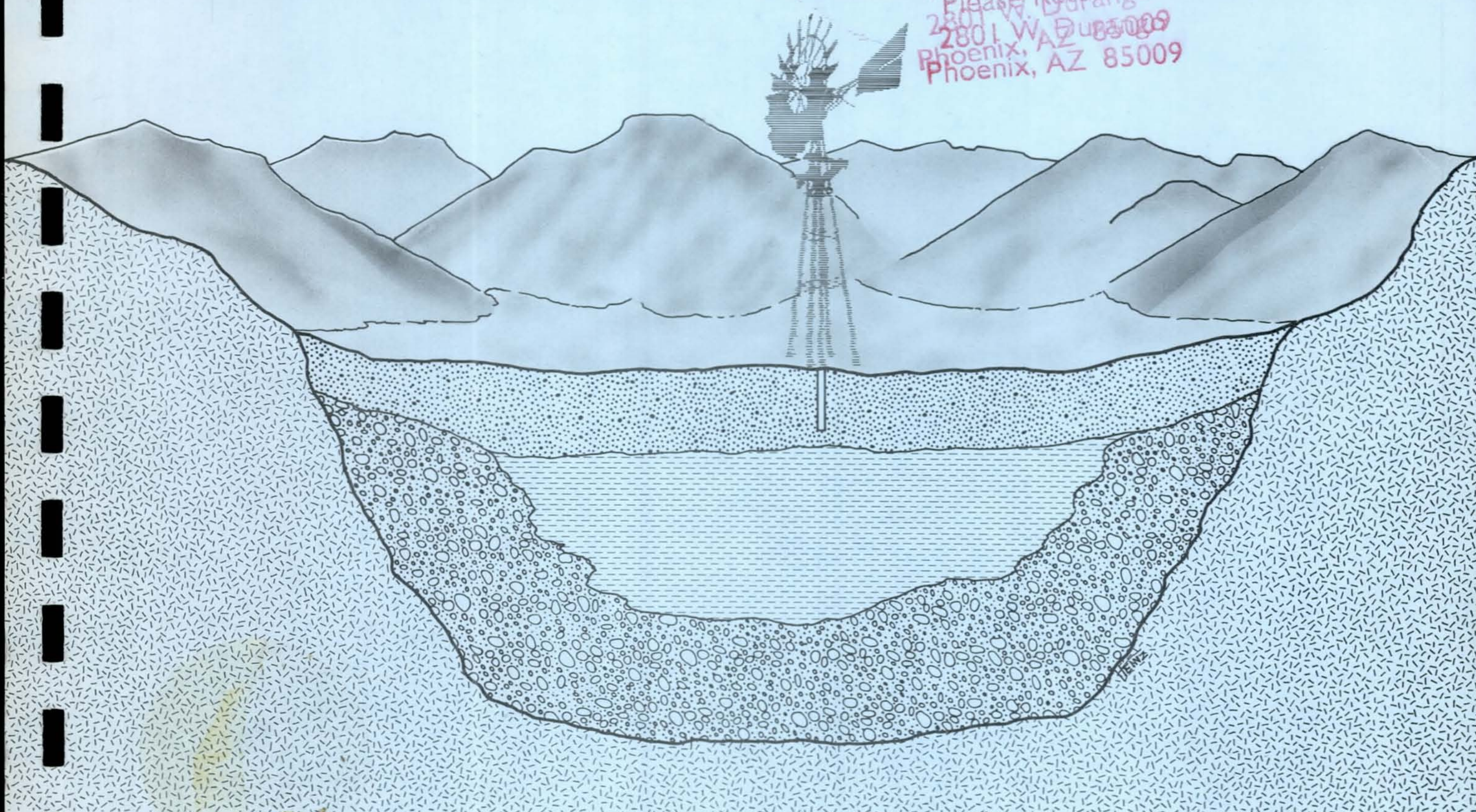
CENTRAL ARIZONA PROJECT

GEOLOGY AND GROUNDWATER RESOURCES REPORT

Maricopa and Pinal Counties, Arizona



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
LOWER COLORADO REGION

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VOLUME 1

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ARIZONA PROJECTS OFFICE
PHOENIX, ARIZONA

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

GEOLOGY AND GROUND-WATER RESOURCES REPORT

CENTRAL ARIZONA PROJECT, ARIZONA

Volume I

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INTRODUCTION

The economy of central Arizona utilizes nearly 100 percent of the indigenous surface water and requires an overdraft on the ground-water reservoirs. Ground water stored in the sediment filled structural basins of central Arizona is being slowly depleted principally by the demands of irrigated agriculture. Construction of the Central Arizona Project is a major step toward supplementing the ground water with a dependable source. The importation of Colorado River water accompanied by a reduction in ground-water pumping will go far to bring into balance the available supply with the demands of irrigated agriculture.

This report presents the results of comprehensive ground-water investigations that were conducted in the central service area of the Central Arizona Project by the Bureau of Reclamation during the 1962-1966 period with a subsequent water level measurement program conducted in the spring of 1972. Subsequent to this study the energy crisis significantly raised the cost of pumping. A 1976 summary of pumping costs is presented in the appendix.

A data base of geologic and hydrologic information was compiled from all available sources. The data available prior to this study were insufficient to discern the geological framework of the various ground-water reservoirs. The configuration and depth to bedrock and the degree of hydraulic connection between individual ground-water basins was a matter of conjecture. Detailed investigations by Reclamation to determine these features included: geologic mapping, geophysical surveys, deep test hole drilling, water level observation well networks, water sampling and laboratory analyses and pumping tests in wells. The objectives of the Bureau of Reclamation's ground-water investigations were threefold: (1) Determine the storage capacity of the ground-water basins underlying the central service area of the project; (2) Determine the average annual recharge available to each basin and the amount of overdraft under preproject conditions; and (3) Provide an adequate data base for making decisions pertaining to conjunctive management of indigenous and imported surface water and the remaining ground water storage.

The central service area is in Pinal and Maricopa Counties, Arizona. It is divided into nine subareas: (1) Eloy-Coolidge; (2) Maricopa-Stanfield; (3) Paradise Valley-Chandler-Queen Creek; (4) Phoenix-Buckeye; (5) Waterman Wash; (6) Harquahala Valley; (7) Tonopah-Arlington; (8) Gila Bend; and (9) Komatke-Sacaton (see Drawing No. 344-314-1030). All of the subareas are hydrologically connected to some degree either by surface channels or ground-water aquifers. The geology and ground-water hydrology of each subarea are evaluated in relation to sound water resources management of the central service area as a whole.

Previous Investigations

The area covered in this report has been partially studied and reported on by various investigators, intermittently since the turn of the century. The earliest work of any detail over a large protion of the area was reported on by W. T. Lee (1904, 1905). Various publications by Messrs. O. E. Meinzer (1915), C. P. Ross (1922), K. Bryan (1922), W. N. White (1934), and G. E. T. Smith (1938, 1940) contributed further to general knowledge of ground-water resources of the overall area. Following the establishment of a cooperative program between the U.S. Geological Survey and Arizona State Land Department in 1940, more qualitative data became available. Ground-water reports by Turner (1940), Babcock (1942), and others were prepared for individual areas, culminating in the 1952 report "Ground Water in the Gila River Basin and Adjacent Areas, Arizona - A "Summary." This report presented selected data and interpretations for much of Arizona. Subsequent reports were again, and are being, prepared for local areas.

Quantitative ground-water analyses directly related to the proposed Central Arizona Project were prepared by Turner and others (1945) and for congressional use by Turner, et al., (1951), and in 1952 by Halpenny, et al. The 1945 material was prepared by the Geological Survey as a ground-water appendix for the Bureau and became part of the feasibility report. During the congressional hearings, the analysis underwent rigorous criticism. The Survey concluded in its own report that the data available were inadequate for a meaningful analysis and recommended a most comprehensive program to obtain the necessary data. This recommendation was also emphasized in the 1952 report.

Much of the data contained in the aforementioned reports and subsequent reports were freely utilized in the preparation of this report. Additional data have been furnished by State and county agencies, municipalities, private companies, irrigation districts, and individuals. Their cooperation is gratefully acknowledged.

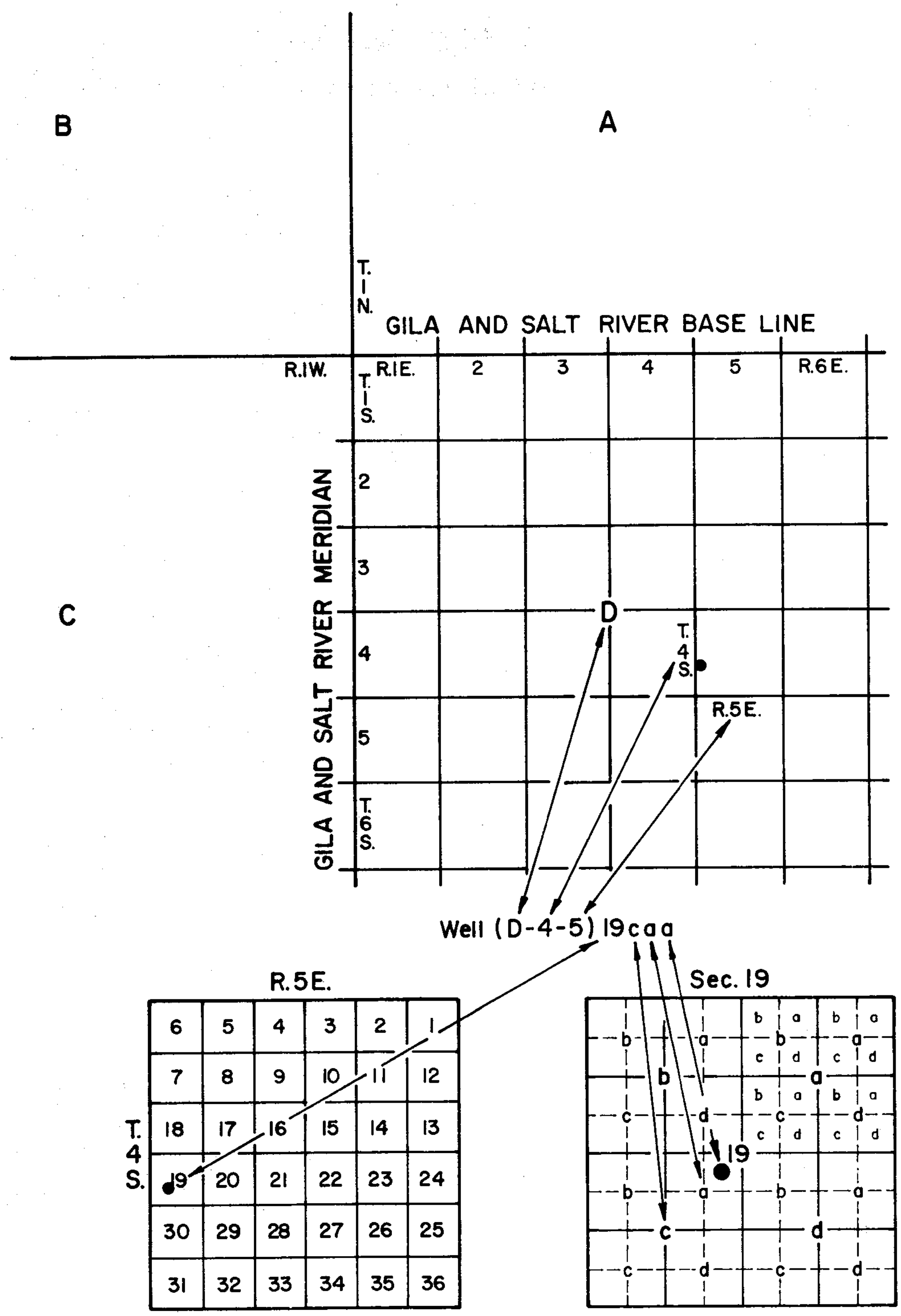
Well Numbering System

Wells have been numbered according to the public land system of rectangular coordinates. The letter-number well identification units designate, in order, the township, range, section, and 10-acre tract within the section. 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 counterclockwise by the capital letters A, B, C, and D. 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 lower case letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes the 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northeast quarter. For example, well number (D-4-5) 19caa designates the well as being in the NE1/4NE1/4SW1/4 Sec. 19, T. 4 S., R. 5 E. See the example that follows on page 5.

Geophysical Program

From the data available prior to this study, it was readily apparent that the geological framework of the various ground-water reservoirs was virtually unknown. The configuration, depth to structural or hydrologic bedrock, and degree of hydrologic interconnection of the various basins were a matter of conjecture. The geologic and attendant hydrogeologic units were not adequately established nor was the occurrence of ground water within these units. Detailed investigations to determine these features were therefore included as an integral facet of the project investigations.

Geophysical surveys were utilized as rapid, relatively inexpensive methods to acquire the necessary information on a scale large enough to reveal



B
A
C
D
T. I N.
GILA AND SALT RIVER BASE LINE
GILA AND SALT RIVER MERIDIAN
R.IW.
R.IE.
2
3
4
5
R.6E.
T. I S.
T. 4 S.
R.5E.
T. 6 S.
Well (D-4-5) 19caa
R.5E.
T. 4 S.
Sec. 19

the broader features of the aggregate, structurally controlled basins. Gravity, airborne magnetic, and seismic refraction methods were utilized. The application of each geophysical method is discussed below.

Gravity -- Because of the density contrast between the Tertiary to Quaternary sediments and the pre-Cenozoic rocks, gravity studies were utilized as the primary method. The gravity survey which included 2,821 gravity stations and covered about 8,600 square miles was conducted during several periods between November 1962 and March 1964. The main objective of the work was to define extensive gravity anomalies produced by thick sections of the Cenozoic rocks. The anomalies thus defined were then interpreted in terms of distribution and thickness of the Tertiary and Quaternary sediments, and the configuration of the surface of the Tertiary and older consolidated sedimentary and igneous rocks. Drawings Nos. 344-314-1258 through -1264 represent Bouger gravity anomaly maps contoured from gravity readings at the 2,821 stations. The Bouger anomaly values range from -26 milligals over Precambrian rock southwest of Gila Bend to -116 milligals over a basin south of Red Rock. The largest local anomalies are in areas underlain by thick Tertiary and Quaternary sediments and, in part, associated volcanics and significant evaporite deposits.

Airborne Magnetic -- The aeromagnetic survey covered an area of about 1,100 square miles and included the Maricopa-Stanfield subarea and part of the Eloy-Coolidge subarea. This area was flown on an experimental basis to evaluate the interpretative results and its contribution to the objectives of the geophysical program. These data are presented in GP-548 published by the U.S. Geological Survey in 1965.

The local magnetic anomalies are produced primarily by compositional variations within the basement rock, by Cenozoic volcanic rocks, and by relief on the top of a magnetic basement rock. Alluvial material and schistose rocks are essentially nonmagnetic. Similar to large negative gravity anomalies, large negative magnetic anomalies reflect areas underlain by thick Cenozoic sediments. The main value of the magnetic data was generally to confirm the gravity interpretations.

Seismic -- Thirteen seismic refraction spreads were shot, ranging in length from 4,400 to 9,020 feet. As many as three spreads were laid end-to-end and shot in such a manner that the composite data were equivalent to that obtained by shooting a single spread.
The seismic data indicated five recognizable layers, ranging in velocity from about 1,800 feet per second for dry, unconsolidated material to over 17,000 feet per second for igneous or metamorphic basement rock. Drawings Nos. 344-314-1261, -1263, and -1264 show the spread locations.

The interpretations of the geophysical data are disseminated throughout the report and are especially prominent under Ground Water Geology.

Test Hole Program

To complete the broad, generalized picture obtained from the geophysical program, an intensified program of core hole drilling and collection of cuttings and water samples from private wells was conducted. In all, 14 test holes were drilled, including Compaction Recorder test hole (see Drawing No. 344-314-1030), within the boundaries of the study area and either partially or completely cored up to depths of about 2,000 feet. In each, electric and/or gamma and sonic logs were run and individual piezometer pipes set in individual water bodies, from which water samples for analysis were drawn, and in which periodic water level measurements have continually been made.

Much of the hydrogeologic and water quality interpretations contained in this report were based on the data provided by the test hole program.

General

The central Arizona Project area is characterized by broad alluvial valleys separated by mountain ranges that rise abruptly to maximum heights of several thousand feet above the remarkably flat valley floors. Each valley is underlain by its related ground water reservoir. The mountain ranges primarily comprise igneous and metamorphic rock types that are essentaially non water bearing. Heterogeneous "basin-fill" deposits, estimated to range in thickness to about 10,000 feet in individual basins, constitute the major ground-water reservoirs The general geology of the area is shown on Drawing No. 344-314-1031.

Geologic Setting

The study area lies within the Basin and Range physiographic (and inherently structural) province that characterizes southern and western Arizona. The outline of this province was probably formed by the regional warping and large scale normal faulting that occurred during middle Tertiary time. Thick sequences of primarily conglomerate and sandstone were deposited during this period contemporaneously with thick accumulations of volcanic rock. Continued differential uplift and subsidence accompanied by normal faulting that probably extended into Pliocene time accentuated the early Basin and Range features. Alluvial and lacustrine-playa type "valley fill" deposits, comprising the effective central Arizona ground water reservoirs, began to accumulate on the dissected middle Tertiary rocks. Uplift and erosion continued into the Quaternary with alternating periods of subsidence and deposition with accompanying volcanic activity. The deposits of middle Tertiary age were involved in major faulting and tilting but those of late Tertiary and Quaternary age have had minor displacement only locally.

The magnitude and periods of uplift or subsidence, the effect of this movement on existing drainage patterns, and contemporaneous volcanic activity have determined the vertical sequence and lateral variations of "valley fill" deposits in any one basin or group of basins. The type of drainage that existed during the "filling" process, major or tributary, interior or through flowing, also is a major determinant of the geologic framework of any one basin.

Detailed structure of individual basins within the study area has largely been obscured by erosion and alluviation. Pediments, characterized by small bedrock masses protruding through thin overlying alluvium along the base of mountain fronts, are readily evident. Valleyward, the pediments terminate abruptly at fault boundaries. The gravity maps, Drawings Nos. 344-314-1258 through -1264, broadly indicate some inferred fault boundaries, the configuration of individual structural depressions, and buried bedrock constrictions.

Stratigraphy

Basement Complex Undifferentiated -- The basement complex that floors the basins and forms the mountain and highland areas surrounding the various basins is primarily Precambrian granite, gneiss, and schist, Laramide-related intrusive granites and extrusive volcanic flows, and middle Tertiary to Precambrian sedimentary rocks. This complex of rocks is of no significance as a source of ground-water supply except in local areas where the middle Tertiary sedimentaries and volcanics are saturated and are a part of the utilized ground-water reservoir.

Late Tertiary to Recent Valley-Fill Deposits --

General -- The effectual ground-water reservoir consists primarily of middle to late Tertiary and Quaternary valley-fill deposits. The division of this vast body of variably consolidated sediments into formational units according to stratigraphic time-lithology systems, generally applicable to bedded sedimentary rocks, is very difficult. This is due to the absence or scarcity of fossiliferous and/or marker horizons, lenticularity of the beds, and lack of well-defined stratified subdivisions in the great bulk of deposits. Some investigators in the area have attempted time division to some extent, on the basis of subtle color differences, and/or grain-size analysis. This methodology is somewhat tenuous. After detailed study of the core samples from the exploration program, and correlation with cuttings and electric logs from test holes and water wells, a threefold division of the water-bearing materials was made on the basis of dominant lithology. The gross distinction between these "units," as they are referred to on the cross sections and text, is remarkably consistent within basins and from basin to basin.

The oldest division of the water-bearing sequence is a variably cemented conglomerate which lies directly on the undifferentiated basement complex. This unit is directly overlain by the Middle Fine-Grained Unit in the larger basins and by the Upper Alluvial Unit in the smaller basins. The Middle Fine-Grained Unit, where present, is directly overlain by the Upper Alluvial Unit. The conglomerate is interpreted to be middle to late Tertiary in age, probably deposited during the accentuated Basin and Range features that resulted from Miocene to Pliocene structural movement. It is further interpreted that the Middle Fine-Grained Unit that occurs in the larger basins was influenced by this middle to late Tertiary movement and volcanic activity.

The characteristics of each of the three water-bearing units are discussed below:

The Lower Conglomerate Unit -- The lithology of the Lower Conglomerate is intimately related to its local source area. If the source area was primarily volcanics, the pebble to cobble size fragments are primarily volcanic, a primarily granite source resulted in primarily granite fragments, etc. The fabric of the conglomerate is suggestive of a fanglomerate-type deposition. The color ranges from buff to brown, quite distinctive from the older Tertiary rocks which are brick red to dark brown. Drawings Nos. 344-314-1251 through -1257 illustrate the structural configuration of the Lower Conglomerate in individual basins.

The Middle Fine-Grained Unit -- The Middle Fine-Grained Unit is defined as an interior-basin deposit, lacustrine and/or playa, and younger in age (Pliocene?) than the Lower Conglomerate. Its areal and vertical configuration is interpreted as being controlled by the middle to late Tertiary normal faulting and volcanic activity. The various basins that do not contain this unit either did not experience this late faulting, or hydrologic conditions were such that through-flowing streams were maintained throughout the middle to late Tertiary. The damming of through-flowing streams by volcanic activity is especially evident in the Arlington and Gila Bend areas. The occurrence of the fine-grained unit is illustrated on Drawings Nos. 344-314-1244 through -1249. Typically, the occurrence is limited to the deep basins. Concurrent and/or post-depositional downwarping is indicated in all areas of occurrence.

The lithology is characterized by a fine interbedded sand and silty clay upper section, a silt and clay (with interbedded sands) with reworked evaporites as a middle section, and primarily evaporites with minor clay and silt in the lower section.

The materials are commonly brown to buff but gray, blue, and green beds are also present, indicative of reducing conditions inherent to a lacustrine environment. Cores from this unit in test hole (D-7-8) 31bba were tested for various physical properties. The materials were classified as lean to fat silty clay, with most of the clay mineral identified as montmorillonite. Sand to silty sand interbeds occur sporadically within the upper and middle sections. These sandy materials are commonly exploited by water wells in the deeper basins, even though quality of water worsens with depth. Wells that penetrate the evaporite section have either been abandoned or the section "cased off."

The Upper Alluvial Unit -- The uppermost of the three vertical zones of the reservoir is herein named the Upper Alluvial Unit. It is inferred that this unit comprises primarily late Pliocene to Recent deposition; it also includes portions of the Lower Conglomerate Unit along the pediment areas and alluvial sediments deposited contemporaneously with the Middle Fine-Grained Unit. In summary, this unit is more of an undifferentiated hydrogeologic unit in that it crosses time and lithologic lines to a much greater extent than the lower units.

Much of this unit is unconsolidated, relatively fresh to slightly weathered detritus of all igneous and metamorphic rock types that surround the area. It also includes reworked older alluvial materials. Much of the younger Quaternary materials were laid down rapidly by streams heavily loaded and of high discharge since there is only sporadic evidence of mature soil profile. The older Plio-Pleistocene materials conversely have developed good soil profiles and strongly developed "hardpan" soils, indicative of deeply weathered conditions.

Much of the material along the axial portion of many of the basins is primarily fine-grained, with the coarser material occurring as near-surface deposits. Drawings Nos. 344-314-1237 through -1243 illustrate the thickness of this unit within the subareas.

Geologic Sections A-A through Y-Y (Drawings Nos. 344-314-1152 through -1192) and companion Hydrologic Sections (Drawings Nos. 344-314-1196 through -1235) illustrate geologic, historic water levels, and quality of water interrelationships within the subareas.

GROUND-WATER CONDITIONS

General

The valley-fill deposits are the principal source of ground water in the Central Arizona Project area. The mountain areas that enclose most of the subareas are effective barriers to ground water movement. Buried bedrock masses often impede movement of ground water between designated subareas. However, there is some degree of interconnection between all of the designated subareas.

Because of the heterogeneity of the valley fill, ground water occurs under a wide range of hydrologic conditions, ranging from semiperched or perched to confined. In all of the major basins that contain lacustrine deposits, four distinct bodies of ground water occur. In downward succession they are (1) bodies of semiperched or perched poor-quality water in the Upper Alluvial Unit that occur at depths of about 100 feet and more below ground surface, (2) the major regional body of unconfined and semiconfined water, the upper portions of which are poor quality in local areas in the Upper Alluvial Unit, (3) a body of semiconfined good to poor-quality water in the Middle Fine-Grained Unit, and (4) a body of confined good to marginal quality water contained within the Lower Conglomerate Unit.

The basins that do not contain the Middle Fine-Grained Unit commonly have but one recognizable water body that is probably unconfined to semiconfined. Local concentrated pumpage, however, has created anomalous water levels within this water body.

The heavy ground-water draft affects the configurations of the different ground-water bodies, and selective pumping has made significant local differences in water levels between the various water bodies. However, control is inadequate to allow individual contouring of each water surface. Drawings Nos. 344-314-968 through -974, -1013 through -1019, and -1265 through -1270, for the years 1952, 1964, and 1972, respectively, illustrate the unconfined to semiconfined water surface elevations throughout the study area and, in selected areas, the elevations of perched or semiperched water where the data were available to generally delineate their occurrence. A few water levels associated with the Lower Conglomerate Unit were used in the contouring of the major regional water body.

The long-term ground-water declines that have prevailed in all of the subareas to be discussed are a direct reflection of excessive ground water withdrawals in the individual subareas and also reflect cumulative effects of contiguous areas. Each occurrence of water is also interrelated so that the effects of recharge or discharge to or from one water body is reflected in another.

Water levels fluctuate seasonally as well as over the long term. There is a short-term decline from a spring peak to a fall low, with subsequent near recovery the following spring. In the natural or near-natural state, seasonal and long-term fluctuations would trend in response to wet and dry cycles. Such fluctuations, however, have been greatly accentuated or even obliterated by the perennial overpumpage.

The detailed discussions of ground-water conditions within each of the subareas are mainly concerned with the 1952 to 1964 study period.

However, to update the information, water level measurements were made in the spring of 1972 in seven of the subareas. Drawings covering the 1964 to 1972 study period are included for each of these subareas, and a brief discussion of ground water conditions is appended to each of the texts.

Eloy-Coolidge Subarea

The Eloy-Coolidge subarea lies in south-central Pinal County and includes the San Carlos Project Irrigation and Drainage District, the Central Arizona Irrigation and Drainage District, and the Randolph Irrigation District (inactive). The Arizona State Land Department designated all lands within the Eloy-Coolidge subarea as critical ground-water areas in 1949 and 1951.

The gravity survey (Drawing No. 344-314-1264) broadly indicated that two adjacent and hydrologically connected structural basins comprise this subarea; a larger and much deeper northeasterly trending basin in the southern portion, separated by a subdued rock constriction from a generally northwesterly trending and shallower basin in the northern portion. The subarea is largely encompassed by mountains comprising basement rock.

The entire sedimentary sequence varies in thickness from 0 to an estimated 9,000 feet in the deepest part of the basin south of Eloy. Many relatively shallow wells penetrate the basement rock along the subarea periphery, primarily in the Casa Grande area. The deepest well in the area, about five miles south of Coolidge, was completed at a depth of 3,250 feet without penetrating rock.

The major source of ground water in this subarea is the Upper Alluvial Unit. This unit ranges in thickness from 0 to over 1,200 feet south of Eloy (see Drawing No. 344-314-1243). Ground water in this unit is generally unconfined; however, perched or semiperched conditions also occur as evidenced by "cascading" wells (see Drawings Nos. 344-314-1019 and -1270). Semiconfined conditions probably also occur at depth locally.

A secondary and more recent source of ground water in this area is from the Lower Conglomerate Unit. In an effort to replace declining well yields, deep wells have been drilled to penetrate this unit. The thickness of this unit ranges from 0 to at least 800 feet, the thickest sections occurring within the deep portions of the basins. The known top surface of the Unit ranges from about 1,200 feet below to about 1,200 feet above sea level (see Drawing No. 344-314-1257). Ground water in this unit is generally confined where overlain by the Middle Fine-Grained Unit, but in those areas where the Upper Alluvial Unit directly overlies it, it may not be confined. In the northwestern portion of the subarea, and possibly in other areas along the western periphery, the older conglomerate of Tertiary Age directly underlies this unit and probably has been included in thickness and elevation calculations.

The Middle Fine-Grained Unit separating the two main water-bearing units is considered an aquiclude, but it does yield minor quantities of water from thin sandy horizons. However, primary and secondary accumulations of evaporite minerals make most of the water too salty for any use. The thickness of this unit ranges from 0 to at least 2,300 feet with thicker sections occurring in the deeper portions of the basins. The top surface of this Unit Unit ranges from 400 feet to 1,200 feet above sea level (see Drawing No. 344-314-1250). The evaporites include mainly selenite, gypsum, halite, and anhydrite which consistently appear as marker horizons on electric logs. The main zone of evaporites usually appears 100 to 200 feet below sea level. The top of the secondary zone intermittently appears 300 to 400 feet above sea level. Ground water in this Unit probably occurs under semiconfined to confined conditions.

Significant recharge in the subarea from surface water sources is restricted to that area served by the San Carlos Project, generally north of the Florence - Casa Grande Canals. Seepage losses from canals and laterals and excess irrigation application are the most significant sources in the entire subarea. Minor recharge also occurs from subsurface inflow, natural percolation in stream channels, peripheral or mountain-front percolation in washes, and an artificial source resulting from compaction of fine-grained sediments within the ground-water reservoir.

Predevelopment ground-water elevation contours (Drawing No. 344-314-1304) indicate that ground-water movement was primarily northwesterly through the subarea, with subsurface inflow generally originating from the Gila and Santa Cruz Rivers. Subsurface outflow was mainly to the Maricopa-Stanfield and Komatke-Sacaton subareas to the west and north, respectively. The subsurface outflow passing into the Maricopa-Stanfield subarea occurred across a section roughly from the Sawtooth to Sacaton Mountains.

By 1952, with intensified ground-water development, ground-water movement has changed significantly (see Drawing No. 344-314-973). While subsurface inflow was yet entering the area along the Santa Cruz and Gila Rivers, subsurface outflow into the Maricopa-Stanfield subarea was eliminated with the formation of a ground-water divide between the Casa Grande and Sacaton Mountains. Subsurface outflow into the Komatke-Sacaton subarea continued as previously. The development of a widespread pumping trough had begun which stretched roughly north-south through the subarea.

By 1964, the effects of perennial overpumpage intensified the pattern of pumping troughs and ground-water divides (see Drawing No. 344-314-1019). Pumping troughs developed east of the Sawtooth Mountains, between the Sawtooth and Casa Grande Mountains, and over the general San Carlos Project area. The ground-water divide between the Casa Grande and Sacaton Mountains was sharply accentuated and minor divides formed northeast and southeast of the Casa Grande Mountains and between the Sawtooth and Casa Grande Mountains. Declining water levels in the area west, north, and south of Picacho Reservoir accentuated the pattern of seepage occurring in this unlined reservoir. Cascading water in wells was first measured in 1964. The contours on the shallow-water body are based on these measurements.

Lines of equal depth to ground water in 1964 (Drawing No. 344-314-981) show variance from about 80 feet below ground surface a few miles southwest of Casa Grande to 340 feet in the extreme southeast portion of the subarea. In the area north of the Florence-Casa Grande Canals the average depth to water in 1964 was about 180 feet, with a maximum of 260 feet in the pumping trough south of Coolidge. In the area south of the Florence-Casa Grande Canals, the average depth to water in 1964 was about 280 feet, with a maximum of 340 feet.

Pumping lifts in the area north of the Florence-Casa Grande Canals, based on data for the 1961 to 1964 period, ranged from about 180 to slightly over 470 feet. Pumping lifts in the area south of the canals ranged from about 240 feet to slightly over 560 feet. As of 1964, it is estimated that about 650 high-capacity wells were pumping in the subarea, ranging in depth from 200 to about 3,200 feet. Capacities of the wells ranged from about 500 to 3,000 gallons per minute. With perennially deeper pump lifts, farmers have trended toward converting from electrical energy to natural gas for economy. In 1964, about 40 percent of the pumpage was from natural gas installations. It is difficult to say whether this trend will continue since it is dependent upon the variable price structures of both sources of energy.

Ground-water declines during the 1952 to 1964 period ranged from about 20 to over 140 feet (see Drawing No. 344-314-1026). The maximum declines occurred about 4 miles south of Coolidge, immediately south of the Casa Grande Mountains and in the area immediately west of the lower Picacho Mountains. The minimum declines occurred along the northern and northwestern portions of the subarea. Average water-level declines for the 1952 to 1964 period, in that part of the area north of the Florence-Casa Grande Canals, were about 60 feet or 5 feet per year, and in the subarea south of the canals about 90 feet or 7.5 feet per year. Long-term water-level declines during the 1923 to 1964 period range from 60 to over 200 feet (Drawing No. 344-314-1305). The hydrologic cross sections (Drawings Nos. 344-314-1196 through -1201) relate the 1952 to 1972 ground-water decline to the hydrogeology.

Test-hole hydrograph (D-9-7) 34ada, Pipes Nos. 1 and 2, Drawing No. 344-314-1285, illustrates the marked difference in water levels inherent to the water bodies contained in the Upper Alluvial and Lower Conglomerate Units. This difference is evident throughout the southern part of the subarea because most of the pumping in the general area is from the Lower Conglomerate Unit. The range and trend of seasonal and long-term fluctuations are also illustrated. During the period of record, the water levels in the Lower Conglomerate Unit, Pipe No. 1, have declined about 75 feet while in the Upper Alluvial Unit, Pipe No. 2, the decline was about 20 feet. Seasonal fluctuations averaged about 15 feet in the lower water body and about 5 feet in the upper water body.

Hydrograph (D-9-8) 35ddd, Drawing No. 344-314-1286, shows a typical long-term water-level fluctuation in the southeastern part of the subarea where most of the surrounding pumping is from the Upper Alluvial Unit.

Hydrograph (D-8-7) 25ddd, Drawing No. 344-314-1286, shows a typical long-term water-level decline of about 200 feet in ten Upper Alluvial Unit in the Eloy area.

The water-level and aquifer compaction observation well, hydrograph (D-7-8) 31bba, Drawing No. 344-314-1284, illustrates the typical, large seasonal fluctuations that occur within a heavily pumped area. For comparison, test-hole hydrographs (D-7-8) 25ccc, Drawing No. 344-314-1285, located on the eastern edge of the heavily pumped area, show the smaller but still substantial seasonal fluctuations. The two piezometer pipe hydrographs in this test hole indicate a water-level differential of about 40 feet within the same hydrogeologic unit (in this case the Upper

Alluvial Unit). This occurs because of differences in lithology or depth of perforations in nearby wells.

Test-hole hydrograph (D-6-9) 27cbb, Drawing No. 344-314-1285, located in an area of no pumping and on the extreme eastern edge of the subarea illustrates the insignificant seasonal fluctuation but still the long-term decline resulting from overpumping to the west.

Hydrographs (D-6-8) 4add, (D-6-6) 7aaa, and (D-6-6) 35add, Drawings Nos. 344-314-1287, and -1286, illustrate typical fluctuations that occur in the San Carlos Project area. Seasonal fluctuations can be seen on (D-6-6) 7aaa (Drawing No. 344-314-1286) for the years 1947 through 1956. Note the rises in water levels after 1958 reflecting the above-average diversions from the Gila River into the Florence-Casa Grande Canal during that period.

The quality of ground water in the Eloy-Coolidge subarea varies greatly both areally and with depth. In general, the water in the Upper Alluvial Unit in the area south of the Florence-Casa Grande Canals is of the sodium-calcium bicarbonate type and commonly is less than 500 parts per million. Deep wells that penetrate the Middle Fine Grained Unit commonly pump water of either the sodium chloride or calcium sulfate type (or admixtures of both) and total dissolved solids range up to 17,000 parts per million. Wells that penetrate the Lower Conglomerate Unit commonly have water of the sodium-calcium bicarbonate type similar to the Upper Alluvial Unit.

North of the Florence-Casa Grande Canals the Upper Alluvial Unit contains water of sodium chloride and calcium sulfate admixtures that commonly contains more than 500 parts per million. Wells that penetrate the Middle Fine Grained Unit commonly exhibit sodium chloride and/or calcium sulfate water that contains up to 4,000 parts per million total dissolved solids. Deep wells that are perforated only in the Lower Conglomerate Unit pump water that is commonly of the sodium chloride or sodium sulfate type. Where the salt section of the Middle Fine Grained Unit is not effectively sealed, these same type wells show admixtures of sodium chloride and calcium sulfate (see Drawing No. 344-314-1283).

The 1964 to 1972 Study Period - - The 1972 ground-water elevation map (Drawing No. 344-314-1270) shows the effect of overpumpage which continued throughout much of the subarea. Pumping troughs were expanded southeast of Eloy, east of the Sawtooth Mountains, and north of the Casa Grande Mountains. Subsurface outflow was limited to the northwest between the Sacaton and San Tan Mountains into the Komatke-Sacaton subarea.

Depths to ground water in 1972 (Drawing No. 344-314-1276) were from 60 to 80 feet below ground surface a few miles southwest of Casa Grande to 440 feet in the center of the pumping trough southwest of Eloy. Average depth to water in the subarea was about 245 feet below ground surface.

The 1964 to 1972 water-level change map (Drawing No. 344-314-1282) shows maximum declines in excess of 80 feet in the pumping trough southeast of Eloy with up to 80-foot declines in the other major pumping holes. The water level within the Upper Alluvial Unit south of Casa Grande Mountains showed little change as indicated by the decline map. However, individual water-level measurements of deeper wells drawing essentially from the Lower Conglomerate Unit in the same area indicated declines in excess of

100 feet for the 1964 to 1972 period which are not reflected on the decline map. This same separation of water levels can be seen in USBR test well (D-9-7) 34ada (Drawing No. 344-314-1285) in which the water level in the Lower Conglomerate Unit (Pipe No. 1) has declined about 80 feet more than that in the Upper Alluvial Unit (Pipe No. 2). Water levels throughout much of the San Carlos Project rose slightly, probably in response to an increase in surface supply for irrigation (see Drawing No. 344-314-1287).

A comparison of elevation contours on the upper semiperched water body indicates that for the 1964 to 1972 period, declines of from 20 to 40 feet occurred throughout much of this area, although in the vicinity of Picacho Reservoir declines were much smaller.

Hydrograph (D-9-8) 35ddd illustrates continuing large water-level declines in the southeastern part of the subarea, but declines in the Upper Alluvial Unit west of Eloy (D-8-7) 25ccc (Drawing No. 344-314-1286) were small.

Hydrographs (D-6-8) 4add and (D-6-6) 35add (Drawing No. 344-314-1287) show the slight water-level rises attributed to increased surface water supplies within the San Carlos Project.

<u>Maricopa-Stanfield Subarea</u>

The Maricopa-Stanfield subarea lies in west-central Pinal County. It contains the Maricopa-Stanfield Irrigation and Drainage District, the Ak Chin Maricopa Indian Reservation Irrigation Project, and parts of the San Carlos Project Irrigation and Drainage District, the Central Arizona Irrigation and Drainage District, and the Chuichu Indian Irrigation Project. The subarea is part of the Gila-Santa Cruz critical area created by the State Land Department in 1951 and expanded in 1954.

The gravity survey (Drawing No. 344-314-1263) indicated a long, relatively narrow basin trending generally northwest with a major gravity low in the northern portion between Maricopa and Stanfield and a subdued smaller low extending southeast from Stanfield. Basement rock is exposed in the mountains that partially surround the subarea. The gravity contours also indicate a shallow southeasterly trending basement extension of the Sacaton Mountains that surfaces as the Casa Grande Mountains. This buried basement ridge almost completely separates this subarea, hydrologically, from the Eloy-Coolidge subarea to the east.

Based on gravity contours, the thickness of the sedimentary sequence overlying the basement complex varies from 0 to an estimated 4,000 feet in the deepest part of the basin south of Maricopa. The deepest well in the subarea some five miles northeast of the gravity low was drilled to a depth of 3,640 feet. Granite was penetrated a 2,160 feet.

Adjacent to the mountains ringing the basin on the east and west, basement rock has been reported in numerous wells at depths ranging from about 100 to over 1,000 feet. In the south end of the basin adjacent to the Casa Grande and Tat Momoli Mountains and the Vaiva Hills, volcanic rocks are interbedded with the conglomerate (Drawing No. 344-314-1256).

The Upper Alluvial and Lower Conglomerate Units contribute significant amounts of ground water to the subarea. The Upper Alluvial Unit ranges in thickness from 0 to more than 600 feet near Maricopa (Drawing No. 344-314-1242). The total thickness of the Lower Conglomerate Unit is not known, but it exceeds 1,500 feet. The top surface of this unit varies from about 1,200 feet above sea level in the southeast part of the subarea to more than 400 feet below sea level in the northern part of the subarea (Drawing No. 344-314-1256). In the deepest part of the basin, wells have not yet fully penetrated this unit.

In the area west and north of Casa Grande, surface exposures of the older Tertiary conglomerate, that has been arbitrarily grouped with the Basement Complex, indicates that it underlies the Lower Conglomerate Unit at shallow depths and cannot be differentiated from the Lower Conglomerate Unit on drillers logs.

The Middle Fine-Grained Unit is considered an aquiclude; however, locally, sandy zones in the upper part of the unit yield water to wells supplementing the water from the Upper Alluvial Unit. This unit only occurs in the northern and north-central part of the subarea. The upper surface of the Middle Fine-Grained Unit ranges from about 600 to about 1,000 feet above sea level (Drawing No. 344-314-1248). The Unit ranges in thickness from 0 to over 1,600 feet. One relatively continuous zone of evaporites, reported to be gypsum, anhydrite and selenite, and varying in thickness from about 300 to 500 feet, occurs in the north-central part of the subarea. It was generally encountered 10 to 50 feet below sea level.

Recharge to the ground-water reservoir of the Maricopa-Stanfield subarea from all sources is minimal. Return flow from excess irrigation water appears to constitute the major source. Minor sources of recharge include natural percolation in stream channels and from peripheral runoff along the mountain fronts and from subsurface inflow into the area. Some induced recharge occurs as a result of the compaction of fine-grained sediments within the ground-water reservoir.

Prior to agricultural development, ground water moved through the area in a generally northwesterly direction. Subsurface inflow was mainly from the Eloy-Coolidge subarea through gaps north and south of the Casa Grande Mountains. Subsurface outflow was to the north into the Komatke-Sacaton subarea along a line roughly extending from the southern tip of the Sierra Estrella to the Sacaton Mountains (Drawing No. 344-314-1304).

The agricultural development that intensified near the end of World War II began to alter the natural ground-water regimen of the subarea. By 1952, ground-water movement was still generally west and northwesterly through the area (Drawing No. 344-314-973). However, subsurface inflow had ceased north of the Casa Grande Mountains due to heavy pumping along both sides of the buried rock ridge joining the Sacaton and Casa Grande Mountains and the formation of a ground-water divide over the ridge. Subsurface outflow was still north into the Komatke-Sacaton subarea.

By 1964, a radical change in the movement of ground water within the subarea had taken place (Drawing No. 344-314-1018). Pumping troughs were well developed along the west side of the basin and in the northeast portion of the basin west of the Sacaton Mountains. Subsurface inflow from the Eloy-Coolidge subarea had essentially ceased. North of the Casa Grande Mountains, the ground-water divide had moved slightly west and was now well defined. South of the Casa Grande Mountains, a pumping trough on the border between the two subareas had caused a reversal in the ground-water gradient with an attendant subsurface flow out of the Maricopa-Stanfield subarea. Subsurface outflow to the north was terminated due to the formation of a ground-water divide extending east and west from Maricopa. By 1964, ground water moving into the area on the northeast from the Komatke-Sacaton subarea was increased significantly because of increased gradients caused by the pumping trough southwest of the Sacaton Mountains. Cascading water in wells became prevalent. Generalized contours of this shallow water body are shown on Drawing No. 344-314-1018. There is not sufficient data available to delineate the piezometric surface of the confined water body.

Depth to ground water in 1964 (Drawing No. 344-314-980) varied from less than 60 feet below ground surface just west of Casa Grande to over 540 feet in the pumping trough west of Stanfield. The weighted average depth to water for the subarea was about 280 feet.

Pumping lifts for the Maricopa-Stanfield subarea, based on 1961-1964 data, varied from about 120 feet to over 590 feet and are believed to exceed 600 feet in the extreme southwestern part of the subarea. In 1964, there were an estimated 600 active high-capacity wells ranging in depth from about 300 to about 2,450 feet with most wells less than 1,200 feet. Well capacities varied widely, ranging from 250 to about 3,000 gallons per minute. Both electricity and natural gas are used to operate the pumps in the subarea with gas energy accounting for about 40 percent of the total pumpage.

The decline in ground-water levels for the 12-year period 1952-1964 ranged from less than 20 to over 260 feet (Drawing No. 344-314-1025). The maximum declines occurred in the pumping trough northwest of Stanfield and in a strip extending south from the west end of the Sacaton Mountains to a point south and west of Stanfield. The areas of least decline were along the eastern edge of the subarea, west of Casa Grande, and north and east of Maricopa. The weighted average ground-water decline throughout the subarea for the 1952-1964 period is about 144 feet or 12 feet per year. The relationship of the declining water table to the water-bearing units for the 1952 to 1972 period is shown on Drawings Nos. 344-314-1202 through -1206.

Hydrograph (D-6-3) 21bcc (drawing No. 344-314-1290) shows the maximum water-level declines occurring in the pumping trough west of Stanfield. During the 1952-64 study period, the water table dropped about 255 feet completely dewatering the Upper Alluvial Unit. Test hole hydrograph (D-6-3) 21bba (Drawing No. 344-314-1288) illustrates the seasonal fluctuations in the Lower Conglomerate Unit averaging about 16 feet, as well as the continuing decline that occurred from 1964 to 1972. Well hydrograph (D-7-5) 5ddd (Drawing No. 344-314-1290) illustrates the overall change in water levels in this area. From 1952 to 1964, the water table declined 160 feet, or over 13 feet per year, and by the mid-fifties the Upper Alluvial Unit had been dewatered in this area. Test hole hydrograph (D-6-5) 19dda (Drawing No. 344-314-1288) shows the seasonal fluctuation in the Lower Conglomerate Unit in the southeastern part of the subarea. The two piezometer pipes show dissimilar levels, indicating the occurrence of differential head within the same hydrologic unit. The seasonal highs and lows, however, occur at the same times, indicating a similar response to nearby pumping. Hydrograph (D-4-3) 17daa (Drawing No. 344-314-1289) shows the comparatively small long-term change in water levels in the Upper Alluvial Unit around Maricopa. From 1952 to 1964, the decline was about 55 feet, or a little less than 5 feet a year. Test hole hydrograph

(D-4-3) 9cdd (Drawing No. 344-314-1288) shows the seasonal fluctuation, ranging to 69 feet, in the same unit in roughly the same area during the period 1964 to 1972. The water-level decline for this period was about 26 feet.

The quality of the ground water in the Maricopa-Stanfield subarea (Drawing No. 344-314-1283) varies with depth and areally, even within the same hydrologic unit. Throughout the central part of the subarea, extending northwest from the Chuichu Indian Project almost to Maricopa, the ground water in the Upper Alluvial Unit and the top of the Middle Fine-Grained Unit is predominately of the sodium-calcium bicarbonate type. This same type of water is found in the Lower Conglomerate Unit in the northeast corner of the subarea. Total dissolved solids in these areas are less than 1,000 parts per million.

In the northern part of the subarea, west of the Sacaton Mountains, the ground water contains varying admixtures of sodium chloride and calcium sulfate. The wells perforated only in the Upper Alluvial Unit yield sodium-calcium sulfate or sodium-calcium chloride type water. The wells penetrating the lower part of the Middle Fine-Grained Unit and/or the Lower Conglomerate Unit generally yield sodium sulfate type water.

Along the eastern edge of the subarea, where the Upper Alluvial Unit lies directly on the Lower Conglomerate Unit, poor-quality water exceeding 3,000 parts per million total dissolved solids was encountered in several shallow wells 100 to 400 feet deep. This water is high in sodium and calcium with sulfate and chloride the major anions. In this area, the quality appears to improve with depth to about 1,000 feet. Well (D-6-5)

19ddd yields water with less than 1,000 ppm from a perforated depth of 600 to 735 feet. In USBR test hole (D-6-5) 19dda, however, with a well screen set in the Lower Conglomerate Unit at 1,160 feet and the interval above 950 feet sealed off, the water produced was high in sodium chloride and calcium sulfate with total dissolved solids of over 2,300 ppm.

Along the western edge of the subarea, where the Middle Fine-Grained Unit is absent, wells produce water of the sodium bicarbonate chloride type ranging from about 1,200 to over 1,600 ppm total dissolved solids.

The 1964 to 1972 Study Period -- Pumping in the subarea continued to deepen the ground-water troughs northwest of Stanfield along the western periphery of the basin and southwest of the Sacaton Mountains. By 1972, nearly all ground-water movement within the subarea was toward these two troughs (Drawing No. 344-314-1269) and ground-water outflow from the subarea was virtually nonexistent except for the small amount to the Eloy-Coolidge subarea south of the Casa Grande Mountains. The ground-water divide west of Casa Grande separated the subarea from the Eloy-Coolidge subarea to the east. Subsurface inflow continued, probably at an increased rate, from the Komatke-Sacaton subarea to the north.

Depths to water in 1972 (Drawing No. 344-314-1275) ranged from 40 feet below land surface west of Casa Grande to 660 feet below land surface west of Stanfield. Average depth to water in the subarea was about 366 feet.

