gravel, sandstone, siltstone and clays. The unit tends to be well-bedded silt, sandy-silt and clays in the center of the valley and grading into clayey-silty gravel near the mountain fronts. This unit may be as much as 800 feet thick (Roeske and Werrell, 1973, p.11). This unit can form steep slopes where capped by well-cemented terrace deposits, but erodes into badlands topography if not protected by the terrace deposits (Brown and others, 1966, p. 16). In 1902, W.P. Blake noted that in the area of Benson on both sides of the San Pedro Valley, there are unconsolidated red clays and sediments in horizontal beds of great thickness, often terraced by river erosion, and extending high up on both sides of the bordering mountains (Meinzer and Kelton, 1913, p.60).

In places, the basin-fill deposits are overlain by the beds of the flood-plain alluvium. They are unconsolidated, lenticular, river- and stream-laid deposits of gravel, sand and silt. These beds are found along the channels and flood plain of the San Pedro River and major tributaries, and range from less than a mile up to two miles in width, and from 40 to150 feet in thickness. Pool and Coes (1999), suggest that the thickness is better defined in the Sierra Vista subwatershed as within the upper 15 meters (approx 50 feet), of the surface.

With the exception of the Pantano (?) Formation, all of the previously mentioned basin-fill units are also present in Allen Flat, however, the units are not as thick (Pitman and others, 1988, p. 65). Depth to bedrock in the Allen Flat sub-basin has been estimated to be from 1,600 to 3,200 feet (Oppenheimer and Sumner, 1980, map).

GROUNDWATER OCCURRENCE

The predominant aquifers in the Upper San Pedro Basin are the basin-fill deposits and the floodplain alluvium (Roeske and Werrell, 1973, p. 24). Groundwater occurs under unconfined conditions in the flood-plain alluvium and under both confined and unconfined conditions in the basin fill.

Basin-Fill Deposits

The basin-fill deposits, consisting of the upper and lower units and the Pantano (?) Formation, form the principal aquifer in the Upper San Pedro Basin. The basin-fill deposits are stratigraphically complex. Locally, some areas exhibit confined conditions, but regionally the basin-fill aquifer is unconfined (Freethey, 1982, p. 49).

Unconfined

Both the upper and lower units are good sources of groundwater, and together they produce most of the water pumped from the regional aquifer. Yields of 100 to 2,800 gallons per minute have been reported from wells completed in the upper and lower units (Roeske and Werrell, 1973, p. 13). The Pantano (?) Formation is generally well cemented and not a reliable aquifer, but well yields up to several hundred gallons per minute have been reported (Roeske and Werrell, 1973, p. 10). In Dec.2001-Jan.2002, measured depths to water in the unconfined areas of the regional aquifer ranged from less than 100 feet to nearly 600 feet below land surface.

Confined

The Upper San Pedro Basin has long been recognized as an area with hundreds of artesian wells. Nearly all of these wells are located in two geographically small areas along the San Pedro River, where silt and clay layers restrict vertical movement of groundwater. The larger of the artesian areas is located roughly between Land and Pomerene, and is about 12 miles long and 2 to 3 miles wide. This area includes Benson and St. David. The confined area near Benson may be more laterally extensive than previously thought (Fluid Solutions, Inc, 2000). A second area, about 10 miles long and 1 mile wide, is located between Hereford and Palominas. In these two areas, deep wells drilled in or adjacent to the flood plain of the San Pedro River encounter confined waters (Heindl, 1952, p. 70). Gravel beds of the lower basin fill are overlain by up to several hundred feet of silt and clay. Depths to the confined waters vary depending upon location. The shallowest is in the Hereford-Palominas area, where well depths of about 200 feet are required (Roeske and Werrell, 1973, p. 12). At St. David, and south to Land, well depths of 300 feet and deeper are required to reach the confined aquifer. The deepest confined waters are found between Benson and Pomerene, at depths of 500 to 1,000 feet. Confined groundwater has also been encountered in the upper unit of the basin fill, where sand and gravel beds are locally overlain by clay and silt lenses. Flowing discharges from these wells are much less than the flowing wells completed in the lower basin fill. In December of 1990, approximately 150 artesian wells were visited while collecting data for HMS 31. Of that group, 47 flowing wells were observed. Many other flowing wells were not accessible, and some wells flow only seasonally. Of the artesian wells that were not flowing, depth to water ranged from a few inches to as much as 50 feet below land surface. In Dec. 2001-Jan. 2002, 16 flowing wells were visited in the Benson/Pomerene area and 17 in the St. David/Land area. This is not intended to imply that there are less flowing wells now than in 1990, just that the emphasis of the Dec.2001-Jan.2002 data collection was to obtain water levels from wells that had previously been measured. No effort was made to seek-out flowing wells.