The 1964 ground-water elevation map was developed using water-level measurements of deep wells in the pumping trough west of Stanfield and shallow wells on and immediately south and west of the Ak Chin Indian Reservation. The zone of steep-gradient trending northwest from the vicinity of Stanfield marks approximately the interface of the two different well types. The spring of 1972 measuring program showed that water levels northeast of this interface were no longer declining in response to pumping in the trough southwest of the interface, probably because the water table had intersected the top of the Fine Grained Unit near its periphery. Therefore, water levels from the shallow wells were not used as regional control in the 1972 ground-water elevation map, and a comparison of the 1964 and 1972 maps gives declines in excess of those shown on Drawing No. 344-314-1281. Declines of more than 120 feet for the 1964 to 1972 period (Drawing No. 344-314-1281) occurred throughout much of the pumping trough along the west side of the subarea and in the heavily pumped areas southeast of Maricopa and around Stanfield. A small area east of Stanfield had maximum declines of 140 feet. An area of no decline was present west and northwest of the Casa Grande Mountains along the ground-water divide, and water levels in some wells within this area rose slightly over the 8-year period. The average decline throughout the subarea for the 1964 to 1972 period was about 88 feet.

A comparison of elevation contours on the upper semiperched water body indicates that, for the 1964 to 1972 period, declines commonly were from 20 to 40 feet.

Hydrograph (D-6-3) 21bcc (Drawing No. 344-314-1290) shows the continuing large declines in the pumping trough west of Stanfield. Hydrographs (D-7-5) 5ddd and (D-4-3) 17daa (Drawings Nos. 344-314-1290 and -1289, respectively) typify areas where declines are smaller.

Komatke-Sacaton Subarea

The Komatke-Sacaton subarea lies within the Gila River Indian Reservation in northwestern Pinal County and a portion of Maricopa County south and west of the Salt river Mountains. The subarea is along the Gila River flood plain from a point north of Coolidge to an arbitrary line between the Sierra Estrella and Salt River Mountains below the confluence of the Gila and Santa Cruz Rivers. The Indian lands of the San Carlos Project lie wholly within the subarea.

In 1954, all of the subarea lying south of the Gila River was added to the Gila-Santa Cruz Critical Area by the State Land Department. In 1956, the balance of the subarea was added to the Salt River Valley Critical Area.

The gravity survey (Drawing No. 344-314-1262) shows a minor low located four miles northwest of Sacaton between the Sacaton and San Tan Mountains. Two small local highs midway through the subarea probably represent a buried basement rock ridge that partially separates this gravity low area from the downstream area. Another minor local high is located about seven to eight miles west of this probable buried ridge. The northwest portion of the subarea along the old channels of the Santa Cruz River is, in large part, an extension of the Maricopa-Stanfield basin. Basement rock surrounding the subarea is interrupted by wide alluvial gaps on the south and east where the Santa Cruz River and Gila River enter the subarea and to the northwest where the Gila River exits between the Sierra Estrella and Salt River Mountains.

The entire sedimentary sequence varies in thickness from 0 to more than 2,000 feet. Along the periphery of the subarea and along buried rock ridges, basement rock is penetrated often at depths ranging from 450 to 600 feet. The deepest well in the subarea, located near the northwest end of the San Tan Mountains, was drilled to 1,290 feet without encountering basement rock.

The major source of ground water to this subarea is from the Upper Alluvial Unit. This unit ranges in thickness from less than 100 feet north of the Sacaton Mountains to about 700 feet just west of the San Tan Mountains and southwest of Chandler (Drawing No. 344-314-1241). Ground water in this unit is generally unconfined; however, semiconfined conditions probably occur locally where there is a large percentage of fine grained material. Perched or semiperched conditions also exist locally in the southwest and northeast portions of the subarea as evidenced by "cascading" wells in and adjacent to the subarea.

A second source of ground water is from the Lower Conglomerate Unit. The top of this unit varies from more than 1,200 feet to about 200 feet above sea level (Drawing No. 344-314-1255). Limited data indicate this unit may be more than 500 feet thick in local areas. Throughout most of the subarea, ground-water levels in this unit conform to those unconfined to semiconfined water levels that occur in the Upper Alluvial Unit but, in the western part of the subarea where the Middle Fine Grained Unit occurs, ground water in the Lower Conglomerate Unit is probably confined.

The Middle Fine Grained Unit is more than 1,000 feet thick near Maricopa, about two miles south of the western part of the subarea, and probably is present in the Komatke-Sacaton subarea although data are not available to define its areal extent or top elevations.

Significant recharge in the subarea from surface-water sources takes place mostly in the southeastern portion, within the Indian lands of the San Carlos Project. The major sources of recharge are canal seepage and deep percolation of excess irrigation application. Natural percolation from major channels of the Gila and Santa Cruz Rivers contributes significant amounts of recharge in some years and minor amounts are contributed by mountain front percolation and subsurface inflow.

Predevelopment ground-water elevation contours indicate that ground-water movement was generally northwesterly through the subarea with subsurface inflow primarily from the south and east from the Maricopa-Stanfield, the Chandler-Queen Creek, and upper Eloy-Coolidge subareas (Drawing No. 344-314-1304). Subsurface outflow to the northwest was between the Sierra Estrella and Salt River Mountains to the Phoenix-Buckeye subarea.

In 1952, the direction of ground-water movement through the subarea was essentially unchanged and subsurface outflow probably continued as before (Drawing No. 344-314-972). Subsurface inflow, however, had been greatly reduced from the Maricopa-Stanfield subarea and virtually eliminated from the Chandler-Queen Creek area. Subsurface inflow continued as previously from the Eloy-Coolidge subarea between the San Tan and Sacaton Mountains.

By 1964, ground-water divides had been created southeast of the Sierra Estrella Mountains and between the San Tan and Salt River Mountains, sharply reducing or eliminating ground-water inflow in these areas. A pumping trough in the Eloy-Coolidge subarea south of Coolidge diverted much of the subsurface flow which had previously entered the Komatke-Sacaton subarea between the Sacaton and San Tan Mountains. Subsurface outflow to the Phoenix-Buckeye subarea continued between the Sierra Estrella and Salt River Mountains, and ground-water movement was initiated south into the pumping trough along the northeast side of Maricopa-Stanfield subarea (Drawing No. 344-314-1017).

Lines of equal depth to ground water in 1964 (Drawing No. 344-314-979) show ground water along the Gila River near Komatke as shallow as 40 feet while at the west end of the Sacaton Mountains adjacent to Maricopa-Stanfield pumping trough, depths to ground water were near 400 feet. Depths to ground water within the Indian lands of the San Carlos Project ranged from less than 80 to 140 feet.

Pumping lifts in the subarea based on data for the 1961 to 1964 period ranged from 100 to 500 feet. As of 1964, about 90 high-capacity wells were pumping in the subarea, ranging in depth from 150 to about 1,250 feet. Capacities of the wells ranged from about 860 to 3,700 gallons per minute.

Long-term ground-water declines during the 1952 to 1964 period ranged from less than 40 to over 200 feet (Drawing No. 344-314-1024). The maximum declines occurred at the west end of the Sacaton Mountains with declines of 100 feet or more at the west end of the San Tan Mountains. Minimum declines in the developed area occurred along and south of the Gila River in the eastern half of the subarea. Average water level declines for the 1952 to 1964 period in the Indian lands of the San Carlos Project were 50 feet or about 4 feet per year.

The hydrologic cross sections (Drawings Nos. 344-314-1207 through -1209) relate the declines in the ground-water levels from 1952 to 1972 to the hydrogeologic units of the subarea.

Hydrograph (D-4-7) 19cdc illustrates the trend of the water table in most of the area (Drawing No. 344-314-1287).

Ground water in the Komatke-Sacaton subarea is generally of the sodium chloride or sodium-calcium chloride type (Drawing No. 344-314-1283). Throughout most of the subarea, the water in the Upper Alluvial Unit and in the Lower Conglomerate Unit, where penetrated, contains from 600 to 1,200 parts per million total dissolved solids. However, an area west of Sacaton contains water with 1,200 to 1,800 parts per million total dissolved solids from the combined Upper Alluvial-Lower Conglomerate Units. In the northern part of the subarea adjacent to the Salt River Mountains, the water in the Upper Alluvial Unit contains poor-quality water with from 1,800 to more than 4,000 parts per million total dissolved solids. No data are available in the northern part of the subarea on the quality of the ground water in the Lower Conglomerate Unit.

<u>The 1964 to 1972 Study Period</u> -- A comparison of the 1964 and 1972 ground-water elevation maps shows that the direction of ground-water movement through the subarea was essentially unchanged. Steepened gradients indicate an increase of subsurface outflow to the Maricopa-Stanfield subarea, especially immediately west of the Sacaton Mountains. Subsurface outflow continued northwest to the Phoenix-Buckeye subarea. Data for the boundary with the Chandler area to the northeast indicate zero change to a rise of less than 20 feet.

The 1972 ground-water depths map (Drawing No. 344-314-1274) shows a range of from about 20 feet below land surface just west of Komatke to more than 420 feet below land surface just west of the Sacaton Mountains. Average depth to water in the subarea was about 128 feet below land surface.

For the period 1964 to 1972, there were minimum ground-water declines in the northern portion of the subarea with some local rises of near 10 feet (Drawing No. 344-314-1280). Maximum declines of more than 80 feet occurred in the pumping trough just west of the Sacaton Mountains and probably equaled the decline along the west side of Maricopa-Stanfield subarea northwest of Maricopa. The average decline for the subarea was about 13 feet.

Hydrograph (D-4-7) 19cdc shows the continuing ground-water decline in the southeastern portion of the subarea.

Paradise Valley-Chandler-Queen Creek Subarea

The Paradise Valley-Chandler-Queen Creek subarea lies in eastern Maricopa and north-central Pinal Counties and includes about one third of the Salt River Project Agricultural Improvement and Power District, the Salt River Indian Irrigation Project, part of the Arcadia Water Company, the Ocotillo Water Conservation District, the Roosevelt Water Conservation District, the San Tan Irrigation District, the Chandler Heights Citrus Irrigation District, the New Magma Irrigation and Drainage District, the Camelback Water Conservation District (Inactive), and the Queen Creek Irrigation District (Inactive). The subarea lies within the Queen Creek-Superstition, Salt River Valley, and Gila-Santa Cruz critical ground-water areas which were originally created in 1951, and subsequently expanded in 1954 and 1956.

The gravity survey (Drawing No. 344-314-1261) indicated one main structural basin with a low east of Chandler and an elongated trough extending east to the subarea boundary. To the north, a narrow north-northwesterly trending trough containing two gravity lows occurs in the Paradise Valley area. The subarea is almost completely surrounded by bedrock.

The entire sedimentary sequence varies in thickness from 0 feet to more than 5,100 feet in Paradise Valley and, based on gravity data, possibly as much as 10,000 feet in the gravity low east of Chandler. Bedrock was reported in several wells throughout the subarea. An oil test well located in T. 4 N., R. 4 E., near the axis of a gravity low in Paradise Valley (Drawing No. 344-314-1261) claimed to have penetrated bedrock at a depth of 5,150 feet, while a water well about five miles to the southeast in Section 2, T. 3N., R. 4 E., logged bedrock at a depth of 3,270 feet. South of Apache Junction, in T. 1 S., R. 8 E., a well is reported to have reached bedrock at a depth of 1,060 feet, while another well about two miles to the southwest was completed to a depth of 1,940 feet without encountering bedrock. A few relatively shallow wells around the edge of the basin also reported bedrock.

The major source of ground water in this subarea is the Upper Alluvial Unit. This unit ranges in thickness from 0 feet around the periphery of the subarea to more than 1,100 feet east of Chandler (Drawing No. 344-314-1240). Ground water in this unit is usually unconfined, but semiconfined conditions exist locally where there is an increase of finer-grained materials. Perched or semiperched conditions also exist as evidenced by numerous "cascading wells" south of the Salt River.

A second source of ground water is from the Lower Conglomerate Unit, mainly from wells located around the periphery of the subarea on the south and east sides. New wells have been drilled and old wells deepened to penetrate this unit. The thickness of the conglomerate ranges from 0 to 2,000 feet or more, the thickest sections occurring within the deep portions of the basins. The elevation of the top of this unit ranges from 1,000 feet above sea level to sea level (Drawing No. 344-314-1254), but limited well data suggest that it may be more than 850 feet below sea level east of Chandler. Ground water is confined where the Middle Fine Grained Unit overlies the Lower Conglomerate Unit. Where the Fine Grained Unit is missing, only one water body is recognized. East of the Phoenix Mountains in the northern portion of the subarea and adjacent to the Salt River Mountains in the southern portion, the older conglomerate of Cretaceous-Tertiary age has been identified. In some wells, this older conglomerate is an important source of ground water. The two conglomerates have been included in the total thickness calculations.

The Middle Fine Grained Unit, which separates the two main water-bearing units, is considered to be an aquiclude, but it does yield minor quantities of water from sand and gravel horizons, as evidenced by a few deep wells south and east of Chandler. The maximum thickness of the Middle Fine Grained Unit in the Chandler-Queen Creek area is not known, but it is estimated that it may be at least 2,000 feet. Ground water in this unit probably occurs under semiconfined to confined conditions and evaporite minerals make much of the water too salty for any use. The evaporites reported, including selenite, gypsum, and anhydrite, appear as marker horizons on some electric logs. The main zone of evaporites commonly occurs within the lower section of the unit, usually 200 to 400 feet below sea level. A second zone of scattered crystals appears intermittently about 200 feet above sea level.

A significant amount of recharge from surface-water sources occurs in the areas served by the irrigation districts. Seepage losses from canals and laterals and excess irrigation water are the major sources. Other minor sources of recharge are M&I effluent and storm drains, subsurface inflow, natural percolation along stream channels, and peripheral or mountain-front percolation in washes.

Predevelopment ground-water elevation contours (Drawing No. 344-314-1304) indicate that ground-water movement within Paradise Valley was generally southerly toward the Salt River. Subsurface inflow was primarily from Cave Creek and adjacent to Granite Reef Dam. Subsurface outflow was accomplished by the Salt River, acting as a natural drain. In the southern part of the subarea, ground-water movement was northwesterly, roughly parallel to the San Tan Mountains, then turned generally westward toward the Salt River Mountains. There was probably a small amount of subsurface inflow along Queen Creek and from the Gila River. Subsurface outflow was to the southwest into the Komatke-Sacaton subarea and westerly into the Phoenix-Buckeye subarea under the Salt River channel and through the gap between the Papago Buttes and the Salt River Mountains.

Ground-water elevation contours for 1952 indicate ground-water movement north of the Salt River continued to the south-southeast, and the areas of subsurface inflow and outflow remained unchanged. In the rest of the subarea, intensified development of ground water had caused significant changes in the direction of ground-water movement (Drawing No. 344-314-971). A widespread pumping trough with its center located about six miles east of Mesa was developing, causing a reversal of the ground-water gradient in the Chandler-Mesa area. At the same time, a ground-water divide was developing between the San Tan and Salt River Mountains and another between the South Mountains and Papago Buttes, virtually eliminating subsurface outflow into the Komatke-Sacaton and Phoenix-Buckeye subareas.

By 1964, the effects of overpumpage had accentuated the development of pumping troughs and ground-water divides (Drawing No. 344-314-1016). A deep pumping trough had developed north of the Salt River near Scottsdale, and the pumping trough east of Mesa had deepened. Subsurface inflow into the subarea continued along the Salt River and Cave Creek, but subsurface outflow into the Phoenix-Buckeye subarea had been eliminated, and subsurface outflow into the Komatke-Sacaton subarea became insignificant.

Data on the perched water body were only available south of the Salt River. Drawing No. 344-314-1016 shows the relationship of the perched to the regional water table. The surface of the confined water body could not be contoured with the available data.

South of the Salt River, the depth to ground water in 1964 (Drawing No. 344-314-978) varied from 80 feet below ground surface, several miles south of Tempe, to more than 520 feet below ground surface east of Mesa near the edge of the Usery Mountains. Adjacent to the Salt River

Mountains, the average depth to water was about 140 feet. East of Mesa and in the vicinity of Queen Creek, the average depth to water was about 340 feet. In Paradise Valley, depth to water ranged from about 100 feet near Papago Buttes to over 300 feet north of Scottsdale. The average depth to water was approximately 250 feet.

On the basis of data for the 1961 to 1964 period, pumping lifts north of the Salt River ranged from about 250 feet to 550 feet or more. South of the Salt River in the western portion of the subarea, pumping lifts range from 190 to 250 feet but increase gradually to the east and northeast where pumping lifts of 450 to 600 feet were common.

As of 1964, about 80 M&I and high-capacity irrigation wells were being operated near Scottsdale and the lower part of Paradise Valley. These wells range in depth from 300 to 1,950 feet, with pumping capacities ranging from 150 to about 2,500 gallons per minute. South of the Salt River, there are about 600 M&I and high-capacity irrigation wells being operated. These wells range from about 150 to 2,700 feet in depth and pump from 500 to more than 3,600 gallons per minute. Throughout the subarea, only about 10 percent of the well installations (mainly around the Queen Creek-Magma area) used natural gas as the source of energy.

Long-term water-level declines from 1952 to 1964 ranged from less than 20 feet to more than 200 feet (Drawing No. 344-314-1023). The maximum declines in the Paradise Valley area occurred northeast of Scottsdale. South of the Salt River, they occurred in the central part of the Chandler-Queen Creek basin about six miles east of Gilbert and along the western end of the Usery Mountains. Minimum declines occurred in the northern part of Paradise Valley and in the area between the South Mountains and the Papago Buttes in the Chandler-Queen Creek area. Ground-water declines in Paradise Valley for the period 1952 to 1964 averaged about five feet per year north of the Arizona Canal and about 11 feet per year south of the canal. In the area south of the Salt River, the average ground-water decline was about 10 feet per year.

Hydrologic cross sections J-J and K-K (Drawings Nos. 344-314-1210 through -1214) relate the 1952 to 1972 water-level decline to the hydrogeology.

The hydrograph of well (D-1-7) 6abb (Drawing No. 344-314-1293) shows the long-term water-level decline in the Upper Alluvial Unit in the area east of Gilbert. The average rate of decline for the period 1952 to 1964 is over 12 feet per year. The apparent temporary recovery in 1963 cannot be explained with the available data. Test hole hydrograph (D-1-6) 27dda (Drawing No. 344-314-1291) about five miles to the southwest illustrates the large seasonal fluctuation due to pumping in the area between 1964 and 1972. Both piezometer pipes in this test hole are set in the Upper Alluvial Unit. The difference in magnitude in the fluctuation could be due to depth, lithology, well development, or a combination of all of these. The fact that the hydrograph does not reflect the yearly decline in the water table seen in the earlier years in hydrograph (D-1-7) 6abb (Drawing No. 344-314-1293) is due to a change in pumping practices in this area starting about 1965 plus an increase in available diverted surface water due to heavy runoff. Test hole hydrograph (D-1-8) 30daa (Drawing No. 344-314-1291) located about 16 miles east of Chandler shows a declining water table in this area during the 1965 to 1972 period. Again, both pipes were set in the Upper Alluvial Unit, and the exaggerated seasonal fluctuation in the upper pipe is probably due to the same factors mentioned for test hole (D-1-6) 27dda.

Hydrographs (D-3-8) 34bbd, which penetrates both the Upper Alluvial and Lower Conglomerate Units, and (D-3-8) 13aaa (Drawing No. 344-314-1293), which penetrates the Upper Alluvial Unit only, show the long-term decline in the southeastern end of the subarea where only one water body is present.

Hydrographs (D-1-4) 27daa and (A-1-5) 28cbb (Drawing No. 344-314-1294) are representative of the lowering water table in the west and northwest parts of the Chandler-Queen Creek area. Both of these wells are in the Upper Alluvial Unit. The temporary rises in the water levels in wells (D-1-4) 27daa and (A-1-5) 28cbb (Drawing No. 344-314-1294) probably mean there was surface water available from the Salt River, and pumping was suspended during these periods.

Records on long-term water-level changes in Paradise Valley are generally lacking, and a representative hydrograph could not be constructed for that area.

The quality of ground water in the Paradise Valley-Chandler-Queen Creek subarea is generally good with total dissolved solids of less than 1,000 ppm over much of the area (drawing No. 344-314-1283). However, it does vary areally and with depth. Ground water from the Upper Alluvial Unit, and the Lower Conglomerate Unit where penetrated, north of the Arizona Canal, is a sodium-calcium bicarbonate type. Water of similar quality and type is also found in the Upper Alluvial Unit in the southeastern portion of the subarea east of the Roosevelt Water Conservation District Canal. No data are available on the water in the Lower Conglomerate Unit. Water from these areas usually contained less than 500 parts per million total dissolved solids. West of the Roosevelt Water Conservation District Canal, the quality of ground water in the Upper Alluvial Unit throughout the rest of the subarea is mainly of the sodium-calcium chloride type and generally ranges from 600 to over 1,800 parts per million of total dissolved solids, except in one area west of Chandler where it exceeds 6,000 parts per million. East and south of Chandler is an area of predominantly calcium chloride type water containing a high percentage of magnesium and sulfate ions. Total dissolved solids in this water range from 600 to over 4,500 parts per million, with the poorest quality water coming from wells less than 450 feet deep. These shallow wells are located in an area served by canals operated by the Salt River Project and the Roosevelt Water Conservation District. Over the years, recharge from return flow of excess irrigation water has undoubtedly contributed to the poor quality of the ground water in this area.

South of the Arizona Canal, deep wells which penetrate the Middle Fine Grained Unit produce a sodium chloride or calcium-chloride type water generally similar to that in the overlying alluvium but with less total dissolved solids. This water generally contains from 600 to 3,200 ppm total dissolved solids. A few deep wells around the edge of the basin, in the southern part of the subarea where a single water body is present, penetrate the Lower Conglomerate Unit. This water is generally a sodium chloride type, similar to water from the Upper Alluvial Unit but with a greater percentage of calcium and bicarbonate ions.

The 1964 to 1972 Study Period -- The 1972 ground-water elevations map (Drawing No. 344-314-1267) shows that the pumping troughs present in 1964 were deepened and expanded during the 8-year period to 1972. A large pumping trough was developing which extended southeastward from Williams Air Force Base and adjacent to the San Tan Mountains. Smaller local pumping holes were indicated immediately north of the San Tan Mountains and west of Gilbert. Subsurface inflow continued along the Salt and Gila Rivers as well as from the north where Cave Creek crosses the subarea. Subsurface outflow, as in 1964, was insignificant.

South of the Salt River, the depth to ground water in 1972 ranged from 60 feet below land surface south of Tempe to more than 580 feet below land surface adjacent to the Usery Mountains (Drawing No. 344-314-1273). East of Mesa and in the vicinity of Queen Creek, the average depth to water was about 380 feet below land surface. North of the Salt River, the depth to ground water ranged from about 100 feet below land surface near Papago Buttes to 400 feet near Scottsdale and adjacent to the McDowell Mountains.

The ground-water decline map for the period 1964-1972 (Drawing No. 344-314-1279) shows that maximum declines of 80 feet or more occurred in the pumping trough near Scottsdale. The average decline north of the Salt River was 42 feet.

South of the Salt River, maximum declines of 60 feet occurred in the pumping trough near Williams Air Force Base and adjacent to the San Tan

Mountains. The average decline for the area south of the Salt River was 28 feet. A large area of no decline occurred in the western half of the area, and water levels in a few wells rose slightly.

A comparison of the elevation contours on the upper "semiperched" water body indicates that there was generally about 10 feet or less decline for the 1964-1972 period.

Hydrographs (D-3-8) 13aaa and (D-3-8) 34bbd (Drawing No. 344-314-1293) illustrate the continuing declines in the pumping trough southeast of Williams Air Force Base. Hydrographs (D-1-4) 27daa and (A-1-5) 28cbb (Drawing No. 344-314-1294) are from the area where increased surface diversions have resulted in no declines or even slight water-level rises over the 1964 to 1972 period.

Phoenix-Buckeye Subarea

The Phoenix-Buckeye subarea lies in east-central Maricopa County and includes the western two-thirds of the Salt River Project Agricultural Improvement and Power District, about one-half of the Buckeye Water Conservation and Drainage District, approximately two-thirds of the Roosevelt Irrigation District and the Maricopa County Municipal Water Conservation District No. 1, McMicken Irrigation District, St. Johns Irrigation District, New State Irrigation and Drainage District, Peninsula Ditch Company, about one-fourth of the South Side Irrigation District, about one-fourth of Gila River Indian Reservation Miscellaneous Irrigation, Arcadia Water Company, the Leon Irrigation District (Inactive), the Maricopa Garden Farms (Inactive), and numerous private and public water companies and utilities. The subarea is contained within the

Salt River Valley critical ground-water area created by the State Land Department in 1951 and expanded in 1956. Township 1 South, Range 1 East, lies outside the critical area.

The gravity survey (Drawing No. 344-314-1260) indicates a large, structurally complex, deep basin centered about eight miles west of Glendale with a southern appendant, east-west-trending trough extending from Tolleson to the Phoenix area. The subarea is generally ringed by basement rock, but has alluvial gaps on the west north of the White Tank Mountains, between the White Tank Mountains and the Buckeye Hills, on the south between the Sierra Estrella and Salt River Mountains, and on the east between the Phoenix Mountains, Papago Buttes, and South Mountains. Gravity data also suggest a system of basement faults.

The entire sedimentary sequence varies in thickness from 0 to an estimated maximum of 10,000 feet within the gravity low west of Glendale. However, no wells have reached bedrock in the latter area. Many relatively shallow wells penetrate bedrock along the southern and eastern peripheries of the subarea, but a well at the extreme eastern end of the trough in Section 30, T. 2 N., R. 4 E., was still in sediments at 2,818 feet. The deepest well in the subarea, located in T. 2 N., R. 1 W., was drilled to a depth of about 4,500 feet within the maximum gravity low west of Glendale without encountering basement rock. A major salt dome has been identified from this hole which encountered a column of salt (halite) more than 3,200 feet thick. Gravity data suggest that the vertical dimension of the structure exceeds 6,500 feet. The dome is arcuate in plan and apparently has a broad triangular base. Initial studies indicate a nonmarine origin.

The major source of ground water in this subarea is the Upper Alluvial Unit. This unit ranges in thickness from 0 to over 1,200 feet about five miles southwest of El Mirage (Drawing No. 344-314-1239). Ground water in this unit is generally unconfined; however, significant occurrences of fine-grained materials do create local semiconfined or confined conditions. Perched or semiperched conditions also occur as evidenced by numerous "cascading" wells.

The Lower Conglomerate Unit is becoming a second, more recent source of ground water as new, deeper wells are drilled or old wells deepened. The top of this unit has been encountered at elevations ranging from more than 1,000 feet above sea level along the eastern periphery of the subarea to more than 400 feet below sea level west of Litchfield Park (Drawing No. 344-314-1253). The penetrated thickness of the Lower Conglomerate Unit ranges from a few feet to nearly 3,300 feet and probably includes portions of the conglomerate of Tertiary age in some areas, mostly along the eastern and southern portions. Ground water in this unit is confined throughout most of the subarea but, where the Middle Fine Grained Unit is absent, exhibits water levels comparable to those in the overlying Upper Alluvial Unit.

The Middle Fine Grained Unit is considered an aquiclude but it does yield some water from the coarser playa deposits mostly east of the Aqua Fria River and from thin sandy horizons. The elevations of the top of this unit as well as its areal extent are shown on Drawing No. 344-314-1246. It ranges in known thickness to nearly 1,500 feet with thicker sections probably occurring in the deeper portions of the basin.

Ground water in this unit occurs under semiconfined to confined conditions. The prevalent occurrence of primary and secondary evaporites in this unit generally deteriorates the quality of the water. Throughout this unit, disseminated gypsum appears intermittently. Deep holes south and east of Luke Air Force Base had encountered great thicknesses of salt variously described as "pure halite," "rock salt," and "anhydrite." Scattered data indicated a thick body of salt, the top of which has been encountered as high as 250 feet above sea level east of Luke Air Force Base and as low as 1,260 feet below sea level south of the base. The discovery hole (B-2-1) 2ccc east of Luke Air Force Base subsequently confirmed the occurrence of a unique salt dome.
Seepage losses from canals and laterals mostly south of the Grand Canal, east of the Aqua Fria River and south of the Roosevelt Irrigation District Canal west of the Aqua Fria River, and excess irrigation application are the most important sources of recharge in the subarea. Other significant sources are seepage of effluent from municipal and industrial use, seepage from flow in major streams and tributaries, and subinflow to the area. Minor recharge occurs from mountain-front percolation and possibly from water derived from compaction of fine-grained sediment in areas of subsidence.

The spring 1923 ground-water elevation contours, assumed to be representative of the period before development of ground water (Drawing No. 344-314-1304), indicate that ground-water movement was generally from the north, northeast, and east to the west and southwest. Subsurface inflow was primarily under the Salt, Gila, New, and Aqua Fria River channels and from the northwest through the alluvial gap north of the White Tank

Mountains. Subsurface outflow to the Tonopah-Arlington subarea was under the Gila River channel between the White Tank Mountains and the Buckeye Hills.

The use of surface water for irrigation in the Salt River Project area since the late 1800s developed high water-table conditions. By 1920, 31 percent of the project area had ground-water levels within 10 feet of the ground surface. To alleviate water logging of crops, water had to be pumped to lower the water table and conveyed out of the area. As a result of this pumping, by 1930 only 0.3 percent of the total project area had water levels within 10 feet of the ground surface. Ground-water elevation contours for 1952 (Drawing No. 344-314-970) show a minor change in ground-water movement. A pumping trough had been created in the Deer Valley area northwest of the Phoenix Mountains with an attendant ground-water divide extending east and north from Peoria, and ground-water movement in the area was induced toward this trough. Ground-water movement through the rest of the subarea was generally unchanged, but heavy pumping in the Chandler-Mesa area with a resultant reversal of the ground-water gradient had eliminated subsurface inflow from the east.

By 1964, continued overpumpage had greatly changed the configuration of ground-water movement in the western and northern portions of the subarea (Drawing No. 344-314-1015). The Deer Valley pumping trough had expanded westward nearly to the Agua Fria River. A large pumping trough centered about five miles west of Litchfield Park included much of the area west of the Agua Fria River and south of Beardsley. Small, local ground-water expressions existed along and north of the Gila River from Goodyear to

Buckeye. The major ground-water divides within the area were between the White Tank Mountains and the Buckeye Hills, northeast of El Mirage between the Litchfield Park and Deer Valley pumping troughs and one extending from Peoria eastward to the Phoenix Mountains, separating Deer Valley from the southeastern portion of the subarea. Subsurface inflow from the east was completely eliminated and ground-water movement within the subarea was fragmented toward each major pumping trough. Subsurface outflow to the Arlington-Tonopah subarea was virtually eliminated. The pattern of ground-water movement within the southern portion of the Salt River Project area remained, for the most part, as it was in 1923.

Lines of equal depth to ground water in 1964 (Drawing No. 344-314-977) show variation from about 20 feet below ground surface along the Gila River south of Buckeye to more than 460 feet in the area northwest of the Phoenix Mountains, with a large area over 400 feet northwest of Litchfield Park. In the Salt River Project area and west of the Agua Fria River in the area south of the Roosevelt Irrigation Canal extending to the western subarea boundary, the depth to water averaged about 125 feet with a maximum depth of 300 feet. Over the remainder of the subarea, the average depth to water was about 340 feet with a maximum of over 460 feet.

Pumps lifts in the Salt River Project area and south of the Roosevelt Irrigation District Canal, based on 1961 to 1964 data, ranged from about 40 feet to over 450 feet. Pumping lifts in the rest of the subarea ranged from about 220 feet to more than 550 feet. As of 1964, it is estimated that about 700 high-capacity wells were pumping in the subarea ranging in depth from 100 to about 3,350 feet. Capacities of the wells ranged from about 550 to nearly 3,800 gallons per minute. Nearly all of the pumpage in the subarea is from electrical energy with probably less than 2 percent from natural gas installations.

Long-term ground-water declines during the 1952 to 1964 period ranged from less than 20 feet to about 180 feet (Drawing No. 344-314-1022). Maximum declines occurred west of Litchfield Park, northwest of Beardsley, and in the Deer Valley area northwest of the Phoenix Mountains. Minimum declines were at the eastern and western extremes of the subarea along and/or adjacent to the Salt and Gila Rivers, respectively. The average water-level decline for the 1952 to 1964 period in the Salt River Project area and the area south of the Roosevelt Irrigation District Canal was about 54 feet, or about 4 feet per year. Over most of the subarea, including the major pumping troughs, average decline for the same period was nearly 130 feet or about 10.8 feet per year.

Drawings Nos. 344-314-1215 through -1221 relate the 1952, 1964, and 1972 ground-water levels to the hydrogeology of the subarea.

In test hole hydrograph (A-3-1) 32adb (drawing No. 344-314-1295), piezometer pipe No. 1 illustrates the seasonal fluctuation resulting from heavy pumping in wells taking water from the Upper Alluvial Unit. Piezometer pipe No. 2, set some 220 feet higher, shows a more subdued reaction and a higher water level. This higher water level is probably caused by recharge from sewage effluent and tail water dumped into the New River which runs close to the well. This water may be causing a ground-water mound to form in the area and has probably influenced the lesser rate of ground-water decline since 1964.

Test hole hydrograph (B-3-1) 32dda (Drawing No. 344-314-1295) located about eight miles east of test hole (A-3-1) 32adb also shows the seasonal fluctuation in the Upper Alluvial Unit. In this area, however, the trend of 1952-1964 water-level declines continues. From 1967 to 1972, the ground water declined 25 feet or about 5 feet per year. This hole is located in an area of heavy pumping and not too far from the pumping hole west of Litchfield Park. The upper piezometer in this hole does not show the seasonal fluctuation but does approximate the yearly decline. It can only be deduced that the lack of a more positive response to seasonal pumping is due to well factors or lithology.

Test hole hydrograph (B-4-1) 25ccc (Drawing No. 344-314-1295) shows seasonal fluctuations in the Lower Conglomerate Unit in the developed area near Beardsley. The decline for the period 1965-1968 was about 12 feet or 4 feet per year. Seasonal fluctuations varied from about 4 to 10 feet.

Test hole hydrograph (A-1-3) 13dbb (Drawing No. 344-314-1299) shows the fluctuation in the Upper Alluvial and Lower Conglomerate Units in the area south of Phoenix. This test hole is located close to the Salt River and reflects the recharge from the river in periods of high flow. The almost instantaneous recovery in December 1966 reflects the effects of the flood that took place that year. The overall rise in the water table is probably due to a change in pumping pattern in this area.

Hydrographs (B-3-1) 15cbb, (B-4-2) 36bcb, (B-4-1) 9bcd, and (B-1-2) 5cbb (Drawings Nos. 344-314-1294, -1296, and -1298) illustrate long-term decline in the Upper Alluvial Unit in or adjacent to the heavily pumped western portion of the subarea. Hydrograph (B-1-3) 21dbb (Drawing No. 344-314-1298) is typical of the relatively small long-range declines south of the White Tank Mountains.

Hydrograph (A-4-1) 22bbb (Drawing No. 344-314-1296) illustrates the large, long-term declines associated with the pumping holes northeast of El Mirage.

Hydrograph (A-1-1) 4aaa (Drawing No. 344-314-1294) is of a well in the Upper Alluvial Unit in an area with surface imports, and the fluctuations indicate a close relationship to the balance between pumping and surface imports.

The quality of ground water in the Phoenix-Buckeye subarea varies both areally and with depth (Drawing No. 344-314-1283). In general, the water in the Upper Alluvial Unit in the area of the Salt River Project is of the sodium-calcium chloride or the calcium-magnesium chloride type ranging from less than 600 to about 1,800 parts per million total dissolved solids.

Shallow ground water in the Upper Alluvial Unit south of the Roosevelt Irrigation District Canal in the southern and western portions of the subarea commonly contains from 1,200 to over 3,000 ppm total dissolved solids. Many wells contain water exceeding 5,000 ppm total dissolved solids. This water ranges from mainly sodium chloride-sulfate to sodium-calcium chloride. Along the northern edge of the Buckeye Hills, a number of wells yield water high in sodium chloride. Throughout the northern portion of the subarea, ground water is generally of the sodium-calcium bicarbonate type with less than 600 ppm total dissolved solids.

Ground water in the Middle Fine Grained Unit in the area north of Luke Air Force Base and the Arizona Canal is generally a sodium or calcium bicarbonate type with total dissolved solids of less than 600 ppm. Throughout the rest of the subarea, ground water is basically a sodium-chloride type with varying mixtures of calcium, magnesium, and sulfate ions. Total dissolved solids range from about 600 to over 5,000 ppm. Water samples from a well which penetrated the evaporite sequence of the Fine Grained Unit showed admixtures of sodium-chloride and calcium-sulphate with total dissolved solids sometimes exceeding 26,000 ppm.

Wells that are perforated only in the Lower Conglomerate Unit and have effectively sealed off the overlying units yield sodium-chloride type water along the southern and southeastern boundaries of the subarea ranging from 600 to about 1,800 ppm total dissolved solids. Along the northern perimeter, sodium-calcium bicarbonate water is prevalent with less than 600 ppm total dissolved solids.

<u>The 1964 to 1972 Study Period</u> -- The two major pumping troughs continued to deepen during the 1964-1972 period although the rate of decline of about 5 feet per year is somewhat less than the 1952 to 1964 study period due to a decrease in total pumpage in the area. The divide between them is at about the same location, just northeast of El Mirage (Drawing No. 344-314-1266). A local ground-water mound had developed south of where the Arizona Canal joins Shunk Creek. Subsurface inflow to the subarea was from the north with no inflow from the east along the Salt River. Subsurface outflow was negligible.

Depths to ground water ranged from less than 20 feet below land surface in local areas along the Salt River to more than 480 feet below land surface in the pumping trough adjacent to the White Tank Mountains and in the area north of the Phoenix Mountains. In the area of the Salt River Project and south of the Roosevelt Irrigation Canal to the western subarea boundary, the average depth to water was about 113 feet below land surface. Throughout the rest of the subarea, the depth to water was about 368 feet below land surface.

Changes in ground-water levels in the subarea for the 1964-1972 period ranged from declines of more than 40 feet over much of the area west of New River to rises of more than 20 feet throughout much of the Salt River Project. In the area of the Salt River Project and south of the Roosevelt Irrigation Canal to the western subarea boundary, the average rise in water levels was from 10 to 15 feet while throughout the rest of the subarea, water levels declined an average of nearly 30 feet.

Hydrographs (B-3-1) 15cbb, (B-4-2) 36bcb, (B-4-1) 9bcd, (B-1-2) 5cbb, and (A-4-1) 22bbb (Drawings Nos. 344-314-1294, -1296, and -1298) illustrate the continuing long-term water-level declines associated with the major pumping troughs west of Litchfield Park and northeast of El Mirage. Hydrographs (A-1-1) 4aaa and (B-1-3) 21dbb (Drawings Nos. 344-314-1294 and -1298, respectively) show the effect on the ground-water level of increased surface diversions (Drawing No. 344-314-1294) to the subarea.

Tonopah-Arlington Subarea

The Tonopah-Arlington subarea lies approximately in the center of western

Maricopa County and includes the Arlington Canal Company, portions of the South Side Irrigation District, Buckeye Water Conservation and Drainage District, and Roosevelt Irrigation District. There are no state-designated critical ground-water areas within this subarea.

The gravity survey (Drawing No. 344-314-1258) indicated two distinct bedrock lows: an elongated east-west trending gravity trough extending from Buckeye, west to the area south of the Palo Verde Hills, and a deep basin east of Tonopah. A generally northwesterly trending gravity high is indicated north of the Gila and Salt River base line about on the line between Ranges 4 and 5 West that may be a subsurface extension of the granite outcrops which occur along the Hassayampa River in Township 2 North, Range 5 West.

The entire sedimentary sequence varies in thickness from 0 tc an estimated 2,000 feet in the basin west of Buckeye. It may be considerably thicker in the basin east of Tonopah but no data are available in this area Granite bedrock has been penetrated at 400 to over 900 feet in the southern portion of the subarea north and west of the Buckeye Hills. Near the eastern boundary of the subarea about one mile west of Buckeye, granite bedrock was encountered at a depth of 1,015 feet.

The major source of ground water in the subarea is the Upper Alluvial Unit. This unit varies in thickness from 0 to 100 feet along the Gila River immediately upstream from Gillespie Dam and adjacent to the Gila Bend Mountains to over 600 feet southeast of Tonopah (Drawing No. 344-314-1237). Ground water in this unit is generally unconfined, but confined or semiconfined conditions occur locally. Perched or semiperched conditions also exist locally due to shallow fine-grained materials.

A second important source of ground water is the Lower Conglomerate Unit. The top of this unit comprises two basins separated by a high and varies in elevation from more than 800 feet above sea level north of the Palo Verde Hills to below sea level in T. 1 S., R. 4 W. (Drawing No. 344-314-1251). The unit ranges in thickness from 0 to at least 1,400 feet and is probably much thicker. Throughout part of the subarea, volcanic rocks occur interbedded with the sedimentary materials in this unit. Ground water in the Lower Conglomerate Unit is confined where it is overlain by the Middle Fine Grained Unit in the southernmost basin, but in those areas where the Upper Alluvial Unit directly overlies it, only one water body is recognized.

The Middle Fine Grained Unit, although considered an aquiclude, yields some water from thin sandy horizons. This water probably occurs under semiconfined to confined conditions. Evaporites make much of the water from this unit too salty for use. These include mostly gypsum and anhydrite with some selenite reported. Some halite may also occur. The main evaporite zone occurs within the lower part of the unit generally at about 200 feet above sea level. A second zone occurs from 400 to 450 feet above sea level; however, disseminated gypsum is present throughout the unit. The elevation of the top of the Middle Fine Grained Unit varies from 660 to about 750 feet above sea level. The areal extent of this unit is shown on Drawing No. 344-314-1244 but, due to a lack of data, the northern limits could not be determined. The Middle Fine Grained Unit ranges in thickness from 0 to at least 800 feet.

Significant recharge from surface-water sources is generally restricted to the area underlying the irrigation districts with seepage losses from canals and laterals, excess irrigation application, and natural percolation from flow in the Gila River as the major sources in the subarea.

Prior to development in the subarea, ground-water movement probably was generally from the north and east to the west and south through the gap between the Buckeye Hills and the Gila Bend Mountains. Subsurface inflow was from the east, between the White Tank Mountains and the Buckeye Hills, and from the north between the White Tank Mountains and the extension of the Big Horn Mountains. Lesser amounts may have been contributed from the west along Centennial Wash. Subsurface outflow was mainly to the south between the Buckeye Hills and the Gila Bend Mountains.

Water-level data for 1952-53 are incomplete and it is not possible to show the effect of progressive ground-water development in the subarea for the 1952-1964 period. Drawing No. 344-314-1013 shows the elevation of the water table in 1964. A ground-water depression due to pumping is present along Centennial Wash between Arlington and the northern extension of the Gila Bend Mountains, and ground-water movement is toward this depression. Subsurface inflow still enters from the north and east but pumping in Harquahala Valley has eliminated subinflow via Centennial Wash. Heavy pumping in Harquahala Valley to the west of Tonopah appears to have induced some degree of subsurface outflow from the Tonopah area between the Big Horn Mountains and the Palo Verde Hills, but the data available are not conclusive. Neither was there sufficient data to delineate the piezometric surface of the confined ground water or the top of the perched water table.

Lines of equal depth to ground water in 1964 (Drawing No. 344-314-975) show a variation from less than 20 feet below ground surface along the Gila River and in a small area north along the Hassayampa River below the Roosevelt Irrigation District Canal spill point to more than 260 feet in the extreme northwest portion of the subarea.

Depth to water in the area south of the Buckeye Canal and east of the Arlington Canal averages about 35 feet. North of the Buckeye Canal terminal, the average depth to water along the Hassayampa River is about 40 feet. However, in this reach, the depth to water east ot the river ranges from 40 to 160 feet and west of the river it varies from about 40 to over 260 feet.

South of the Gila and Salt River base line and west of the Arlington Canal, depth to water varies from 80 to over 220 feet.

Pumping lifts in the area south of the Roosevelt Irrigation District Canal, for the 1960 to 1964 period, ranged from about 40 feet to over 200 feet. Pumping lifts in the Tonopah area are as much as 330 feet. As of 1964, it is estimated that at least 125 high-capacity wells were pumping in the subarea, ranging in depth from 160 feet to 1,990 feet. Capacities of the wells ranged from 225 to 3,000 gallons per minute. Some of the deep wells adjacent to the Palo Verde Hills have been abandoned due to low yields. Nearly all of the wells in the subarea use electrical energy for power.

Lack of data precluded construction of a map showing the change in ground-water levels from 1952 to 1964. Estimated ground-water declines from the early 1950s to 1964 ranged from 0 feet along and adjacent to Gila and Hassayampa Rivers to 70 feet west of Arlington. Throughout most of the subarea, water-level declines for the 1952 to 1964 period were from 20 to 40 feet or 2 to 3 feet per year. Average estimated declines in and adjacent to the pumping trough west of Arlington were 60 to 70 feet for the same period or 5 to 6 feet per year. Drawings Nos. 344-314-1222 through -1255 relate water levels to the hydrogeology where data are available.

Hydrographs of wells (B-2-7) 27aab and (B-1-6) 7bdd (Drawings Nos. 344-314-1300 and -1301, respectively) which penetrate both the Upper Alluvial Unit and the Lower Conglomerate Unit illustrate the long-term declines which are associated with heavy pumping which started in the mid-1950s in the Tonopah area.

Hydrographs (B-1-4) 27abb and (C-1-5) 34adc (Drawings Nos. 344-314-1298 and -1301, respectively) illustrate the lack of significant long-term water-level decline in the areas where recharge is available from surface water sources.

Hydrograph (B-1-6) 27cbc (Drawing No. 344-314-1301) shows long-term decline in a well within the Lower Conglomerate Unit associated with the heavily pumped area west of Arlington.

The quality of ground water in the Tonopah-Arlington subarea varies areally (Drawing No. 344-314-1283) and also with depth where the Middle Fine Grained Unit is present. In general, water in the Upper Alluvial Unit and Lower Conglomerate Unit north of the Roosevelt Irrigation

District Canal (extended) is of the sodium-bicarbonate type and usually has less than 600 parts per million total dissolved solids.

Ground water in the Upper Alluvial Unit south of the Roosevelt Irrigation District Canal and east of the Hassayampa River and Arlington Canal is of the sodium-chloride, sulfate type and ranges from 1,800 to over 8,000 ppm, most commonly containing from 2,000 to 4,000 parts per million. Significant deterioration of the quality of ground water throughout the area from Gillespie Dam to the Aqua Fria River probably began with the construction of Gillespie Dam in 1921. The dam seriously restricted subsurface outflow in this area and allowed the dissolved solids, carried down to the water table by the infiltration of return flow from excess irrigation, to accumulate.

During the 1920s and continuing through the late 1940s, most of the irrigation water available to the Buckeye Water Conservation and Drainage District was diverted from the Gila River, which in periods of low flow contained relatively high amounts of dissolved solids.

Starting about 1928, the Roosevelt Irrigation District began importing water from east of the Aqua Fria River. This water was pumped from wells in the Tolleson area and in the 1930s averaged about 1,500 parts per million total dissolved solids.

Repeated irrigation applications with these imported waters resulted in a temporary slight rise in the water table, together with an accumulation of salts in the soil and ground-water reservoir. A comparison of ground-water analyses made in 1937 and 1946 shows that the total dissolved solids in a few wells near Buckeye doubled during this period. A corresponding rise in dissolved solids in the R.I.D. wells west of the Agua Fria River occurred between 1930 and 1940. As ground-water pumpage increased and surface diversions, especially to the Buckeye Conservation District, decreased ground-water levels began to decline. Analyses of water from the R.I.D. wells west of the Agua Fria and B.C.D. wells through 1964 show year to year fluctuations of total dissolved solids, but indicate that generally the deterioration of ground-water quality apparently ceased in the mid-forties. Some of the reasons which may account for this are:

1. A gradual change in character and quantity of surface diversions to the B.C.D. Canal from large quantities of Gila River water which included poor-quality return irrigation flows, to smaller quantities of Gila River water supplemented by relatively good quality ground-water imported from the Salt River Project.

2. With declining well yields and the addition of deeper wells in the districts, a larger percentage of the pumped water used for irrigation is from the Lower Conglomerate Unit and is of better quality.

3. Blending and selective pumping of wells have maintained a more constant quality of applied water.

4. Moderate declines in water levels throughout the area have created additional "Storage space" above the ground-water reservoir, thus reducing the amount of salts that reach the water table.

5. The total irrigation deliveries have declined since the midfifties.

With the exception of infrequent floods, surface flows which reach Gillespie Dam are comprised of return irrigation water originating upstream. Low flows reaching Gillespie Dam in 1944-45 contained about 4,000 ppm total dissolved solids, and surface-water records for 1960-65 show that the weighted average flow at the dam contains from 4,000 to 6,000 ppm. Shallow ground water upstream from the dam reflects its origin from these poor-quality surface flows.

In the area of the pumping low west of Arlington, the ground-water quality is deteriorating probably due to the increase in recharge from the Gila River area resulting from a reversal of the ground-water gradient, and to the cessation of inflow from the Harquahala Valley area. Ground water from wells in this area drawing mostly from the Lower Conglomerate Unit is sodium chloride type water with from 800 to over 1,800 parts per million total soluble salts.

Deep wells northeast of Hassayampa which were perforated in the lower part of the salt zone in the Middle Fine Grained Unit as well as in the Lower Conglomerate Unit yield sodium sulfate-chloride water with more than 3,000 parts per million total dissolved solids. Northwest of Buckeye, shallow wells perforated in the Upper Alluvial Unit yield sodium chloride-sulfate type water containing over 4,500 parts per million total dissolved solids.

The 1964 to 1972 Study Period -- The 1972 ground-water elevations map (Drawing No. 344-314-1265) shows that ground-water movement in the Arlington-Tonopah subarea was basically the same as in 1964. The pumping hole west of Arlington had been somewhat deepened and expanded and concentrated pumping between Tonopah and the Palo Verde Hills appears to be creating a hole there.

Depth to ground water ranges from 40 feet below land surface where the Roosevelt Irrigation District Canal reaches the Hassayampa River to more than 280 feet below land surface north of Tonopah (Drawing No. 344-314-1271).

For the 1964 to 1972 period, there was no decline in most of the area south of the Roosevelt Irrigation District Canal and east of the Arlington Canal as well as along and immediately west of the Hassayampa River. Water levels in some wells within this area showed slight rises. Maximum declines of more than 40 feet occurred south and east of Tonopah. In the developed areas with no surface water supply, the average decline was about 28 feet.