In 1903, a maximum discharge of 80 gallons per minute was observed in the artesian wells of the Upper San Pedro Basin. The average discharge was about 10 gallons per minute (Lee, 1905, p. 169). In December of 1990, estimated discharges ranged from over 50 gallons per minute to a trickle. Although no flowing wells were observed in the Hereford-Palominas area, some wells were reported to flow seasonally.

Flood-Plain Alluvium

The flood-plain alluvium is more porous and permeable than the basin fill. However, due to its limited areal extent, it is only an important aquifer locally, along the flood plains of the major watercourses of the valley. Water levels are generally less than 50 feet below the land surface, and fluctuate seasonally in response to a combination of factors including riparian use, pumpage and recharge from river flow. Because of its high permeability and close proximity to the river, the flood-plain alluvium is easily recharged, and rapid recovery rates in wells are common. Many of the irrigation wells in the basin obtain water from the flood-plain alluvium (Roeske and Werrell, 1973, p. 11). Discharges from wells commonly range from 200 to 1,800 gallons per minute, and some have produced up to 2,000 gallons per minute (Roeske and Werrell, 1973, p. 13).

Secondary Sources

A pediment or isolated alluvial aquifer is located along the northeastern slope of the Huachuca Mountains, south of Sierra Vista. Very shallow water levels, some less than 30 feet below land surface, have been measured in this area. Other secondary sources of groundwater include the crystalline rocks and consolidated sedimentary rocks, which make up the mountains surrounding the basin. Where sufficiently fractured and saturated, these rocks may yield a few gallons per minute to wells.

Recently the presence of a limestone aquifer in the Whetstone Mountains has been emphasized by the discovery of Kartchner Caverns, now a world-renowned state park. Limestone caves also exist in the Huachuca Mountains in the southern part of the basin, although they do not have the importance of Kartchner Caverns. A publication by Graf (1999) discusses the hydrology of the cave. There are three aquifer systems within park boundaries. Graf (1999) indicates a degree of hydraulic separation between the regional basin fill aquifer and the park aquifers. The hydrologic significance of the water in the limestones is not fully understood at this time (Don Pool, U.S. Geological Survey, per. commun., 2003).

Numerous springs are located in limestones in the surrounding mountains. Discharges from these springs are generally smal l and may have periods of no flow. The most significant springs in the basin are located in Garden Canyon in the Huachuca Mountains, where combined maximum discharge has reached 1,800 gallons per minute (Brown and others, 1966, p. 36). Prior to the summer of 2003, many of the springs in Garden Canyon were dry, or near dry (Don Pool, U. S. Geological Survey, per. commun., 2003).

RECHARGE

The aquifers in the Upper San Pedro Basin are recharged by mountain-front runoff, river and streambed infiltration, underflow from Mexico, and seepage from applied irrigation. Due to high evapotranspiration rates, direct recharge from precipitation seepage is negligible. The average annual regional recharge is estimated to be about 29,600 acre-feet per year (Arizona Department of Water Resources, 2004).

DISCHARGE

Groundwater is discharged in the Upper San Pedro Basin by both natural and artificial means. Freethey and Anderson (1986, sheet 3), estimate that less than 1,000 acre-feet per year of groundwater was discharged to the Lower San Pedro Basin as outflow under pre-developmental conditions. This figure is likely little changed today. Contributing to total discharge are wells, evapotranspiration, evaporation of surface water from the perennial reach of the San Pedro River (Hereford to Fairbank), contributions from the groundwater systems to the San Pedro and Babocomari Rivers as baseflows, and municipal, agricultural, industrial and domestic wells. Numerous springs along the San Pedro River also contribute to total groundwater discharge. Discharge for most of these springs has not been quantified. Production from wells and riparian evapotranspiration are the major sources of groundwater discharge. Public supply wells (including domestic wells and military uses) and irrigation wells are the largest groundwater pumpers, followed by industrial users. In 2002, an estimated 26,000 acre-feet (Arizona Department of Water Resources, 2004, table 2, p. 42) was pumped in the Upper San Pedro Basin; 16,100 was pumped for municipal uses, 7,500 for agricultural uses, and 2,400 for other uses. (Arizona Department of Water Resources, 2004). A large number of flowing wells, exist in the basin, especially near Benson and St. David. In spite of the large numbers of flowing wells, total discharge from this source is thought to be quite small, owing to low rates of flow from each well. In 1990, an estimated 37,000 acre-feet of groundwater was pumped, not including riparian demand. The peak year for pumping was 1981, when 75,000 acre-feet were pumped. Since 1966, 1,412,000 acre-feet of groundwater has been pumped from the Upper San Pedro Basin (Anning Duet, 1994, sheet 1). Pre-1966 pumping records are not available for this basin. Riparian groundwater demand has been estimated at about 19,800 acre-feet for 2002, (Arizona Department of Water Resources, 2004).

MOVEMENT AND STORAGE

Direction of groundwater flow generally mirrors surface-water drainage in the basin. Groundwater moves from the mountain fronts and higher elevations toward the center of the basin, then moves in a north-northwest direction along the axis of the valley. Natural flow direction has been disrupted near Sierra Vista due to the development of a significant groundwater depression. Water under the influence of the depression now flows toward its center. In the southern part of the Allen Flat sub-basin groundwater flows to the south and west, into the Sierra Vista sub-basin. In places, groundwater can also freely move between alluvial units within the aquifers. Some exchange of water between the confined parts of the regional aquifer and the flood-plain aquifer can also take place due to well casings perforated in both aquifers and due to corroded well casings.

There are an estimated 20,000,000 acre-feet of groundwater stored in the Upper San Pedro Basin (ADWR, 2004). This estimate is considerably less than the estimate reported in HMS 31 because a new geophysical study (Gettings and Houser, 2000) indicates that bedrock is more shallow in the basin than previously assumed, thus limiting the vertical extent of the aquifer.

WATER LEVEL CHANGES

Ground water levels in the Upper San Pedro Basin fluctuate seasonally in response to pumping and recharge, especially in the flood-plain alluvium along the San Pedro River. Recent drought conditions in the Southwest have affected the Upper San Pedro Basin, and groundwater declines within the basin reflect the lack of recharge, particularly along stream courses. However, as hydrographs point out in the following discussion, some water level changes have not been drastic in the Upper San Pedro Basin. There are areas where decline has been historically noted, and declines in these areas has continued. The most unexpected changes have occurred in an area between Bisbee and Naco. Declines in the Bisbee-Naco area are among the largest observed in the basin over the 11 year period between 1990 and Dec.2001-Jan.2002. Specific areas are discussed below.

Hydrographs referred to are located on Sheet 2. These hydrographs were also discussed in HMS 31. Not all hydrographs discussed in HMS 31 are discussed in HMS 34 because some wells were destroyed or were not available for measurement between 1990 and Dec. 2001-Jan.2002. Discussions of the following areas are not necessarily based on well defined boundaries or geo-political areas. They are instead discussions of general areas.

Allen Flat Sub-basin

Very little change has taken place in the Allen Flat sub-basin. Hydrographs (A and B) clearly show the stable conditions that have existed since 1990.

Sierra Vista Sub-basin

North of Pomerene
Twenty wells were measured along the San Pedro River at ranches and farms north of Pomerene, from the rivers confluence with Tres Alamos Wash to the Narrows. Conditions at these wells ranged from essentially no change to a maximum rise of 11.1 feet, with an average rise of 4.7 feet. Just south of the Narrows, seven measured wells showed changes ranging from a rise of 0.1 foot to a decline of 5.3 feet, with an average decline of 1.5 feet. The wells measured in this area are largely shallow wells used for irrigation and stock purposes. Irrigation has continued in the area where modest decline was noted. However, where water level rises were recorded, irrigation pumpage has decreased since 1990.

Benson- Pomerene
In the Benson-Pomerene area, wells completed in both the shallow aquifer and the deeper (artesian) regional aquifer are common, however a majority of the wells in Pomerene are shallow. Sixteen flowing wells were observed in the Benson-Pomerene area. Modest water level declines were recorded in both aquifers. In the shallow aquifer water level changes range from a rise of 0.5 feet to a decline of 10.2 feet, however most declines are in the 1.0 to 5.0 foot range. Most of the deep wells are south of Pomerene in the Benson area. Changes in these wells range from a maximum rise of 0.3 feet to a maximum decline of 18.9 feet, with most declines in the 4.0 to 9.0 foot range.