Hydrographs (B-2-7) 27aab and (B-1-6) 7bdd (Drawings Nos. 344-314-1300 and -1301) illustrate the continuing ground-water declines due to pumping in the Tonopah area. The effect of increased surface diversions to the southeastern portion of the subarea can be seen in hydrograph (C-1-5) 34adc (Drawing No. 344-314-1301).

Gila Bend Subarea

The Gila Bend subarea lies in southwestern Maricopa County and includes the Gila Bend Indian Reservation Irrigation, Maricopa County Southern Water Conservation District (inactive), and the Gila Water Conservation District (inactive). There are no state-designated critical ground-water areas within this subarea.

The gravity survey (Drawing No. 344-314-1259) indicated at least two structural basins comprising the subarea: one basin defined by a major gravity low east and southeast of Gila Bend which probably extends northward to the low indicated south of Gillespie Dam; and a second poorly defined gravity low north and northeast of Theba. Extreme gravity mass anomalies within the basement rock surrounding this basin, however, may have obscured its delineation on the gravity map. The subarea is generally enclosed by basement rock except for an arbitrary boundary on the southwest.

The entire sedimentary sequence varies in thickness from 0 to at least 2,000 feet and may be significantly thicker in the gravity low southeast of Gila Bend. The two deepest wells in the subarea, located north and south of Theba, were drilled to 2,070 and 2,065 feet, respectively, and did not reach basement rock. A few relatively shallow wells report granite along the subarea periphery at the north end of the Maricopa Mountains, and a test hole drilled at Gillespie Dam penetrated granite at 981 feet.

The major source of ground water in this subarea is the Upper Alluvial Unit. This unit ranges in thickness from 0 to over 1,000 feet northeast of Gila Bend (Drawing No. 344-314-1238). Ground-water occurrence in this unit is generally unconfined to semiconfined. Perched or semiperched conditions exist locally as evidenced by reports of "cascading" wells. Data are not available to delineate the configuration of this water body.

A second ground-water source of increasing importance is the Lower Conglomerate Unit. As increased demands were placed upon the ground-water reservoir, new, deeper wells were installed and old wells deepened, penetrating as much as 1,000 feet of the Lower Conglomerate Unit. The top surface of this unit ranges from about 600 feet above sea level, just south of the Buckeye Hills, where it underlies the Upper Alluvial Unit to more than 600 feet below sea level where it underlies the Middle Fine Grained Unit near Theba (Drawing No. 344-314-1252). Part of this unit is exposed at the surface north of Gila Bend at the southeastern edge of the Gila Bend Mountains and is interpreted herein as including the locally named Tertiary Sil Murk Formation. The Sil Murk's total exposed thickness is estimated to be about 1,700 feet, comprising mostly pebble to boulder conglomerates, with a relatively thin interbedded volcanic and conglomeritic sequence near the top. Such a volcanic sequence as described above was penetrated east and west of Gila Bend as shown on Drawings Nos. 344-314-1183 through -1187. From the exposure north of Gila Bend, the unit slopes gently to the south and southwest developing into a north to northeast trending trough near Theba. Test hole (C-5-4) 33 ddc encountered about 800 feet of a granitic cobble to boulder conglomerate above a volcanic sequence which is inferred to be part of the Sil Murk formation. A group of wells to the west also encountered a volcanic sequence at an elevation about 1,000 feet higher in elevation. The gravity map strongly suggests a basement fault between these two areas. It is interpreted that the gravity low east of Gila Bend reflects this increased thickness of sedimentary deposits, possibly the upper bouldery conglomerate referred to in the Sil Murk type section.

Throughout most of the areas where the Lower Conglomerate Unit occurs, it is overlain by the relatively coarse sediments of the Upper Alluvial Unit and essentially only one water level is common to both Units. Within an eight-mile area immediately upstream from Painted Rock Dam, however, water in this Unit is locally confined by a significant overlying clay member of the Upper Alluvial Unit. Confined ground water probably also occurs in the Theba area, where the Middle Fine Grained Unit overlies the Lower Conglomerate Unit (Drawing No. 344-314-1252).

The Middle Fine Grained Unit in the Theba area is considered an aquiclude, separating the two main water-bearing units although it probably yields minor amounts of water to wells from interbedded sandy zones. Some of this water is of poor quality and unusable for irrigation. The Unit ranges from 0 to nearly 700 feet thick based upon limited data. "Much gypsum" is reported in one well at 140 feet below sea level. These are inadequate data to delineate any significant evaporites throughout the Unit. The areal extent and occurrence of this Unit, as shown on Drawing No. 344-314-1245, probably indicates a closed basin of limited expression that was not defined by the gravity survey. Similarly, although a zone or zones of significant evaporites cannot be delineated, poor quality water from wells that penetrate this Unit strongly suggest that such deposits do occur. Ground water in this Unit probably occurs under semiconfined to confined conditions.

Significant recharge from surface-water sources in the subarea is accomplished through seepage losses from canals and laterals, natural downward percolation of flow in the Gila River and side washes, and by return flows of excess irrigation application.

Prior to development in the subarea, ground-water movement was essentially parallel to surface drainage. Subsurface outflow probably took place to the west around both ends of the Painted Rock Mountains.

By 1952, after over 15 years of ground-water development in the northern portion of the subarea, a ground-water divide had developed about nine miles northeast of Gila Bend with a pumping depression north of the divide (Drawing No. 344-314-969). All movement of ground water in this area was toward the depression. Ground-water movement throughout most of the southern portion of the subarea apparently had not been greatly affected.

By 1964, continued overdraft and additional ground-water development had deepened and expanded the pumping depression and moved the ground-water divide several miles south. Conversely, a ground-water mound caused by percolation of excess irrigation water had developed north of Theba (Drawing No. 344-314-1014). Ground water moved outward in all directions away from this mound increasing the subsurface outflow south of the Painted Rock Mountains. With the construction of Painted Rock Dam in 1958, subsurface outflow in this area essentially ceased.

Lines of equal depth to ground water in 1964 (Drawing No. 344-314-976) show a range from about 20 feet below ground surface along the Gila River a few miles east of Painted Rock Dam to over 300 feet along the northwestern edge of the Maricopa Mountains. Depth to water in the intensely developed area north and east of Gila Bend ranges from 80 to about 300 feet. Depth to water west of Gila Bend ranges from 20 to 160 feet.

Pumping lifts for the entire subarea vary from less than 30 feet along the Gila River east of Painted Rock Dam to over 350 feet along the northern edge of the Maricopa Mountains. Well records from the Maricopa County Southern Water Conservation District (inactive) show pumping lifts of 180 to 270 feet in 1963 and 1964. It is estimated that, as of 1964, there were about 125 high-capacity irrigation wells in the subarea ranging in depth from 300 to about 1,600 feet. Capacities of the irrigation wells ranged from less than 700 to over 4,000 gallons per minute. The majority of the irrigation wells in the subarea use electrical energy but several of the more recent wells use natural gas.

Long-term ground-water changes during the 1952 to 1964 period ranged from a rise of 20 feet to declines of over 80 feet (Drawing No. 344-314-1021). The area of maximum declines, more than 80 feet, centered in the pumping depression located about 10 miles northeast of Gila Bend. North of Theba, the water table has risen over a relatively large area in response to return flow from excess irrigation water diverted from the Gila Bend Canal. The irrigated area along the Gila River channel east of Painted Rock Dam shows little to no change probably due to the combination of increased recharge from occasional flood flows in the Gila River impounded by Painted Rock Dam, and the reduction of subsurface outflow effected by the dam. The hydrologic sections, Drawings Nos. 344-314-1226 through -1230, relate the 1952 and 1964 ground-water levels to the hydrogeology in the subarea.

Test hole hydrograph (C-5-4) 33ddc (Drawing No. 344-314-1299) illustrates the short-term fluctuation and long-term declines in the subarea. This test well is not in a developed area and the magnitude of the fluctuations and yearly declines is subdued, but nevertheless reflects storage depletion caused by pumping in a nearby area. The short-term declines due to intermittent pumpage that commonly partially recover within a month or two are up to 1 1/2 feet in magnitude. The long-term decline is a steady downward trend averaging about 2 1/2 feet a year. Since the Upper and

Lower units have a common water level in this area, only minor seasonal variations occur between the upper and lower piezometers.

Hydrographs (C-3-4) 9baa and (C-4-4) 9baa (Drawing No. 344-314-1298) illustrate the typical long-term declines averaging about 5 feet a year that occur in the heavily pumped portion of the subarea. The rise seen in hydrograph (C-3-4) 9baa is probably due to a reported decrease in pumping in this general area since 1960.

The quality of ground water in the Gila Bend subarea varies greatly both areally and with depth (Drawing No. 344-314-1283) and can be directly related to the source of recharge. Ground water in the Upper Alluvial Unit, excluding the Theba area, is generally sodium chloride water ranging from 600 to 2,500 ppm total dissolved solids. The poorer quality water which has 1,800 to 2,500 ppm is found along the upper portion of the Gila Canal and along the channel and adjacent flood plains of the Gila River. This water is mainly return irrigation flows from areas above Gillespie Dam which, in periods of low flow, may sometimes exceed 7,500 ppm and average 4,000 to 6,000 ppm total dissolved solids.

The quality of ground water in the area underlain by the Middle Fine Grained Unit in the area around Theba varies greatly with depth (Drawings Nos. 344-314-1228, -1229, and -1230). Historically, ground water in this area was probably similar to that in other parts of the subarea not influenced by surface water. Surface imports to the Theba area, which constitute the main source of irrigation water, often contain 4,000 to 5,000 parts per million total dissolved solids. Accumulation of salts as a result of long-term irrigation applications has deteriorated the quality associated with the developing ground-water mound.

Ground water associated with the Middle Fine Grained Unit is of the sodium chloride sulfate type, indicative of evaporites.

In the Lower Conglomerate Unit, it is similar to that in the Upper Alluvial Unit, not influenced by surface-water imports. The contrast of waters was demonstrated by well (C-6-6) 8dcd, a well 2,065 feet deep, which encountered the Lower Conglomerate Unit at a depth of 1,400 feet. It was perforated for a 50-foot interval above and for a 400-foot interval below the Middle Fine Grained Unit and, subsequently, yielded water with about 1,500 parts per million total dissolved solids. In 1955, a cement plug was set near the bottom of the Middle Fine Grained Unit (at 1,200 or 1,400 feet) and the well was perforated above this depth. The water pumped from the new perforated interval had about 7,400 parts per million with high sulfate content and the well was abandoned.

The 1964 to 1972 Study Period -- The Gila Bend subarea was not included in the 1972 water-level measurement program, and data were not collected which would define ground-water changes throughout the subarea. A general decrease in pumpage since 1961 as well as a shift in the pumping pattern has alleviated conditions in areas where the largest declines occurred during the 1952 to 1964 period. Hydrographs (C-4-4) 9baa and (C-3-4) 9baa (Drawing No. 344-314-1298) which represent such areas, indicate that ground-water levels have ceased declining and may even be rising slightly. A recent increase in ground-water development has been occurring in the southwestern portion of the subarea, but data were not collected to show its effect on the ground-water table.

Harquahala Valley Subarea

The Harquahala Valley subarea occupies most of that portion of Harquahala Valley that lies in western Maricopa County and includes the Harquahala Valley Irrigation District. The area is not in a state-designated critical ground-water area.

The gravity survey (Drawing No. 344-314-1258) indicates an elongated northwesterly trending basin centered around a bedrock low located adjacent to the northwest corner of the subarea. The constricted southern portion of this low extends into the subarea and appears to terminate on the south end of the valley against a bedrock high formed by the Gila Bend and Saddle Mountains. The subarea is largely encompassed by bedrock on three sides. The northwestern boundary is an arbitrary line drawn to include the developed area but having no other hydrologic or geologic significance.

The entire sedimentary sequence varies in thickness from 0 to an estimated 5,000 feet in the deepest part of the basin northwest of the subarea boundary and is probably more than 4,000 feet in the northwest corner of the subarea. Some relatively shallow wells along the eastern and southern peripheries of the subarea penetrate thick volcanic flows but granite bedrock has not been reported in any well logs. The deepest well in the subarea, in Section 16, T. 1 N., R. 9 W., penetrated over 2,400 feet of sediments before encountering hard drilling which may have been either an older rock unit or granite bedrock.

The major source of ground water in this subarea is the Upper Alluvial Unit. This unit ranges in thickness from 0 feet along the mountain peripheries to over 1,300 feet in the northwest corner of the subarea (Drawing No. 344-314-1237). Ground water in this unit is generally unconfined; however, semiconfined conditions may occur as a result of local lithology. Perched or semiperched conditions also occur as evidenced by recorded notations of "cascading" in some wells.

A second, important source of ground water is from the Lower Conglomerate Unit. As well yields and the water table declined, farmers deepened existing wells, or drilled new wells to penetrate more of this lower unit. The thickness of the Lower Conglomerate Unit ranges from about 100 feet to at least 1,225 feet in T. 1 N., R. 9 W., and is probably thicker to the northwest in the deepest portion of the basin. The elevation of the top of this unit varies from about 600 feet above sea level to more than 100 feet below sea level (Drawing No. 344-314-1251). Ground water in the Lower Conglomerate Unit is generally unconfined and forms a single water body with that in the overlying Upper Alluvial Unit. Locally, however, confined or semiconfined conditions may exist.

The Middle Fine Grained Unit commonly found in the deep portions of other large basins could not be defined within the boundaries of this subarea. However, the presence of a large percentage of silt and/or clay included in the Upper Alluvial Unit in the deeper part of the subarea indicates the probability that the Middle Fine Grained Unit is present to the northwest.

Recharge to the subarea from surface-water sources occurs sporadically from infiltration of flows in Centennial Wash and its tributaries, and minor amounts may be contributed by percolation at the mountain fronts.

Subsurface inflow from the undeveloped area to the northwest contributes most of the recharge to the subarea.

Prior to ground-water development, ground-water movement was generally from northwest to southeast and moved out of the subarea at a very low gradient through a gap between the Saddle and Gila Bend Mountains. Subsurface inflow was from the northwest. Pumping of ground water for irrigation in the subarea began in 1951, and the ground-water elevation contours based on 1952 and 1953 data show the beginning of a pumping hole northwest of Saddle Mountain (Drawing No. 344-314-968). This ground-water low diverted much of the subsurface flow but there was probably still a slight amount of outflow to the southeast. With intensified development, the pumping hole has expanded to extend over most of the subarea. Elevation contours drawn from 1964 data (Drawing No. 344-314-1013) show that ground-water movement out of the basin has ceased. The ground-water gradient has been reversed, and all flow is toward the pumping low centered about four miles northwest of Saddle Mountain. Subsurface inflow from the north was essentially unchanged, and some inflow may have been initiated from the Tonopah area to the east, through the gap between the Bighorn Mountains and the Palo Verde Hills but the volume of flow, if any, cannot be determined.

There is some evidence for local perched or semiperched water bodies but not sufficient data to delineate them.

Lines of equal depth to ground water for 1964 (Drawing No. 344-314-975) show variance from about 80 feet below ground surface where Centennial Wash leaves the subarea to over 440 feet in the southwest along the front of Eagletail Mountains. Commonly, depths to water throughout the subarea are from 300 to 380 feet below ground surface.

Pumping lifts in the subarea ranged from 200 to 500 feet in 1964 but were generally from 350 to 450 feet. It is estimated that about 100 high-capacity wells were pumping in the subarea ranging in depth from 400 to about 2,400 feet. Capacities of the wells ranged from less than 700 to about 3,000 gallons per minute. Many of the early irrigation wells used electrical energy and a few used diesel fuel; however, the majority of the new, deeper irrigation wells use natural gas. Data for the 1962 to 1964 period show that about 75 percent of the total pumpage was from natural gas installations.

Long-term ground-water declines in the subarea during the 1952 to 1964 period ranged from about 40 feet to 180 feet (Drawing No. 344-314-1020). Maximum declines up to 15 feet per year occurred in the heavily developed area northwest of Saddle Mountain. With the exception of the extreme southeast corner of the subarea, declines for the 1952 to 1964 period averaged 120 feet or about ten feet per year. Drawings Nos. 344-314-1231, -1232, and -1233 relate the 1952 to 1972 ground-water decline to the hydrogeology.

Data are not available to illustrate the nature and magnitude of short-term or seasonal water-level flucutations related to pumping for irrigation, although such fluctuations must exist.

The hydrographs of wells (B-1-9) 7bcc and (B-2-9) 13baa (Drawing No. 344-314-1300) illustrate typical long-term water-level delcines from the Upper Alluvial Unit that occur within the heavily pumped areas.

Hydrograph (C-1-9) 11dcb (Drawing No. 344-314-1301) illustrates the long-term water-level declines in the heavily pumped southern portion of the subarea.

The quality of ground water in the Harquahala Valley subarea is consistently good relative to that in most other areas (Drawing No. 344-314-1283). It is generally of the sodium chloride-bicarbonate type and ranges from less than 500 to over 1,250 parts per million total dissolved solids. No quality distinction is evident in the subarea between water from the Upper Alluvial Unit or the Lower Conglomerate Unit.

Specific conductance data indicate that ground water toward the north-eastern periphery of the subarea is generally less than 600 parts per million total dissolved solids but gets progressively higher in dissolved solids toward the center of the valley where it is generally from 700 to 900 parts per million.

The 1964 to 1972 Study Period -- The 1972 ground-water elevations map (Drawing No. 344-314-1265) shows the continuing effect of massive over-draft in the Harquahala Valley subarea. The large ground-water trough, which underlies much of the subarea, has been expanded and deepened and peripheral ground-water gradients are much steeper than in 1964. A shift in the pumping pattern has accentuated the southern portion of the trough and ground water now moves toward this area as well as to the low northwest of Saddle Mountain.

Lines of equal depth to water (Drawing No. 344-314-1271) show variance from about 120 feet below land surface where Centennial Wash leaves the subarea to 560 feet below land surface in the southwesternmost corner of the subarea. Average depth to water in the subarea is about 400 feet below land surface.

Ground-water declines for the 1964 to 1972 period (Drawing No. 344-314-1277) range from 20 feet in the extreme northwest corner of the subarea to more than 120 feet in much of the southern portion of the subarea where the heavy pumping has been concentrated since 1968-1969. The average decline in the subarea for the 1964 to 1972 period was about 90 feet.

Hydrographs (B-1-9) 7bcc and (C-1-9) 11dcb (Drawings Nos. 344-314-1300 and -1301, respectively) illustrate the continuing sharp decline in the subarea with the greatest rate of decline occurring in the southwestern portion. Hydrograph (B-2-9) 13baa shows the effect of the near cessation of pumping in that area about 1970.

Waterman Wash Subarea

The Waterman Wash subarea lies within southwestern Maricopa County. The valley is bounded on the north by the Buckeye Hills, on the east by the Sierra Estrella Mountains, and along the west and south by the Maricopa Mountains.

The Rainbow Valley Irrigation District, the only water services organization in the subarea, is located in the northcentral portion of the valley and includes essentially all of the developed lands.

During the period of study, this area was not included in a state-designated critical ground-water area.

The gravity survey (Drawing No. 344-314-1259) indicated a single northwesterly trending, structural basin with the low centered slightly toward the western edge of the valley. The gravity configuration infers a basin-forming fault along the east side of the structure. The Subarea is in large part enclosed by basement rock.

The entire sedimentary sequence varies in thickness from 0 to an estimated 3,000 feet in the deepest part of the basin. A few wells drilled near the northwestern periphery of the subarea penetrated basement rock between 700 and 1,000 feet, but none of the wells within the central part of the subarea have reached basement rock.

The Upper Alluvial Unit and the Lower Conglomerate Unit both contribute significant amounts of ground water to the subarea.

The Upper Alluvial Unit ranges in thickness from 0 to more than 700 feet near the deep central portion (Drawing No. 344-314-1238). Ground water in the unit is generally unconfined; however, semiconfined conditions may exist due to local lithology. Perched or semiperched conditions may also occur locally.

The Lower Conglomerate Unit comprises more than half of the total drilled depths in many of the irrigation wells of the subarea. The maximum penetrated thickness of the Lower Conglomerate Unit is about 950 feet, but its total thickness probably exceeds 2,000 feet. The elevation of the top of this unit ranges from about 400 to over 700 feet above sea level in the portion of the subarea where data were available to define it (Drawing No. 344-314-1252). Available drillers logs do not indicate the occurrence of the Fine Grained Unit in this subarea. Ground water in the Lower Conglomerate Unit is generally unconfined; however, confined or semiconfined conditions may exist locally due to differential cementation within the unit.

Recharge in the subarea from surface-water sources is mainly from infiltration of flows in Waterman Wash and its tributaries. Minor recharge also may occur from mountain front percolation and possibly from subsurface inflow at the southern end of the subarea. Total recharge to the subarea is very small.

Prior to ground-water development in the subarea, ground-water movement was probably from southeast to northwest generally in the same direction as surface drainage. Ground water may have moved out of the subarea between the Buckeye Hills and the Sierra Estrella Mountains and also to the west between the Buckeye Hills and the Maricopa Mountains.

By 1952, substantial ground-water development had taken place in the northern portion of the subarea creating a shallow pumping trough centered beneath Waterman Wash (Drawing No. 344-314-969). Most ground-water movement was toward this trough and any subsurface outflow was essentially eliminated.

By 1964, continued overpumping had expanded and accentuated the pumping trough beneath the main irrigated area in the northern part of the subarea (Drawing No. 344-314-1014).

Lines of equal depth to ground water in 1964 (Drawing No. 344-314-976) show a range from about 180 feet below ground surface at the northwest extreme where Waterman Wash leaves the subarea to more than 340 feet toward the eastern and western peripheries and along Waterman Wash at the south line of T. 3 S. Depths to ground water at the extreme southeastern end of the subarea exceeded 400 feet. Depths to ground water in the northern developed portion of the subarea were generally from 200 to 300 feet.

Pumping lifts in the subarea based on data for the 1961 to 1964 period ranged from 290 to about 450 feet. As of 1964, there were about 50 high-capacity wells pumping in the subarea ranging in depth from 465 to 1,600 feet. Capacities of the wells ranged from about 650 to nearly 3,700 gallons per minute. In 1964, about 90 percent of the pumpage for irrigation in the subarea was from natural gas installations.

Long-term ground-water declines during the 1952 to 1964 period ranged from less than 60 feet to more than 100 feet (Drawing No. 344-314-1021). Average declines were about 85 feet or 7 feet per year. Declines decreased as distance from the centers of pumping increased, with minimum declines of 3 feet or less occurring at the extreme southeastern end of the subarea. Drawings Nos. 344-314-1234 and -1235 relate the 1952 to 1964 ground-water decline to the hydrogeology.

Hydrographs (C-2-2) 10ccc, (C-2-2) 12add, and (C-2-2) 25ccc (Drawing No. 344-314-1302) illustrate the magnitude of long-term declines in the developed area. These hydrographs are of wells which penetrate both the Upper Alluvial Unit and the Lower Conglomerate Unit. The recent decrease in the rate of decline is a result of decreased pumpage since 1961. Data are not available to illustrate the nature and magnitude of short-term or seasonal fluctuations in this area. Hydrograph (D-4-1) 28cdd (Drawing

No. 344-314-1302) illustrates the nature and magnitude of the long-term fluctuation in the area of minimum declines near the southeastern extreme of the subarea.

The quality of ground water in the Waterman Wash subarea appears to vary areally but does not appear to change with depth. The water is generally of the sodium chloride type, but water in the northwest corner of the area is of sodium bicarbonate type (Drawing No. 344-314-1283). Ground water in the subarea varies from less than 450 to nearly 2,000 parts per million total dissolved solids. The southern and northwestern parts of the subarea have the lowest dissolved solids, usually from 450 to less than 700 parts per million. Ground water in the developed area east of Waterman Wash generally has more than 1,000 parts per million and in T. 2 S., R. 1 W. some wells have from 1,200 to 2,000 parts per million total dissolved solids. The relationship of the poorer quality ground water to some areas of significant ground-water decline may indicate a gradual deterioration of quality with depth although this is not evident from analyses in wells of different depths. High fluoride concentrations characterize most of the ground water in the subarea.

<u>The 1964 to 1972 Study Period</u> -- The hydrographs from the Waterman Wash subarea (Drawing No. 344-314-1302) indicate that water levels are continuing to decline. In the most heavily developed northern portion of the valley, however, the rate of decline was less for the 1964 to 1972 period than it was in the 1950s. A decrease in irrigated acres and increased farm efficiency resulted in a small decrease in pumpage since the peak in 1961. Hydrographs (C-3-1) 21dcc and (D-4-1) 28cdd which are

representative of the less developed southern end of the valley indicate that water levels there are declining at an accelerated rate, although declines are still small. This may be due to an increase in development of this portion of the valley and/or to a time lag in the effect of pumping in the northern portion of the valley.

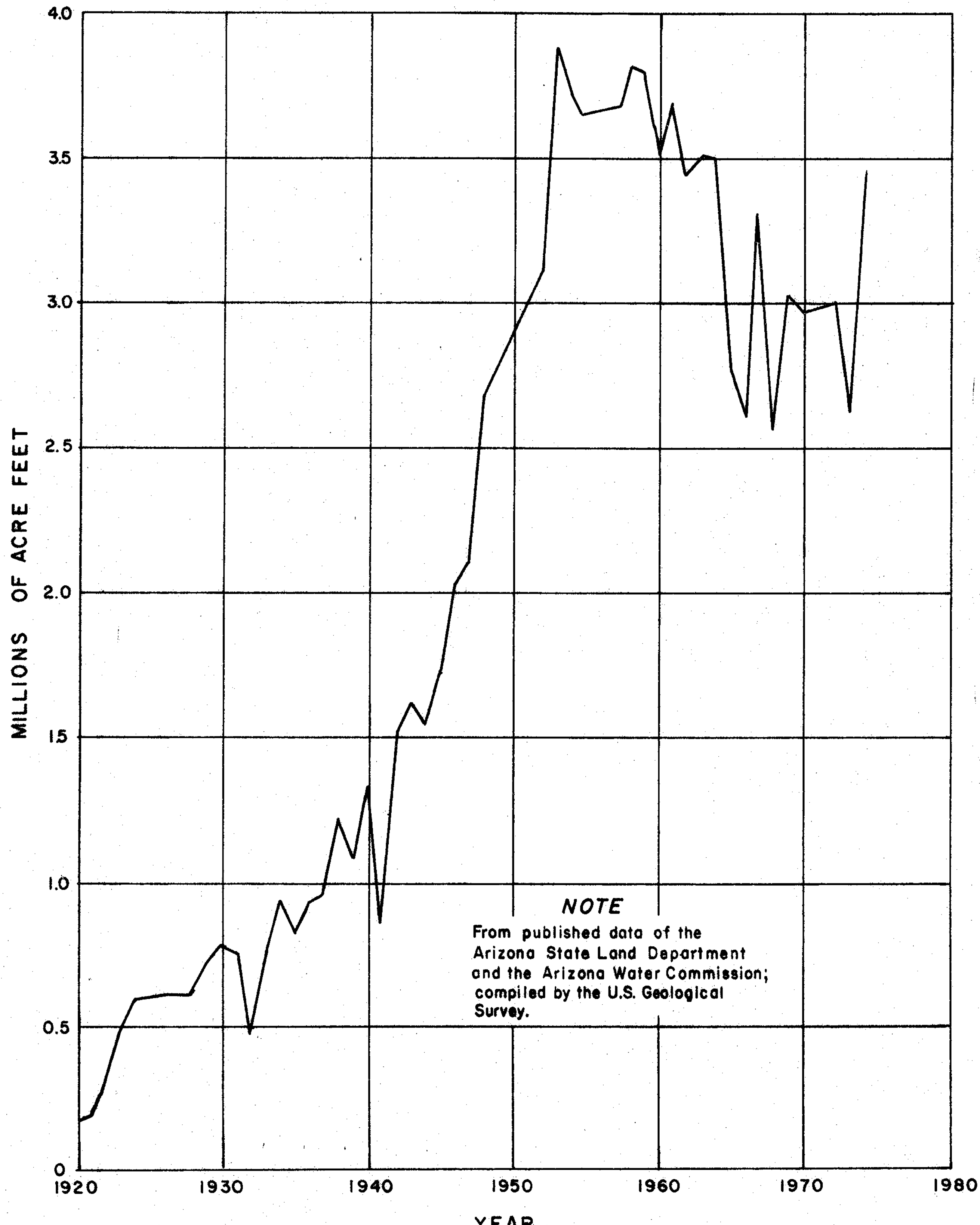
GROUND-WATER USE AND WATER-LEVEL DECLINES

Ground water is the primary source for all uses in the CAP area. Irrigation water use far exceeds any other use of water in the study area. In 1964, ground water supplied 70 percent of the total water demand. With near maximum development of local surface-water supplies, ground water has met the water requirements of much of the dynamic agricultural and urban growth since the early 1940s. Historic ground-water use in the study area is shown graphically on figure 1.

Pumpage prior to 1920 is characterized by slow but steady growth with most of the pumpage concentrated in Pinal County. With the advent of the Salt River Project, however, and high water table conditions resulting from canal seepage and excess irrigation application, large-scale pumpage for drainage was initiated in the Salt River Valley. By 1920, pumpage in the Salt River Valley surpassed that pumpage prevalent in Pinal County. Steady growth persisted to the early 1940s which marked the beginning of massive ground-water development. From 1942 to 1952, ground-water use increased from 1.5 million to slightly over 3.1 million acre-feet; 1953 marks the peak year with pumpage of about 3.9 million acre-feet. Since 1953, there has been an erratic but steady decline of pumpage attributable to many factors, the more important of which are lower cotton prices, higher costs of pumping, decline in well yields, and more efficient use of water, primarily by lining farm water conveyance systems, etc. As of 1964, over 4,000 high-capacity wells were in service in the study area. These wells ranged to over 3,000 feet in depth and generally are capable of pumping about 500-3,000 gallons per minute. Because of the long growing season, many irrigation wells pump throughout the year.

Figure A

GROUND-WATER PUMPAGE IN
CENTRAL ARIZONA PROJECT AREA
1920-1974
(EXCLUDING TUCSON AREA)



The long-term ground-water declines prevalent in the central Arizona area are a direct reflection of excessive ground-water withdrawals in each subarea and also reflect cumulative effects from surrounding areas. These declines are accentuated in areas where surface-water supplies are nonexistent or where the utilized ground-water reservoir is limited by hydrogeological conditions.

The following Table 1. summarizes the ground-water declines that occurred during the 1952-1964 period:

TABLE 1

SUMMARY OF GROUND-WATER DECLINES IN TH
CENTRAL ARIZONA PROJECT AREA, 1952-1964

Unit: Feet

Subarea	Maximum	Minimum	Mean	Average Annual
Eloy-Coolidge	141	27	80	7
Maricopa-Stanfield	271	56	150	12
Komatke-Sacaton	135	40	70	6
Paradise Valley-Chandler-Queen Creek	179	52	105	9
Phoenix-Buckeye	165	17	80	7
Arlington-Tonopah	30	10	20	2
Gila Bend	73	0 a/	30	2 a/
Waterman Wash	90	76	85	7
Harquahala Valley	133	72	120	10

a/ Includes significant area of ground-water rise

Individual drawings illustrating the 1952-1964 water-level declines are included for each subarea. Drawing No. 344-314-1305 shows the estimated water-level declines for the 1923-1964 period. As supplemental data, water-level change maps for each subarea are presented for the 1964-1972 period.

COST OF PUMPING

The University of Arizona College of Agriculture conducted an intensive study of pumping costs in cooperation with the Bureau of Reclamation that resulted in Technical Bulletin 182, published in April 1967. The summary and conclusions contained in Bulletin 182 are presented below:

> This study was made to determine costs individual farmers incur in pumping water for irrigation in Maricopa and Pinal Counties of central Arizona. Wells powered by electric motors, referred to as electric wells, and by natural gas engines, referred to as gas wells, were included in the study. Fixed, added capital, and variable costs are portrayed on an acre-foot, and acre-foot per foot of lift basis. The capital investment in wells is shown in conjuction with analysis of fixed costs. Physical data on the wells, hours run, acre-feet of water pumped, power or fuel consumption and efficiency also are included.
>
> Data for the study were obtained from a random sample of wells of individual farmers, five major irrigation districts, two large corporate farms (included with irrigation districts in the study), well drilling and pump companies, and power and natural gas suppliers.
>
> The approach followed was to develop costs and related data for the farm survey electric wells, the farm survey gas wells, and for the irrigation districts as separate groups. Since relatively accurate data were available for large numbers of wells in the irrigation districts (all were electric wells), the objective was to use district well costs as a check on, or to substantiate, the farm survey well costs. The farm survey well costs are believed to represent more closely costs individual farmers will incur than do irrigation district costs.
>
> The typical well in the farm survey had a 20-inch casing and was approximately 1,000 feet deep. Irrigation district wells were slightly larger but averaged only 675 feet in depth. The column pipe was typically 10 or 12 inches in diameter, the average for district and farm survey gas wells being about one inch larger than the average for farm survey electric wells. Column length averaged 415 feet for farm survey electric wells, about 480 feet for the gas wells, and about 300 feet for the district wells. Pumping lift averaged about 380 feet for the farm survey electric wells, 435 feet for the gas wells, and about 265 feet for the district wells. Farm survey electric motors averaged about 210 horsepower compared with 190 horsepower for district wells. The natural gas engines averaged about 365 horsepower.
>
> During 1963, farm survey electric wells were operated an average of 3,763 hours and farm survey gas wells an average of 3,717 hours. Irrigation district wells were operated an average of 4,520 hours.

The quantity of water pumped per well averaged 870-acre feet for farm survey electric wells and 1,084 acre-feet for farm survey gas wells. Irrigation district wells averaged 1,558 acre-feet per well. Discharge averaged about 1,255 gallons per minute for farm survey electric wells and 1,585 gallons per minute for the gas wells. Irrigation district wells averaged 1,810 gallons per minute

Overall efficiency of the pump and power unit averaged 52 percent for farm survey electric wells and 13 percent for the natural gas wells. Compared with maximum efficiency attainable under ideal conditions-74 percent for electric wells and 18 percent for natural gas wells-the gas wells were operating at approximately the same level of efficiency as the farm survey electric wells. Overall efficiency of irrigation district wells averaged nearly 59 percent, matcrially higher than the farm survey electric wells. The average replacement cost new of farm survey electric wells was nearly $33,000, using 1963 costs. About 50 percent of the total investment was in the well and casing, 25 percent in the pump, and 25 percent in the power unit.

The average replacement cost new of farm survey gas wells was a little over $49,000 per well, the higher replacement cost relative to electric wells being due to the relatively higher price of natural gas engines and the somewhat larger and deeper wells. About 38 percent of the total investment was in the well and casing, 22 percent in the pump, and about 40 percent in the power unit. See tabulation on the following page.

	Cost per Acre-Foot[1]			Cost per Acre-Foot-Foot		
	District Wells	Farm Survey Wells		District Wells	Farm Survey Wells	
		Electric	Gas		Electric	Gas
	($)	($)	($)	(Cents)	(Cents)	(Cents)
Fixed Costs						
Depreciation	.78	1.48	2.20	.29	.40	.53
Inter. on Invest. @ 6%	.57	1.13	1.36	.21	.30	.31
Property Taxes	.43	.77	.74	.16	.20	.17
Total	1.78	3.38	4.39	.66	.90	1.01
Added Capital Costs	.13	.42	.55	.05	.11	.13
Variable Costs						
Fuel[2]	4.09	6.98	4.29	1.53	1.85	.99
Repairs	.66[3]	1.21	1.43	2.25[3]	.32	.33
Lubrication		.13	.38		.03	.08
Attendance		.08	.09		.02	.02
Total	4.75	8.40	6.19	1.78	2.22	1.42
Total Costs	6.66	12.20	11.13	2.49	3.23	2.56

[1]These costs relate to the cost of operating an established well. A charge is not included for management required in arranging for drilling and equipping the well, or in operating the well except as it may be included as a part of the "attendance" cost. Moreover, a cost is not included for the land where the well is located including land required for access.

[2]Electricity at nine mills per KWH and natural gas at 40 cents per MCF (thousand cubic feet).

[3]Includes lubrication and attendance.

Estimated fixed, added capital, and variable costs per acre-foot and per acre-foot per foot of lift are as follows:

As indicated above, the costs for the farm survey wells are believed to be fairly representative of costs typical farmers incur in pumping water, assuming a nine-mill rate for electricity and natural gas at 40 cents per thousand cubic feet.

Cost estimates for the farm survey electric and farm survey gas wells given in the table are not entirely comparable due to differences in lift, size of well, and quantity of water pumped.

Costs for district wells probably are lower than typical farmer costs for a number of reasons: (1) Repairs, lubrication and attendance are actual costs the districts incurred. These costs may be low relative to individual farmer costs due to quantity discounts on parts and since some of the districts do their own repair work. (2) The efficiency of irrigation district wells averages higher than individual farmer wells. (3) The average amount of water pumped annually by irrigation districts is substantially greater than the amount pumped by individual farmers. Therefore, fixed costs per acre-foot and per acre-foot per foot of lift are much lower for irrigation district wells than for individual farmer wells. (4) The irrigation district costs per acre-foot are relatively low due to the relatively lower pumping lift in the districts than in areas outside the districts.

The cost estimates given in the table represent the average situation. Costs vary from area to area and from well to well for a number of reasons. Equations given in the report facilitate estimating costs per acre-foot and per acre-foot per foot of lift.

Electric power and natural gas rates have a significant influence on pumping costs. As indicated above, a rate of nine mills per KWH was used in deriving fuel costs in the table. Within the Maricopa-Pinal County farming area average rates vary from .7506 cents to 1.0861 cents per KWH, with a result that variable costs per acre-foot of lift vary from 2.036 cents to 2.786 cents. With a pumping lift of 400 feet this small difference amounts to $3.00 per acre-foot. Natural gas costs per acre-foot per foot of lift vary from 0.929 cents to 1.152 cents due to differences in rates charged per MCF. With a lift of 400 feet this small difference amounts to about 90 cents per acre-foot pumped.

Efficiency of the pump and power unit also has a significant influence on pumping costs. Raising efficiency of electric wells from 40 to 65 percent reduces power costs 40 percent. With a 378-foot lift (the average for farm survey wells) this amounts to about $3.35 per acre-foot. Savings in the power cost of pumping 685 acre-feet with a 420 foot lift would equal the estimated repair costs for raising efficiency from 40 to 65 percent.

LAND SUBSIDENCE

Since the early 1940s, land subsidence has been a relatively unrecognized but increasing problem in the central Arizona area. It was not until the early 1960s that the magnitude of subsidence had been evaluated only locally and yet today vertical and horizontal control is still inadequate to evaluate the problem throughout the study area. An interagency committee on land subsidence in Arizona has been informally established, and working subcommittees are collecting data that will result in an initial report.

Most of the subsidence can be attributed to the intensive ground-water pumping and the severe water-level declines attendant to perennial, massive overdraft. Ground-water pumpage during the past 20 years approaches 70 percent of the total water supply of the area. Total water-level declines, derived from the earliest records, approach 300 feet in some areas. Most of this decline took place since 1952. It is estimated that at least 1,000 square miles in the study area have been affected by subsidence. It is most severe in the Eloy-Coolidge subarea where this subsidence has exceeded seven feet during the last 20 years.

During this investigation, studies were initiated to define the magnitude of rate of subsidence, by conducting vertical and horizontal surveys along a line in Pinal County beginning in 1964. Subsequently, a test hole, (D-7-8) 31bba, was drilled and cored to determine the physical properties of the materials experiencing subsidence. In cooperation with the U. S. Geological Survey, water level and compaction recorders were installed in this hole and two other abandoned wells in the study area to relate subsurface rate of compaction to water-level fluctuation and surface rate of subsidence. The rate of subsurface compaction in the test hole approximated 1.0 foot during the period March 1965 to January 1972. The magnitude of surface subsidence other than in the Eloy area approximates maximums of 2.5 to 3 feet during the last 20 years. Drawings Nos. 344-314-1284, -1292, and -1297 illustrate the relationship between compaction and water-level fluctuation in the three instrumented subsidence wells.

Attendant to the land subsidence are earth fissures that occur primarily along the peripheries of the subsiding areas. Drawing Nos. 344-314-1260, -1263, and -1264 illustrate the distribution and configuration of these fissures related to the gravity contours. It is apparent that the fissures mostly parallel regional basement structure and probably reflect the nearby buried Basin and Range fault scarps. Their occurrence can be interpreted as being primarily tension cracks demarking the subsiding area basinward and the nonsubsiding area along the pediment areas. The buried fault scarps in effect act as a "hinge line" marking lithologic as well as structural changes.

Land subsidence and accompanying earth fissure phenomenon will continue to occur as long as ground-water overdraft continues. Damage to wells and other engineering structures in subsiding areas cannot be avoided.

Source of Ground Water

The ultimate source of ground water in the CAP area is the precipitation on the area and on its tributary drainage basins. Recharge is accomplished by infiltration from stream channels, canals, and laterals, by subsurface inflow in permeable materials from adjacent areas and by infiltration of excess irrigation water.

Recharge from direct infiltration of rainfall over the entire project area is considered to be insignificant. The average annual rainfall is very low; subsequently, soil-moisture deficiencies are perennially prevalent.

Infiltration from streams was the principal source of recharge before the advent of large-scale irrigation. But with maximized surface-water development, the occurrence of surface flows within the area is so infrequent and of such small magnitude that this source is considered relatively nominal.

Infiltration losses in unlined canals and laterals are the primary contributors to ground-water recharge. Since most of the soil types in the study area are relatively permeable, conveyance losses in canals and laterals approach 35 percent in some systems. Surface and pumped water are frequently comingled in such systems.

Infiltration from excess irrigation water is highly variable from subarea to subarea and frequently within a subarea. Important factors are (1) the depth to the historically high point of ground water; (2) the availability of relatively low-cost surface water; (3) the cost of pumped water; and (4) the occurrence of impermeable horizons above the regional ground-water level. Any one, or combination of the above factors determines the potential of such recharge. The depth to a historically high ground-water level assumes major importance in evaluating infiltration of excess irrigation water in areas of perennially declining water levels. The moisture content of the materials within the depth interval underlying the soil profile and overlying saturated sediments must be at or near field capacity (or specific retention) before any appreciable downward movement of water can occur. In those areas where ground water was historically at minimum depths, for example above 50 feet, even though ground-water levels have subsequently declined greatly, the materials within the "dewatered" interval are still at or near field capacity and can transmit downward any excess irrigation water. If depths to ground water were historically at maximum depths, for example 100 feet and below, the intervening sediments are not at field capacity and cannot transmit appreciable quantities of recharge to the underlying saturated section. If any excess irrigation water does occur, it is merely going into these materials under unsaturated-flow conditions and raising the moisture content upwards toward the effective field capacity.

The availability of low-cost surface water and the cost of pumped water appear to have a great effect on farm efficiencies and, consequently, the amount of excess irrigation water available for potential recharge. In those areas that are dependent on high-cost pumped water for irrigation, total pumpage more closely approaches the consumptive use than those areas that also have a surface-water supply.

Areas that require additional water for leaching purposes coincide with those areas that have had historically extremely high ground water. These areas are minor within the study area, however, and it is assumed that most, if not all, of this water becomes active recharge, although these same areas also usually contain poor-quality water.

The occurrence of widespread semiperched water bodies in a few of the major subareas indicates that appreciable quantities of excess irrigation water are impeded from becoming active recharge by relatively shallow impermeable horizons. These water bodies generally comprise poor-quality water.

Recharge-Discharge Analysis

The ground-water analysis presented in the 1961 Central Arizona Project appraisal report utilized readily available data and included areas both within and outside of the direct service area. The analysis was based on the empirical relationship between change in ground-water levels and pumpage. Although the method was technically correct, it presented a vastly oversimplified analysis because of expediency.

For this study, two independent methods were used to estimate change in ground water storage in each subarea as a check on the accuracy of each estimate. The first method was direct, deriving an estimate of volume of sediments dewatered from historic water-level measurements and applying an estimated specific yield. The second method was more intuitive and involved computing all components of recharge and discharge to and from the ground-water reservoir. This method also served to identify the major contributors to recharge. The specific yield method derived a negative change in storage, which indicated the average net overdraft that occurred during the study period. The inventory method utilized 1952-1964 average water quantities as a function of recharge and discharge. The increments of recharge and discharge are shown and explained on Table 2 following this page.

A period of record for the analysis was selected primarily on the availability and quality of historic data. The period was also selected to be as long term as possible so that extreme variations in any set of data would not overly influence the results. On this basis, the period 1952-1964 was selected.

Specific Yield Method -- The "specific yield" method required estimates of specific yield. Accordingly, about 3,000 drillers logs throughout the area were processed, assigning arbitrary values to described sediments on each log. Derived values of specific yield were estimated for vertical increments of 50, 100, and 200 feet. Long-term water-level data were also required with which to estimate storage capacity of the ground-water reservoir at the start and end of a chosen study period. The main difficulty associated with this method was estimating values of historic ground-water decline and specific yield values outside of the developed areas where water-level and drill-hole data are almost nonexistent.

The values chosen for specific yield were based largely on published material on similar valley-fill deposits. These values were assigned to the various lithologic descriptions reported in well logs (See Table 3) following page 101. The well logs were then assembled in township - range groups.

Table 2
Quantitative Ground-Water Analysis of the Central Arizona Project Area
Average Annual Quantities for the 1952-64 Period

Unit: Acre-feet

	Discharge			Recharge							Summary					
	Irrigation Pumpage (1)	M&I Pumpage (2)	Phreato-phytes (3)	Major Streams (4)	Peripheral (Minor Streams) (5)	Net Subinflow (6)	Canal Seepage (7)	Excess Irrigation Application (8)	M&I Effluent (9)	Subsurface Compaction (10)	Total Discharge (11)	Total Recharge (12)	Apparent Overdraft (13)	Storage Change (14)	Mean of Two Methods (rounded) (15)	Ground Water in Storage (16)
Eloy-Coolidge	564,000	5,000	2,000	11,000	2,000	30,000	99,000	74,000a/	2,000	17,000a/	571,000	235,000	336,000	321,000	329,000	28,900,000
Maricopa-Stanfield	419,000	<1,000	—	8,000	1,000	3,000	—	16,000b/	—	5,000a/	420,000	33,000	387,000	410,000	399,000	15,500,000
Komatke-Sacaton	136,000	<1,000	45,000	13,000	2,000	(2,000)a/	36,000	12,000c/	—	—	182,000	61,000	121,000	123,000	122,000	14,500,000
Paradise Valley-Chandler-Queen Creek	741,000	20,000	—	8,000	2,000	1,000	200,000	101,000d/	10,000	5,000b/	761,000	327,000	434,000	452,000	443,000	36,400,000
Phoenix-Buckeye	843,000	100,000	14,000	13,000	5,000	16,000	206,000	132,000e/	85,000	5,000b/	957,000	462,000	495,000	423,000	459,000	35,600,000
Tonopah-Arlington	135,000	<1,000	12,000	8,000	4,000	3,000	17,000	19,000f/	—	—	147,000	51,000	96,000	71,000	84,000	22,400,000
Gila Bend	149,000	<1,000	1,000	5,000	3,000	6,000	19,000	10,000g/	—	—	150,000	43,000	107,000	100,000	104,000	22,600,000
Waterman Wash	49,000	<1,000	—	<1,000	<1,000	<1,000	—	—	—	—	49,000	3,000	46,000	44,000	45,000	8,600,000
Harquahala Valley	119,000	<1,000	—	2,000	<1,000	18,000	—	—	—	—	119,000	21,000	98,000	100,000	99,000	6,300,000
Totals	3,155,000	127,000	74,000	69,000	21,000	76,000	577,000	364,000	97,000	32,000	3,356,000	1,236,000	2,121,000	2,044,000	2,084,000	190,800,000

(1) Estimated with following: $\frac{\text{Consumptive Use}}{\text{Farm Efficiency}} - \frac{\text{Net surface water diversion}}{\text{at farmer's headgate}}$ = Required pumpage to satisfy Farm Delivery Demand; all data derived by Hydrology Division.

(2) As estimated by Hydrology Division and/or from actual records.

(3) Gross consumptive use estimated by Hydrology Division; net ground-water use estimated as 50 percent of gross use.

(4) Estimated as 35% of average annual streamflow that enters subarea boundary; streamflow data derived by Hydrology Division.

(5) Estimated as 50% of average annual runoff that enters subarea peripheral areas; runoff data derived by Hydrology Division.

(6) Net quantities as computed from 1952 and 1964 ground-water configurations; average transmissibilities developed from published and unpublished pump-test data a/ net suboutflow because of a gradient reversal.

(7) Includes both surface and ground water where applicable; actual losses less estimated 5% irrecoverable losses; canal deliveries on net basis (less export).

(8) Gross return flows estimated as 20 percent of Farm Delivery Demand. Active increment to recharge based on the percentage of developed area having historic ground-water depths of 50 feet or less. Percentages used as follows: a/ 57%, b/ 19%, c/ 41%, d/ 50%, e/ 59%, f/ 52%, g/ 31%.

(9) Estimated as 50% of gross water requirement supplied by surface and ground water; also includes recharge in urban areas derived from yard irrigation, septic tanks, storm drains, etc.

(10) Derived from land-subsidence data; interpreted as annual volume of land subsidence equal to loss of water volume available to pumping in fine-grained sediments; a/ computed, b/ estimated.

(11) Totals of columns (1), (2), and (3).

(12) Totals of columns (4) through (10).

(13) Column (11) less column (12).

(14) Storage change, equivalent to overdraft, developed by the Specific Yield Method.

(15) Mean deviation of two methods columns (13) and (14) ranged from 1,000 to 36,000 acre-feet or from 0.9% to 7.8% of the mean.

(16) Ground water in storage, as of 1964, to 1,000 feet from land surface or hydrologic bedrock if less than 1,000 feet.

For the depth zones 50-100, 100-200, 200-300, 300-400, 400-500, 500-600, 600-800, and 800-1,000, an average specific yield was computed for each township and range. Each township and range and portions thereof were assembled for each designated subarea. From 1952 depth-to-water contour maps, a center-of-township depth was computed and converted to volume of saturated materials with the use of the average township specific yield. The storage capacity for each designated subarea was then obtained as the sum of all townships and ranges. Storage change for each subarea over the period of record was obtained by finding the difference (+ or -) between the 1952 and 1964 storage capacities. An accompanying product of this computation was the ground water in storage, to a depth of 1,000 feet or hydrologic bedrock, as of 1964.

Inventory Method -- The "inventory" method required data on crop acreages, consumptive use, farm efficiencies, streamflow and precipitation records, canal diversions, main and lateral canal losses, stream channel percolation rates, and metropolitan area supplies and effluent flows. Additional data were required on hydraulic gradients and transmissibilities of subsurface materials to compute subsurface inflows and outflows.

Generally, the data input to this method of analysis were adequate. Less often the data were inadequate or nonexistent and estimates were required. Experience in other areas and sources in the literature provided many of the interpretative estimates necessary to quantify various increments of recharge. These are shown on Table 3 following this page. Ground-water pumpage was derived rather than utilizing pumpage because of unexplainable discrepancies in the published data.

Discussion of Analysis

The two methods of analysis were in close agreement in many of the subareas (comparison of columns 13 and 14, Table 2). This propitious agreement, notwithstanding the many assumptions and sometimes questionable quality of data, does not infer absolute quantification. However, it does indicate the relative magnitudes of the various components of recharge and justifies, to a sufficient degree, confidence in the methodology. Divergence was most pronounced in the Phoenix-Buckeye subarea where pumpage and recharge increments of urban water uses were difficult to quantify with any great level of confidence.

Throughout the project area, there is a vast difference between "natural" and "artificial" recharge; "natural" defined as occurring solely through nature, and "artificial" defined as occurring with or by man's manipulation whether planned or incidental. Columns 4, 5, and 6, Table 2, indicate natural recharge of about 170,000 acre-feet. Columns 7 through 10 indicate artificial recharge of about 1.1 million acre-feet. Natural recharge is almost insignificant when compared to overdraft and/or artificial recharge, either total or in individual subareas. The positive effects of the Salt River Project cannot be overemphasized for, without its surface-water supplies and resulting artificial recharge, the water supply situation in large portions of Maricopa County and lesser portions of Pinal County would be even more dramatically negative than it is today. The same effects of surface-water supplies are similar in the San Carlos Project lands.

Recharge from excess irrigation applications (column 8) is estimated to be about 360,000 acre-feet per year during the 1952-64 period. The method

Table 3

Assigned Values of Specific yield in the Central Arizona Area

Material	Assigned Specific Yield (percent)
1. Gravel; sand and gravel; related coarse gravelly deposits; sand, medium to coarse grained, well sorted	25
2. Sand, medium to coarse grained, well sorted fine sand; tight sand; tight gravel; related deposits	16
3. Silt; gravelly clay; sandy clay; sandstone; conglomerate; related deposits	9
4. Clay and related very fine grained deposits	3
5. Igneous or metamorphic bedrock	0

Table 4

COMPARISON OF GROUND-WATER CONDITIONS BY SUBAREA

Subarea	Percent (1952-64 Average Annual Overdraft / Ground Water in Storage, 1964)	Percent of Total CAP Overdraft	Percent of Total Ground Water in Storage 1964
Eloy-Coolidge	1.1	16	16
Maricopa-Stanfield	2.5	20	9
Komatke-Sacaton	0.84	6	8
Paradise Valley-Chandler-Queen Creek	1.6	22	15
Phoenix-Buckeye	1.4	21	18
Tonopah-Arlington	0.36	3	13
Gila Bend	0.44	5	13
Waterman Wash	0.52	2	5
Harquahala Valley	1.6	5	3
		100	100

of computation was explained earlier in the report. The total estimated average annual irrigation farm delivery demand throughout the study area was about 3.9 million acre-feet. If 20 percent of this total would approximate 780,000 acre-feet of recharge from excess irrigation application, about 420,000 acre-feet per year is unaccounted for in the recharge analysis. A possible explanation is twofold:

A. The occurrence of perched or semiperched water bodies is known in three subareas. The areal configuration and vertical extent of these bodies cannot be distinguished with any reasonable accuracy from presently available data. Some of the unaccounted-for water is undoubtedly responsible for these occurrences.

B. In areas where vertical percolation is not inhibited by fine-grained materials and where the historic ground-water levels were below 50 feet, these waters are merely increasing the moisture content of the dessicated shallow subsurface materials. The available storage capacity underlying areas having a history of ground-water levels below 50 feet throughout the study area is so great as to discreetly mask the effect of this "unaccounted for" water. This available storage capacity, conservatively estimated for the area having a history of development, is about 15 million acre-feet.

Table 4 following page 102 compares ground-water conditions in each of the subareas. The comparison indicates the relative disproportionality of ground water conditions.

Current Ground-Water Conditions

Current water-level trends generally confirm the validity of the 1952-1964 base-period analysis. Above-average surface-water supplies and the accompanying contraction of ground-water pumpage during the 1964-1972 period has resulted in a leveling off of the long-term water-level declines and in some instances an initiation of water-level rises. For example, the Paradise Valley-Chandler-Queen Creek, Phoenix-Buckeye, and Arlington-Tonopah subareas during the 1952-1964 period received an average annual gross diverted surface-water supply of about 730,000 acre-feet; during the 1964-1968 period this annual surface-water supply averaged about 1.2 million acre-feet with a maximum of about 1.5 million acre-feet in 1966. Average annual pumpage in these subareas during the 1952-1964 period was about 1.8 million acre-feet; during the 1964-1968 period the annual pumpage averaged about 1.5 million acre-feet. The estimated 1952-1964 average annual overdraft in these three subareas totaled about 986,000 acre-feet (Table 2, column 15; See Table 2 following page 100). The almost 500,000 acre-feet increase in gross surface-water diversions, the 300,000 acre-feet decrease in average annual pumpage, significant increase in natural recharge from spilled flows in the Salt River channel, and above-normal flows in minor streams would suggest that in individual years, during the 1964-1968 period, there was a near water-budget balance on a gross subarea basis. No doubt local overdraft conditions persisted in areas unfavorably located with relation to surface-water availability and/or primary recharge areas.

The near-stabilization of, or rising water levels that have occurred in portions of the project area are the result of a current "wet" cycle. Other areas in the State that have intensive ground-water development but no surface-water development did not share in this improving ground-water condition. This emphasizes the importance of surface-water availability in the long-term storage function of the ground-water reservoirs. Central Arizona Project surface-water imports to the central Arizona area will result in dramatic water-level rises in most areas of application.

APPENDIX

1976 Cost of Pumping

Cost of Pumping

The University of Arizona, College of Agriculture, conducted an intensive study of pumping cost in cooperation with several firms who furnished data pertaining to the cost of pumping irrigation water in Arizona. Arizona pump water budgets were prepared by the University of Arizona for Maricopa, Pima, and Pinal Counties. 1/ Other budgets were prepared for other counties but this summary is confined to the three counties mentioned above.

Summary of the Pumping Costs for Various Pumping Lifts by Energy Source in the Three Counties

The data presented gives the reader a quick comparison of the cost of pumping an acre-foot of water from a given depth in an area by energy source, the ranking of energy sources in terms of cost of pumping, and the effect of increased pumping lift on pumping cost by energy sources.

Pumping cost projections were made for an average well found in a cropping area. Specifications were developed for this well and assumptions were made concerning the life expectance and salvage value of the major components of the well and the interest rate to charge on the investment. Current price quotations were obtained from the trade for each major component and the annual fixed costs(depreciation, interest, and taxes on the average investment, and insurance) were calculated. The fixed cost per acre-foot of water pumped was computed by dividing the total annual fixed cost by the number of acre-feet of water that would have been pumped in 3,600 hours (150 days) of operation at the specified rate of discharge. Trade sources indicated that 3,500 to 3,700 hours of pump operation was rather common.

The variable cost of pumping an acre-foot of water is a function of pumping depth (lift), overall pumping efficiency, the unit price of energy used to drive the pump, and the cost of plant repairs, maintenance, lubrication, and attendance.

The overall pumping efficiency used in these calculations for each energy source was as follows:

Natural Gas - 15.4 percent	Diesel - 16.0 percent
Electricity - 54.0 percent	LP Gas - 13.1 percent

These values were calculated from the efficiencies of the component parts of the system. For example, the overall efficiency for an electric power well was calculated by multiplying the efficiency of the motor (.90) by the efficiency of the pump (.60) by the efficiency of the drive line (1.0). The result is .54 or 54 percent overall efficiency.

1/ Hathorn, Scot Jr., "Arizona Pump Water Budgets," 1976, for Maricopa, Pima, and Pinal Counties.

The efficiency of an electric motor operating under an uniform load varies by about 2 percent. An efficiency figure of 90 percent is commonly accepted by engineers. Since the electric motor connects directly to the pump shaft, there is no loss in the transfer of power from the motor to the pump shaft.

The efficiency of the pump can vary widely, from about 80 percent when new to any lower value, depending on the amount of wear on the bowls as a result of abrasive action of sand and other particles in the water and the corrosive action from minerals dissolved in the water. An efficiency value of 60 percent was chosen as a representative figure for a pump that has been reasonably maintained.

Commonly accepted thermal efficiencies for natural gas, LP gas, and diesel engines are 23, 23, and 28 percent, respectively (8, p. 39) 2/. These engines transmit power to the pump through a 90 degree gear drive with a 5 percent loss in power or an efficiency factor of .95. Using values of .27 for the engine, .95 for the drive line, and .60 for the pump, an overall efficiency of 15.4 percent was calculated for natural gas and LP gas engines. For diesel engines, and overall efficiency of 16.0 percent was obtained.

Data for pumping costs by energy source for each cropping area were taken from the tables in Appendix A and recorded in text Table 1. In addition, pumping costs by energy source were computed for 50-foot increments of lift over the range of pumping lifts encountered in each cropping area. These data are tabulated in Table A for each of the three counties.

After examining these data closely, the following observations can be made:

1. When the pumping costs per acre-foot of water are ranked in ascending order of magnitude, natural gas in most areas is the most economical energy source followed in order by electricity, diesel, and LP gas.

2. The advantage of the lowest cost energy source over each competing higher cost energy source increases with lift. This follows from the increased energy requirement associated with deeper lifts and a resulting increase in the proportion of total pumping cost due to energy outlays.

To obtain a detailed analyses of the study it would be necessary to review "The Pump Water Budgets for 1976," as prepared by the university.

2/ Industry experience with newer high compression natural gas engines suggests that the thermal efficiency may be 28-29 percent rather than 23 percent. The Soils, Water, and Engineering Department, College of Agriculture, University of Arizona, in that thermal efficiencies of 27 to 29 percent are obtainable on well maintained high compression natural gas engines.

Table A

Total Cost Per Acre-Foot of Pumping Water For Selected Areas for Various Lifts by Source of Energy, Pinal County, 1976

AREA	PUMPING LIFT (feet)	ENERGY SOURCE NATURAL GAS	ELECTRICITY	DIESEL	LP GAS
Coolidge	295	18.78	15.41	30.76	38.15
	345	20.65	17.12	34.45	43.26
	* 395	22.52	18.83	38.13	48.39
	445	24.39	20.54	41.82	53.51
	495	26.25	22.24	45.50	58.63
Casa Grande	405	27.65	22.81	41.66	54.19
	455	29.52	24.52	45.34	59.31
	505	31.38	26.24	49.03	64.43
	* 555	33.25	27.94	52.71	69.55
	605	35.11	29.65	56.40	74.67
	655	36.98	31.36	60.09	79.79
	705	38.84	33.07	63.78	84.91
Eloy	455	34.99	29.54	53.42	64.86
	505	37.02	31.36	57.26	70.13
	555	39.03	33.16	61.09	75.40
	* 605	41.05	34.98	64.93	80.67
	655	43.06	36.78	68.77	85.94
	705	45.09	38.60	72.61	91.21
	755	47.11	40.41	76.45	96.48
Stanfield	510	31.70	40.77	50.17	65.09
	560	33.57	43.84	53.86	70.20
	* 610	35.43	46.90	57.54	75.33
	660	37.30	49.97	61.23	80.44
	710	39.16	53.03	64.92	85.57
Maricopa	330	19.25	17.25	31.16	40.87
	380	21.10	19.09	34.83	45.98
	430	22.96	20.93	38.51	51.09
	* 480	24.82	22.77	42.19	56.20
	530	26.67	24.61	45.87	61.31
	580	28.53	26.45	49.54	66.42
	630	30.38	28.29	53.22	71.53

* AVERAGE LIFT IN THE AREA.

Note: Costs for the average lift in each area were compiled from Appendix A Tables 1-20. Costs for other lifts were computed by adjusting the total pumping cost per acre-foot for changes resulting from the amount of energy used as the lift was varied and for the amount of change resulting from increases or decreases in the number of bowl stages for each 50-foot change in pumping lift. The cost of one stage of bowls (including 4% sales tax) was $284 for the Coolidge, Casa Grande, and Stanfield areas, $335 for the Eloy area, and $425 for the Maricopa area.

Table A

Total Cost Per Acre-Foot of Pumping Water for Selected Areas for Various Lifts by Source Energy, Maricopa County, 1976

AREA	PUMPING LIFT (feet)	ENERGY SOURCE NATURAL GAS	ELEC-TRICITY	DIESEL	LP GAS
Gila Bend	205	11.37	14.87	17.11	25.16
	255	13.18	17.86	20.36	30.33
	* 305	15.00	20.85	23.60	35.49
	355	16.82	23.82	26.83	40.65
	405	18.64	26.81	30.07	45.82
Aguila	355	21.44	26.38	31.70	45.34
	405	23.28	29.38	34.96	50.53
	455	25.12	32.38	38.22	55.71
	* 505	26.95	35.38	41.48	60.90
	555	28.79	38.39	44.74	66.08
	605	30.63	41.39	48.00	71.27
	655	32.46	44.39	51.26	76.46
Rainbow Valley	380	20.97	27.73	31.57	46.44
	430	22.86	30.78	34.87	51.67
	* 480	24.75	33.83	38.18	56.89
	530	26.65	36.88	41.48	62.13
	580	28.54	39.93	44.79	67.36
Harquahala Valley	380	24.88	29.83	34.67	50.48
	430	26.77	32.87	37.97	55.71
	480	28.65	35.91	41.28	60.94
	530	30.54	38.97	44.58	66.17
	* 580	32.42	42.01	47.89	71.41
	630	34.30	45.06	51.19	76.63
	680	36.18	48.12	54.50	81.87
	730	38.07	51.16	57.80	87.10
	780	39.95	54.20	61.11	92.33
Queen Creek	480	30.41	38.32	43.18	62.65
	530	32.44	41.50	46.62	68.02
	* 580	34.47	44.68	50.05	73.89
	630	36.49	47.86	53.49	78.75
	680	38.51	51.03	56.93	84.11
	730	40.54	54.21	60.37	89.48

* AVERAGE LIFT IN THE AREA.

Note: Costs for the average lift in each area were compiled from Appendix A Tables 1-20. Costs for other lifts were computed by adjusting the total pumping cost per acre-foot for changes resulting from the amount of energy used as the lift was varied and for the amount of change resulting from increases or decreases in the number of bowl stages for each 50-foot change in pumping lift. The cost of one stage of bowls (including 4% sales tax) for all areas was $425.

Table A

Total Cost Per Acre-Foot of Pumping Water for Selected Areas for Various Lifts by Source Energy, Pima County, 1976

AREA	PUMPING LIFT (feet)	ENERGY SOURCE NATURAL GAS	ELECTRICITY	DIESEL	LP GAS
Avra Valley	258	17.48	22.19	23.80	34.17
	308	19.39	25.41	27.08	39.29
	* 358	21.29	28.64	30.36	44.40
	408	23.20	31.87	33.64	49.52
	458	25.10	35.10	36.92	54.63
Marana	205	16.72	19.99	22.00	30.09
	255	18.70	23.29	25.35	35.29
	* 305	20.68	26.60	28.71	40.48
	355	22.67	29.91	32.06	45.68
	405	24.64	33.21	35.42	50.86

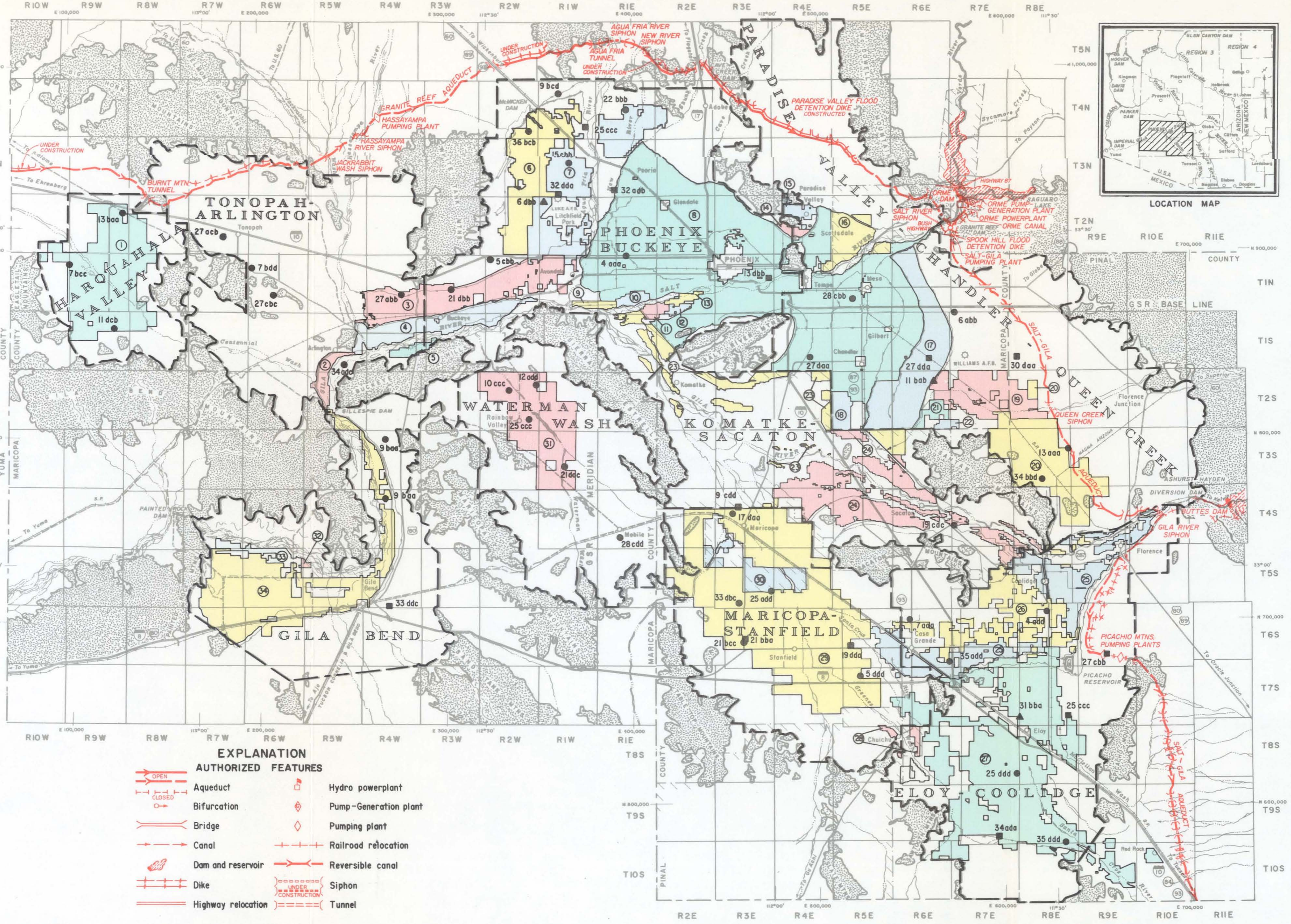
*AVERAGE LIFT IN THE AREA.

Note: Costs for the average lift in each area were compiled from Appendix A Tables 1-8. Costs for other lifts were computed by adjusting the total pumping cost per acre-foot for changes resulting amount of change resulting from increases or decreases in the number of bowl stages for each 50-foot change in pumping lift. The cost of one stage of bowls (including 4% sales tax) for all areas was $322.

EXPLANATION

- ▲ 6 ddb — Compaction recorder
- ● 13 baa — Hydrograph wells
- ■ 33 ddc — U.S.B.R. test holes
- Mountainous areas
- Subarea boundaries
- Indian reservation boundaries
- (10) Water service organizations and boundaries

1. Harquahala Valley Irrigation District
2. Arlington Canal Company
3. Roosevelt Irrigation District
4. Buckeye Water Conservation and Drainage District
5. South Side Irrigation District
6. Maricopa County Municipal Water Conservation District No. I
7. McMicken Irrigation District
8. Salt River Project Agricultural Improvement and Power District.
9. St. Johns Irrigation District
10. New State Irrigation and Drainage District
11. Peninsula Ditch Company
12. Leon Irrigation District (Inactive)
13. Maricopa Garden Farms (Inactive)
14. Arcadia Water Company
15. Camelback Water Conservation District (Inactive)
16. Salt River Indian Irrigation Project
17. Roosevelt Water Conservation District
18. Ocotillo Water Conservation District
19. Queen Creek Irrigation District
20. New Magma Irrigation and Drainage District
21. San Tan Irrigation District
22. Chandler Heights Citrus Irrigation District
23. Gila River Indian Reservation Miscellaneous Irrigation
24. San Carlos Project - Indian Lands
25. San Carlos Project Irrigation and Drainage District
26. Hohokam Irrigation and Drainage District
27. Central Arizona Irrigation and Drainage District
28. Chuichu Indian Irrigation Project
29. Maricopa - Stanfield Irrigation and Drainage District
30. Ak Chin (Maricopa) Indian Reservation Irrigation
31. Rainbow Valley Irrigation District
32. Gila Bend Indian Reservation Irrigation
33. Gila Water Conservation District (Inactive)
34. Maricopa County Southern Water Conservation Dist. (Inactive)



EXPLANATION
AUTHORIZED FEATURES

- Aqueduct
- Bifurcation
- Bridge
- Canal
- Dam and reservoir
- Dike
- Highway relocation
- Hydro powerplant
- Pump-Generation plant
- Pumping plant
- Railroad relocation
- Reversible canal
- Siphon
- Tunnel

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA

LOCATION MAP
GROUND-WATER STUDIES

SCALE OF MILES

MAP NO. 344-314-1030
JUNE 30, 1972

Rev. 12-76

GENERAL MAPS

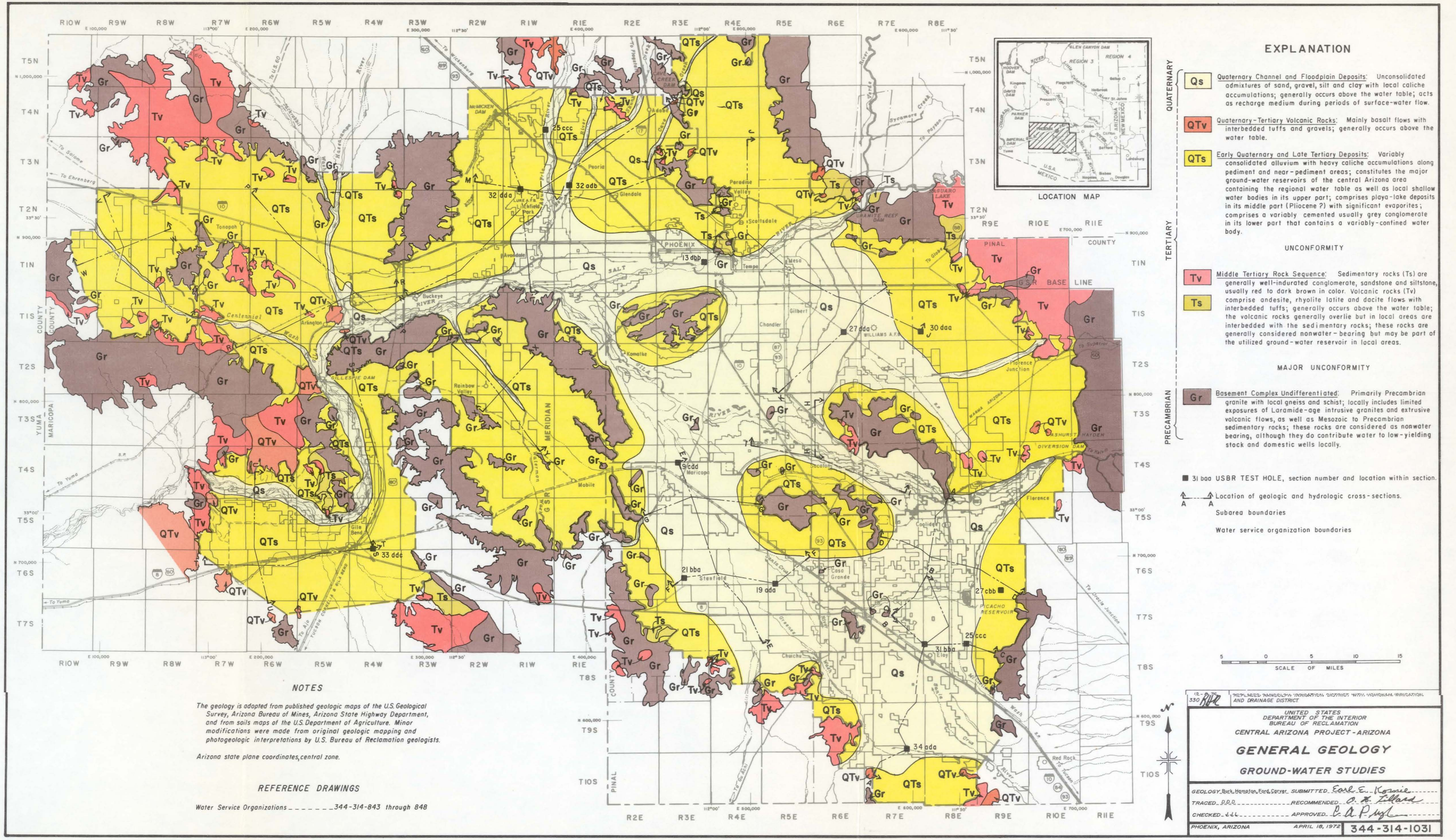
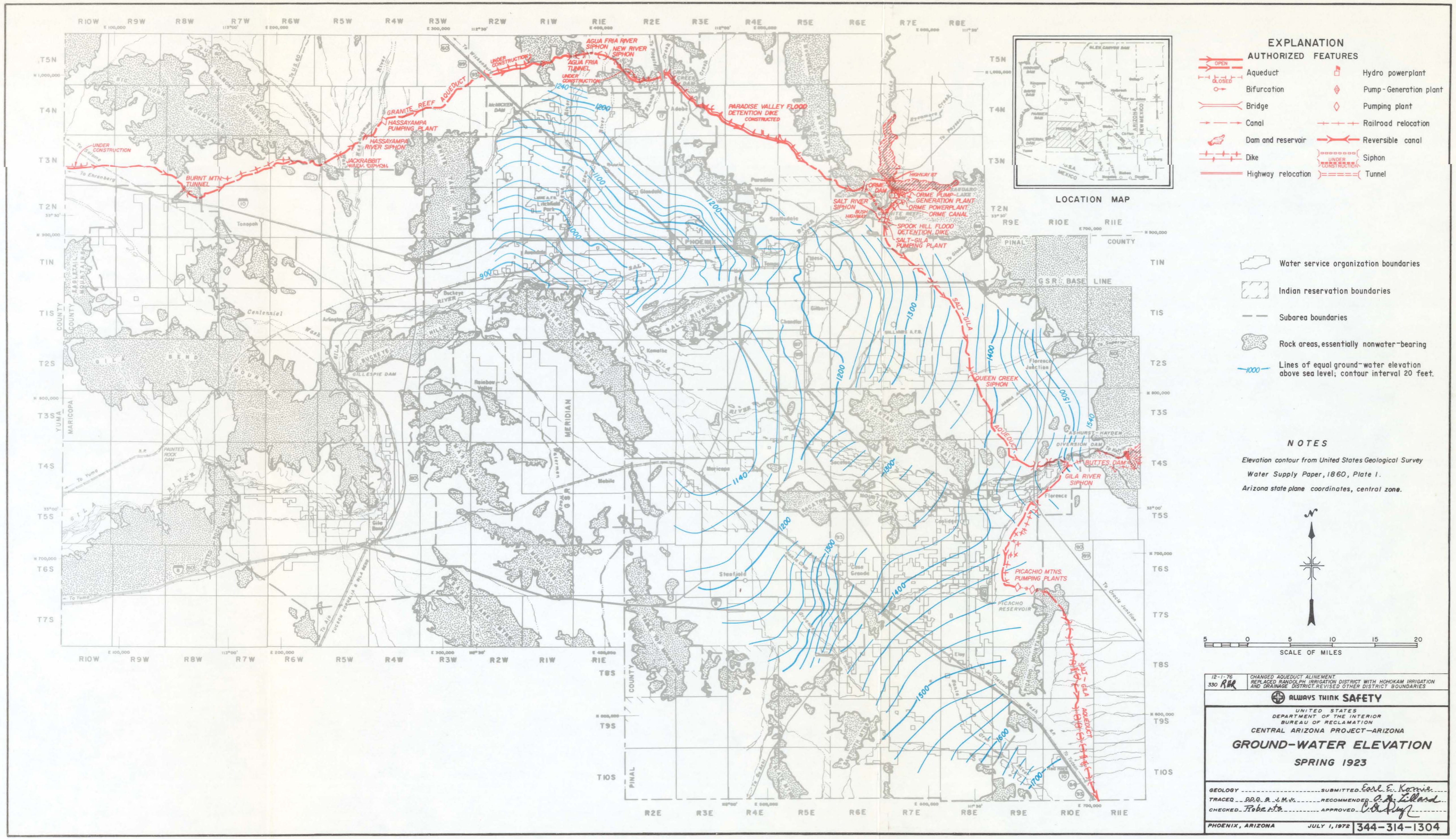

EXPLANATION
QUATERNARY
Qs
Quaternary Channel and Floodplain Deposits: Unconsolidated admixtures of sand, gravel, silt and clay with local caliche accumulations; generally occurs above the water table; acts as recharge medium during periods of surface-water flow.
QTv
Quaternary-Tertiary Volcanic Rocks: Mainly basalt flows with interbedded tuffs and gravels; generally occurs above the water table.
QTs
Early Quaternary and Late Tertiary Deposits: Variably consolidated alluvium with heavy caliche accumulations along pediment and near-pediment areas; constitutes the major ground-water reservoirs of the central Arizona area containing the regional water table as well as local shallow water bodies in its upper part; comprises playa-lake deposits in its middle part (Pliocene ?) with significant evaporites; comprises a variably cemented usually grey conglomerate in its lower part that contains a variably-confined water body.
UNCONFORMITY
TERTIARY
Tv
Ts
Middle Tertiary Rock Sequence: Sedimentary rocks (Ts) are generally well-indurated conglomerate, sandstone and siltstone, usually red to dark brown in color. Volcanic rocks (Tv) comprise andesite, rhyolite latite and dacite flows with interbedded tuffs; generally occurs above the water table; the volcanic rocks generally overlie but in local areas are interbedded with the sedimentary rocks; these rocks are generally considered nonwater-bearing but may be part of the utilized ground-water reservoir in local areas.
MAJOR UNCONFORMITY
PRECAMBRIAN
Gr
Basement Complex Undifferentiated: Primarily Precambrian granite with local gneiss and schist; locally includes limited exposures of Laramide-age intrusive granites and extrusive volcanic flows, as well as Mesozoic to Precambrian sedimentary rocks; these rocks are considered as nonwater bearing, although they do contribute water to low-yielding stock and domestic wells locally.
31 baa USBR TEST HOLE, section number and location within section.
A A Location of geologic and hydrologic cross-sections.
Subarea boundaries
Water service organization boundaries
LOCATION MAP
PHOENIX
SCALE OF MILES
5 0 5 10 15
NOTES
The geology is adopted from published geologic maps of the U.S. Geological Survey, Arizona Bureau of Mines, Arizona State Highway Department, and from soils maps of the U.S. Department of Agriculture. Minor modifications were made from original geologic mapping and photogeologic interpretations by U.S. Bureau of Reclamation geologists.
Arizona state plane coordinates, central zone.
REFERENCE DRAWINGS
Water Service Organizations .... 344-314-843 through 848
AND DRAINAGE DISTRICT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT - ARIZONA
GENERAL GEOLOGY
GROUND-WATER STUDIES
GEOLOGY Burk, Hampton, Ford, Carver SUBMITTED
TRACED D.D.D. RECOMMENDED
CHECKED APPROVED
PHOENIX, ARIZONA APRIL 18, 1972
344-314-1031

Figure 1



EXPLANATION
AUTHORIZED FEATURES
OPEN
CLOSED
Aqueduct
Bifurcation
Bridge
Canal
Dam and reservoir
Dike
Highway relocation
Hydro powerplant
Pump-Generation plant
Pumping plant
Railroad relocation
Reversible canal
UNDER CONSTRUCTION
Siphon
Tunnel
Water service organization boundaries
Indian reservation boundaries
Subarea boundaries
Rock areas, essentially nonwater-bearing
1000
Lines of equal ground-water elevation above sea level; contour interval 20 feet.
LOCATION MAP
NOTES
Elevation contour from United States Geological Survey Water Supply Paper, 1860, Plate I.
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-1-76 330 RAR
CHANGED AQUEDUCT ALINEMENT.
REPLACED RANDOLPH IRRIGATION DISTRICT WITH HOHOKAM IRRIGATION AND DRAINAGE DISTRICT. REVISED OTHER DISTRICT BOUNDARIES
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND-WATER ELEVATION
SPRING 1923
GEOLOGY
SUBMITTED Earl E. Kornie
TRACED D.D.D. & J.M.Jr.
RECOMMENDED O.K. Tillard
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
344-314-1304

Figure 2

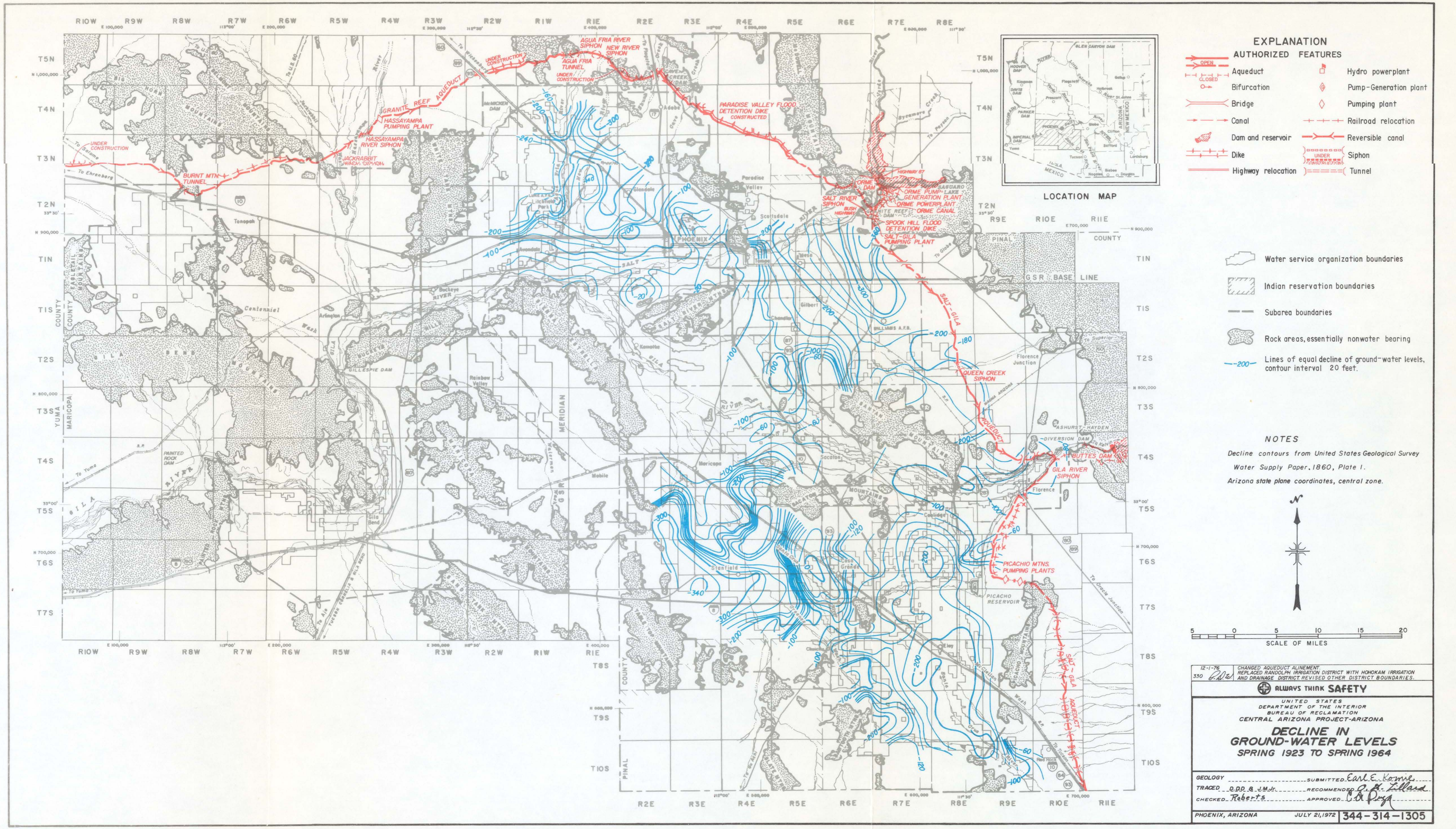

EXPLANATION
AUTHORIZED FEATURES
Aqueduct
Bifurcation
Bridge
Canal
Dam and reservoir
Dike
Highway relocation
Hydro powerplant
Pump-Generation plant
Pumping plant
Railroad relocation
Reversible canal
Siphon
Tunnel
Water service organization boundaries
Indian reservation boundaries
Subarea boundaries
Rock areas, essentially nonwater bearing
Lines of equal decline of ground-water levels, contour interval 20 feet.
LOCATION MAP
NOTES
Decline contours from United States Geological Survey Water Supply Paper. 1860, Plate I.
Arizona state plane coordinates, central zone.
SCALE OF MILES
CHANGED AQUEDUCT ALINEMENT. REPLACED RANDOLPH IRRIGATION DISTRICT WITH HOHOKAM IRRIGATION AND DRAINAGE DISTRICT REVISED OTHER DISTRICT BOUNDARIES.
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
DECLINE IN GROUND-WATER LEVELS
SPRING 1923 TO SPRING 1964
PHOENIX, ARIZONA
JULY 21, 1972
344-314-1305
PHOENIX
GRANITE REEF AQUEDUCT
SALT-GILA AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
QUEEN CREEK SIPHON
GILA RIVER SIPHON
BURNT MTN. TUNNEL
HASSAYAMPA PUMPING PLANT
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
PARADISE VALLEY FLOOD DETENTION DIKE
SALT-GILA PUMPING PLANT

Figure 3

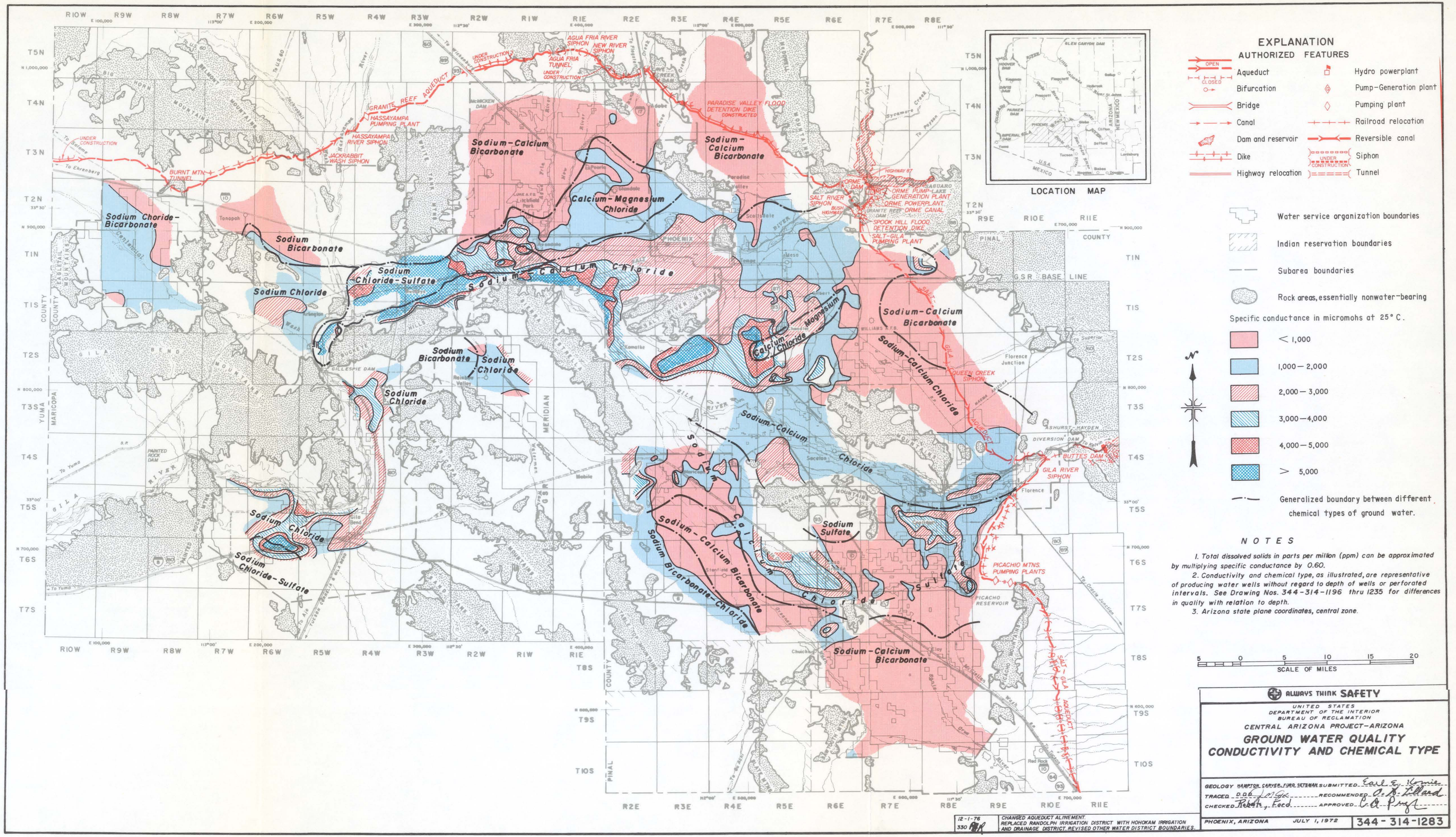
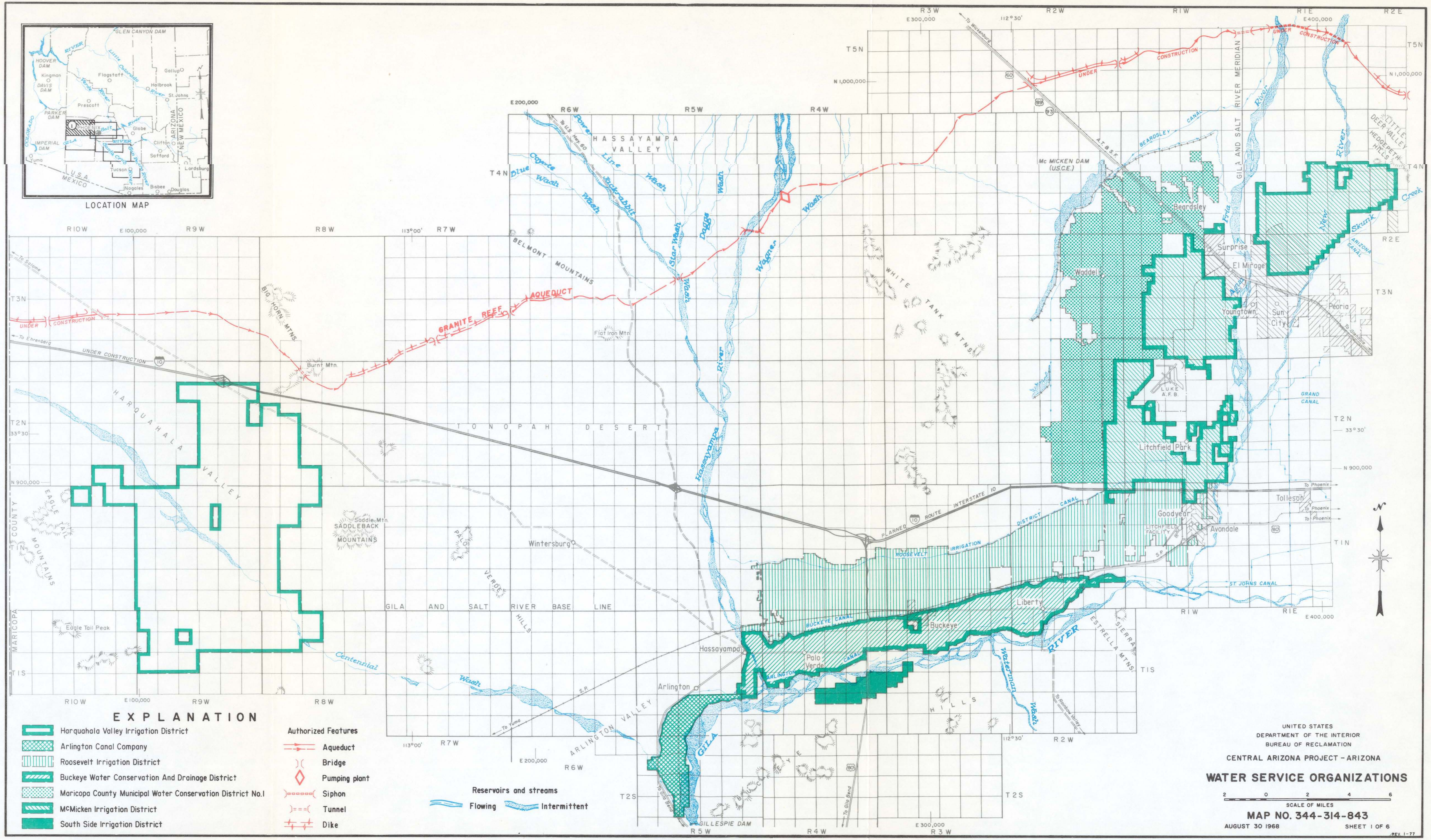

EXPLANATION
AUTHORIZED FEATURES
Aqueduct
Bifurcation
Bridge
Canal
Dam and reservoir
Dike
Highway relocation
Hydro powerplant
Pump-Generation plant
Pumping plant
Railroad relocation
Reversible canal
Siphon
Tunnel
Water service organization boundaries
Indian reservation boundaries
Subarea boundaries
Rock areas, essentially nonwater-bearing
Specific conductance in micromohs at 25° C.
< 1,000
1,000 — 2,000
2,000 — 3,000
3,000 — 4,000
4,000 — 5,000
> 5,000
Generalized boundary between different chemical types of ground water.
NOTES
1. Total dissolved solids in parts per million (ppm) can be approximated by multiplying specific conductance by 0.60.
2. Conductivity and chemical type, as illustrated, are representative of producing water wells without regard to depth of wells or perforated intervals. See Drawing Nos. 344-314-1196 thru 1235 for differences in quality with relation to depth.
3. Arizona state plane coordinates, central zone.
LOCATION MAP
SCALE OF MILES
Sodium-Calcium Bicarbonate
Sodium-Calcium Bicarbonate
Calcium-Magnesium Chloride
Sodium Choride-Bicarbonate
Sodium Bicarbonate
Sodium Chloride-Sulfate
Sodium-Calcium Chloride
Sodium Chloride
Sodium-Calcium Bicarbonate
Calcium-Magnesium Chloride
Sodium-Calcium Chloride
Sodium Bicarbonate
Sodium Chloride
Sodium Chloride
Sodium-Calcium Chloride
Sodium-Calcium Chloride
Sodium Chloride
Sodium Chloride-Sulfate
Sodium Sulfate
Sodium Bicarbonate-Chloride
Sodium-Calcium Bicarbonate
Sulfate
Sodium-Calcium Bicarbonate
GRANITE REEF AQUEDUCT
HASSAYAMPA PUMPING PLANT
HASSAYAMPA RIVER SIPHON
JACKRABBIT WASH SIPHON
BURNT MTN TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
AGUA FRIA TUNNEL
PARADISE VALLEY FLOOD DETENTION DIKE
SALT RIVER SIPHON
ORME DAM
ORME PUMP-LAKE GENERATION PLANT
ORME POWERPLANT
ORME CANAL
SPOOK HILL FLOOD DETENTION DIKE
SALT-GILA PUMPING PLANT
QUEEN CREEK SIPHON
BUTTES DAM
GILA RIVER SIPHON
PICACHO MTNS. PUMPING PLANTS
SALT-GILA AQUEDUCT
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND WATER QUALITY
CONDUCTIVITY AND CHEMICAL TYPE
PHOENIX, ARIZONA
JULY 1, 1972
344-314-1283
12-1-76
CHANGED AQUEDUCT ALINEMENT.
REPLACED RANDOLPH IRRIGATION DISTRICT WITH HOHOKAM IRRIGATION AND DRAINAGE DISTRICT. REVISED OTHER WATER DISTRICT BOUNDARIES.