From west of Benson to the western Upper San Pedro Basin boundary, water level declines in the 5.0 to 7.0 foot range are common, with a maximum recorded decline of 11 feet. These are predominantly domestic and stock wells. Higher rates of groundwater decline are found in Township 17S, Range 19E. This area contains wells that supply the Town of Benson and development associated with nearby Kartchner Caverns State Park.

St. David-Land
The St. David-Land area has a great number of wells completed in both the shallow aquifer and the deeper regional (artesian) aquifer. Water level changes ranging from a maximum decline of 11.1 feet to a maximum rise of 11.0 feet were observed, and many wells continue to flow. Hydrograph (C) shows that the regional aquifer has undergone gentle rise since the 1990 measurement. The greatest changes have occurred in the shallow aquifer where the 11.1 foot decline was observed. In the area south of St. David, declines in the range of less than 1.0 foot per year are found in the shallow aquifer, which is recharged by the river. The recent drought conditions have kept river flow at a minimum, thereby limiting recharge to the shallow aquifer and contributing to the observed declines. The least amount of change was found in wells completed in the regional aquifer. Several wells reflect a rise in water level.

Sierra Vista-Huachuca City-Nicksville
Water level declines in this area have been noted for decades. Water levels have continued to decline in the 11 years since 1990. Well measurements in and around Sierra Vista reveal declines for the 1990-Dec.2001-Jan.2002 period ranging from 1.2 feet to a maximum of 14.8 feet in a public supply well for Sierra Vista. This well has declined an average of 1.4 feet per year for the last 11 years. Most of the wells in this area of the cone are declining at a rate of less than 1 foot per year however. These findings are consistent with previous decline rates. Hydrographs K,L,M and O show the steady decline in the water table in the area of the cone of depression. Well (D-21-20) 33ACC, which had previously exhibited the largest decline (42.2 feet from 1958-1990, or an average of 1.3 feet per year), declined a total of only 1.2 feet since 1990.

Based on 1968 data, a small elliptical cone of depression was first described by Roeske and Werrell, (1973, p.16). The depression was enclosed within the 4,150 foot contour. It encompassed about 5 square miles and was centered in section 33, Township 21 South, Range 20 East. The major axis of the elliptical cone was northeast-southwest in orientation. Data collected by the U. S. Geological Survey in the winter of 1977-78 supports Konieczki's (1980, sheet 1) reference to the small depression centered within the 4,150 foot contour near Sierra Vista-Fort Huachuca. Putman and others (1988, p.98), using data collected in the winter of 1985-86, stated that the cone of depression within the 4,150 foot contour still extended in a northeast-southwest direction, and had increased areally to the east and southeast of Sierra Vista, to about 7.5 square miles. A maximum decline of 9.2 feet was observed between 1985 and 1990 at well (D-21-21) 31CAC, while the minimum observed decline was 2.2 feet at well (D-21-20) 35CBC for this period.

In 1990, the cone was centered or deepest in section 33, Township 21 South, Range 20 East. The deepest part of the cone could be encircled by the 4,100 foot water-level altitude contour. Water levels in wells within the influence of the depression were generally declining at approximately 0.5 to 1.0 foot per year. The depression was generally expanding in an east-south-easterly direction from the deepest part of the cone.

In Dec.2001-Jan.2002, the cone was still centered in section 33, Township 21 South, Range 20 East and the deepest part of the cone can still be encircled by the 4100 foot water-level contour.

Declines for 1990-Dec.2001-Jan.2002 became less pronounced north of Sierra Vista. Between Sierra Vista and Huachuca City declines in the 5.0 to 7.0 foot range are common, (see hydrograph J). North of Huachuca City declines are in the 1.0 to 5.0 foot range for the 1990-Dec.2001-Jan.2002 period, (see hydrograph I). One exception was public supply well (D-20-19) 14ADD, which declined 13.4 feet (1.2 ft/yr) since 1990.

South of Sierra Vista toward Nicksville a wide range of declines, as well as rises, were recorded on either side of State Route 92. The largest declines occur in public supply wells, ranging from 26.4 to 35.4 feet since 1990. The closer the proximity to the Huachuca Mountains foothills, the more varied the water levels become, ranging from a decline of 8.7 feet to a rise of 16.6 feet. Many of the wells in the area are completed in either the pediment aquifer or in fractured hardrock. In either case, these wells are more susceptible to rainfall or drought conditions than those completed in the regional aquifer.