Figure 4



LOCATION MAP
EXPLANATION
Harquahala Valley Irrigation District
Arlington Canal Company
Roosevelt Irrigation District
Buckeye Water Conservation And Drainage District
Maricopa County Municipal Water Conservation District No.1
McMicken Irrigation District
South Side Irrigation District
Authorized Features
Aqueduct
Bridge
Pumping plant
Siphon
Tunnel
Dike
Reservoirs and streams
Flowing
Intermittent
HASSAYAMPA VALLEY
HARQUAHALA VALLEY
TONOPAH DESERT
GRANITE REEF AQUEDUCT
UNDER CONSTRUCTION
BELMONT MOUNTAINS
WHITE TANK MTNS
BIG HORN MTNS
SADDLEBACK MOUNTAINS
EAGLE TAIL MOUNTAINS
GILA AND SALT RIVER BASE LINE
GILA AND SALT RIVER MERIDIAN
Mc MICKEN DAM (U.S.C.E.)
GILLESPIE DAM
Waddell
Beardsley
Surprise
El Mirage
Youngtown
Sun City
Peoria
LUKE A.F.B.
Litchfield Park
Goodyear
Avondale
Tolleson
Buckeye
Liberty
Palo Verde
Hassayampa
Arlington
Wintersburg
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
BEARDSLEY CANAL
GRAND CANAL
ST JOHNS CANAL
ARIZONA CANAL
GILA RIVER
Hassayampa River
Agua Fria
New River
Centennial Wash
Waterman Wash
ESTRELLA MTNS.
SIERRA
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT – ARIZONA
WATER SERVICE ORGANIZATIONS
SCALE OF MILES
MAP NO. 344-314-843
AUGUST 30 1968
SHEET 1 OF 6
REV. 1-77

Figure 5

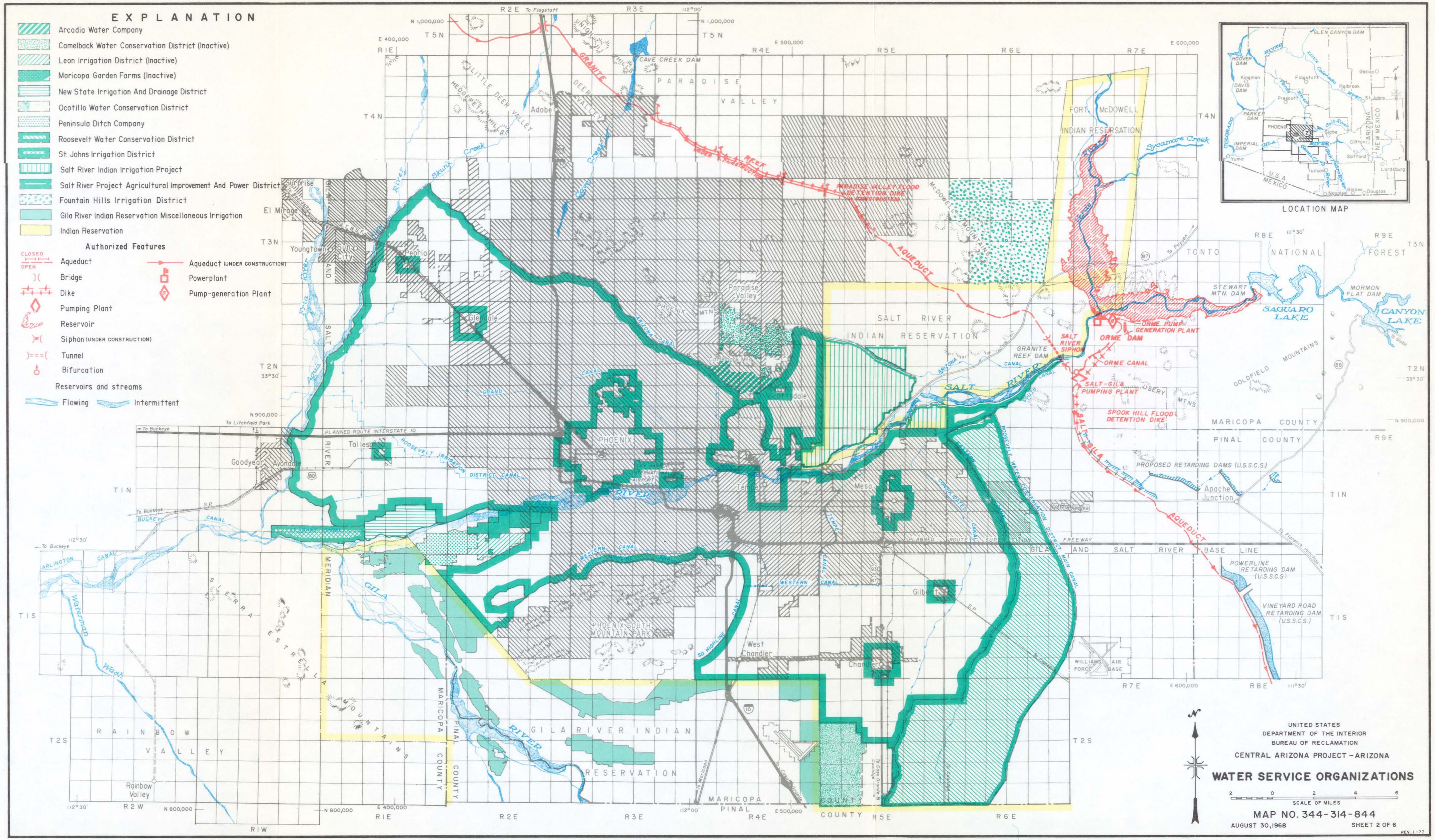
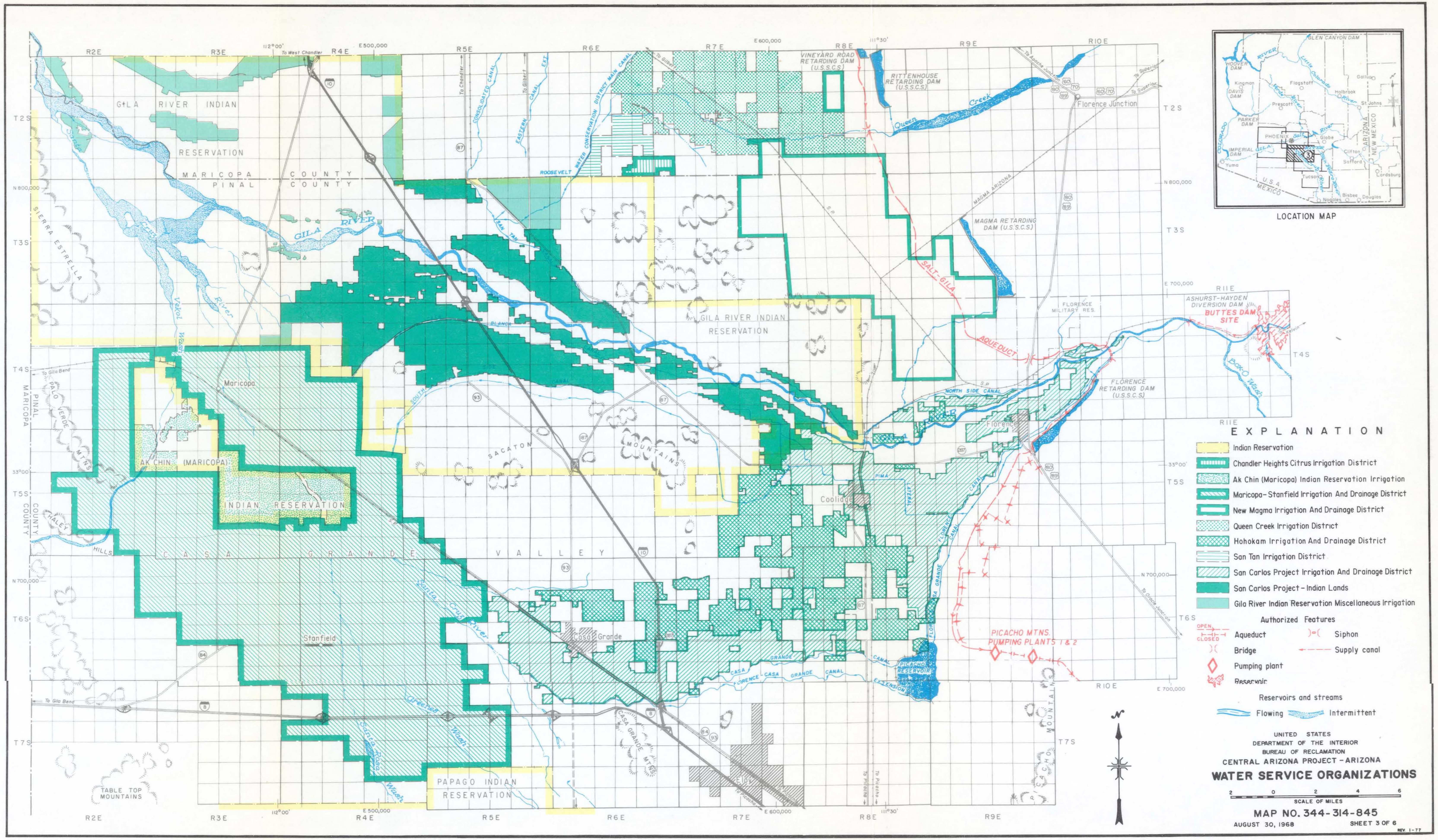

EXPLANATION
Arcadia Water Company
Camelback Water Conservation District (Inactive)
Leon Irrigation District (Inactive)
Maricopa Garden Farms (Inactive)
New State Irrigation And Drainage District
Ocotillo Water Conservation District
Peninsula Ditch Company
Roosevelt Water Conservation District
St. Johns Irrigation District
Salt River Indian Irrigation Project
Salt River Project Agricultural Improvement And Power District
Fountain Hills Irrigation District
Gila River Indian Reservation Miscellaneous Irrigation
Indian Reservation
Authorized Features
CLOSED
OPEN
Aqueduct
Aqueduct (UNDER CONSTRUCTION)
Bridge
Powerplant
Dike
Pump-generation Plant
Pumping Plant
Reservoir
Siphon (UNDER CONSTRUCTION)
Tunnel
Bifurcation
Reservoirs and streams
Flowing
Intermittent
LOCATION MAP
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT – ARIZONA
WATER SERVICE ORGANIZATIONS
SCALE OF MILES
MAP NO. 344-314-844
AUGUST 30, 1968
SHEET 2 OF 6
PHOENIX
SALT RIVER INDIAN RESERVATION
FORT McDOWELL INDIAN RESERVATION
GILA RIVER INDIAN RESERVATION
PARADISE VALLEY
RAINBOW VALLEY
SIERRA ESTRELLA MOUNTAINS
SAGUARO LAKE
CANYON LAKE
ORME DAM
GRANITE REEF AQUEDUCT
SALT-GILA AQUEDUCT
MARICOPA COUNTY
PINAL COUNTY
TONTO NATIONAL FOREST

Figure 6



LOCATION MAP
EXPLANATION
Indian Reservation
Chandler Heights Citrus Irrigation District
Ak Chin (Maricopa) Indian Reservation Irrigation
Maricopa-Stanfield Irrigation And Drainage District
New Magma Irrigation And Drainage District
Queen Creek Irrigation District
Hohokam Irrigation And Drainage District
San Tan Irrigation District
San Carlos Project Irrigation And Drainage District
San Carlos Project - Indian Lands
Gila River Indian Reservation Miscellaneous Irrigation
Authorized Features
Aqueduct
Siphon
Bridge
Supply canal
Pumping plant
Reservoir
Reservoirs and streams
Flowing
Intermittent
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT - ARIZONA
WATER SERVICE ORGANIZATIONS
SCALE OF MILES
MAP NO. 344-314-845
AUGUST 30, 1968
SHEET 3 OF 6
REV. 1-77
GILA RIVER INDIAN RESERVATION
MARICOPA COUNTY
PINAL COUNTY
AK CHIN (MARICOPA) INDIAN RESERVATION
CASA GRANDE VALLEY
PAPAGO INDIAN RESERVATION
TABLE TOP MOUNTAINS
SACATON MOUNTAINS
SIERRA ESTRELLA
Maricopa
Stanfield
Casa Grande
Coolidge
Florence
Florence Junction
Eloy
ASHURST-HAYDEN DIVERSION DAM
BUTTES DAM SITE
FLORENCE RETARDING DAM (U.S.S.C.S.)
MAGMA RETARDING DAM (U.S.S.C.S.)
RITTENHOUSE RETARDING DAM (U.S.S.C.S.)
VINEYARD ROAD RETARDING DAM (U.S.S.C.S.)
FLORENCE MILITARY RES.
PICACHO MTNS. PUMPING PLANTS 1 & 2
PICACHO RESERVOIR
SALT-GILA AQUEDUCT
NORTH SIDE CANAL
FLORENCE-CASA GRANDE CANAL
GILA RIVER

Figure 7

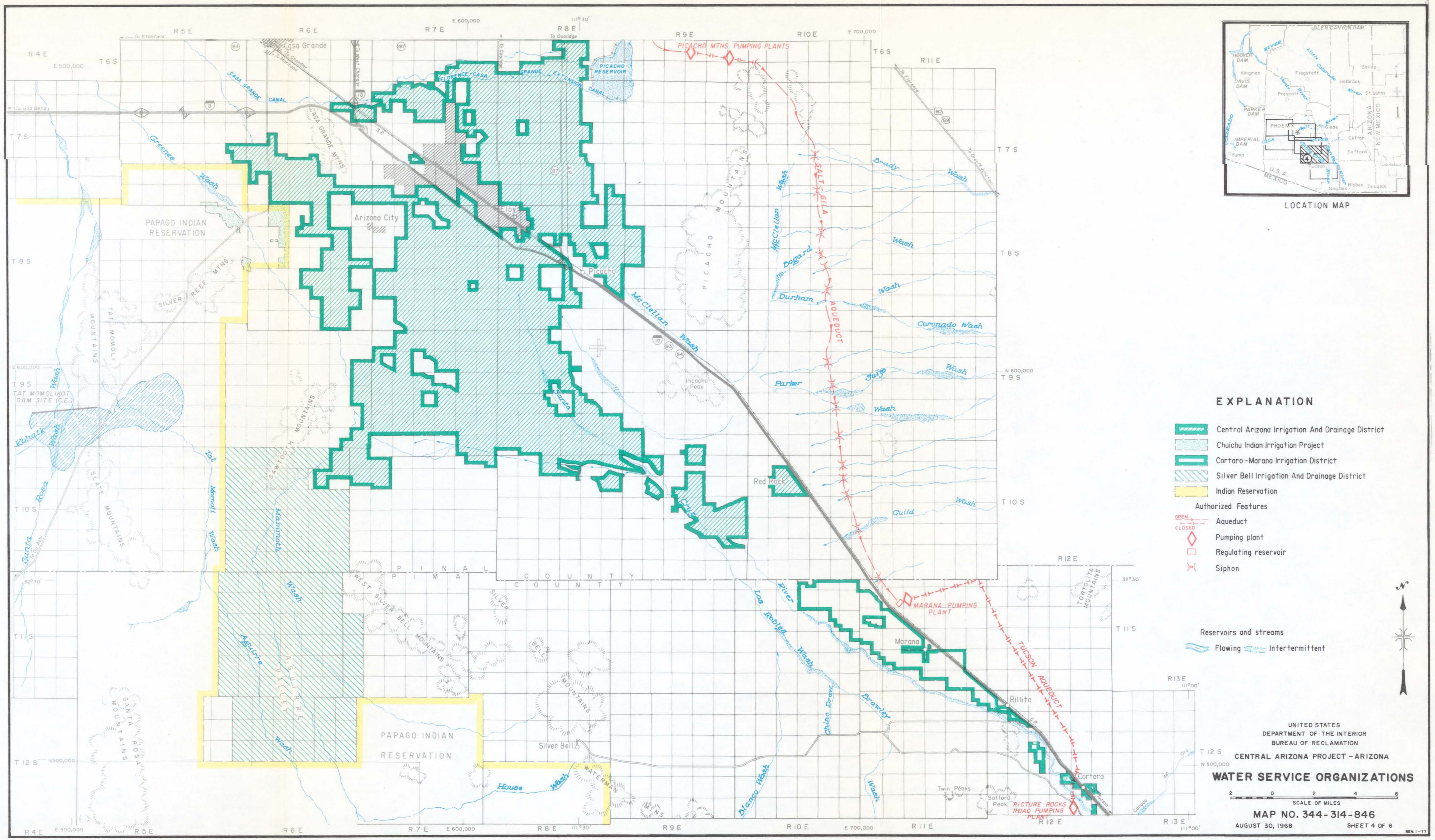
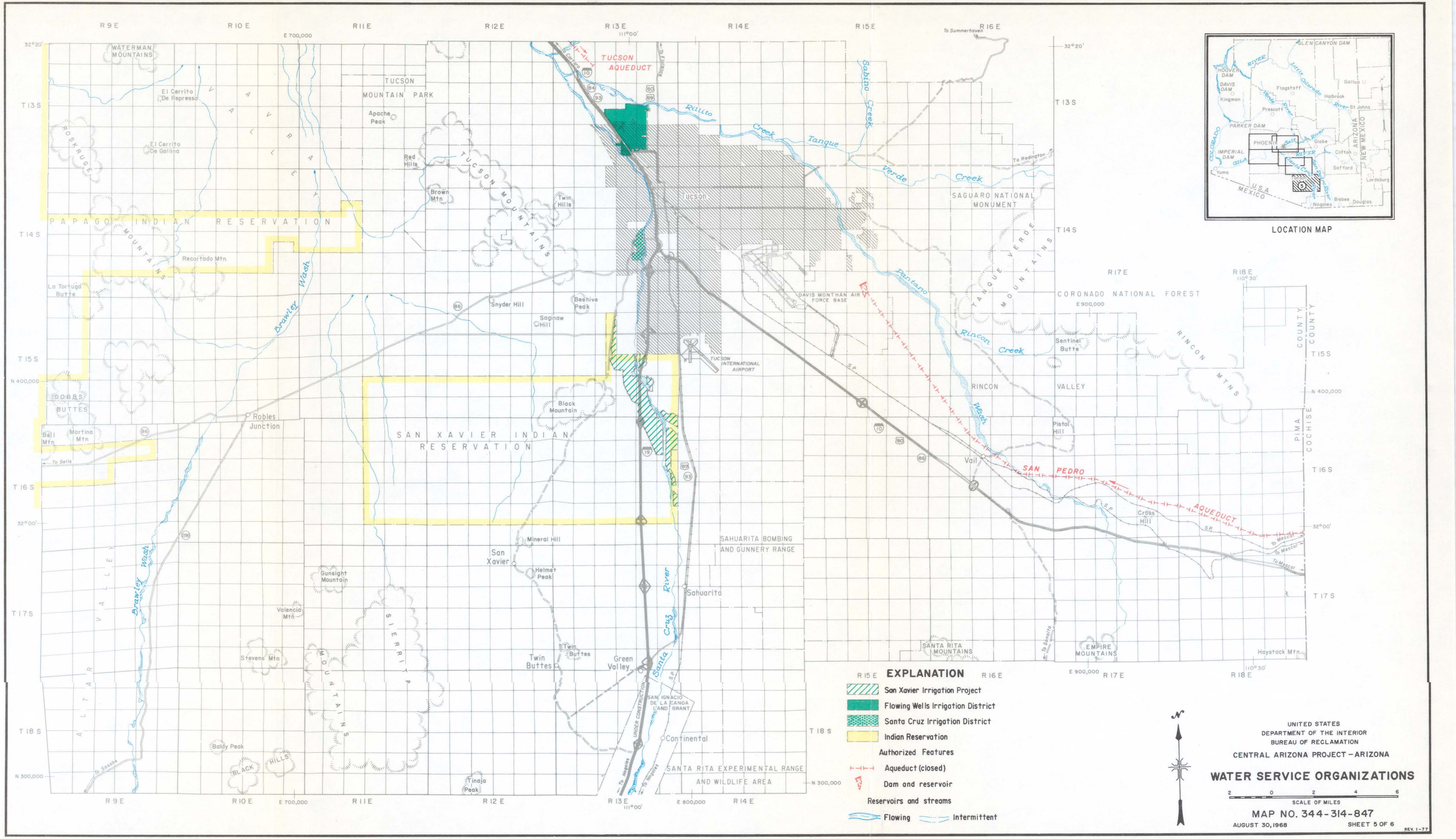
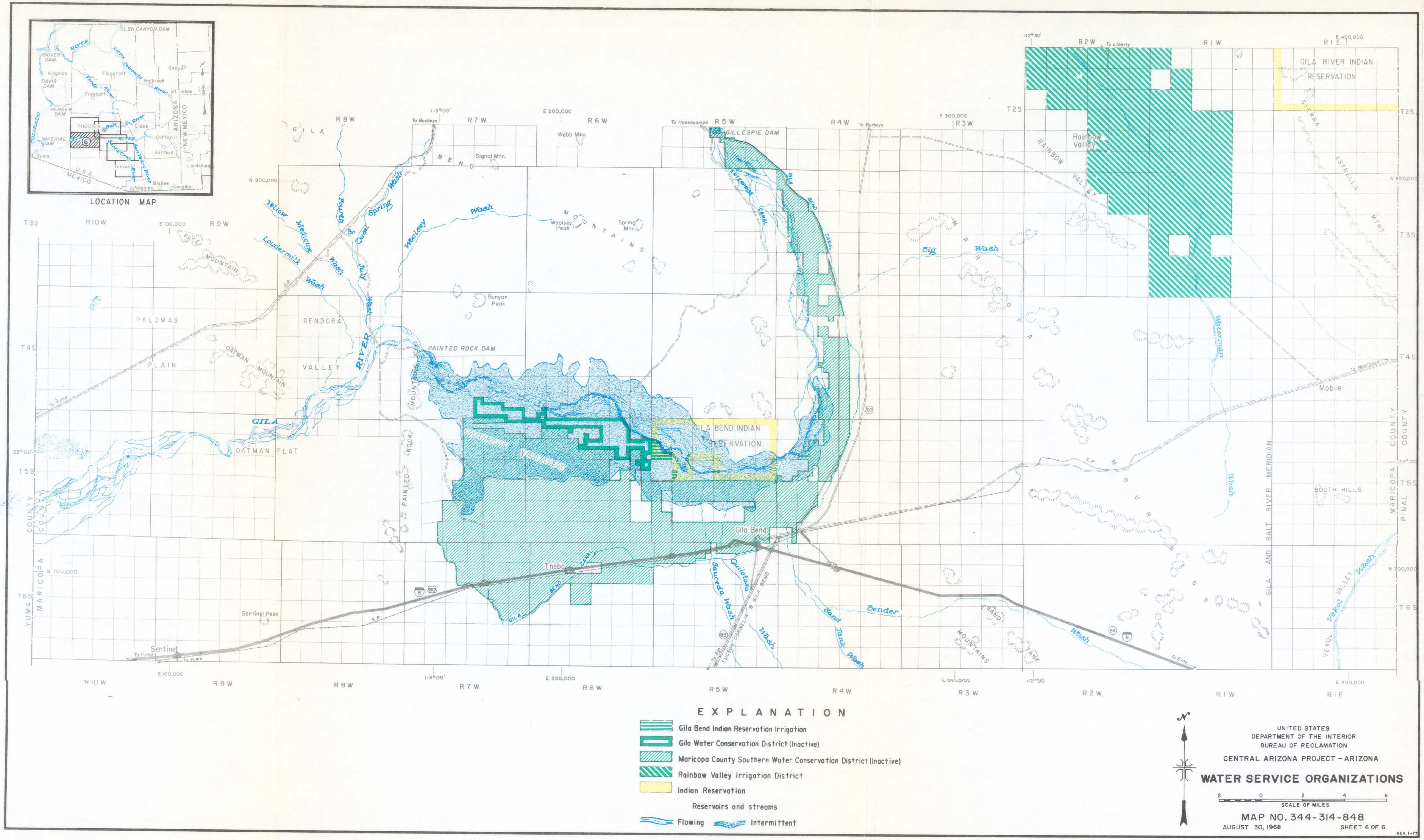

EXPLANATION
Central Arizona Irrigation And Drainage District
Chuichu Indian Irrigation Project
Cortaro-Marana Irrigation District
Silver Bell Irrigation And Drainage District
Indian Reservation
Authorized Features
Aqueduct
Pumping plant
Regulating reservoir
Siphon
Reservoirs and streams
Flowing
Intertermittent
LOCATION MAP
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT - ARIZONA
WATER SERVICE ORGANIZATIONS
SCALE OF MILES
MAP NO. 344-314-846
AUGUST 30, 1968
SHEET 4 OF 6
Casa Grande
Arizona City
Picacho
Red Rock
Marana
Rillito
Cortaro
Silver Bell
PAPAGO INDIAN RESERVATION
PICACHO MTNS. PUMPING PLANTS
PICACHO RESERVOIR
MARANA PUMPING PLANT
PICTURE ROCKS ROAD PUMPING PLANT
SALT-GILA AQUEDUCT
TUCSON AQUEDUCT
FLORENCE-CASA GRANDE EXTENSION CANAL
CASA GRANDE CANAL
PINAL COUNTY
PIMA COUNTY
TAT MOMOLIKOT DAM SITE (C.E.)

Figure 8



LOCATION MAP
EXPLANATION
San Xavier Irrigation Project
Flowing Wells Irrigation District
Santa Cruz Irrigation District
Indian Reservation
Authorized Features
Aqueduct (closed)
Dam and reservoir
Reservoirs and streams
Flowing
Intermittent
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT – ARIZONA
WATER SERVICE ORGANIZATIONS
SCALE OF MILES
MAP NO. 344-314-847
AUGUST 30, 1968
SHEET 5 OF 6
TUCSON AQUEDUCT
SAN PEDRO AQUEDUCT
Tucson
TUCSON MOUNTAIN PARK
TUCSON MOUNTAINS
PAPAGO INDIAN RESERVATION
SAN XAVIER INDIAN RESERVATION
SAGUARO NATIONAL MONUMENT
CORONADO NATIONAL FOREST
TANQUE VERDE MOUNTAINS
RINCON VALLEY
RINCON MTNS
DAVIS MONTHAN AIR FORCE BASE
TUCSON INTERNATIONAL AIRPORT
SAHUARITA BOMBING AND GUNNERY RANGE
SANTA RITA EXPERIMENTAL RANGE AND WILDLIFE AREA
SANTA RITA MOUNTAINS
EMPIRE MOUNTAINS
SIERRITA MOUNTAINS
ALTAR VALLEY
AVRA VALLEY
Santa Cruz River
Rillito Creek
Tanque Verde Creek
Pantano Wash
Rincon Creek
Brawley Wash
Sabino Creek
Robles Junction
San Xavier
Sahuarita
Green Valley
Continental
Vail

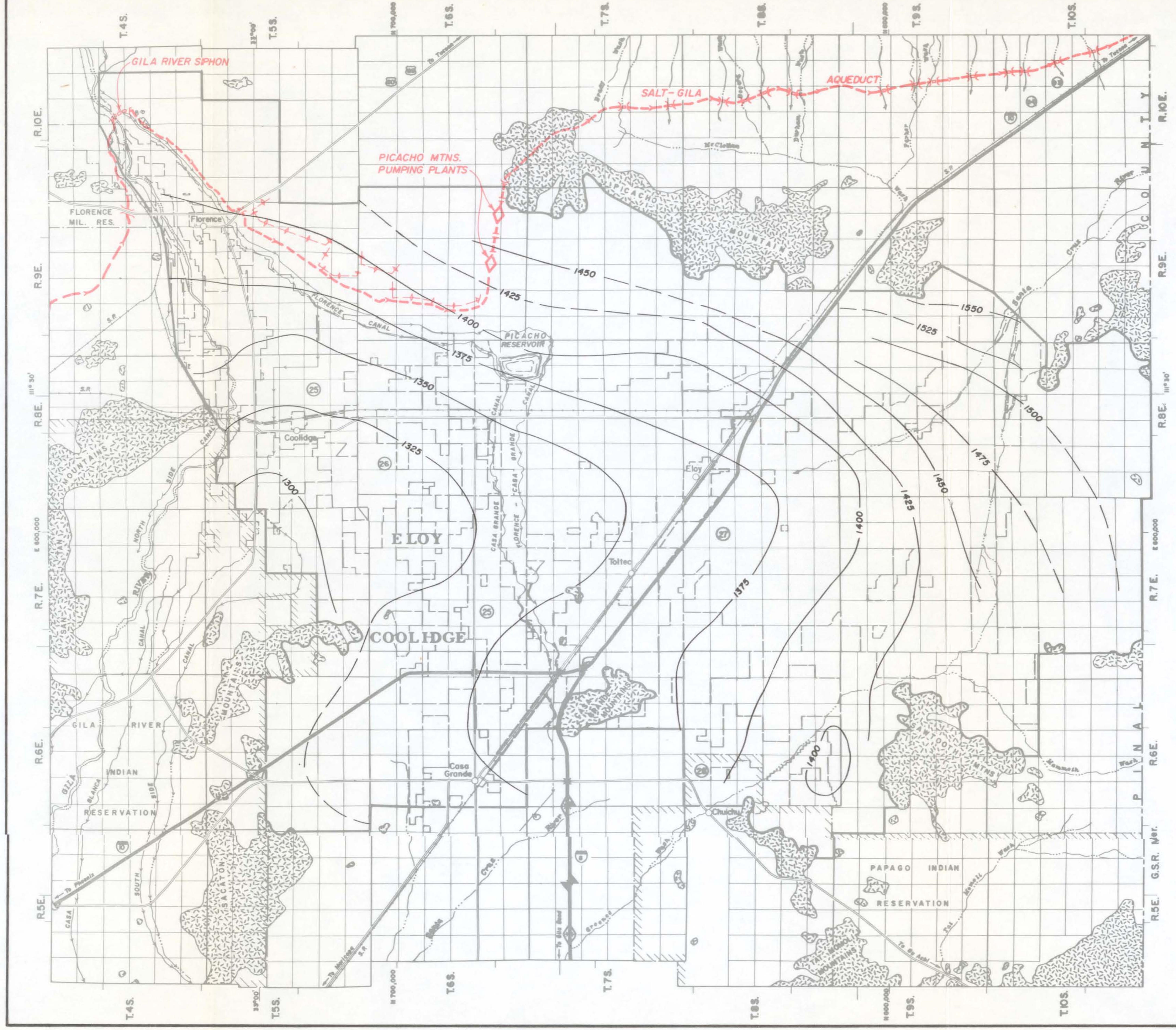
Figure 9



EXPLANATION
Gila Bend Indian Reservation Irrigation
Gila Water Conservation District (Inactive)
Maricopa County Southern Water Conservation District (Inactive)
Rainbow Valley Irrigation District
Indian Reservation
Reservoirs and streams
Flowing
Intermittent
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT - ARIZONA
WATER SERVICE ORGANIZATIONS
SCALE OF MILES
MAP NO. 344-314-848
AUGUST 30, 1968
SHEET 6 OF 6
LOCATION MAP
GILA BEND INDIAN RESERVATION
GILA RIVER INDIAN RESERVATION
PAINTED ROCK DAM
GILLESPIE DAM
Gila Bend
Rainbow Valley
Mobile
Thebo
Sentinel

Figure 10

ELOY – COOLIDGE SUBAREA



EXPLANATION

AUTHORIZED FEATURES

- Open aqueduct
- Pumping plant
- Siphon
- Bridge

- Indian reservation boundaries
- Reservation boundaries
- Water service organizations and boundaries
- (25) San Carlos Project – Irrigation and Drainage District
- (26) Hohokam Irrigation and Drainage District
- (27) Central Arizona Irrigation and Drainage District
- (28) Chuichu Indian Irrigation Project
- Rock areas, essentially nonwater bearing
- Subarea boundary
- 1300 Lines of equal ground-water elevation above sea level, dashed where inferred; contour interval 25 feet.

NOTES

Modified from United States Geological Survey open file report, "Ground-Water in the Gila River Basin and Adjacent Areas, Arizona" 1952.

Arizona state plane coordinates, central zone.

SCALE OF MILES: 2 1 0 2 4 6

12-20-76 330 G.D.L.	REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT–ARIZONA

GROUND-WATER ELEVATIONS
SPRING 1952
ELOY – COOLIDGE SUBAREA

GEOLOGY Hampton & Roberts — SUBMITTED Earl E. Kornie
TRACED M.F.W. — RECOMMENDED O. H. Lillard
CHECKED Roberts — APPROVED C. A. Dug

PHOENIX, ARIZONA — JULY 1, 1972 — SHEET 7 OF 7 — 344-314-974

Figure 11

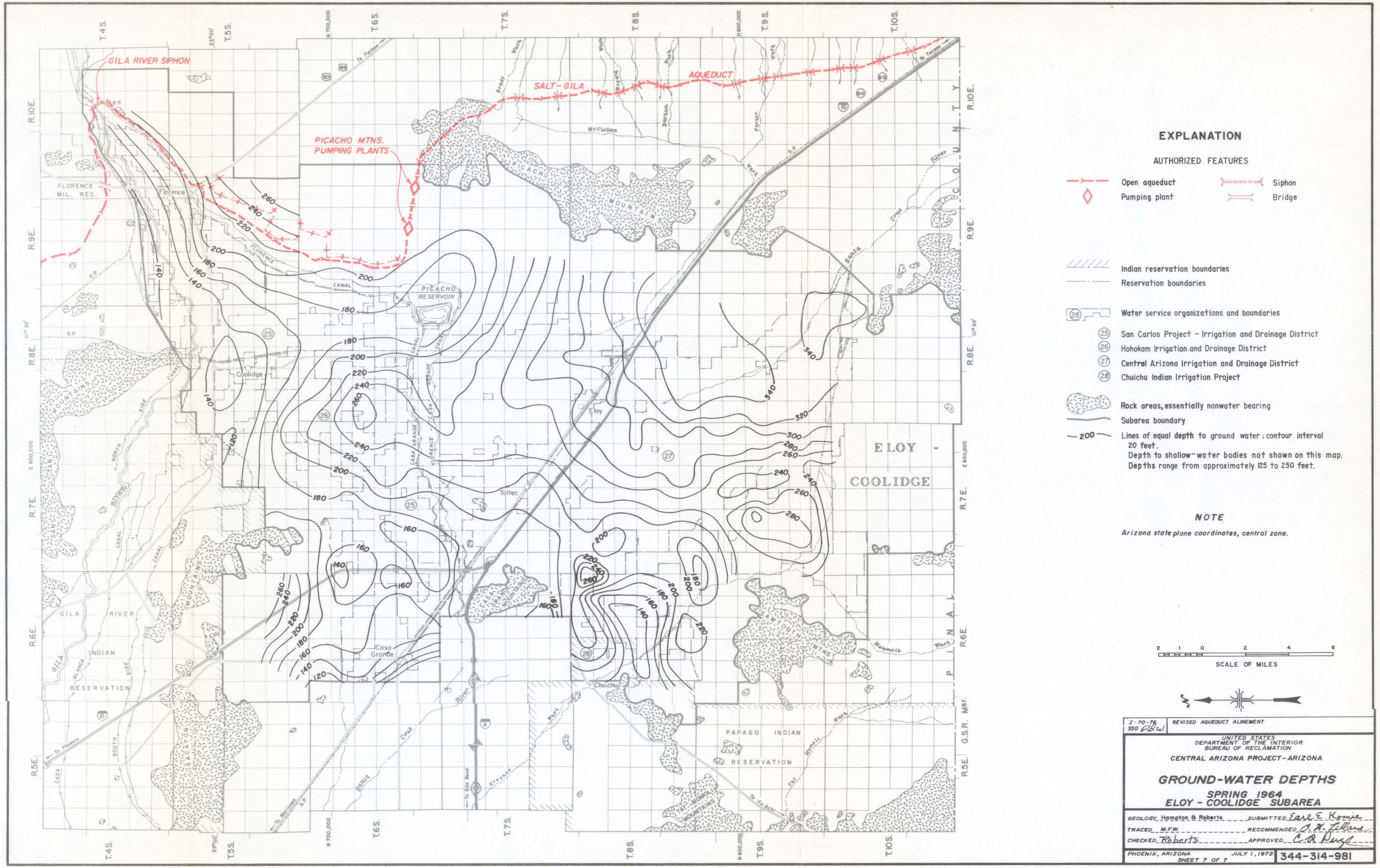

GILA RIVER SIPHON
SALT - GILA
AQUEDUCT
PICACHO MTNS.
PUMPING PLANTS
FLORENCE
MIL. RES.
Florence
PICACHO
RESERVOIR
Coolidge
Eloy
Toltec
Casa
Grande
Chuichu
ELOY - COOLIDGE
GILA RIVER
INDIAN
RESERVATION
PAPAGO INDIAN
RESERVATION
EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
San Carlos Project - Irrigation and Drainage District
Hohokam Irrigation and Drainage District
Central Arizona Irrigation and Drainage District
Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal depth to ground water; contour interval 20 feet.
Depth to shallow-water bodies not shown on this map.
Depths range from approximately 125 to 250 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER DEPTHS
SPRING 1964
ELOY - COOLIDGE SUBAREA
GEOLOGY Hampton & Roberts
TRACED M.F.W.
CHECKED Roberts
SUBMITTED
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 7 OF 7
344-314-981

Figure 12

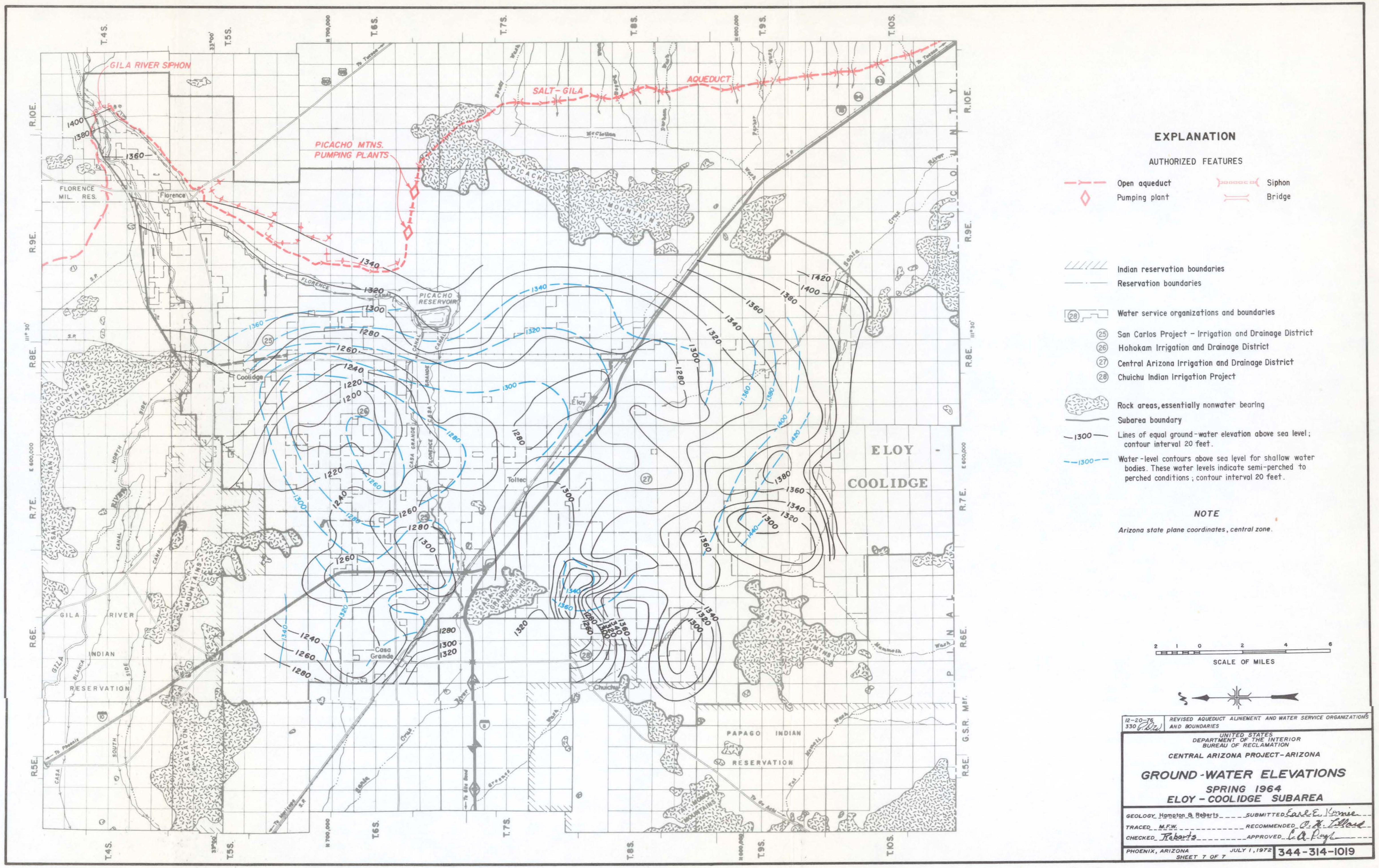

EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
25 San Carlos Project - Irrigation and Drainage District
26 Hohokam Irrigation and Drainage District
27 Central Arizona Irrigation and Drainage District
28 Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal ground-water elevation above sea level; contour interval 20 feet.
Water-level contours above sea level for shallow water bodies. These water levels indicate semi-perched to perched conditions; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
GILA RIVER SIPHON
SALT-GILA AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
PICACHO RESERVOIR
FLORENCE MIL. RES.
Florence
Coolidge
Eloy
Toltec
Casa Grande
Chuichu
ELOY - COOLIDGE
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
PINAL COUNTY
12-20-76 330 REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1964
ELOY - COOLIDGE SUBAREA
GEOLOGY Hampton & Roberts
SUBMITTED Earl E. Kornie
TRACED M.F.W.
RECOMMENDED O. H. Tillard
CHECKED Roberts
APPROVED C. A. Pugh
PHOENIX, ARIZONA
SHEET 7 OF 7
JULY 1, 1972
344-314-1019

Figure 13

EXPLANATION

AUTHORIZED FEATURES

Open aqueduct
Pumping plant
Siphon
Bridge

Indian reservation boundaries
Reservation boundaries

Water service organizations and boundaries
(25) San Carlos Project - Irrigation and Drainage District
(26) Hohokam Irrigation and Drainage District
(27) Central Arizona Irrigation and Drainage District
(28) Chuichu Indian Irrigation Project

Rock areas, essentially nonwater bearing
Subarea boundary
—100— Lines of equal decline of ground-water levels; contour interval 20 feet.

NOTE

Arizona state plane coordinates, central zone.

2 1 0 2 4 6
SCALE OF MILES

12-20-76 330	REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT-ARIZONA

DECLINE IN GROUND-WATER LEVELS
SPRING 1952 TO SPRING 1964
ELOY - COOLIDGE SUBAREA

GEOLOGY Hampton — SUBMITTED Earl E. Kosmie
TRACED M.F.W. — RECOMMENDED O. H. Lillard
CHECKED Roberts — APPROVED C. A. Pugh

PHOENIX, ARIZONA — JULY 1, 1972 — SHEET 7 OF 7 — 344-314-1026

Figure 14

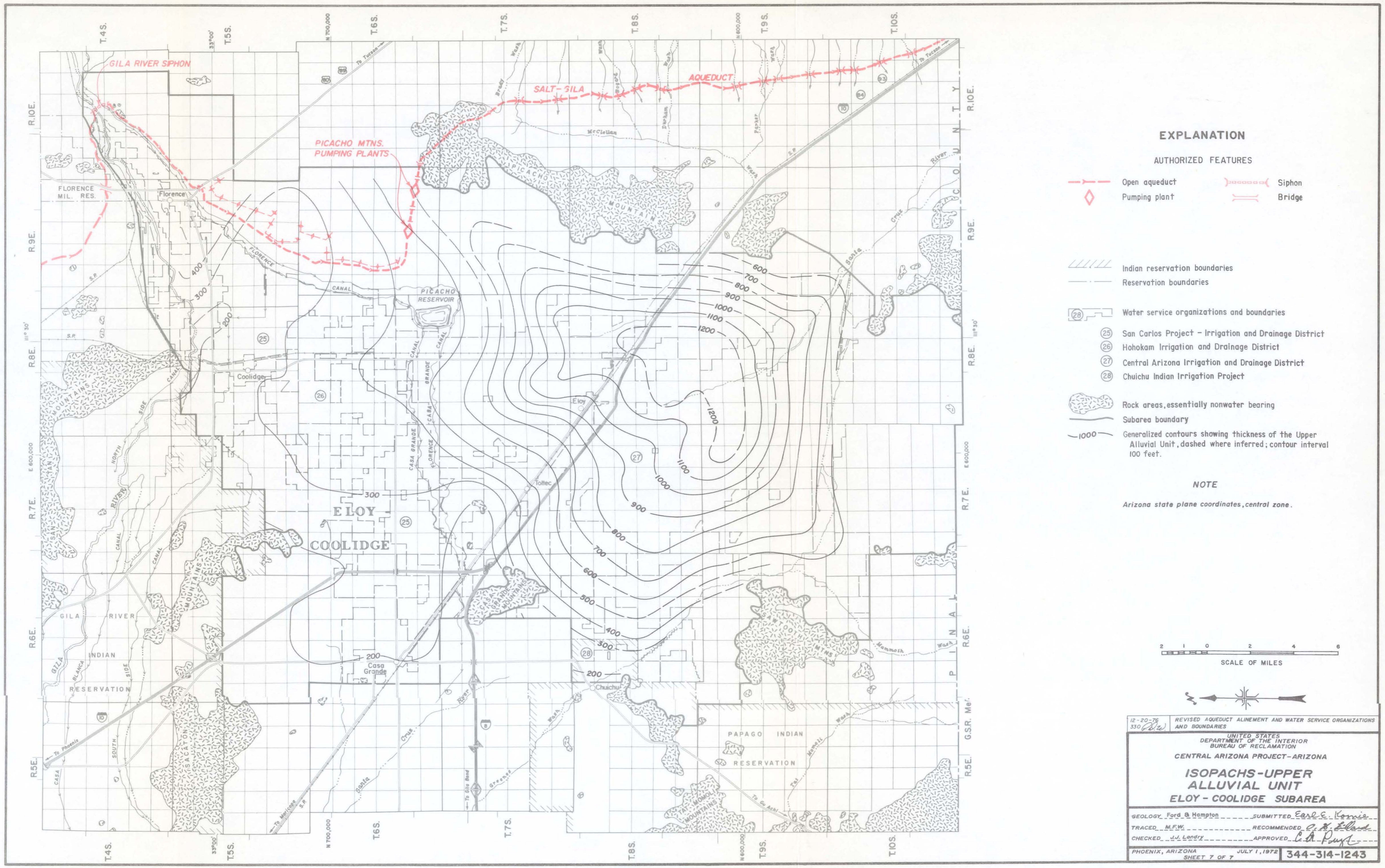

EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
25 San Carlos Project - Irrigation and Drainage District
26 Hohokam Irrigation and Drainage District
27 Central Arizona Irrigation and Drainage District
28 Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
1000 Generalized contours showing thickness of the Upper Alluvial Unit, dashed where inferred; contour interval 100 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 330 REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
ISOPACHS-UPPER ALLUVIAL UNIT
ELOY - COOLIDGE SUBAREA
GEOLOGY Ford & Hampton
TRACED M.F.W.
CHECKED J.J. Landry
SUBMITTED Earl E. Komie
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
SHEET 7 OF 7
JULY 1, 1972
344-314-1243
GILA RIVER SIPHON
SALT-GILA
AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
PICACHO RESERVOIR
PICACHO MOUNTAINS
ELOY
COOLIDGE
Florence
Coolidge
Eloy
Toltec
Casa Grande
Chuichu
FLORENCE MIL. RES.
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
PINAL COUNTY
T.4S.
T.5S.
T.6S.
T.7S.
T.8S.
T.9S.
T.10S.
R.10E.
R.9E.
R.8E.
R.7E.
R.6E.
R.5E.

Figure 15

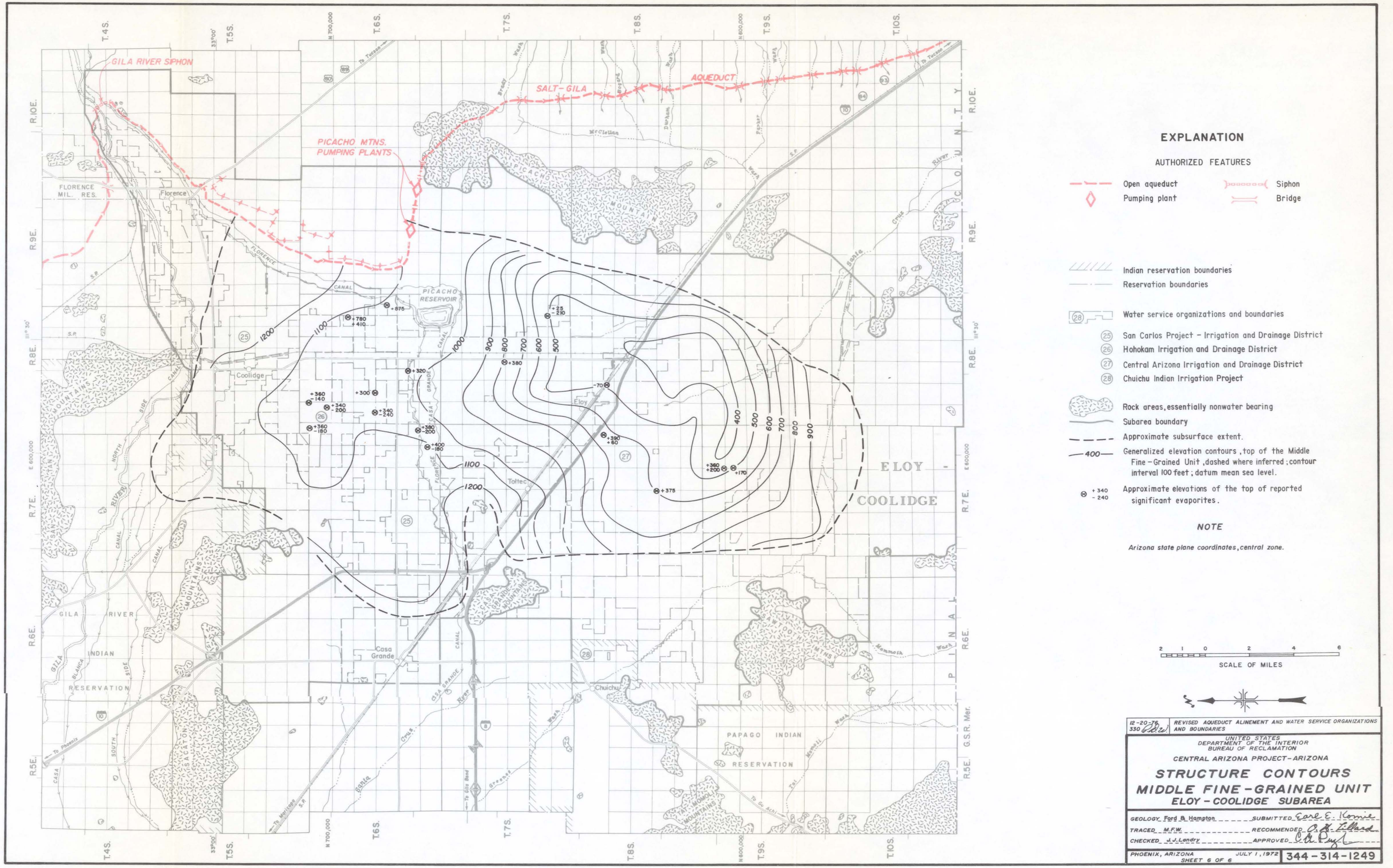

EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
(25) San Carlos Project - Irrigation and Drainage District
(26) Hohokam Irrigation and Drainage District
(27) Central Arizona Irrigation and Drainage District
(28) Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
Approximate subsurface extent.
400 Generalized elevation contours, top of the Middle Fine-Grained Unit, dashed where inferred; contour interval 100 feet; datum mean sea level.
+340 -240 Approximate elevations of the top of reported significant evaporites.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
GILA RIVER SIPHON
SALT-GILA
AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
PICACHO RESERVOIR
FLORENCE MIL. RES.
Florence
Coolidge
Eloy
Toltec
Casa Grande
Chuichu
ELOY - COOLIDGE
PICACHO MOUNTAINS
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
P I N A L C O U N T Y
T.4S.
T.5S.
T.6S.
T.7S.
T.8S.
T.9S.
T.10S.
R.10E.
R.9E.
R.8E.
R.7E.
R.6E.
R.5E.
G.S.R. Mer.
12-20-76 330
REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
STRUCTURE CONTOURS
MIDDLE FINE-GRAINED UNIT
ELOY - COOLIDGE SUBAREA
GEOLOGY Ford & Hampton
SUBMITTED Earl E. Komie
TRACED M.F.W.
RECOMMENDED O. H. Tillard
CHECKED J.J. Landry
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 6 OF 6
344-314-1249

Figure 16

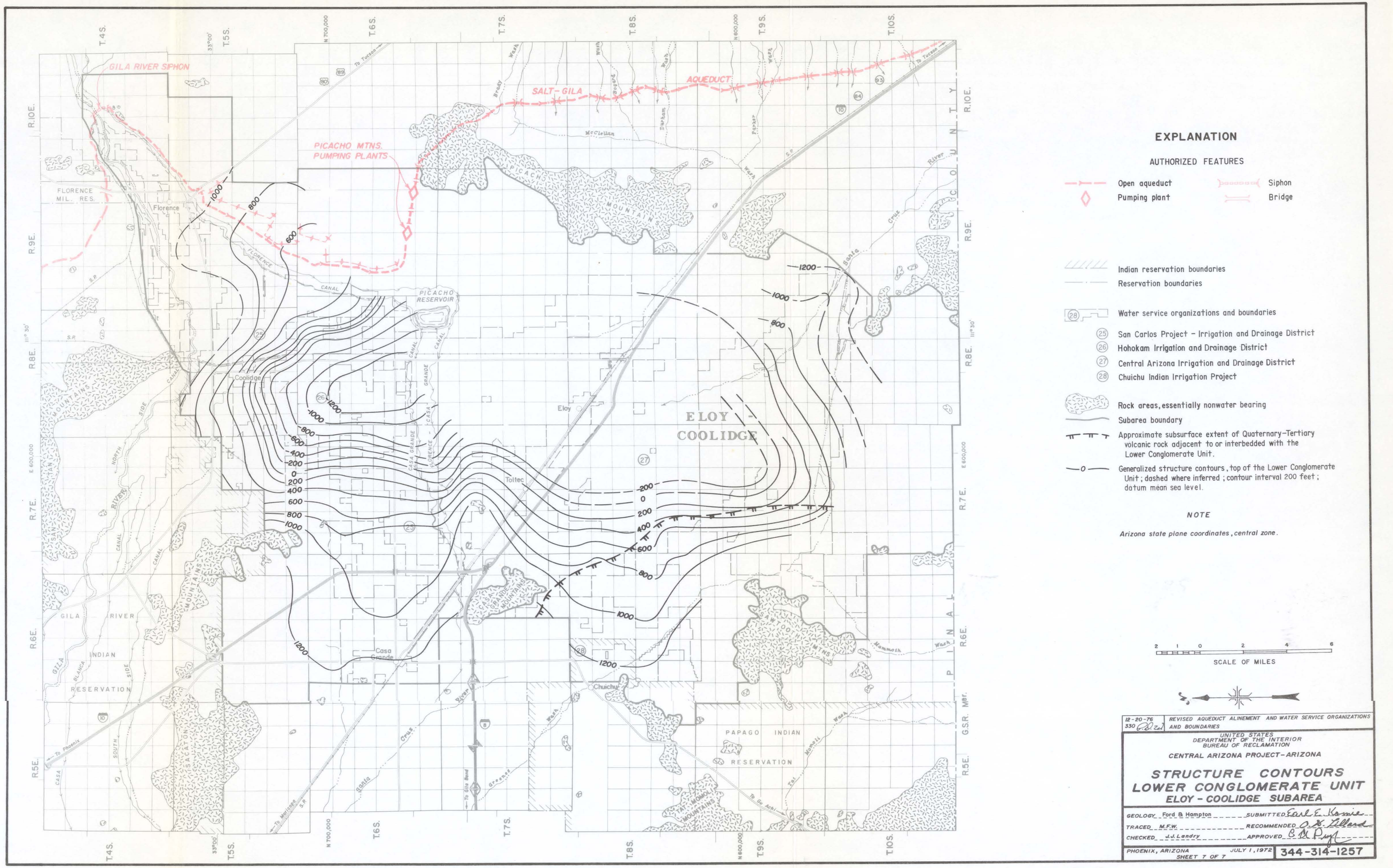
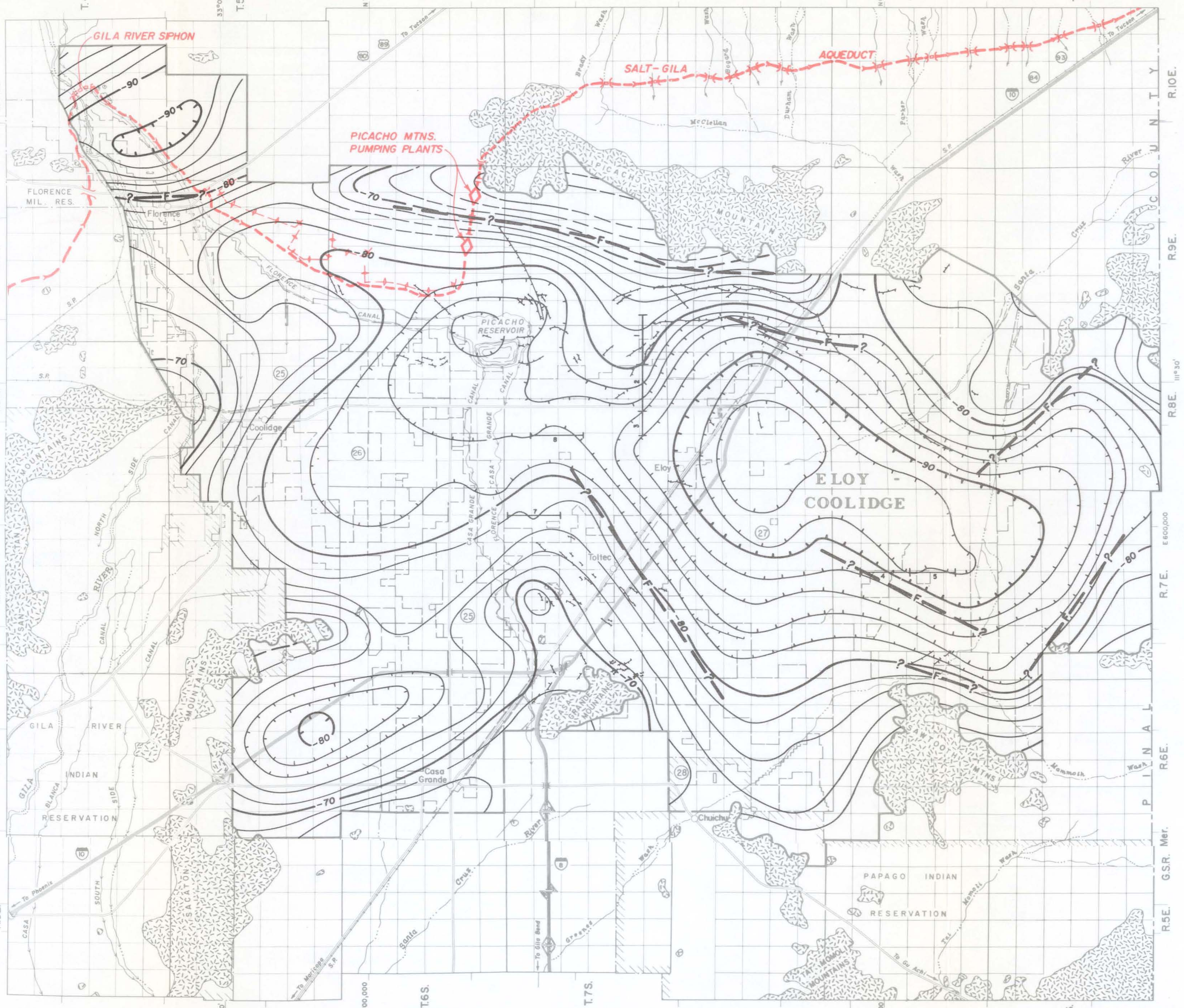

EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
25 San Carlos Project - Irrigation and Drainage District
26 Hohokam Irrigation and Drainage District
27 Central Arizona Irrigation and Drainage District
28 Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
Approximate subsurface extent of Quaternary-Tertiary volcanic rock adjacent to or interbedded with the Lower Conglomerate Unit.
Generalized structure contours, top of the Lower Conglomerate Unit; dashed where inferred; contour interval 200 feet; datum mean sea level.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
GILA RIVER SIPHON
SALT-GILA AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
PICACHO RESERVOIR
FLORENCE MIL. RES.
Florence
Coolidge
Eloy
Toltec
Casa Grande
Chuichu
ELOY - COOLIDGE
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
PINAL COUNTY
12-20-76 330 REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
STRUCTURE CONTOURS
LOWER CONGLOMERATE UNIT
ELOY - COOLIDGE SUBAREA
GEOLOGY Ford & Hampton
SUBMITTED Earl E. Kosmie
TRACED M.F.W.
RECOMMENDED O. H. Tillard
CHECKED J.J. Landry
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 7 OF 7
344-314-1257

Figure 17



EXPLANATION

AUTHORIZED FEATURES

- Open aqueduct
- Pumping plant
- Siphon
- Bridge
- Indian reservation boundaries
- Reservation boundaries
- Water service organizations and boundaries
  - (25) San Carlos Project - Irrigation and Drainage District
  - (26) Hohokam Irrigation and Drainage District
  - (27) Central Arizona Irrigation and Drainage District
  - (28) Chuichu Indian Irrigation Project
- Rock areas, essentially nonwater bearing
- Subarea boundary
- -80 Gravity contours, dashed where inferred; contour interval 2 milligals.
- ?—F— Inferred basement fault from gravity configuration.
- Earth fissures, as of 1964.
- Refraction seismic spread, as indicated U.S. Geological Survey, 1964.

NOTES

This map based on data developed from a cooperative program between the Bureau of Reclamation with the U.S. Geological Survey, resulting in "Geophysical Investigation Map GP-615" published in 1968.

Arizona state plane coordinates, central zone.

SCALE OF MILES: 2 1 0 2 4 6

12-20-76 330	REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT–ARIZONA

BOUGUER ANOMALY
ELOY - COOLIDGE SUBAREA

GEOLOGY______ SUBMITTED Earl E. Kosmie
TRACED M.F.W. RECOMMENDED A. H. Lillard
CHECKED Roberts APPROVED [signature]

PHOENIX, ARIZONA JULY 1, 1972 SHEET 7 OF 7 **344-314-1264**

Figure 18

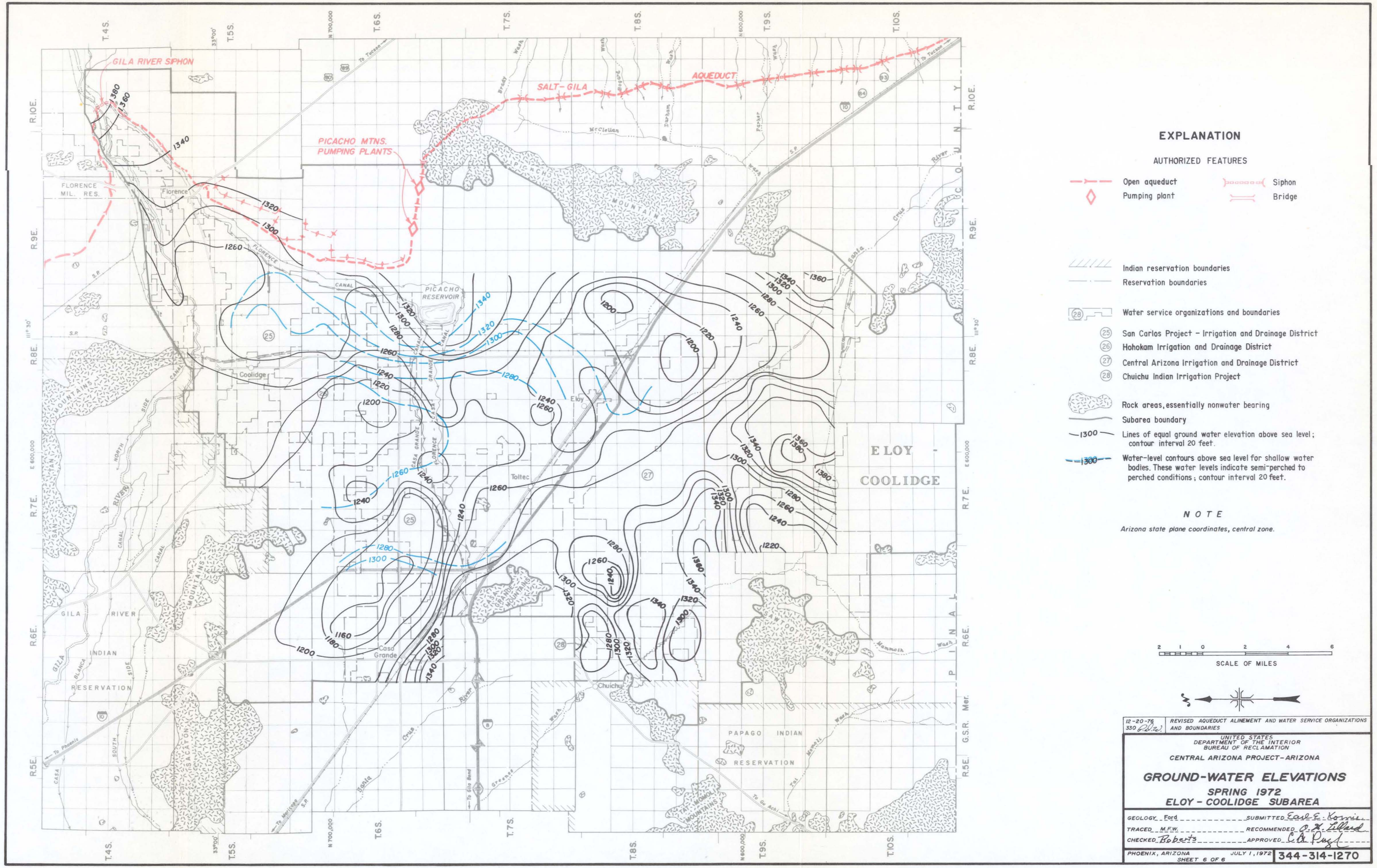

EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
25 San Carlos Project - Irrigation and Drainage District
26 Hohokam Irrigation and Drainage District
27 Central Arizona Irrigation and Drainage District
28 Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal ground water elevation above sea level; contour interval 20 feet.
Water-level contours above sea level for shallow water bodies. These water levels indicate semi-perched to perched conditions; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
GILA RIVER SIPHON
SALT-GILA AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
FLORENCE MIL. RES.
Florence
FLORENCE CANAL
PICACHO RESERVOIR
Coolidge
Eloy
Toltec
Casa Grande
Chuichu
ELOY - COOLIDGE
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
PINAL COUNTY
12-20-76 330 REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1972
ELOY - COOLIDGE SUBAREA
GEOLOGY Ford
SUBMITTED Earl E. Kosmic
TRACED M.F.W.
RECOMMENDED
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA
SHEET 6 OF 6
JULY 1, 1972
344-314-1270

Figure 19

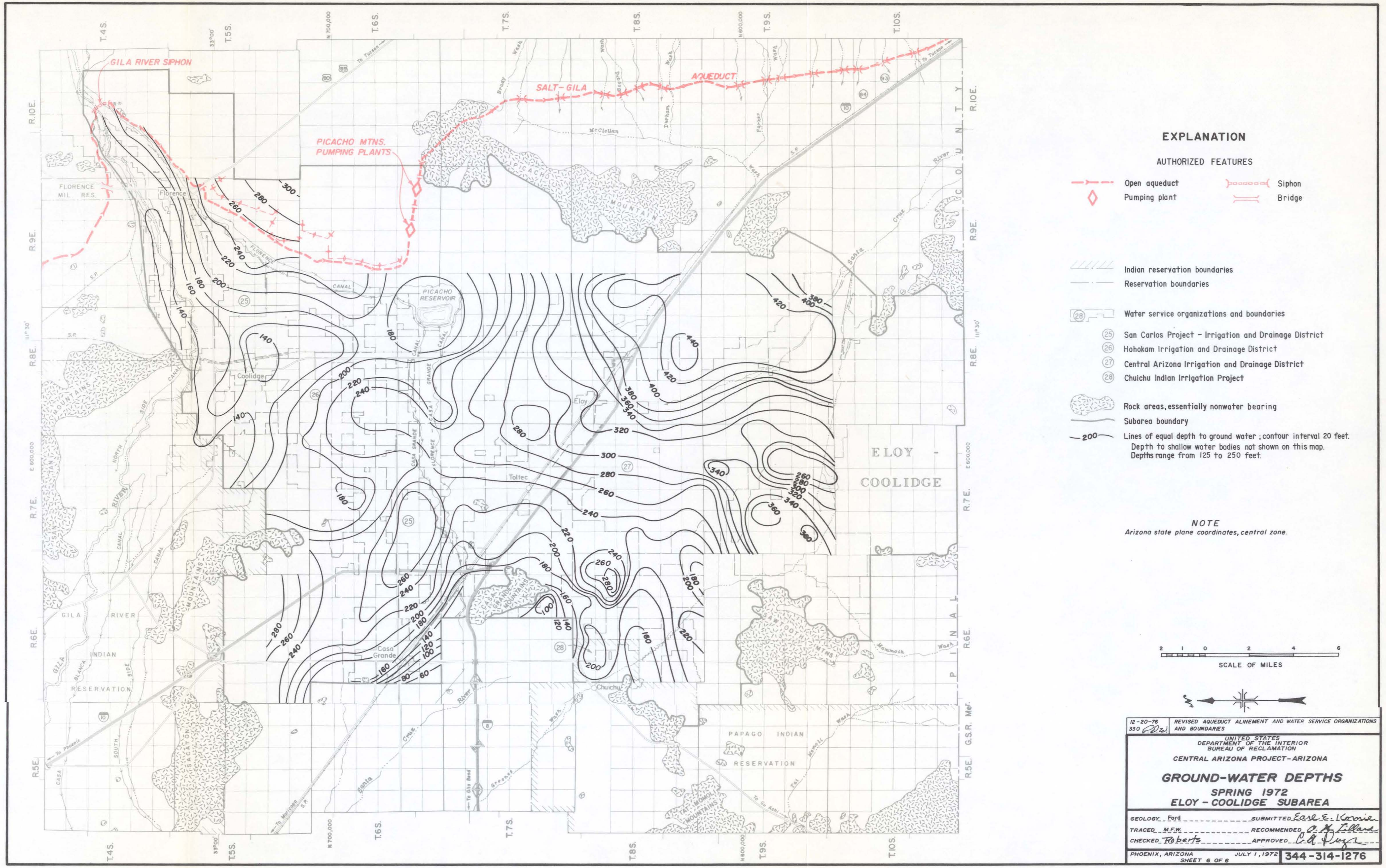

GILA RIVER SIPHON
SALT-GILA AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
FLORENCE MIL. RES.
Florence
Coolidge
Eloy
Toltec
Casa Grande
Chuichu
PICACHO RESERVOIR
PICACHO MOUNTAINS
ELOY - COOLIDGE
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
25 San Carlos Project - Irrigation and Drainage District
26 Hohokam Irrigation and Drainage District
27 Central Arizona Irrigation and Drainage District
28 Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
200 Lines of equal depth to ground water; contour interval 20 feet. Depth to shallow water bodies not shown on this map. Depths range from 125 to 250 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 330 REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER DEPTHS
SPRING 1972
ELOY - COOLIDGE SUBAREA
GEOLOGY Ford
SUBMITTED Earl E. Kornie
TRACED M.F.W.
CHECKED Roberts
PHOENIX, ARIZONA JULY 1, 1972
SHEET 6 OF 6
344-314-1276

Figure 20

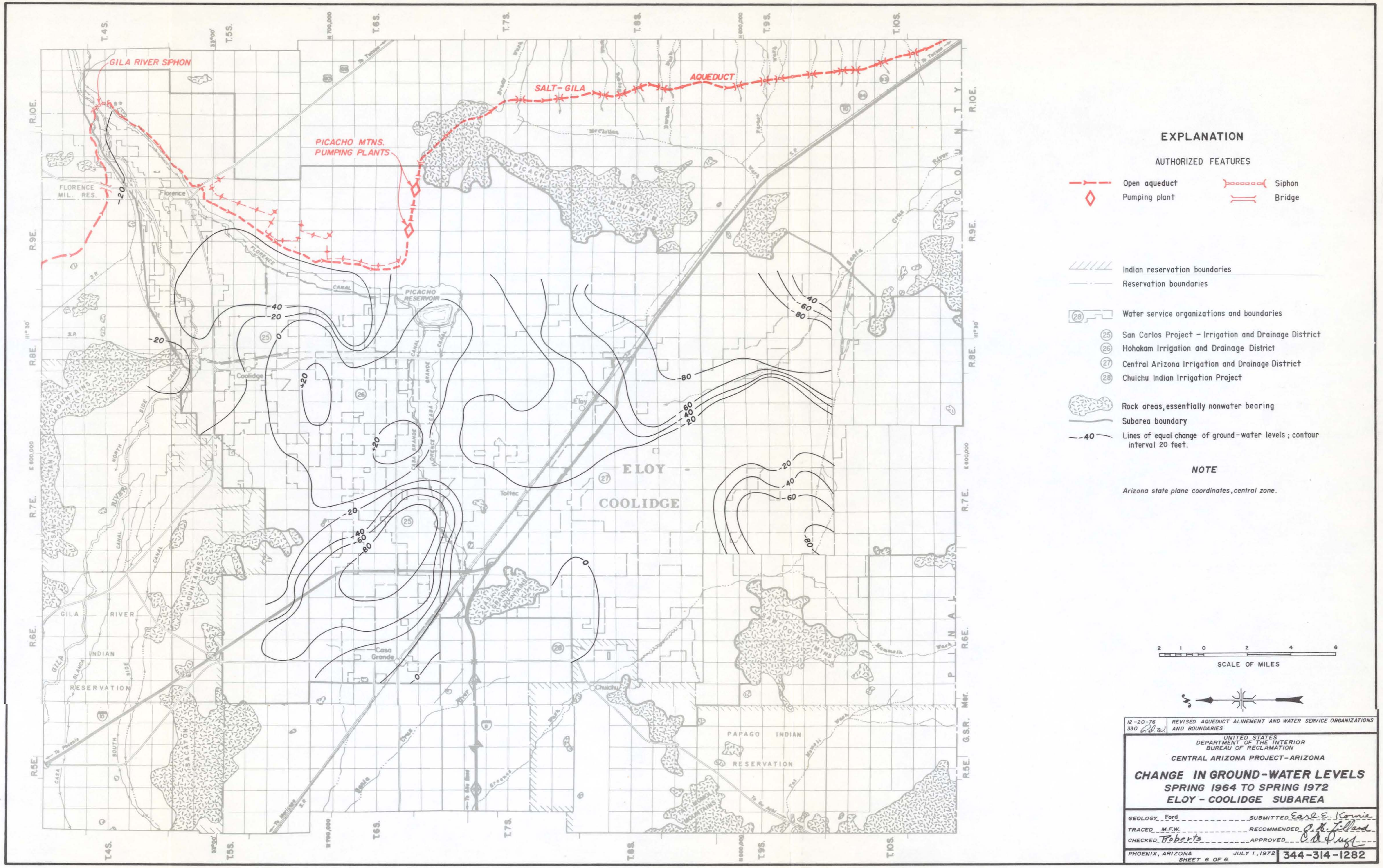
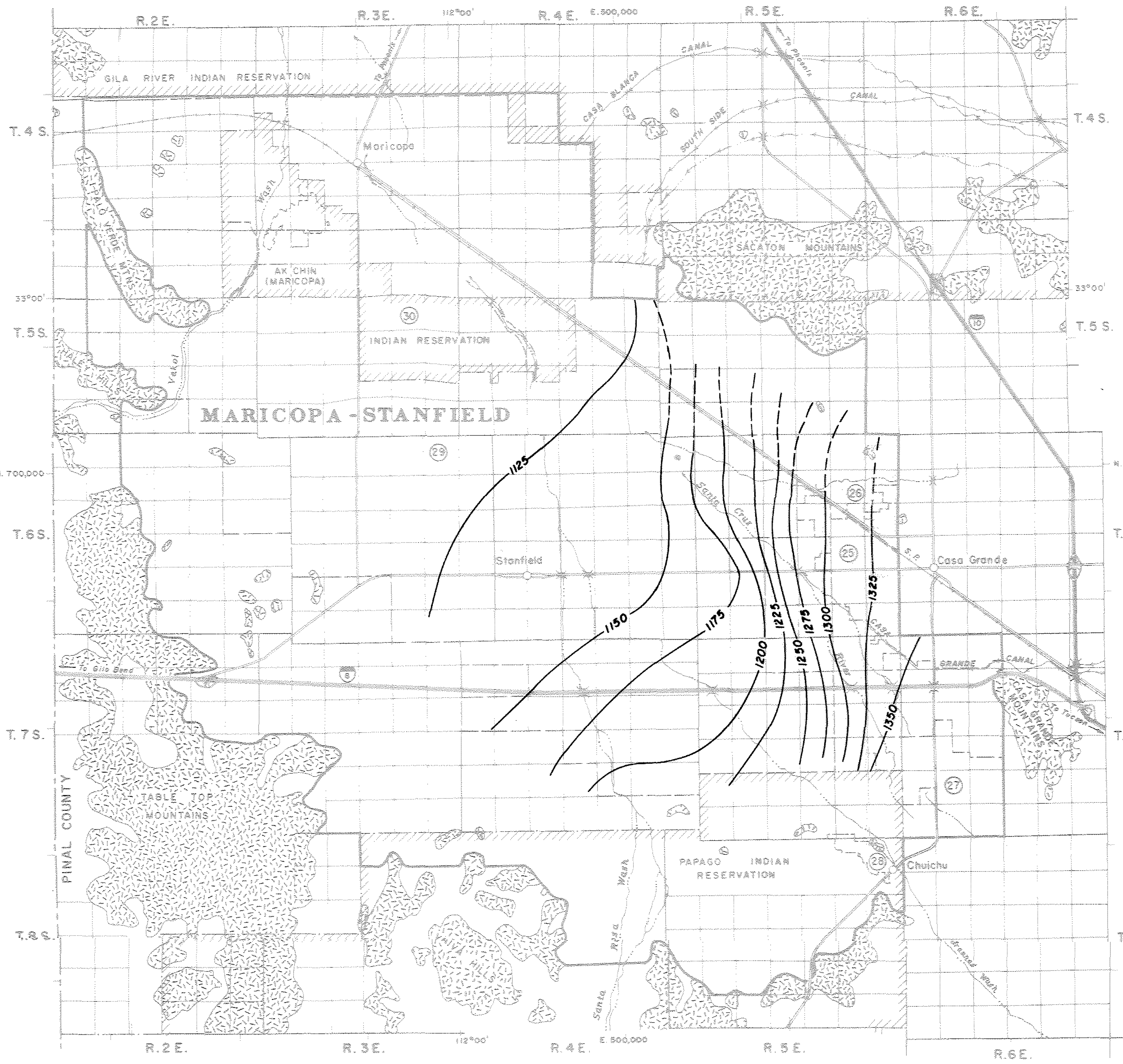

EXPLANATION
AUTHORIZED FEATURES
Open aqueduct
Pumping plant
Siphon
Bridge
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
San Carlos Project - Irrigation and Drainage District
Hohokam Irrigation and Drainage District
Central Arizona Irrigation and Drainage District
Chuichu Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal change of ground-water levels; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
GILA RIVER SIPHON
SALT-GILA
AQUEDUCT
PICACHO MTNS. PUMPING PLANTS
FLORENCE MIL. RES.
Florence
Coolidge
Eloy
ELOY
COOLIDGE
PICACHO RESERVOIR
Toltec
Casa Grande
Chuichu
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
12-20-76 330
REVISED AQUEDUCT ALINEMENT AND WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
CHANGE IN GROUND-WATER LEVELS
SPRING 1964 TO SPRING 1972
ELOY - COOLIDGE SUBAREA
GEOLOGY Ford
SUBMITTED Earl E. Kornie
TRACED M.F.W.
RECOMMENDED
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 6 OF 6
344-314-1282

Figure 21

MARICOPA– STANFIELD SUBAREA



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage District

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa–Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater bearing

Subarea boundary

—1200— Lines of equal ground-water elevation above sea level, dashed where inferred; contour interval 25 feet.

NOTES

Modified from U.S. Geological Survey open file report, "Ground Water in the Gila River Basin and Adjacent Areas, Arizona" 1952.

Arizona state plane coordinates central zone.

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

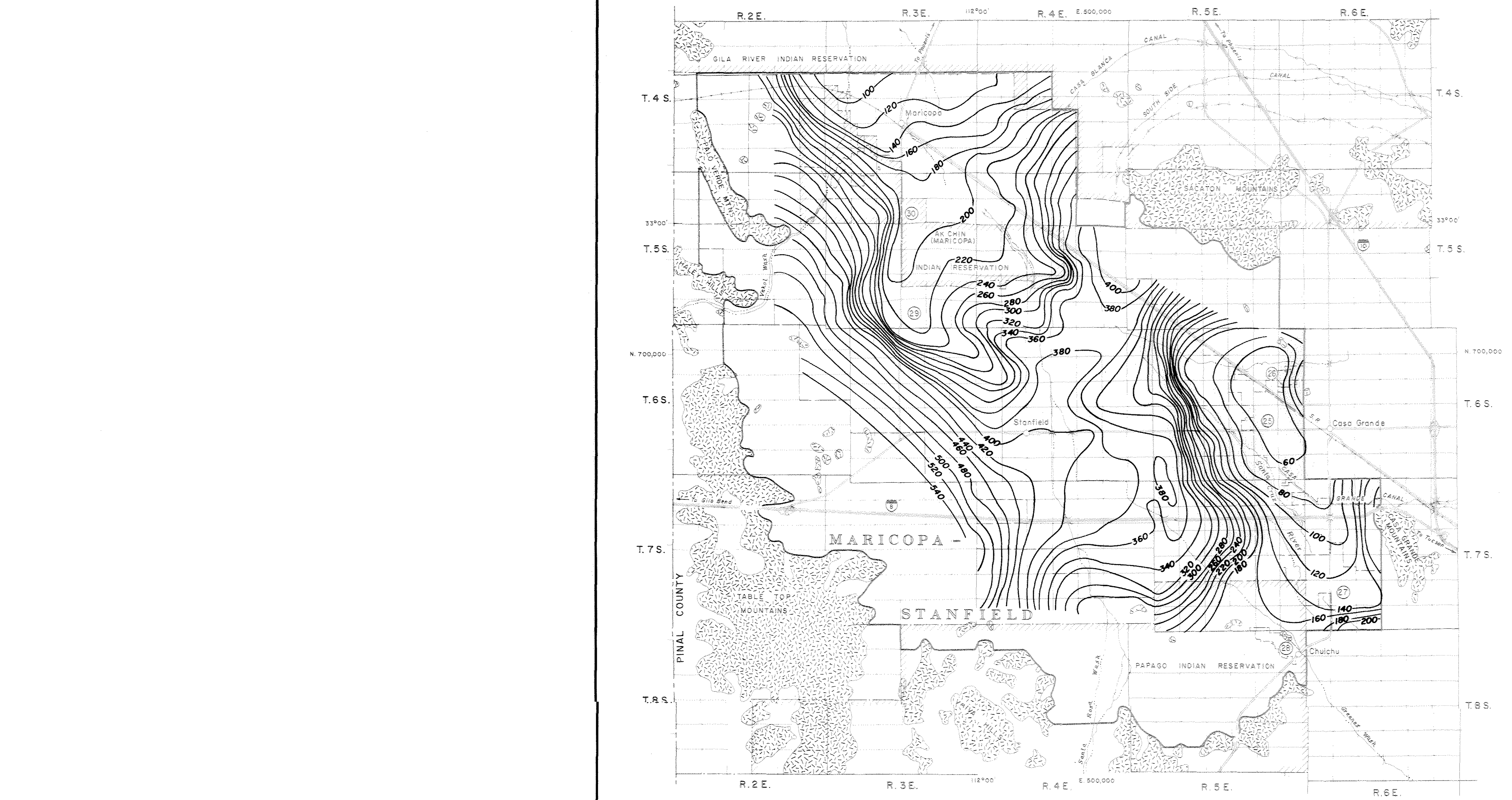
CENTRAL ARIZONA PROJECT–ARIZONA

GROUND-WATER ELEVATIONS
SPRING 1952
MARICOPA–STANFIELD SUBAREA

GEOLOGY ______ SUBMITTED Earl E. Kornie
TRACED G.F.O. ______ RECOMMENDED O. H. Lillard
CHECKED Roberts ______ APPROVED C. A. Pugh

PHOENIX, ARIZONA JULY 1, 1972 SHEET 6 OF 7 | 344-314-973

Figure 22



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage District

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa-Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater-bearing

Subarea boundary

60 — Lines of equal depth to groundwater; contour interval 20 feet.

Depth to shallow-water bodies not shown on this map. Depths range from approximately 100 to 250 feet.

NOTE

Arizona state plane coordinates, central zone.

N

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT-ARIZONA

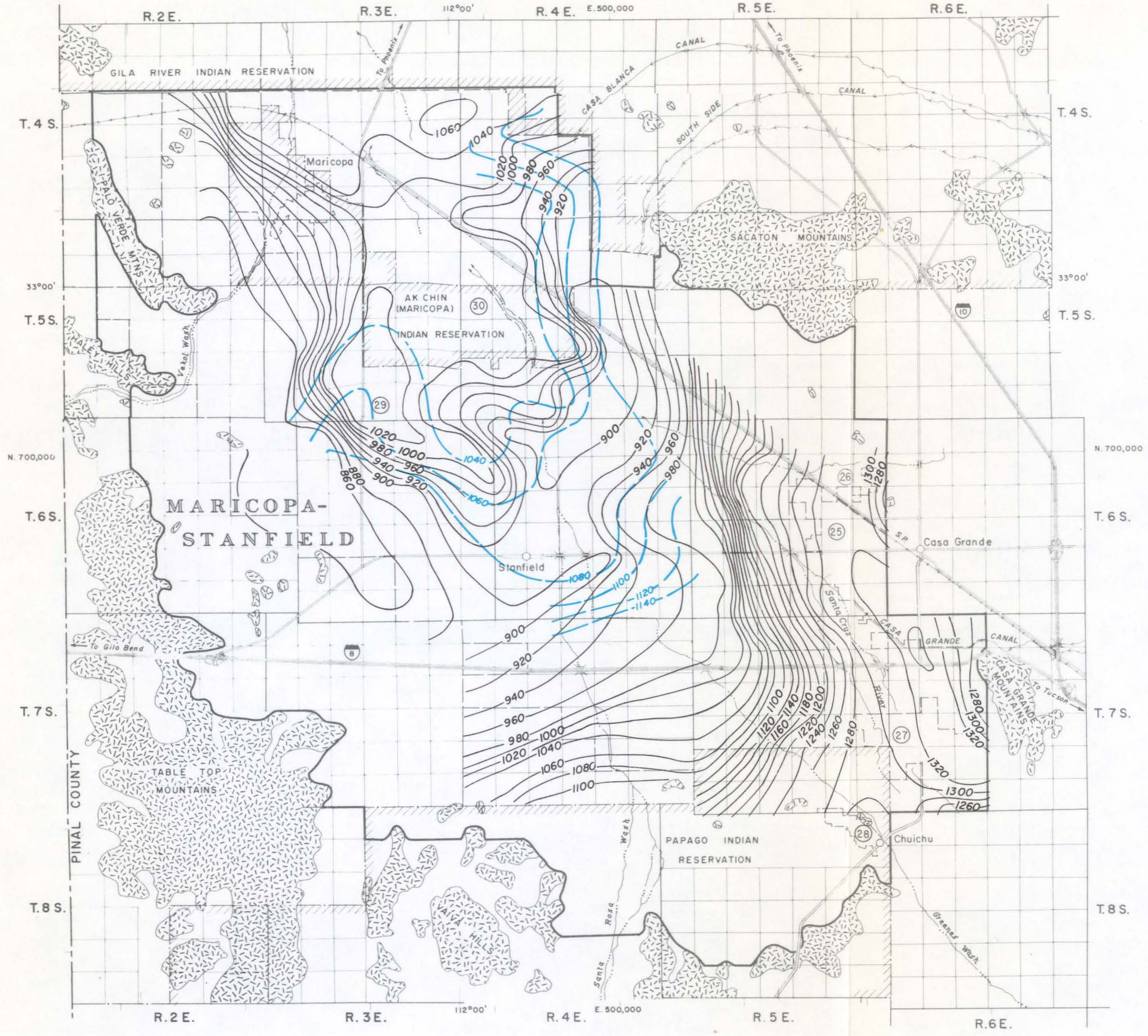
GROUND-WATER DEPTHS
SPRING 1964

MARICOPA-STANFIELD SUBAREA

GEOLOGY Hampton & Roberts SUBMITTED Earl E. Komis
TRACED G.F.O. RECOMMENDED
CHECKED Roberts APPROVED

PHOENIX, ARIZONA JULY 1, 1972 SHEET 6 OF 7 **344-314-980**

Figure 23



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage District

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa-Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater bearing

Subarea boundary

—980— Lines of equal ground-water elevation above sea level; contour interval 20 feet.

-·-1040-·- Water-level contours above sea level for shallow water bodies. These water levels indicate semi-perched to perched conditions; contour interval 20 feet.

NOTE

Arizona state plane coordinates, central zone.

SCALE OF MILES (2 1 0 2 4 6)

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

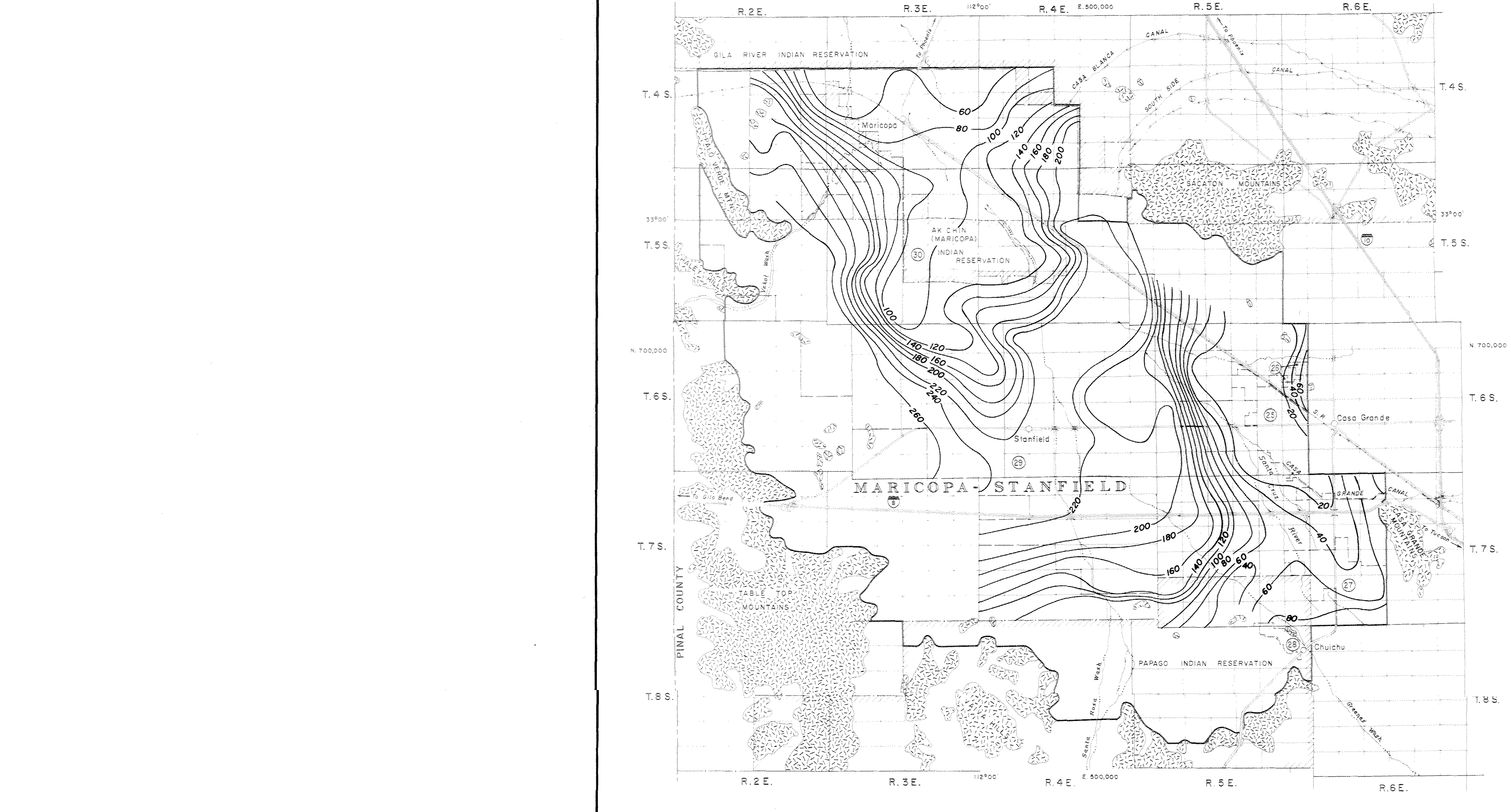
CENTRAL ARIZONA PROJECT-ARIZONA

GROUND-WATER ELEVATIONS
SPRING 1964
MARICOPA-STANFIELD SUBAREA

GEOLOGY Hampton & Roberts — SUBMITTED Earl E. Kornie
TRACED G.F.O. — RECOMMENDED O. H. Lillard
CHECKED Roberts — APPROVED C. A. Pugh

PHOENIX, ARIZONA JULY 1, 1972 SHEET 6 OF 7 — 344-314-1018

Figure 24



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage Drainage

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa-Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater-bearing

Subarea boundary

—60— Lines of equal decline of ground-water levels; contour interval 20 feet.

NOTE

Arizona state plane coordinates, central zone.

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT–ARIZONA

DECLINE IN GROUND-WATER LEVELS
SPRING 1952 TO SPRING 1964
MARICOPA-STANFIELD SUBAREA

GEOLOGY Hampton & Roberts SUBMITTED Earl E. Kome
TRACED G.F.O. RECOMMENDED [signature]
CHECKED Roberts APPROVED [signature]

PHOENIX, ARIZONA JULY 1, 1972 SHEET 6 OF 7 | 344-314-1025

Figure 25

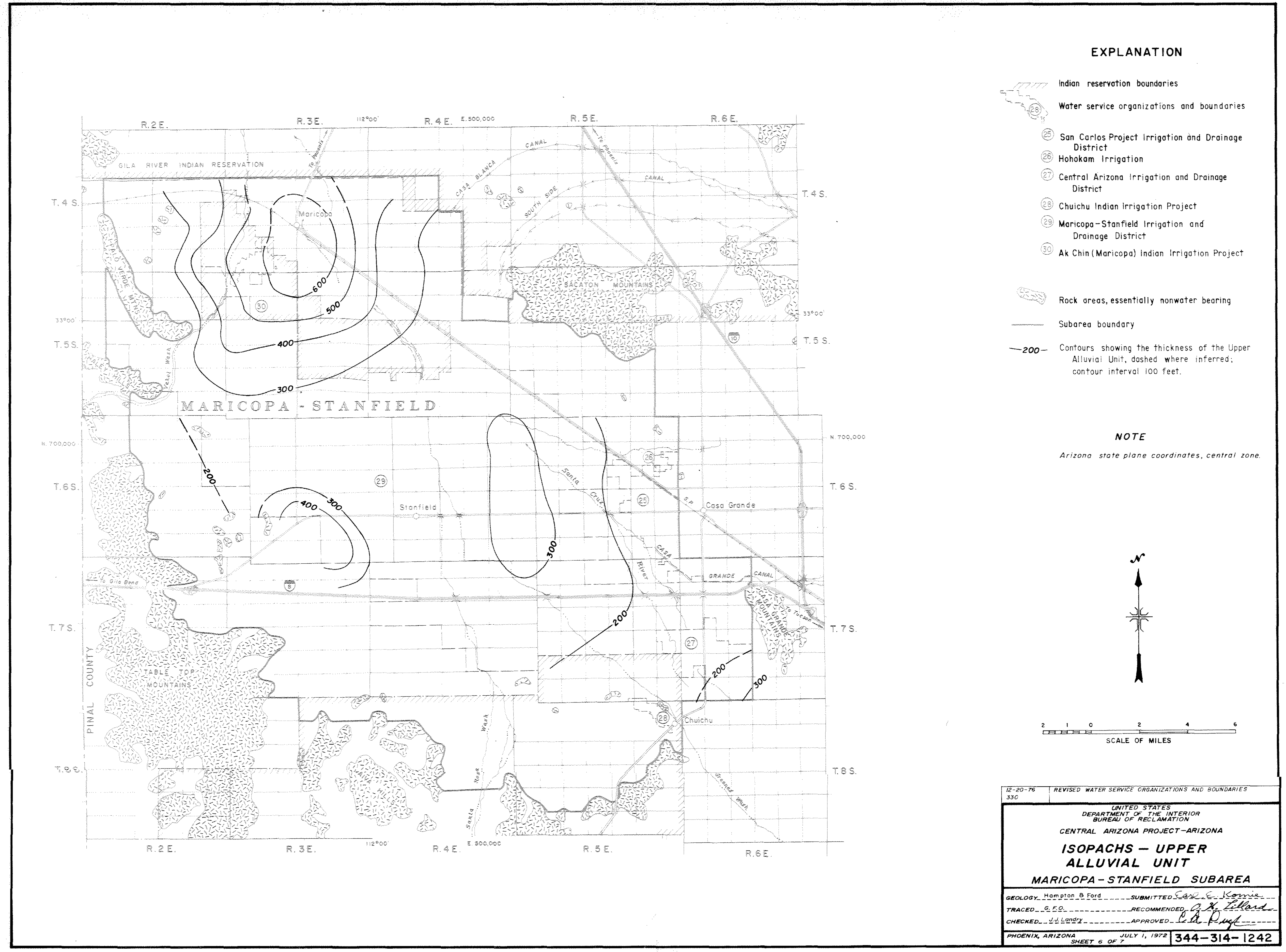
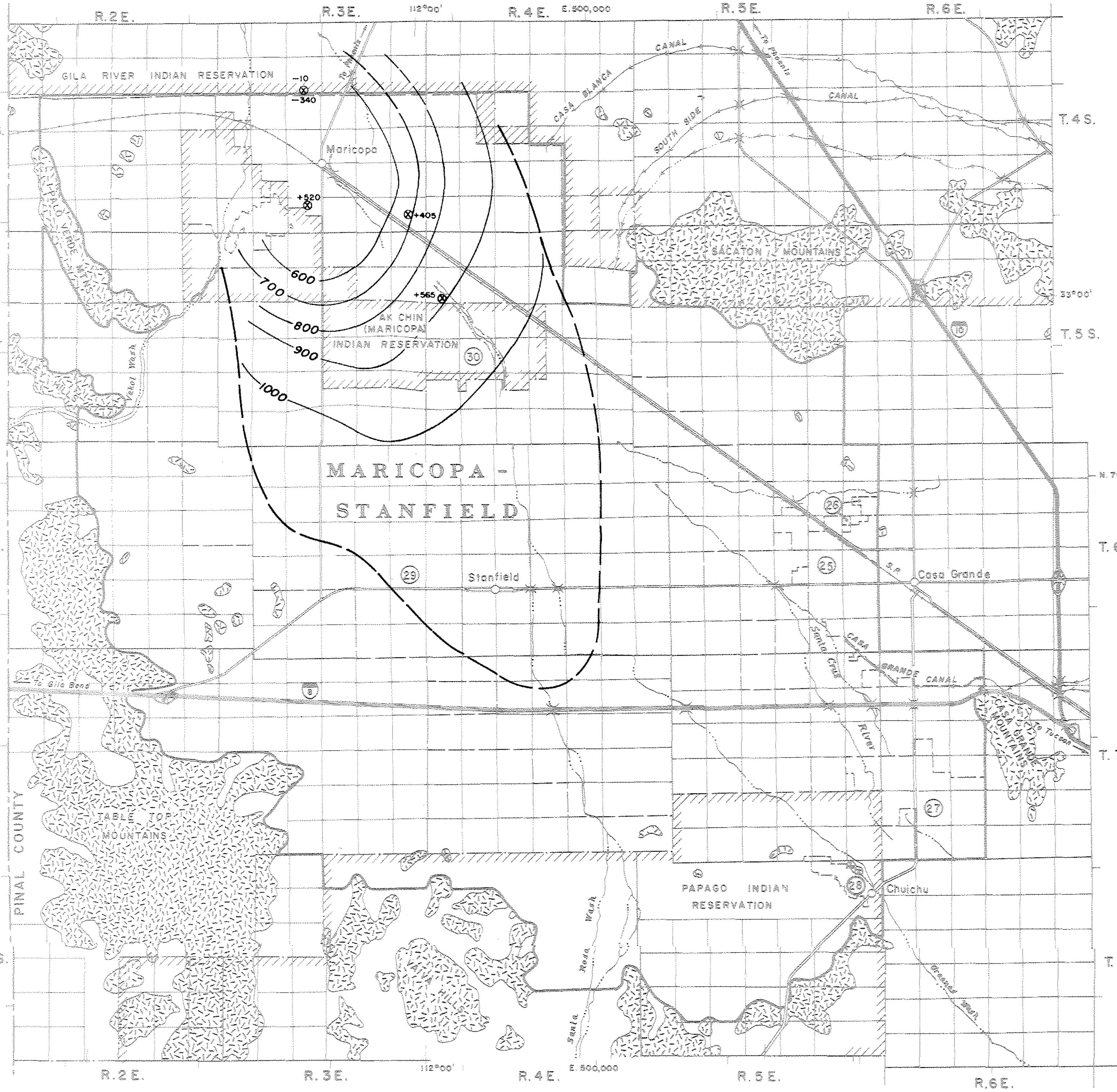

EXPLANATION
Indian reservation boundaries
Water service organizations and boundaries
25 San Carlos Project Irrigation and Drainage District
26 Hohokam Irrigation
27 Central Arizona Irrigation and Drainage District
28 Chuichu Indian Irrigation Project
29 Maricopa-Stanfield Irrigation and Drainage District
30 Ak Chin (Maricopa) Indian Irrigation Project
Rock areas, essentially nonwater bearing
Subarea boundary
—200— Contours showing the thickness of the Upper Alluvial Unit, dashed where inferred; contour interval 100 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R.2E.
R.3E.
R.4E.
R.5E.
R.6E.
T.4S.
T.5S.
T.6S.
T.7S.
T.8S.
GILA RIVER INDIAN RESERVATION
MARICOPA - STANFIELD
SACATON MOUNTAINS
TABLE TOP MOUNTAINS
PINAL COUNTY
Maricopa
Stanfield
Casa Grande
Chuichu
N 700,000
E 500,000
112°00'
33°00'
12-20-76 330 REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
ISOPACHS — UPPER ALLUVIAL UNIT
MARICOPA-STANFIELD SUBAREA
GEOLOGY Hampton B Ford
TRACED G.F.O.
CHECKED J.J. Landry
SUBMITTED
RECOMMENDED
APPROVED
PHOENIX, ARIZONA JULY 1, 1972 SHEET 6 OF 7
344-314-1242

Figure 26



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage Distrct

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa-Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater-bearing

Subarea boundary

Approximate subsurface extent.