Tombstone
Declines are common in the Tombstone area, ranging from less than 1 foot to as much as 23 feet. Many of the declines are in shallow wells (windmills) located in or near washes. These declines clearly reflect the drought conditions which have persisted in recent years. Three deep (600-890 feet) public supply wells exhibit declines ranging from 3.3 feet to 23.1 feet.

Naco
Among the sharpest declines in the basin, are those having occurred in the Naco area. These declines are consistently in the mid-20 foot range. The range of declines was from 9.8 feet to 32.1 feet. However, farther west, toward the San Pedro River, changes ranged from a rise of 1.0 to a decline of 4.1 feet, which are more consistent with those observed in the rest of the basin.

United States Border to State Route 90 (including Palominas-Hereford)
The reach of the San Pedro River from the United States-Mexico Border, to State Route 90 has shown no remarkable change since 1990. This area, which includes the communities of Palominas and Hereford, reflects water level changes ranging from declines of 4.9 feet, and rises to 7.0 feet. Most of the wells show a change of plus or minus 3 feet. When considered over an 11 year period, these changes are quite small. Hydrograph (S) shows stable water table conditions in the Palominas area. West of the San Pedro River in the eastern half of T22S, R21E, wells show declines in the 2.0 to 7.0 foot range. However, Hydrograph (P) shows that no drastic change has taken place.

WATER QUALITY

No water quality samples were taken by ADWR for this update of HMS 31. This was due to budgetary and staffing constraints. Text below is taken largely from Barnes, 1997 (HMS 31).

The groundwater of the Upper San Pedro Basin is generally of good chemical quality. Of the 155 total samples, the MCL's for fluoride or dissolved solids were exceeded in only 25 wells. Of the 25 wells in which one or both of the MCL's were exceeded, 20 of the wells are located either in the confined part of the regional aquifer or in the flood-plain alluvium. Water from these two areas is generally used for irrigation. When the basin is viewed in its entirety, these two areas represent a very small percentage of the total area.

Water samples from 155 wells and springs were collected in 1990 for the HMS 31 (Barnes, 1997). Of that number, 59 were detailed analyses and the remainder were analyzed for fluoride, specific-conductance and pH only. No samples were collected for the present HMS.

The maximum contaminant level (MCL) for fluoride in Arizona public drinking water is 4.0 milligrams per liter (mg/L), as established by the U. S. Environmental Protection Agency (1986, p. 11396-11397) and the Arizona Department of Environmental Quality (1989, p. 7). The MCL is an enforceable standard set by the U. S. Environmental Protection Agency for drinking water. States must comply with this standard, but are free to set levels which are more stringent.

Dissolved-solids concentrations may be approximated by multiplying specific-conductance values by 0.6, which is the approximate ratio of dissolved solids in mg/L to specific conductance in microsiemens per centimeter at 25°C.(mS/cm), The U. S. Environmental Protection Agency has established the secondary maximum contaminant level (SMCL) for dissolved solids at 500 mg/L, which is approximately equivalent to a specific-conductance value of 833 mS/cm. The SMCL's are guidelines only, and are not enforceable standards (U.S. Environmental Protection Agency, 1988, p. 9). The SMCL's are based on aesthetic qualities such as taste, odor and color. Water with contaminant levels above the SMCL are not necessarily a health risk.

Flood-Plain Alluvium

Some of the poorest quality water in the basin is found in the flood-plain alluvium. Between St. David and the Narrows, the specific-conductance values are the highest in the basin, ranging from 850 to 2,800 µS/cm, or approximately 510 to 1,680 mg/L dissolved solids in 1990. South of St. David, specific-conductance values ranged from 307 to 620 mS/cm, or approximately 184 to 372 mg/L dissolved solids, decreasing in value with distance south of St. David. Fluoride values ranged from a low of 0.2 mg/L northwest of Hereford to a high of 3.0 mg/L near St. David. North of St. David values range from 0.5 to 1.9 mg/L and south of St. David from 0.2 to 1 .0 mg/L. Average water temperature in the flood-plain alluvium is about 19.6 °C (67.3 °F).