600 — Generalized elevation contours, top of the Middle Fine-Grained Unit, dashed where inferred; contour interval 100 feet; datum mean sea level.

⊗-10 Approximate elevation of the top of reported significant evaporites.

NOTE

Arizona state plane coordinates, central zone.

N

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

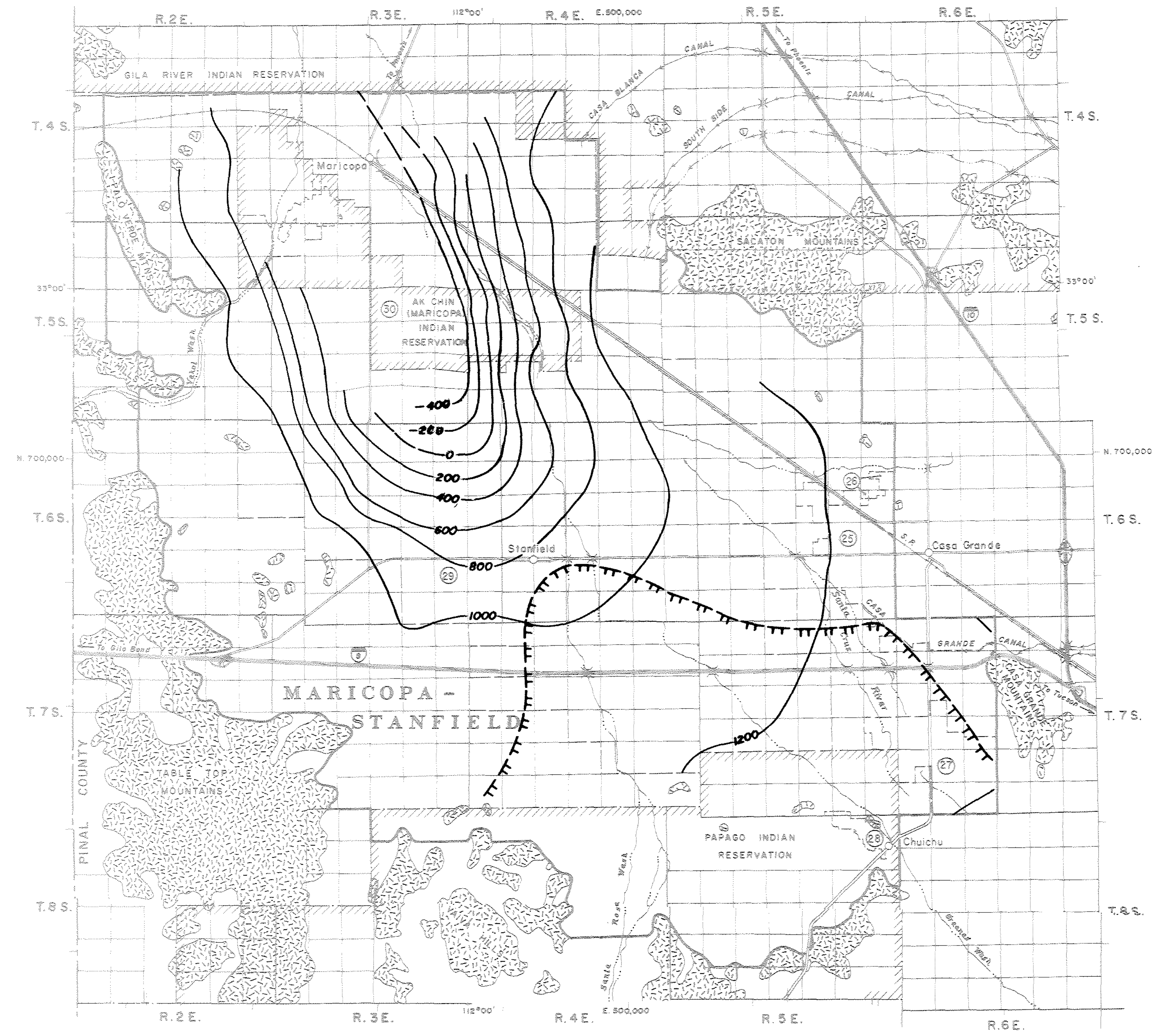
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA

STRUCTURE CONTOURS
MIDDLE FINE-GRAINED UNIT
MARICOPA-STANFIELD SUBAREA

GEOLOGY Ford & Hampton SUBMITTED Earl E. Kernis
TRACED G.F.O. RECOMMENDED O. H. Lillard
CHECKED J.J. Landry APPROVED [signature]

PHOENIX, ARIZONA JULY 1, 1972 SHEET 5 OF 6 344-314-1248

Figure 27



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage District

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa-Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater-bearing

Subarea boundary

Approximate subsurface extent of Quaternary-Tertiary volcanic rock adjacent to or interbedded with the Lower Conglomerate Unit.

Generalized structure contours, top of the Lower Conglomerate Unit; dashed where inferred; contour interval 200 feet; datum mean sea level.

NOTE

Arizona state plane coordinates, central zone.

N

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT-ARIZONA

STRUCTURE CONTOURS LOWER CONGLOMERATE UNIT MARICOPA-STANFIELD SUBAREA

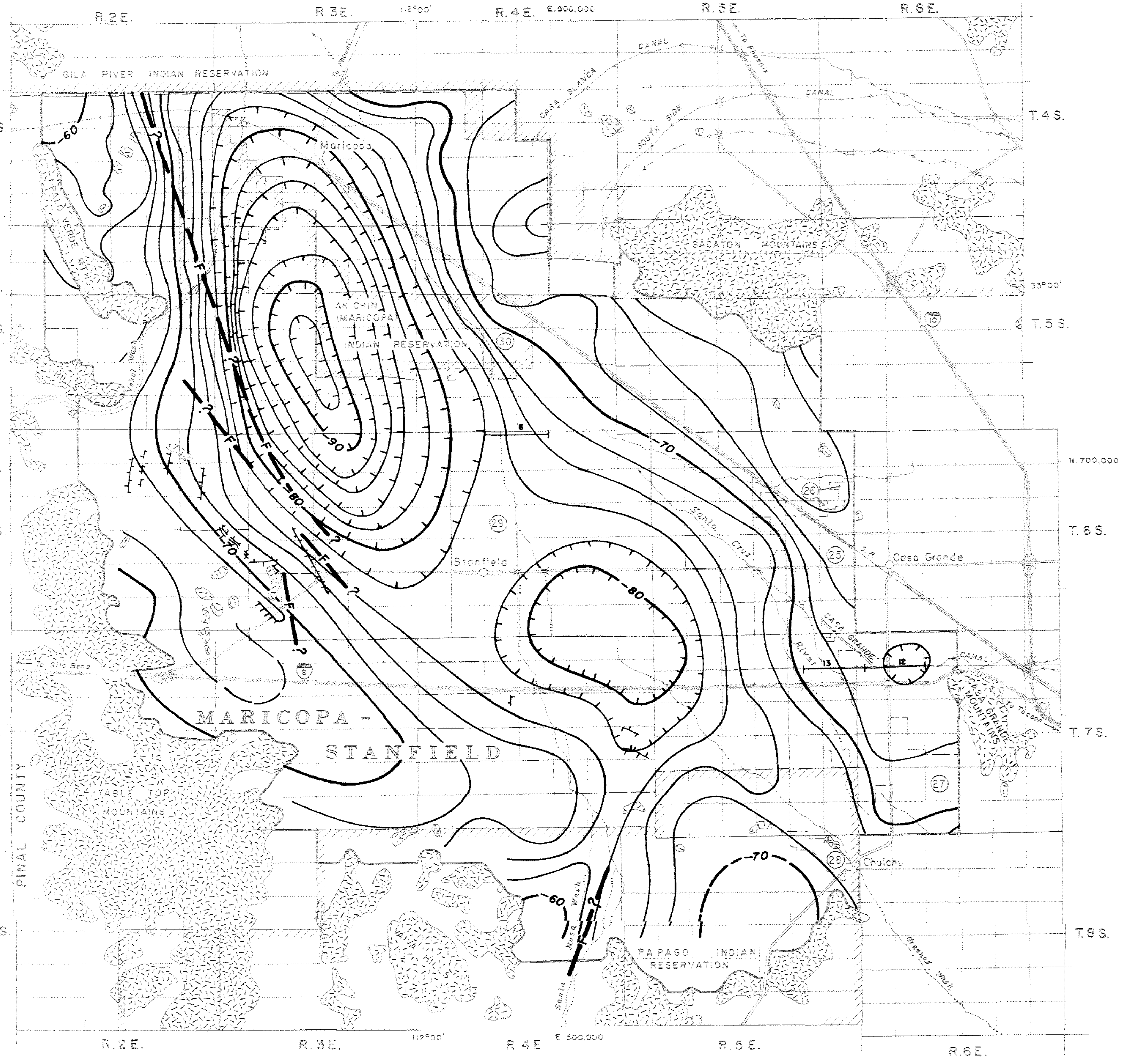
GEOLOGY Ford & Hampton SUBMITTED

TRACED G.F.O. RECOMMENDED

CHECKED APPROVED

PHOENIX, ARIZONA JULY 1, 1972 SHEET 6 OF 7 344-314-1256

Figure 28



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District
(26) Hohokam Irrigation and Drainage District
(27) Central Arizona Irrigation and Drainage District
(28) Chuichu Indian Irrigation Project
(29) Maricopa–Stanfield Irrigation and Drainage District
(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater bearing

Subarea boundary

—80— Gravity contours, dashed where inferred; contour interval 2 milligals.

—F—?— Inferred basement fault from gravity configuration.

Earth fissures, as of 1964.

13 12 Refraction seismic spread, as indicated U.S. Geological Survey, 1964.

NOTES

This map based on data developed from a cooperative program between the Bureau of Reclamation with the U.S. Geological Survey, resulting in "Geophysical Investigation Map GP-615" published in 1968.

Arizona state plane coordinates, central zone.

N

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT–ARIZONA

BOUGUER ANOMALY

MARICOPA–STANFIELD SUBAREA

GEOLOGY________ SUBMITTED Earl E. Kornie
TRACED G.E.O. ________ RECOMMENDED O. K. Lillard
CHECKED Roberts ________ APPROVED C. A. Pugh

PHOENIX, ARIZONA JULY 1, 1972 SHEET 6 OF 7 | 344-314-1263

Figure 29

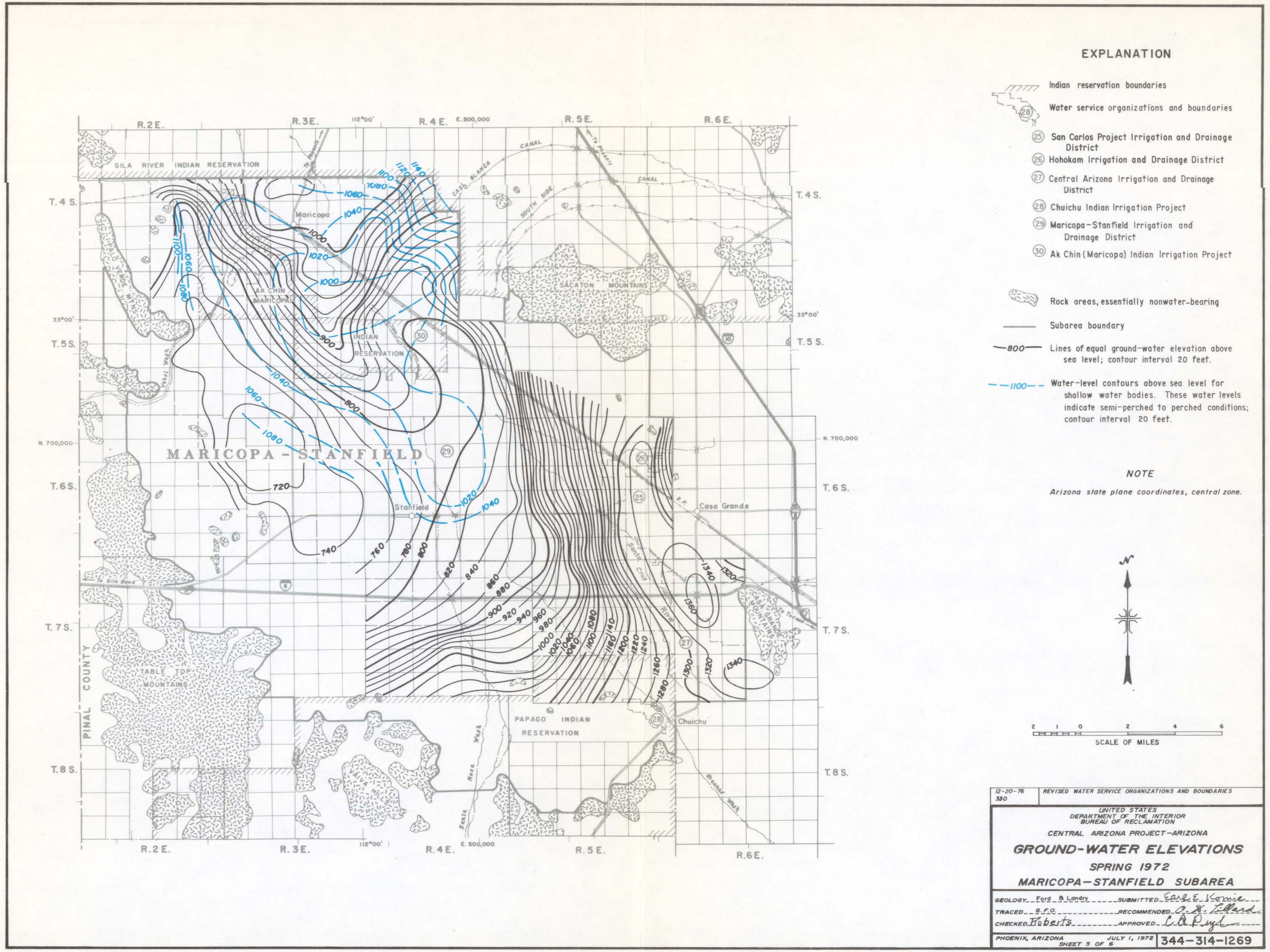
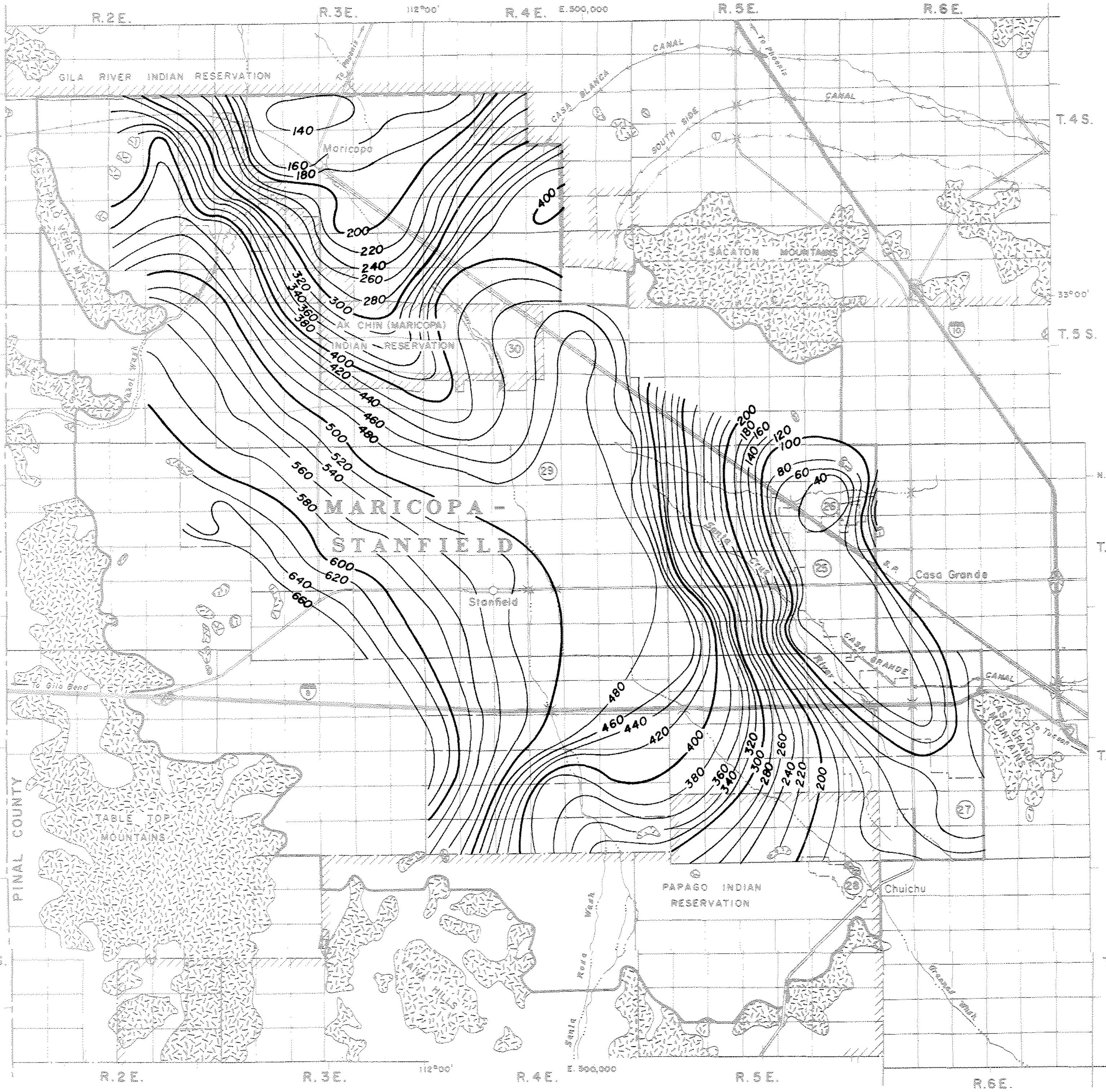

EXPLANATION
Indian reservation boundaries
Water service organizations and boundaries
25 San Carlos Project Irrigation and Drainage District
26 Hohokam Irrigation and Drainage District
27 Central Arizona Irrigation and Drainage District
28 Chuichu Indian Irrigation Project
29 Maricopa-Stanfield Irrigation and Drainage District
30 Ak Chin (Maricopa) Indian Irrigation Project
Rock areas, essentially nonwater-bearing
Subarea boundary
800 Lines of equal ground-water elevation above sea level; contour interval 20 feet.
1100 Water-level contours above sea level for shallow water bodies. These water levels indicate semi-perched to perched conditions; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R.2E.
R.3E.
R.4E.
R.5E.
R.6E.
112°00'
E. 500,000
N. 700,000
33°00'
T.4S.
T.5S.
T.6S.
T.7S.
T.8S.
GILA RIVER INDIAN RESERVATION
MARICOPA - STANFIELD
AK CHIN (MARICOPA) INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
SACATON MOUNTAINS
TABLE TOP MOUNTAINS
PINAL COUNTY
Maricopa
Stanfield
Casa Grande
Chuichu
CASA BLANCA CANAL
SOUTH SIDE CANAL
12-20-76
330
REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1972
MARICOPA-STANFIELD SUBAREA
GEOLOGY Ford & Landry
SUBMITTED Earl E. Komie
TRACED G.F.O.
RECOMMENDED O. H. Tillard
CHECKED Roberts
APPROVED C. A. Pugh
PHOENIX, ARIZONA
SHEET 5 OF 6
JULY 1, 1972
344-314-1269

Figure 30



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage District

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa-Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater-bearing

Subarea boundary

—100— Lines of equal depth to ground water; contour interval 20 feet.

Depth to shallow-water bodies not shown on this map. Depths range from 150 to 300 feet.

NOTE

Arizona state plane coordinates, central zone.

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT-ARIZONA

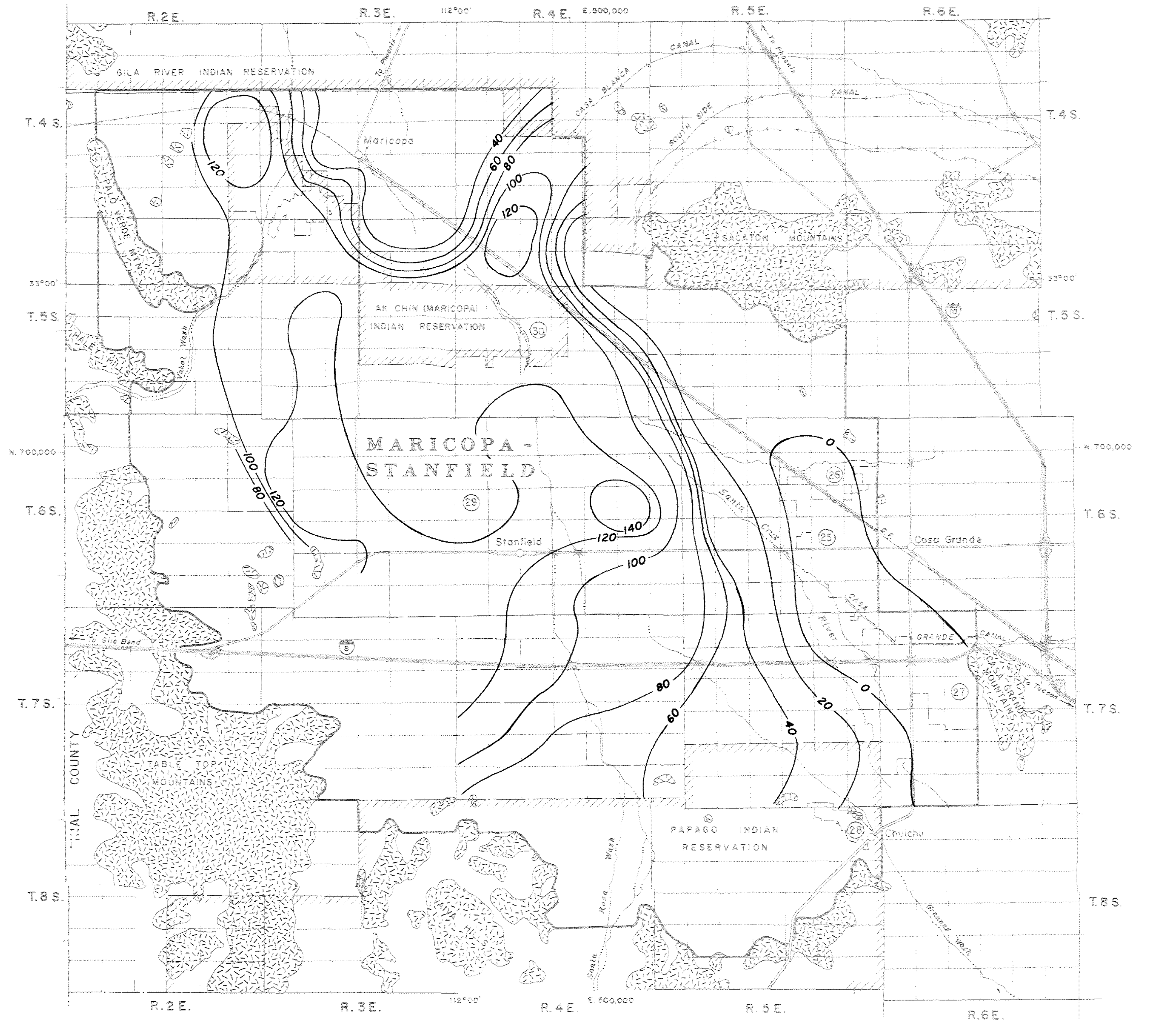
GROUND-WATER DEPTHS

SPRING 1972

MARICOPA-STANFIELD SUBAREA

GEOLOGY Ford	SUBMITTED Earl C. Kossuie
TRACED GFO	RECOMMENDED O. K. Tillard
CHECKED Roberts	APPROVED C. A. Pugh
PHOENIX, ARIZONA JULY 1, 1972 SHEET 5 OF 6	344-314-1275

Figure 31



EXPLANATION

Indian reservation boundaries

Water service organizations and boundaries

(25) San Carlos Project Irrigation and Drainage District

(26) Hohokam Irrigation and Drainage D

(27) Central Arizona Irrigation and Drainage District

(28) Chuichu Indian Irrigation Project

(29) Maricopa–Stanfield Irrigation and Drainage District

(30) Ak Chin (Maricopa) Indian Irrigation Project

Rock areas, essentially nonwater bearing

Subarea boundary

—0— Lines of equal decline of ground-water levels; contour interval 20 feet.

NOTE

Arizona state plane coordinates, central zone.

N

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED WATER SERVICE ORGANIZATIONS AND BOUNDARIES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT–ARIZONA

DECLINE IN GROUND-WATER LEVELS
SPRING 1964 TO SPRING 1972

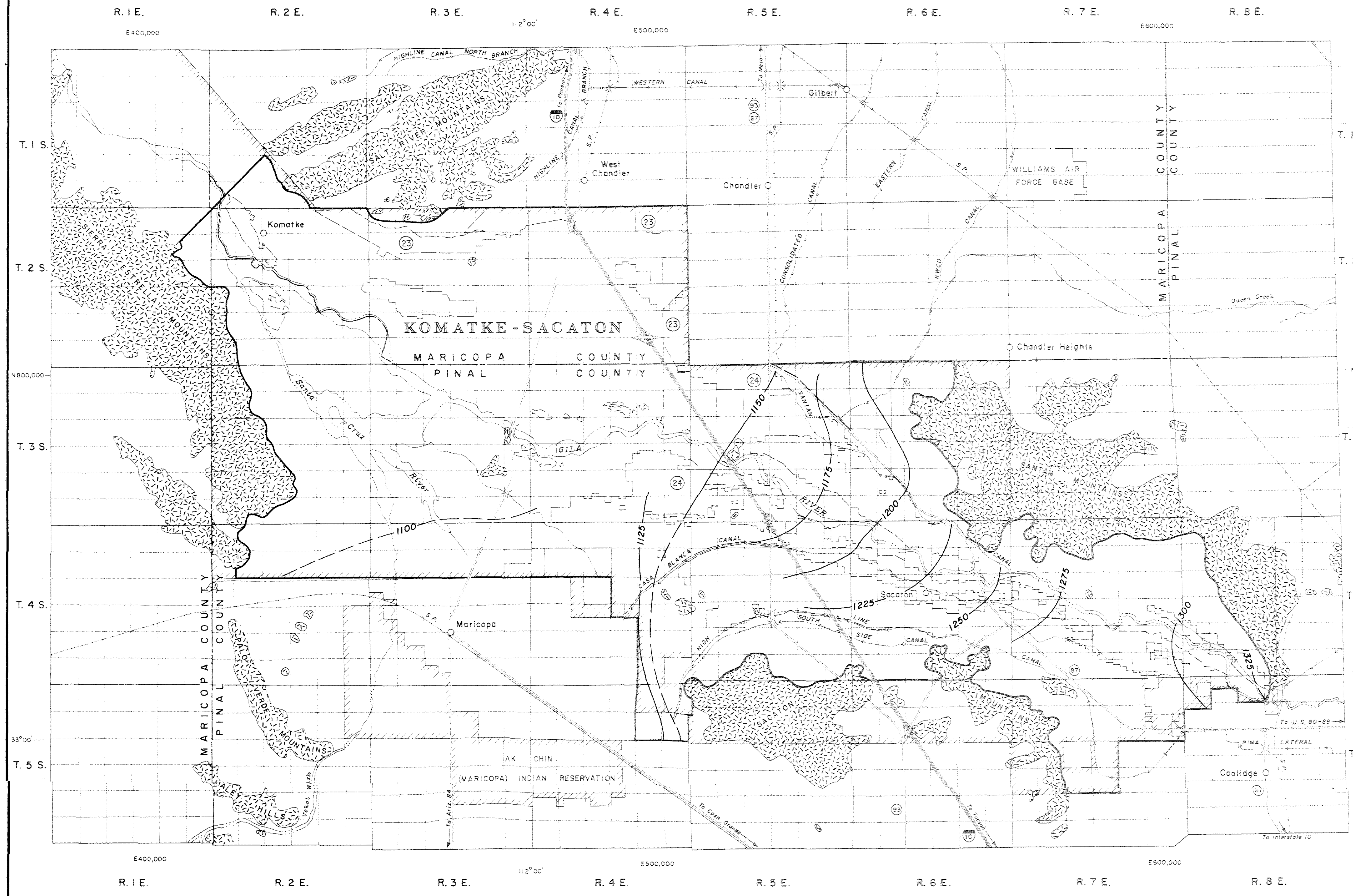
MARICOPA–STANFIELD SUBAREA

GEOLOGY Ford SUBMITTED Carl E. Kamie
TRACED G.F.O. RECOMMENDED C. H. Lillard
CHECKED Roberts APPROVED C A Pugh

PHOENIX, ARIZONA JULY 1, 1972 SHEET 5 OF 6 | 344-314-1281

Figure 32

KOMATKE — SACATON SUBAREA



EXPLANATION

- Indian reservation boundaries
- Reservation boundaries
- Water service organizations and boundaries
  - (23) Gila River Indian Reservation Miscellaneous Irrigation
  - (24) San Carlos Project—Indian Lands
- Rock areas, essentially nonwater bearing
- Subarea boundary
- —1225— Lines of equal ground-water elevation above sea level; dashed where inferred; contour interval 25 feet.

NOTES

Modified from U. S. Geological Survey open file report, "Ground Water in the Gila River Basin and Adjacent Areas, Arizona" 1952.

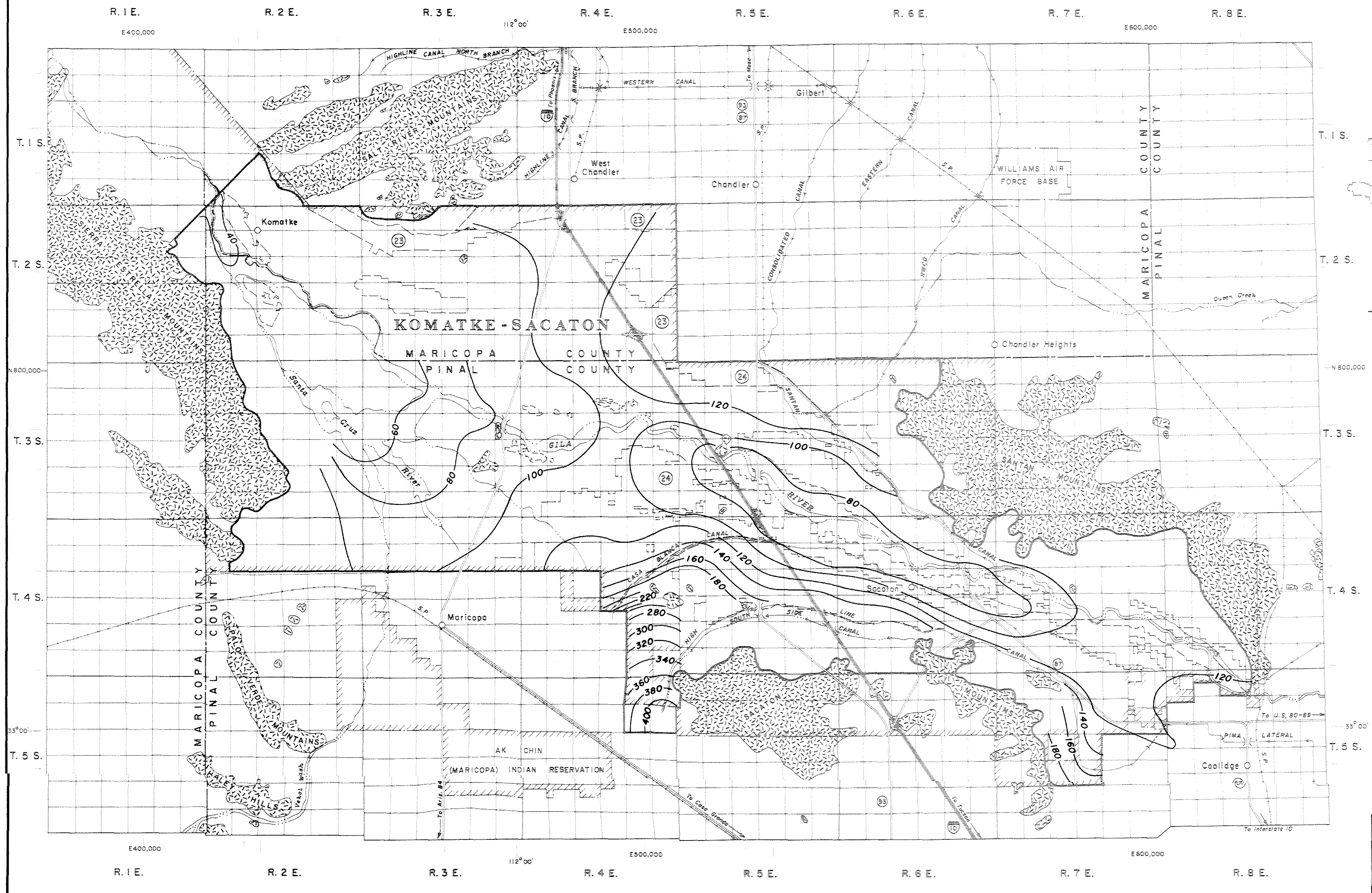
Arizona state plane coordinates, central zone.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA

GROUND-WATER ELEVATIONS
SPRING 1952
KOMATKE—SACATON SUBAREA

DRAWN Hampton & Roberts	SUBMITTED Earl E. Kornie
TRACED W. J. L.	RECOMMENDED O. H. Lillard
CHECKED Ford	APPROVED C. A. Pugh
PHOENIX, ARIZONA JULY 1, 1972 SHEET 5 OF 7	344-314-972

Figure 33



EXPLANATION

Indian reservation boundaries

Reservation boundaries

Water service organizations and boundaries

(23) Gila River Indian Reservation Miscellaneous Irrigation

(24) San Carlos Project—Indian Lands

Rock areas, essentially nonwater bearing

Subarea boundary

—100— Lines of equal depth to ground-water; contour interval 20 feet.

NOTE

Arizona state plane coordinates, central zone.

SCALE OF MILES (2 1 0 2 4 6)

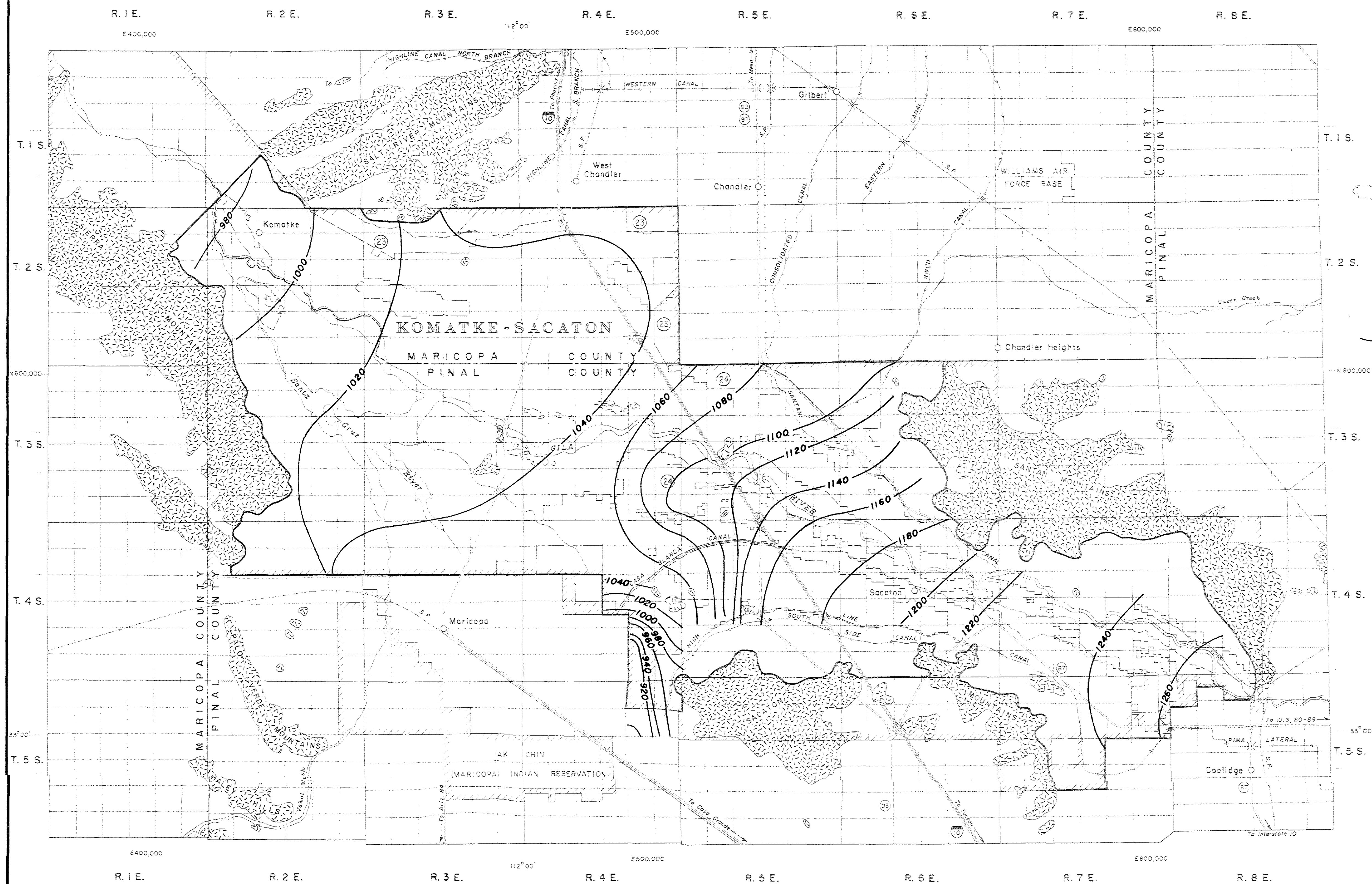
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA

GROUND-WATER DEPTHS
SPRING 1964
KOMATKE-SACATON SUBAREA

DRAWN Hampton & Roberts SUBMITTED Earl E. Towne
TRACED W.J.L. RECOMMENDED
CHECKED Ford APPROVED

PHOENIX, ARIZONA JULY 1, 1972 SHEET 5 OF 7 **344-314-979**

Figure 34



EXPLANATION

- Indian reservation boundaries
- Reservation boundaries
- Water service organizations and boundaries
- (23) Gila River Indian Reservation Miscellaneous Irrigation
- (24) San Carlos Project—Indian Lands
- Rock areas, essentially nonwater bearing
- Subarea boundary
- —1200— Lines of equal ground-water elevation above sea level; contour interval 20 feet.

NOTE

Arizona state plane coordinates, central zone.

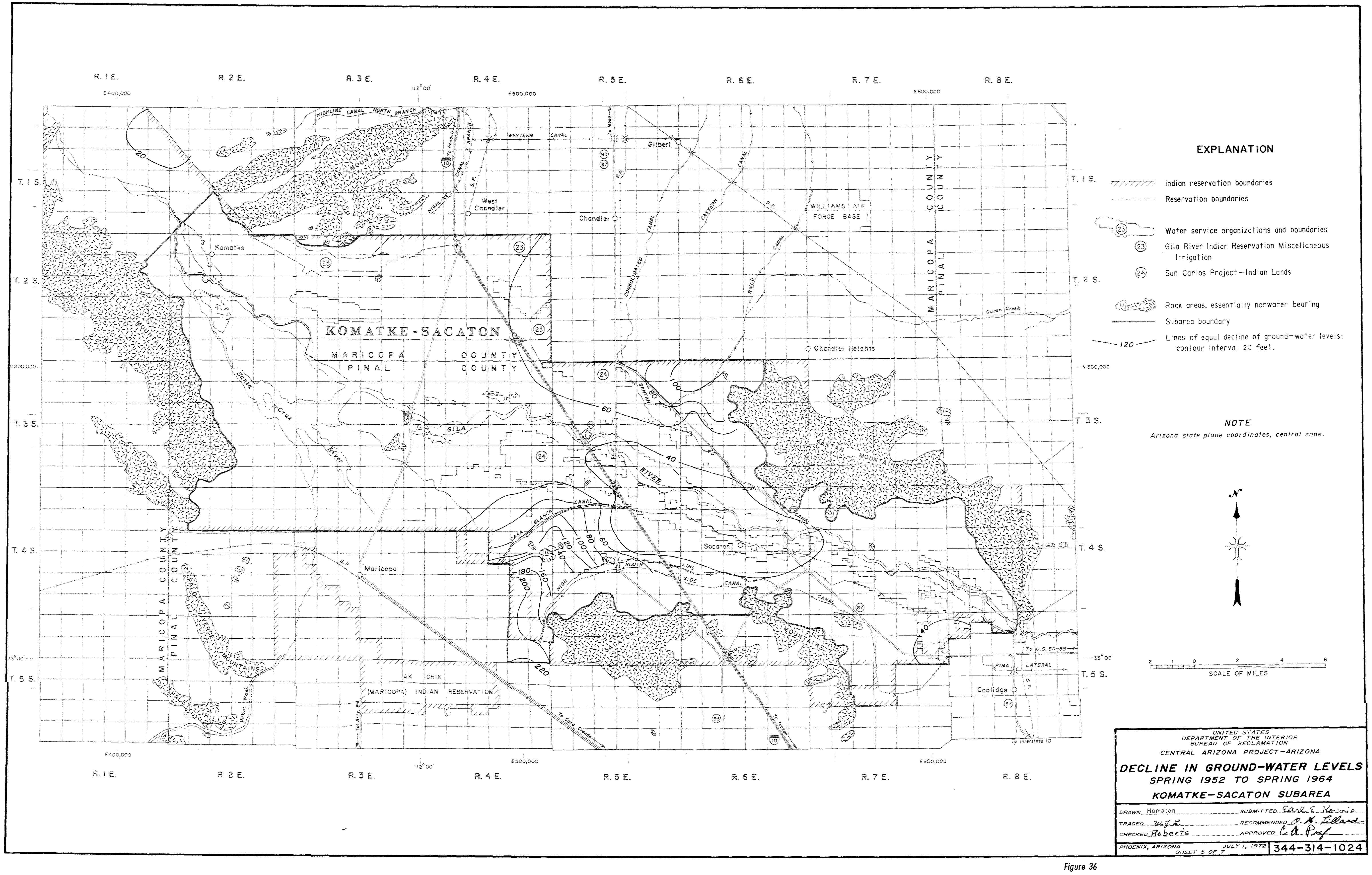
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA

GROUND-WATER ELEVATIONS
SPRING 1964

KOMATKE-SACATON SUBAREA

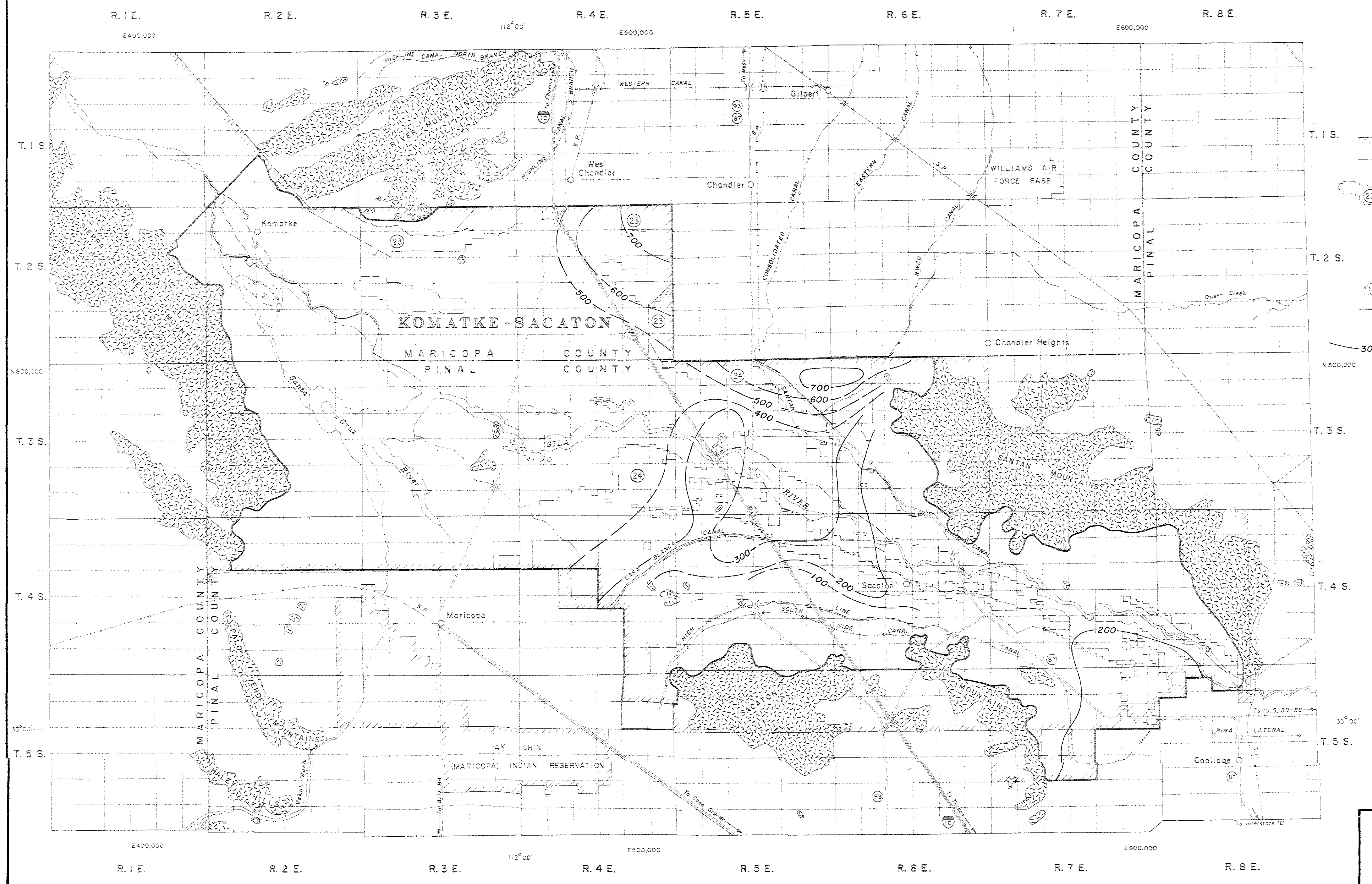
DRAWN Hampton & Roberts	SUBMITTED Earl E. Kovnie
TRACED W.J.L.	RECOMMENDED O. H. Lillard
CHECKED Roberts	APPROVED C.A. Pugh
PHOENIX, ARIZONA JULY 1, 1972 SHEET 5 OF 7	344-314-1017

Figure 35



EXPLANATION
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
Gila River Indian Reservation Miscellaneous Irrigation
San Carlos Project—Indian Lands
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal decline of ground-water levels; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
KOMATKE-SACATON
MARICOPA COUNTY
PINAL COUNTY
AK CHIN (MARICOPA) INDIAN RESERVATION
WILLIAMS AIR FORCE BASE
Komatke
West Chandler
Chandler
Gilbert
Chandler Heights
Maricopa
Sacaton
Coolidge
GILA RIVER
SALT RIVER MOUNTAINS
SACATON MOUNTAINS
WESTERN CANAL
HIGHLINE CANAL NORTH BRANCH
CASA BLANCA CANAL
SOUTH SIDE CANAL
PIMA LATERAL
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 6 E.
R. 7 E.
R. 8 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
DECLINE IN GROUND-WATER LEVELS
SPRING 1952 TO SPRING 1964
KOMATKE-SACATON SUBAREA
DRAWN Hampton
SUBMITTED Earl E. Komie
TRACED W.J.L.
RECOMMENDED
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA JULY 1, 1972
SHEET 5 OF 7
344-314-1024

Figure 36



EXPLANATION

- Indian reservation boundaries
- Reservation boundaries
- Water service organizations and boundaries
- (23) Gila River Indian Reservation Miscellaneous Irrigation
- (24) San Carlos Project—Indian Lands
- Rock areas, essentially nonwater bearing
- Subarea boundary
- 300 — Contours showing the thickness of the upper alluvial unit; dashed where inferred; contour interval 100 feet.