Basin–Fill Deposits

In the artesian area from St. David north to Benson, specific-conductance values range from 180 to 550 µS/cm, or approximately 108 to 330 mg/L dissolved solids, which is well within the SMCL limits. Fluoride values range from 0.1 to 8.8 mg/L; the higher values generally occur from just south of Benson to Land. The temperature of the artesian waters averages 24.2 °C (75.6°F). There is a small area from just southwest to northwest of Pomerene in which five flowing wells were sampled. These wells have anomalously high temperatures which range from 28 °C to 30 °C and average 28.9 °C (84°F). Each of these wells is at least 1,000 feet deep. Other artesian wells in the same general area produce water in the 20°C to 25°C range.

Only five of the wells sampled in the unconfined regional aquifer produce water which exceeds one of the MCL's for fluoride or dissolved solids. This certainly is supportive of historical claims that the regional aquifer is of good quality. Fluoride values in the unconfined regional aquifer range from 0.1 mg/L to a high of 4.0 mg/L. Specific-conductance values range from 160 µS/cm to 3,100 µS/cm, and average 448 µS/cm. Temperatures range from 17 °C to 29 °C, and averages 22.2 °C (72°F).

High sulfate and/or nitrate levels were detected in a few wells in the Upper San Pedro Basin. These wells are mainly located in the flood-plain alluvium, roughly from St. David to the Narrows. The sulfate MCL of 250 mg/L was exceeded at three wells and the nitrate MCL of 10 mg/L was exceeded at two wells. One well, (D-19-20) 3ODAA (360 mg/L), southeast of the Whetstone Mountains, completed in the regional aquifer produces water with high sulfate concentrations.

Water from 13 springs was analyzed for HMS 31. Fluoride values range from 0.5 to 1.9 mg/L. Specific-conductance values range from 210 to 833 mS/cm, which is approximately 126 to 500 mg/L dissolved solids. Temperatures range from 7.5 °C at spring (D-17-23) 04BCC to 24.5 °C at spring (D-17-23) 18AAD, both located in the Dragoon Mountains.

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BASE MAP FROM U.S. GEOLOGICAL SURVEY
1:250,000 TUCSON (1977), NOGALES (1969), AND DOUGLAS (1959)

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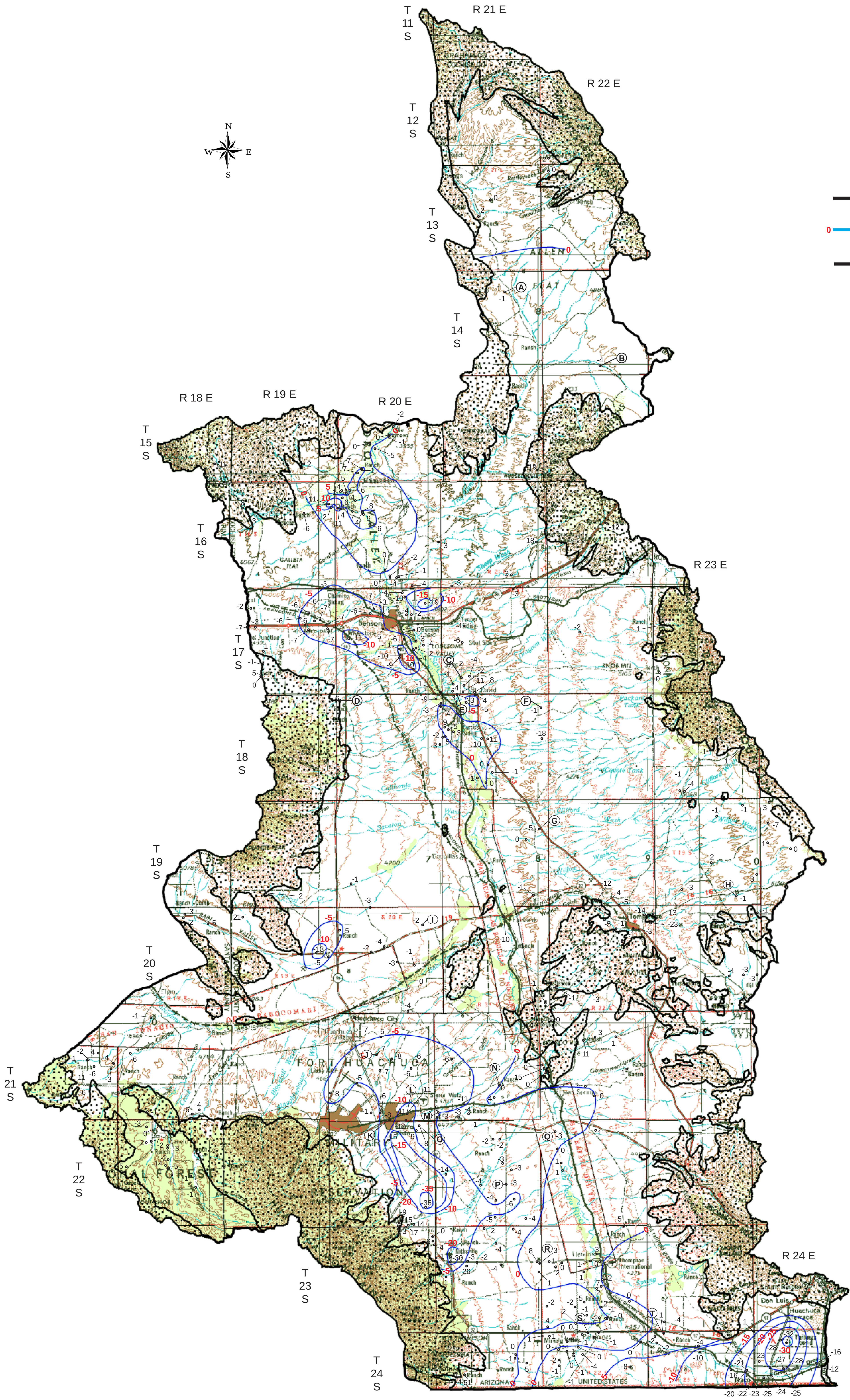
MAPS SHOWING GROUNDWATER CONDITIONS IN THE UPPER SAN PEDRO BASIN, COCHISE, GRAHAM AND SANTA CRUZ COUNTIES, ARIZONA—DEC. 2001- JAN. 2002

BY

R.L. BARNES & F. PUTMAN

THESE HYDROLOGIC MAPS ARE AVAILABLE UPON REQUEST FROM THE ARIZONA DEPARTMENT OF WATER RESOURCES, INFORMATION CENTRAL, 500 NORTH THIRD STREET, PHOENIX, ARIZONA, 85004. THE HYDROLOGIC DATA ON WHICH THESE MAPS ARE BASED ARE AVAILABLE AT THE ADWR BOOKSTORE. 602 417-2485

PREPARED IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY



LEGEND - EXPLANATION

+10 **WELL IN WHICH WATER LEVEL WAS MEASURED IN DEC., 2001- JAN 2002 - -** Number, +10, is the difference, in feet, between Dec.1990 and Dec. 2001-Jan. 2002

(A) **WELL IN WHICH A HYDROGRAPH DEPICTING CHANGES IN DEPTH TO WATER IS SHOWN**

ALLUVIAL-FILL DEPOSITS (CONSISTS OF SILT, SAND, CLAY, GRAVEL, AND CONGLOMERATE)

HARDROCK GRANITIC, METAMORPHIC, VOLCANIC OR CONSOLIDATED SEDIMENTARY ROCK - WATER MAY OCCUR IN WEATHERED OR FRACTURED ZONES, JOINT SYSTEMS, OR FLUVIAL DEPOSITS OVERLYING BEDROCK.

BOUNDARY BETWEEN HARDROCK AND ALLUVIUM

0 0 **WATER LEVEL CHANGE CONTOURS** - REPRESENTS THE APPROXIMATE LINE OF EQUAL CHANGE IN WATER LEVEL, to Dec. 2001-Jan. 2002. CONTOUR INTERVAL IS 5 FOOT. DASHED WHERE INFERRED.

BOUNDARY OF UPPER SAN PEDRO BASIN

FOR READERS WHO PREFER TO USE METRIC UNITS RATHER THAN INCH-FEET UNITS, THE CONVERSION FACTORS FOR THE TERMS USED IN THIS REPORT ARE LISTED BELOW:

ENGLISH UNITS		METRIC UNITS	
1	INCH	25.4	MILLIMETERS
1	FOOT	0.3048	METERS
1	MILE	1.609	KILOMETERS
1	SQUARE MILE	2.59	SQUARE KILOMETERS

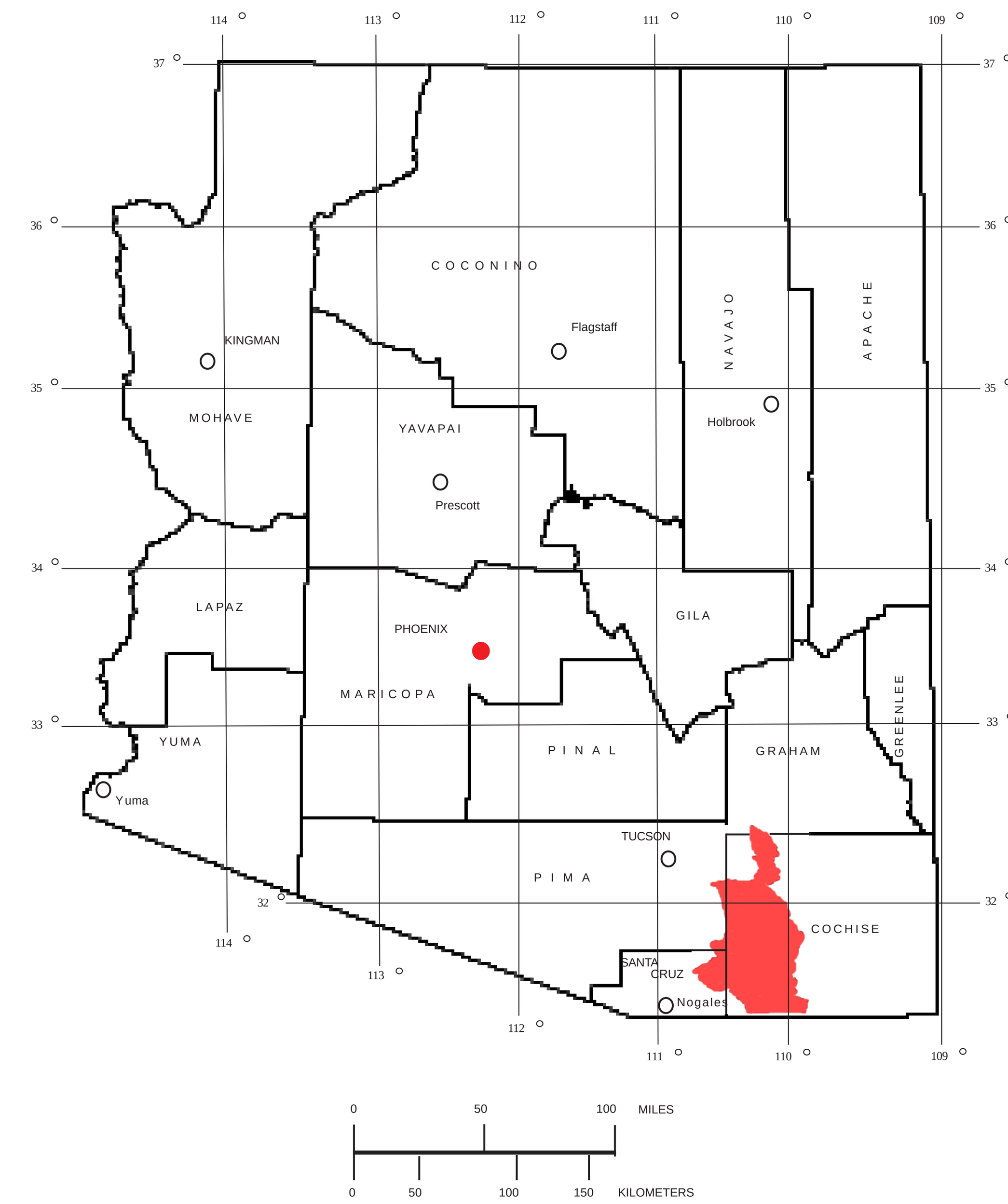
SCALE BARS

5 0 5 STATUTE MILES

5 0 5 10 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

BLACK NUMBERED LINES INDICATE THE 10,000 METER UNIVERSAL TRANSVERSE MERCATOR GRID, ZONE 12 1977 MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 13DEGREES (230 MILS) EASTERLY FOR THE CENTER OF THE WEST EDGE TO 121/2 (220 MILS) EASTERLY FOR THE CENTER OF THE EAST EDGE



INDEX MAP SHOWING AREA OF REPORT (SHADED)

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS SHOWN ON THE MAP

(Dashed line indicates an inferred water level)

BASE MAP FROM U.S. GEOLOGICAL SURVEY
1:250,000 TUCSON (1977), NOGALES (1969), AND DOUGLAS (1959)

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