NOTE

Arizona state plane coordinates, central zone.

SCALE OF MILES (2 1 0 2 4 6)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA

ISOPACHS—UPPER ALLUVIAL UNIT

KOMATKE-SACATON SUBAREA

DRAWN Hampton & Ford	SUBMITTED Earl C. Korn
TRACED W.J.L.	RECOMMENDED O. H. Lillard
CHECKED J.J. Landry	APPROVED C. A. Pugh
PHOENIX, ARIZONA JULY 1, 1972 SHEET 5 OF 7	344-314-1241

Figure 37

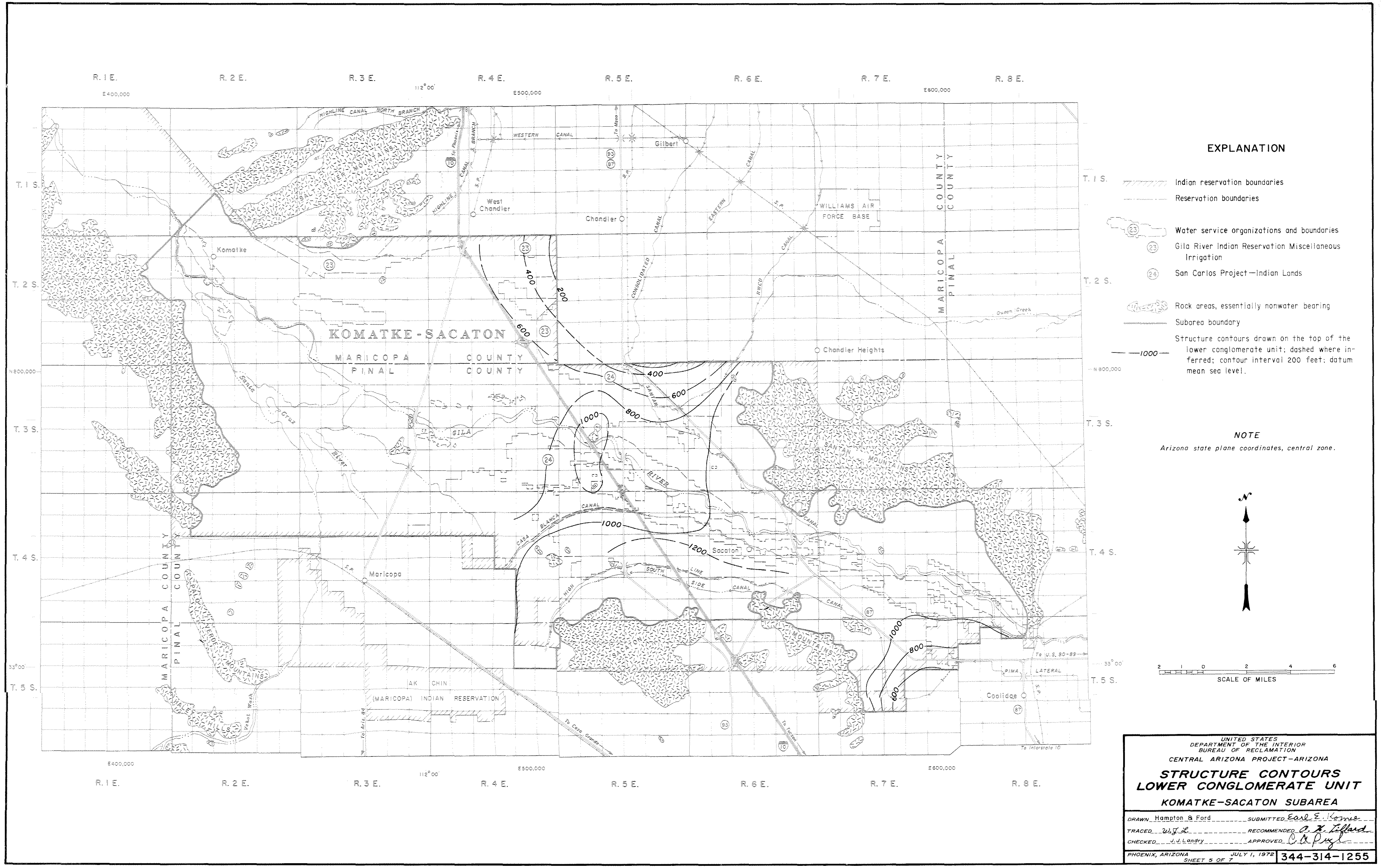

EXPLANATION
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
Gila River Indian Reservation Miscellaneous Irrigation
San Carlos Project—Indian Lands
Rock areas, essentially nonwater bearing
Subarea boundary
Structure contours drawn on the top of the lower conglomerate unit; dashed where inferred; contour interval 200 feet; datum mean sea level.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
KOMATKE-SACATON
MARICOPA COUNTY
PINAL COUNTY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
STRUCTURE CONTOURS
LOWER CONGLOMERATE UNIT
KOMATKE-SACATON SUBAREA
DRAWN Hampton & Ford
TRACED
CHECKED J.J. Landry
SUBMITTED
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 5 OF 7
344-314-1255

Figure 38

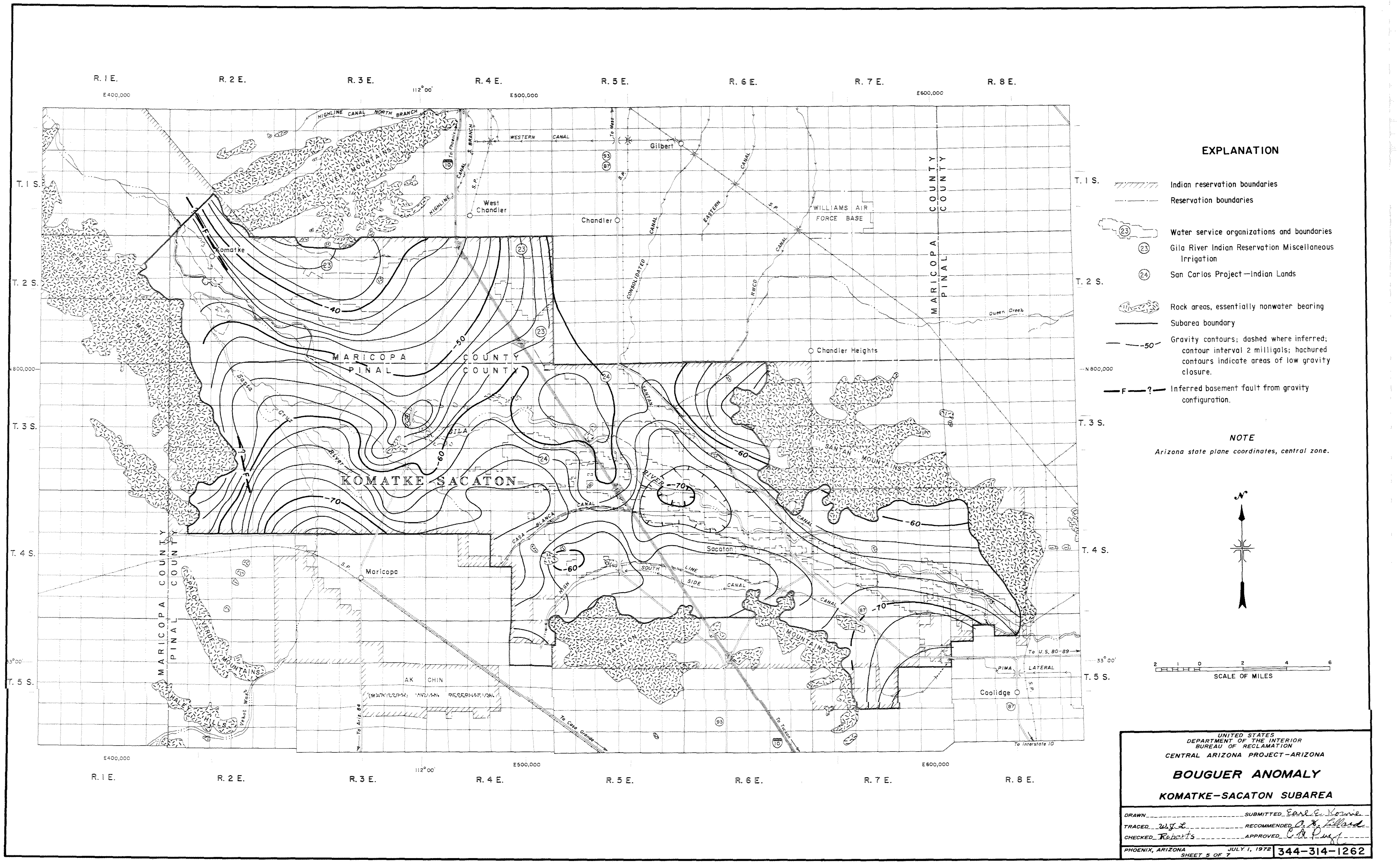

EXPLANATION
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
23 Gila River Indian Reservation Miscellaneous Irrigation
24 San Carlos Project—Indian Lands
Rock areas, essentially nonwater bearing
Subarea boundary
Gravity contours; dashed where inferred; contour interval 2 milligals; hachured contours indicate areas of low gravity closure.
Inferred basement fault from gravity configuration.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 6 E.
R. 7 E.
R. 8 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
E400,000
E500,000
E600,000
N800,000
112°00'
33°00'
KOMATKE SACATON
MARICOPA COUNTY
PINAL COUNTY
SALT RIVER MOUNTAINS
SIERRA ESTRELLA MOUNTAINS
SACATON MOUNTAINS
SAN TAN MOUNTAINS
PALO VERDE MOUNTAINS
HALEY HILLS
AK CHIN
MARICOPA INDIAN RESERVATION
WILLIAMS AIR FORCE BASE
Komatke
West Chandler
Chandler
Gilbert
Chandler Heights
Maricopa
Sacaton
Coolidge
Queen Creek
Gila River
HIGHLINE CANAL NORTH BRANCH
WESTERN CANAL
CONSOLIDATED CANAL
EASTERN CANAL
RWCD CANAL
CASA BLANCA CANAL
SOUTH SIDE CANAL
PIMA LATERAL
To U.S. 80-89
To Interstate 10
To Casa Grande
-40
-50
-60
-70
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
BOUGUER ANOMALY
KOMATKE-SACATON SUBAREA
DRAWN
SUBMITTED
TRACED
RECOMMENDED
CHECKED
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 5 OF 7
344-314-1262

Figure 39

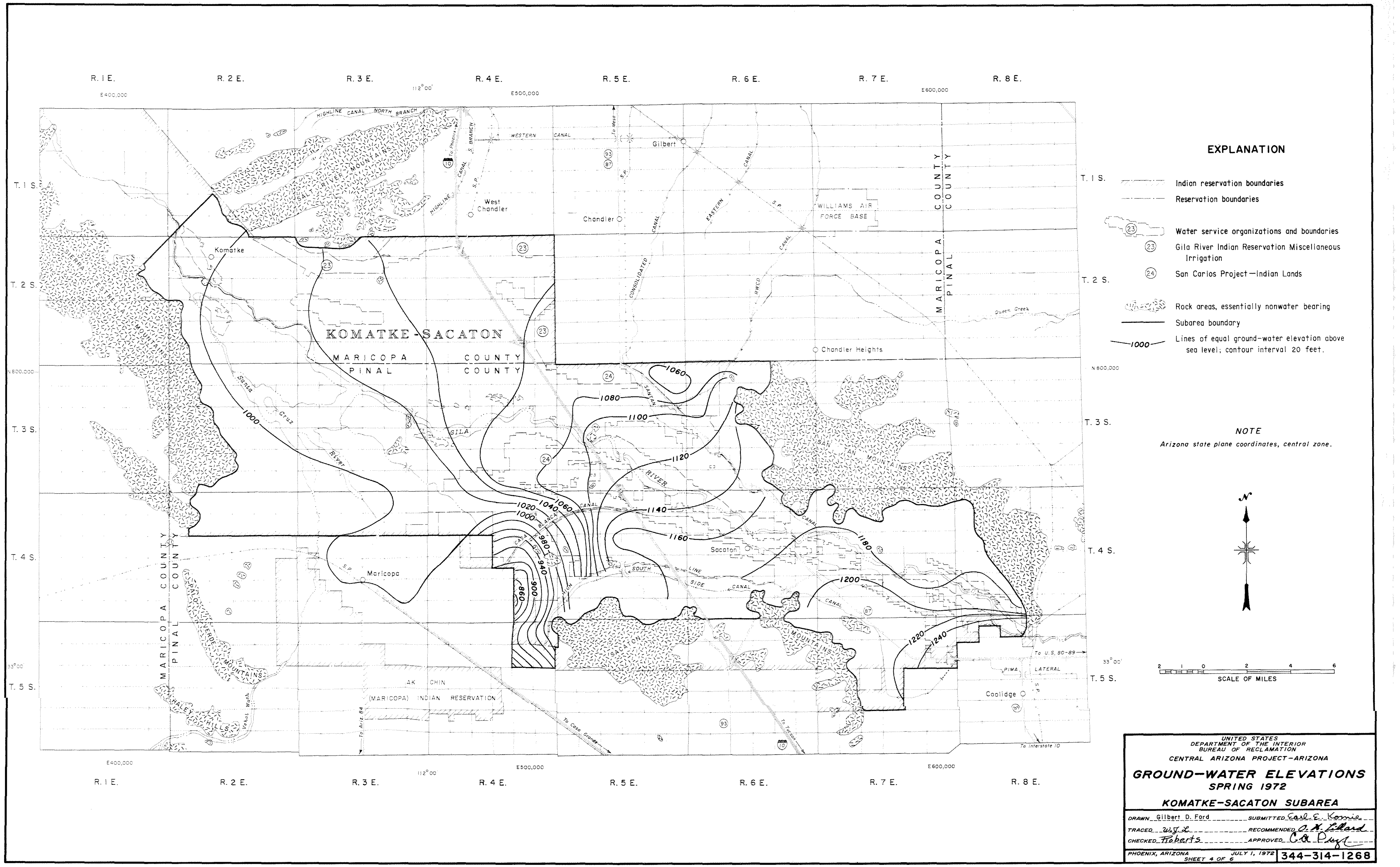
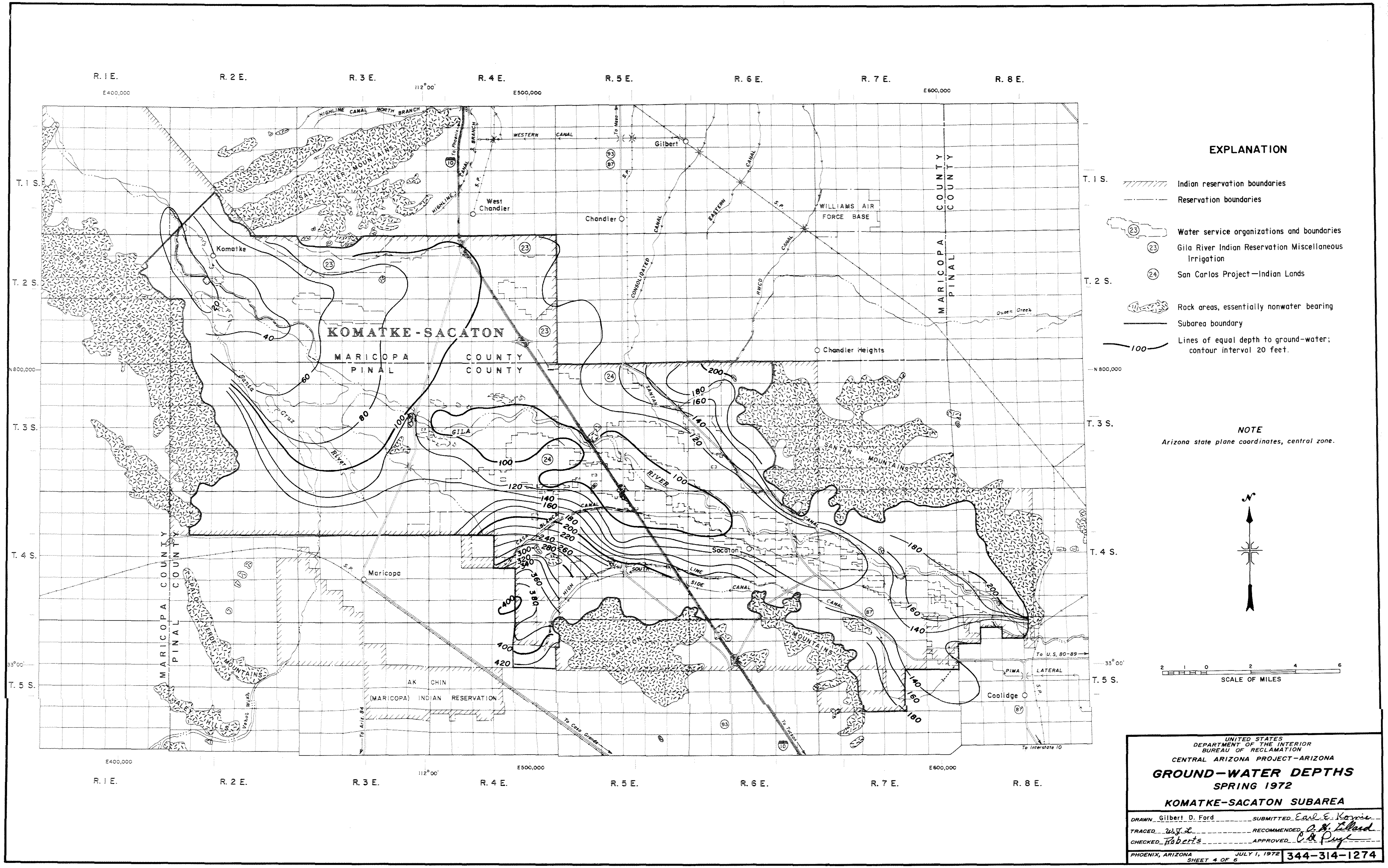
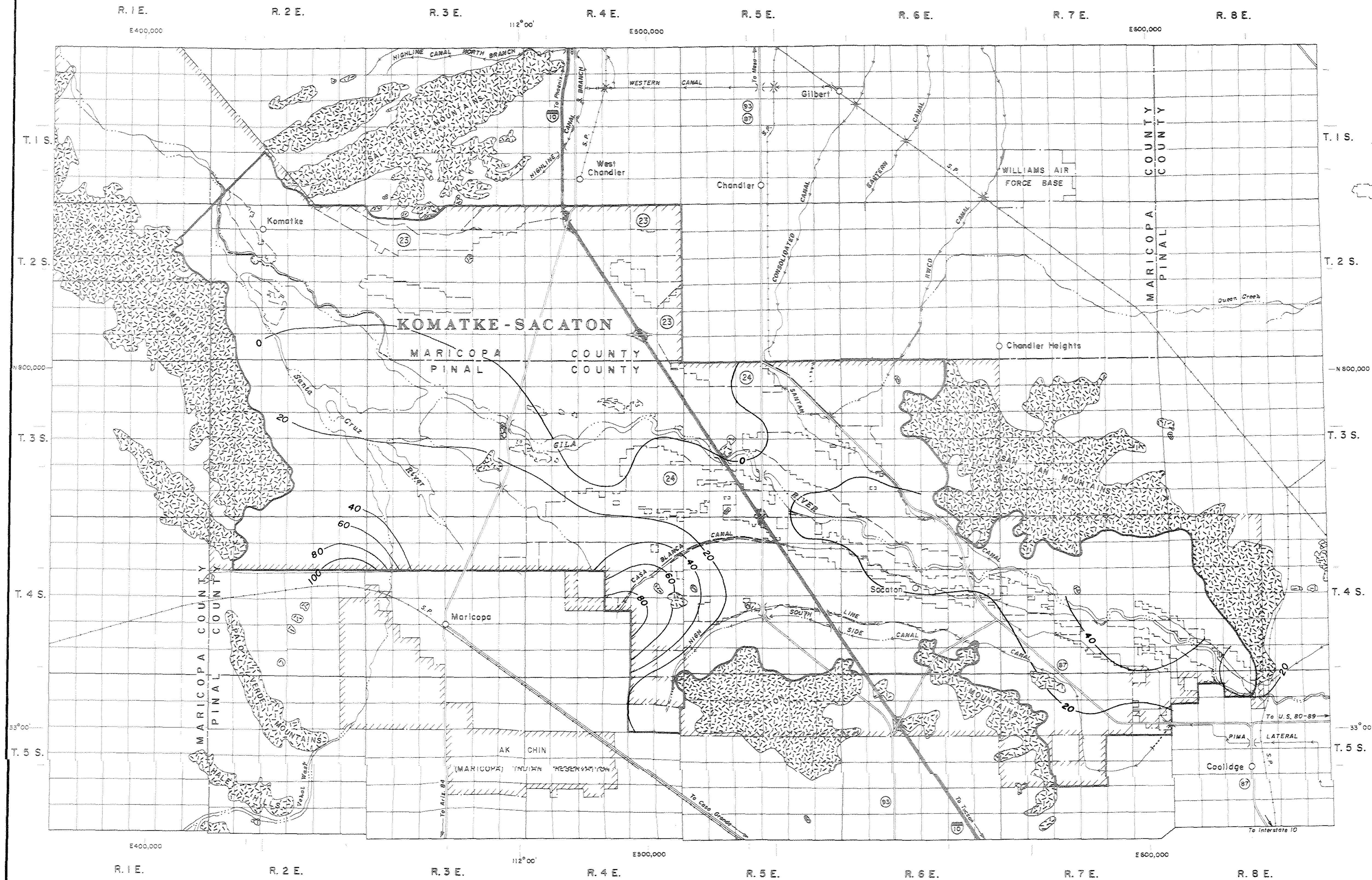

EXPLANATION
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
23 Gila River Indian Reservation Miscellaneous Irrigation
24 San Carlos Project—Indian Lands
Rock areas, essentially nonwater bearing
Subarea boundary
1000 Lines of equal ground-water elevation above sea level; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
KOMATKE-SACATON
MARICOPA COUNTY
PINAL COUNTY
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 6 E.
R. 7 E.
R. 8 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
Komatke
West Chandler
Chandler
Gilbert
Chandler Heights
Sacaton
Maricopa
Coolidge
WILLIAMS AIR FORCE BASE
AK CHIN (MARICOPA) INDIAN RESERVATION
SALT RIVER MOUNTAINS
SIERRA ESTRELLA MOUNTAINS
SACATON MOUNTAINS
Gila River
Santa Cruz River
1000
1020
1040
1060
1080
1100
1120
1140
1160
1180
1200
1220
1240
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND—WATER ELEVATIONS
SPRING 1972
KOMATKE—SACATON SUBAREA
DRAWN Gilbert D. Ford
SUBMITTED Earl E. Komie
TRACED W.J.L.
RECOMMENDED O. K. Lillard
CHECKED Roberts
APPROVED C.A. Pugh
PHOENIX, ARIZONA JULY 1, 1972
SHEET 4 OF 6
344—314—1268

Figure 40



EXPLANATION
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
Gila River Indian Reservation Miscellaneous Irrigation
San Carlos Project—Indian Lands
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal depth to ground-water; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
KOMATKE-SACATON
MARICOPA COUNTY
PINAL COUNTY
Komatke
West Chandler
Chandler
Gilbert
WILLIAMS AIR FORCE BASE
Chandler Heights
Sacaton
Maricopa
Coolidge
AK CHIN (MARICOPA) INDIAN RESERVATION
GILA RIVER
SACATON MOUNTAINS
SANTAN MOUNTAINS
HIGHLINE CANAL NORTH BRANCH
WESTERN CANAL
CONSOLIDATED CANAL
EASTERN CANAL
SOUTH SIDE CANAL
PIMA LATERAL
Queen Creek
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 6 E.
R. 7 E.
R. 8 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
E400,000
E500,000
E600,000
N800,000
112°00'
33°00'
To U.S. 80-89
To Interstate 10
To Casa Grande
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND—WATER DEPTHS
SPRING 1972
KOMATKE-SACATON SUBAREA
DRAWN Gilbert D. Ford
SUBMITTED Earl E. Kovnic
TRACED W.J.L.
RECOMMENDED
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 4 OF 6
344-314-1274

Figure 41



EXPLANATION

Indian reservation boundaries

Reservation boundaries

Water service organizations and boundaries

(23) Gila River Indian Reservation Miscellaneous Irrigation

(24) San Carlos Project—Indian Lands

Rock areas, essentially nonwater bearing

Subarea boundary

Lines of equal decline of ground-water; contour interval 20 feet.

NOTE

Arizona state plane coordinates, central zone.

SCALE OF MILES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA

DECLINE IN GROUND-WATER LEVELS
SPRING 1964 TO SPRING 1972
KOMATKE-SACATON SUBAREA

DRAWN Gilbert D. Ford — SUBMITTED Earl E. Kome
TRACED W.J.L. — RECOMMENDED [signature]
CHECKED Roberts — APPROVED [signature]

PHOENIX, ARIZONA — JULY 1, 1972 — SHEET 4 OF 6 — 344-314-1280

Figure 42

PHOENIX — BUCKEYE SUBAREA

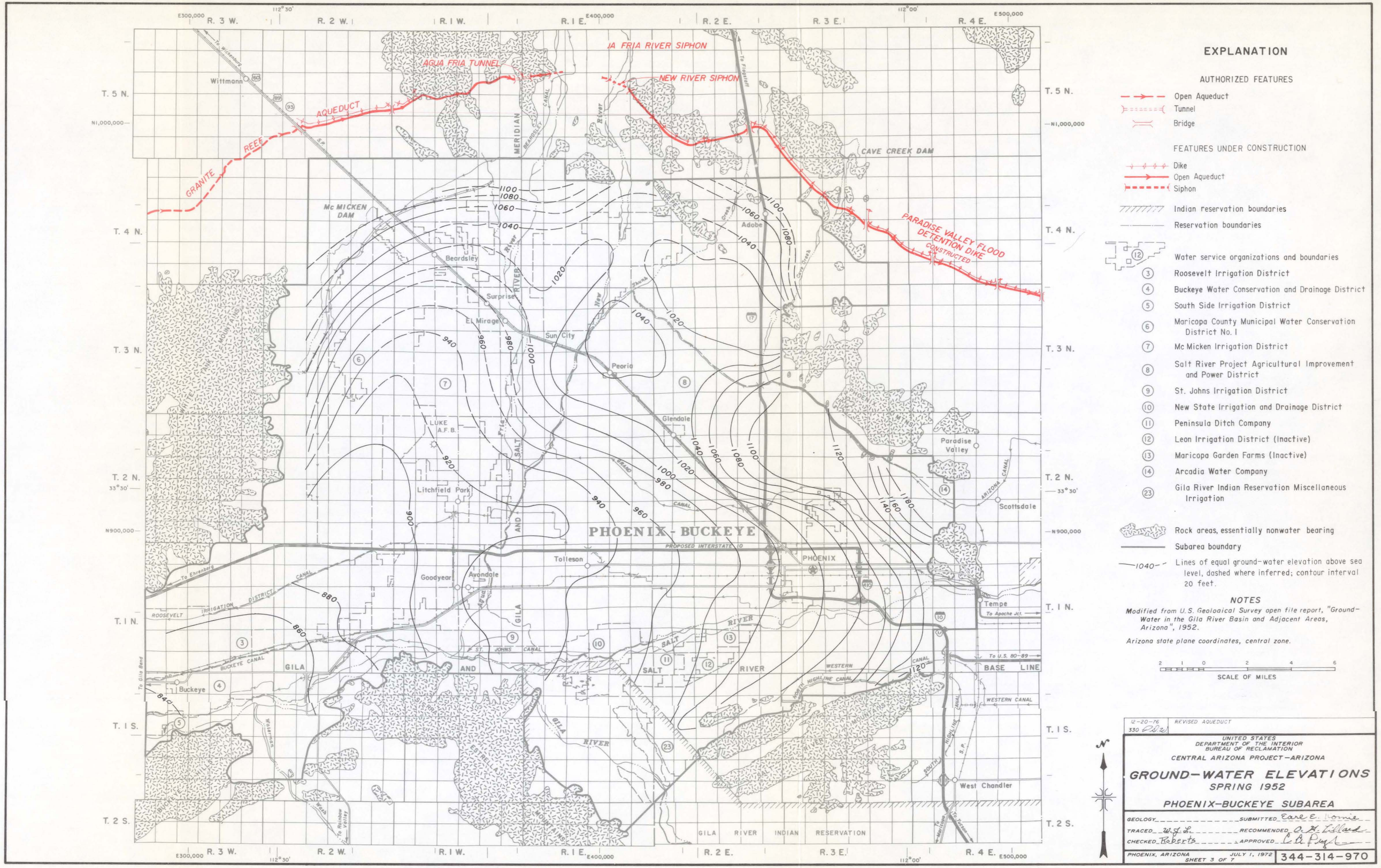

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
FEATURES UNDER CONSTRUCTION
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
1040 Lines of equal ground-water elevation above sea level, dashed where inferred; contour interval 20 feet.
NOTES
Modified from U.S. Geological Survey open file report, "Ground-Water in the Gila River Basin and Adjacent Areas, Arizona", 1952.
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 REVISED AQUEDUCT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1952
PHOENIX-BUCKEYE SUBAREA
PHOENIX, ARIZONA JULY 1, 1972 SHEET 3 OF 7
344-314-970
PHOENIX-BUCKEYE
AGUA FRIA TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
GRANITE REEF AQUEDUCT
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE CONSTRUCTED
Mc MICKEN DAM
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Paradise Valley
Scottsdale
Adobe
LUKE A.F.B.
Litchfield Park
Goodyear
Avondale
Tolleson
PHOENIX
Tempe
Buckeye
West Chandler
PROPOSED INTERSTATE 10
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ST. JOHNS CANAL
WESTERN CANAL
HIGHLINE CANAL
GILA AND SALT RIVER
GILA RIVER
SALT RIVER
BASE LINE
GILA RIVER INDIAN RESERVATION
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.

Figure 43

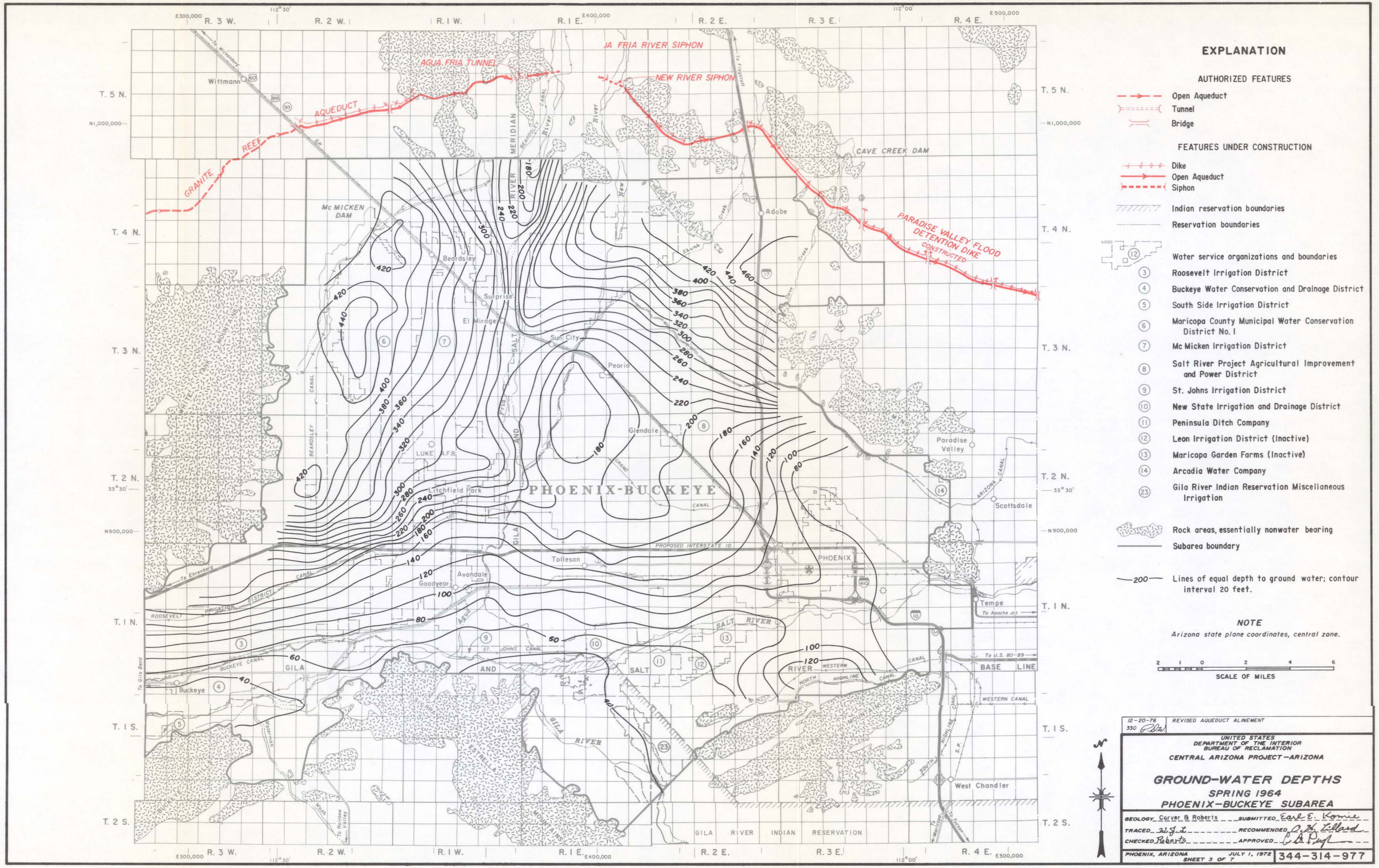

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
FEATURES UNDER CONSTRUCTION
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. I
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
200 Lines of equal depth to ground water; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 330 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND-WATER DEPTHS
SPRING 1964
PHOENIX—BUCKEYE SUBAREA
GEOLOGY Carver & Roberts SUBMITTED Earl E. Komie
TRACED W.J.L. RECOMMENDED
CHECKED Roberts APPROVED
PHOENIX, ARIZONA JULY 1, 1972 SHEET 3 OF 7
344-314-977
PHOENIX-BUCKEYE
AGUA FRIA TUNNEL
AQUEDUCT
GRANITE REEF
NEW RIVER SIPHON
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE
Mc MICKEN DAM
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Adobe
Paradise Valley
Scottsdale
LUKE A.F.B.
Litchfield Park
Tolleson
Avondale
Goodyear
PHOENIX
Tempe
Buckeye
West Chandler
GILA RIVER INDIAN RESERVATION
BASE LINE
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.

Figure 44

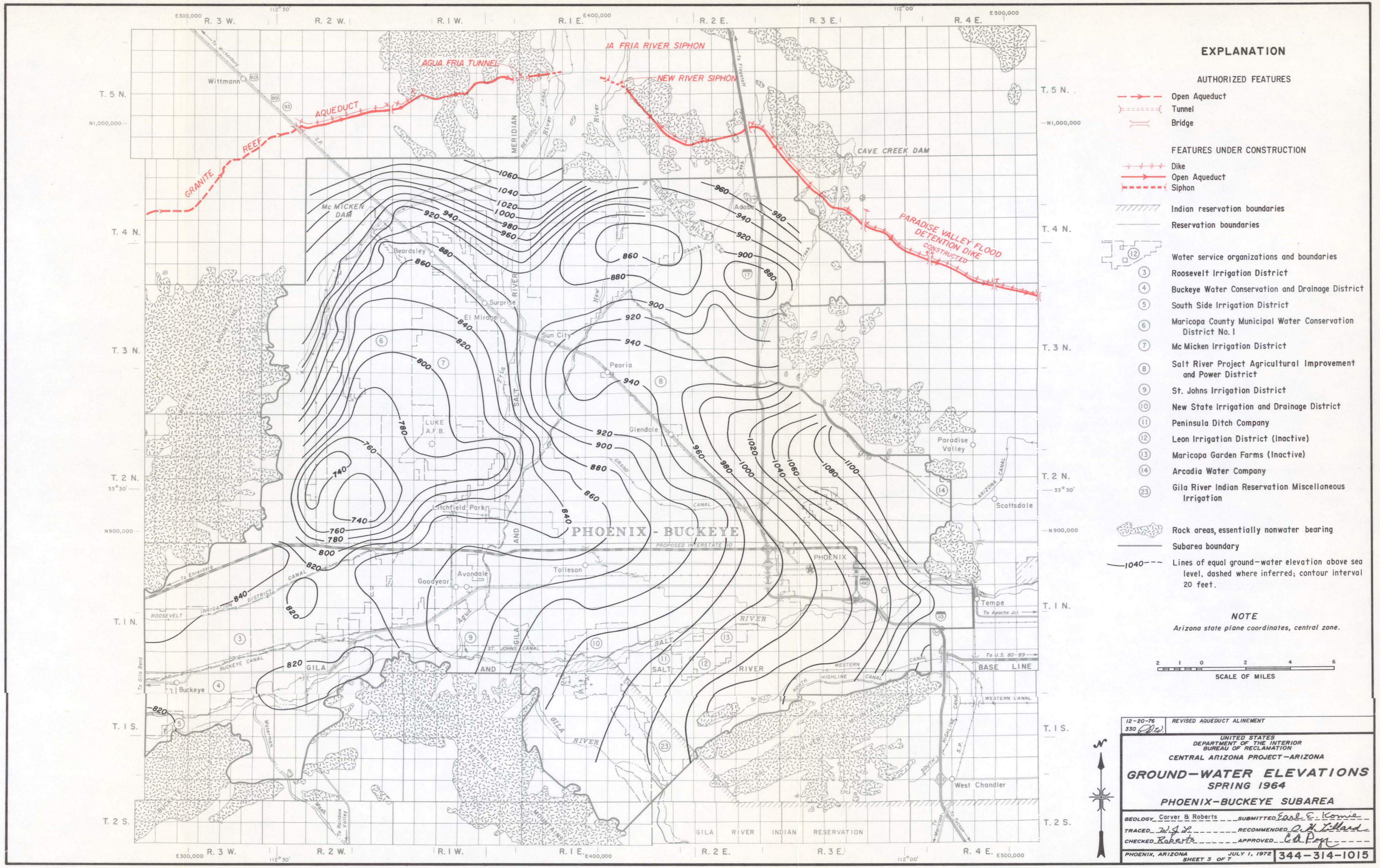

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
FEATURES UNDER CONSTRUCTION
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
1040 Lines of equal ground-water elevation above sea level, dashed where inferred; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND—WATER ELEVATIONS
SPRING 1964
PHOENIX—BUCKEYE SUBAREA
GEOLOGY Carver & Roberts
PHOENIX, ARIZONA JULY 1, 1972
SHEET 3 OF 7
344-314-1015
PHOENIX - BUCKEYE
AGUA FRIA TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
GRANITE REEF AQUEDUCT
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE
Mc MICKEN DAM
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
LUKE A.F.B.
Litchfield Park
Goodyear
Avondale
Tolleson
PHOENIX
Paradise Valley
Scottsdale
Tempe
Buckeye
West Chandler
Adobe
BASE LINE
GILA RIVER INDIAN RESERVATION
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.

Figure 45

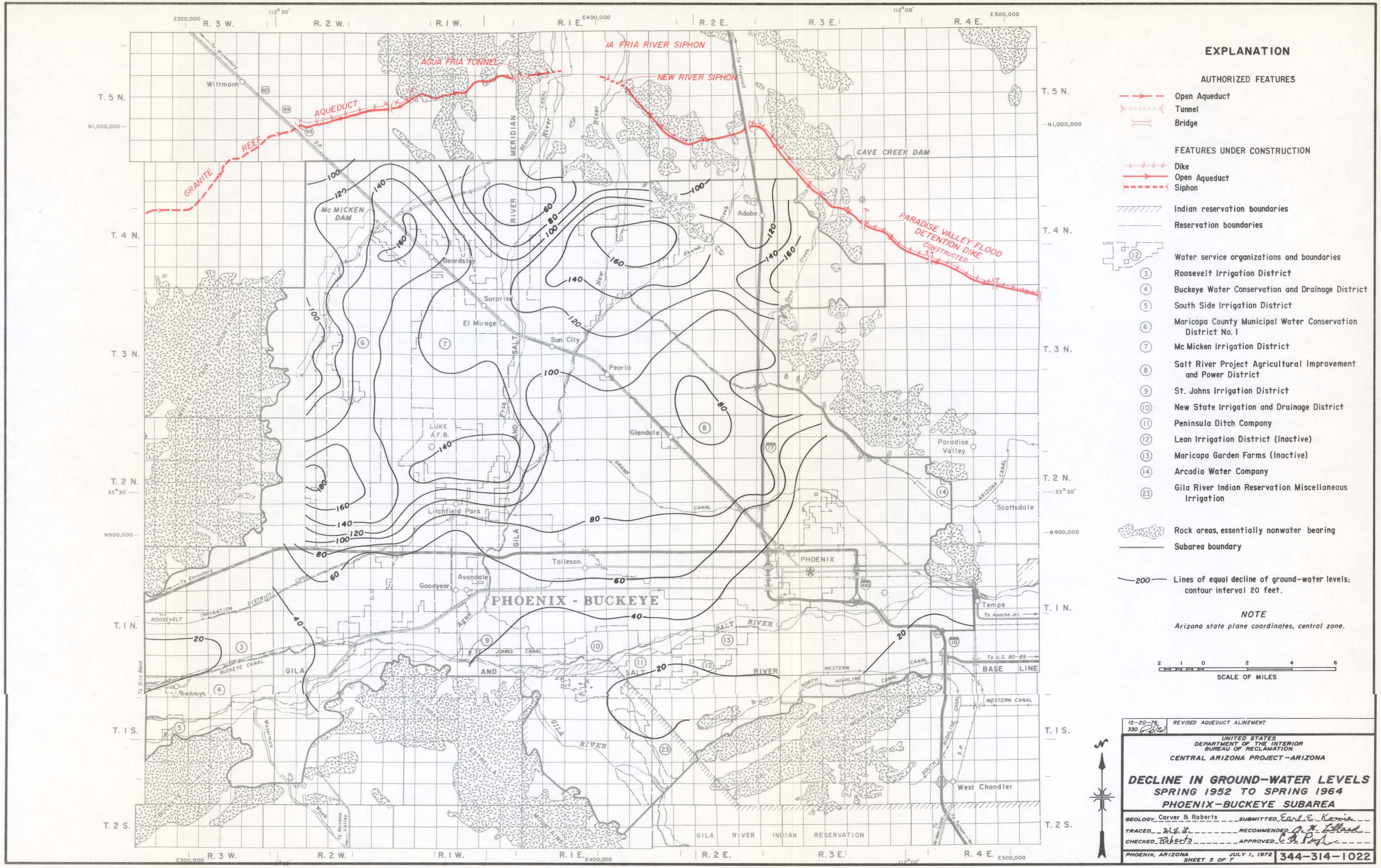

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
FEATURES UNDER CONSTRUCTION
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
200 Lines of equal decline of ground-water levels; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
AGUA FRIA TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
GRANITE REEF AQUEDUCT
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE
Mc MICKEN DAM
PHOENIX - BUCKEYE
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Luke A.F.B.
Litchfield Park
Tolleson
Avondale
Goodyear
Adobe
Paradise Valley
Scottsdale
PHOENIX
Tempe
West Chandler
Buckeye
GILA RIVER INDIAN RESERVATION
BASE LINE
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
DECLINE IN GROUND-WATER LEVELS
SPRING 1952 TO SPRING 1964
PHOENIX-BUCKEYE SUBAREA
GEOLOGY Carver & Roberts
PHOENIX, ARIZONA JULY 1, 1972 SHEET 3 OF 7
344-314-1022

Figure 46

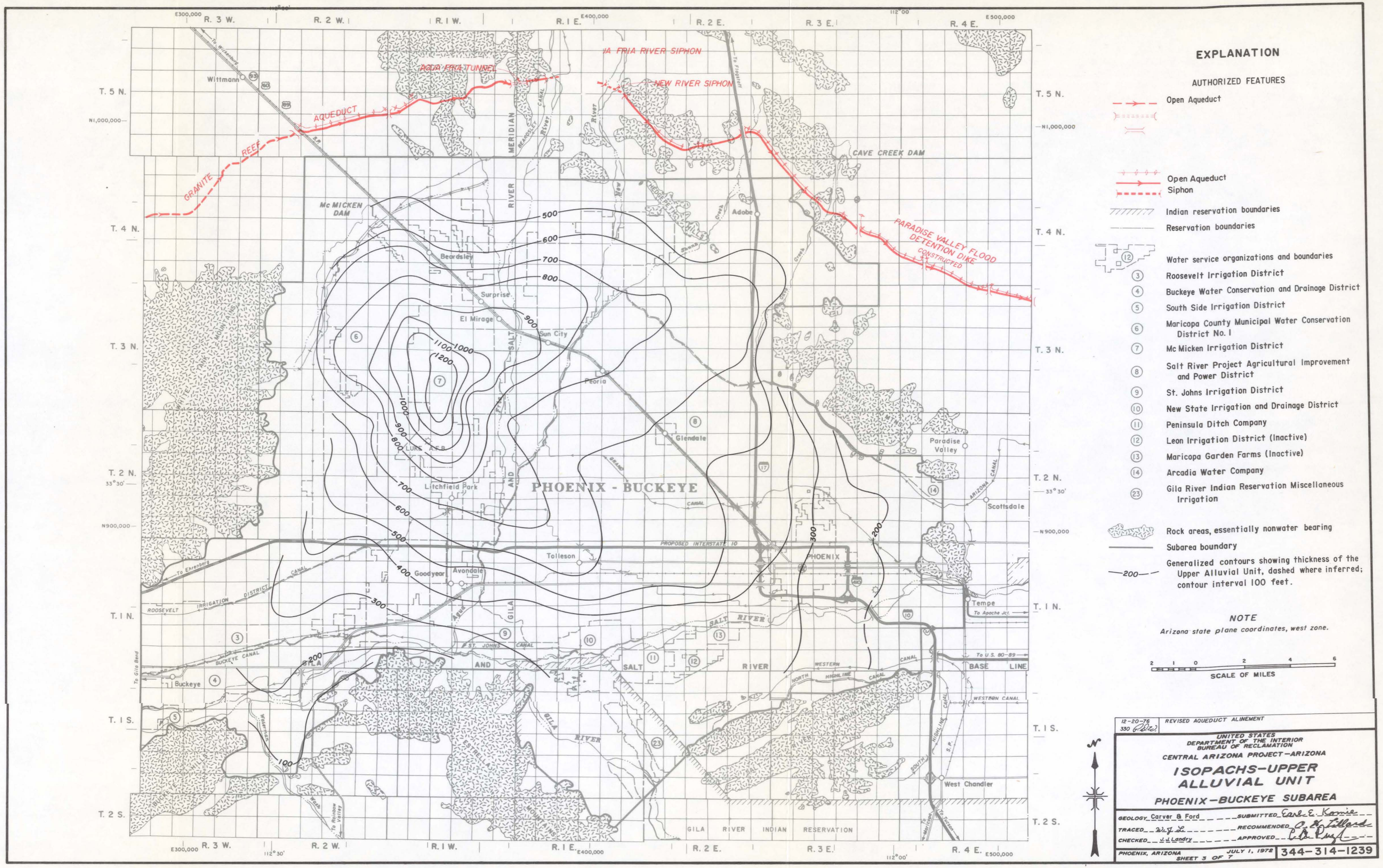

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
Generalized contours showing thickness of the Upper Alluvial Unit, dashed where inferred; contour interval 100 feet.
NOTE
Arizona state plane coordinates, west zone.
SCALE OF MILES
12-20-76
330
REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
ISOPACHS—UPPER ALLUVIAL UNIT
PHOENIX—BUCKEYE SUBAREA
GEOLOGY Carver & Ford
TRACED W.J.L.
CHECKED J.J. Landry
SUBMITTED Earl E. Kernie
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 3 OF 7
344-314-1239
PHOENIX - BUCKEYE
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
AGUA FRIA TUNNEL
GRANITE REEF AQUEDUCT
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE CONSTRUCTED
Mc MICKEN DAM
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Luke A.F.B.
Litchfield Park
Tolleson
Goodyear
Avondale
PHOENIX
Tempe
Scottsdale
Paradise Valley
Adobe
Buckeye
West Chandler
BASE LINE
GILA RIVER INDIAN RESERVATION
PROPOSED INTERSTATE 10
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
E300,000
E400,000
E500,000
N1,000,000
N900,000
33°30'
112°30'
112°00'

Figure 47

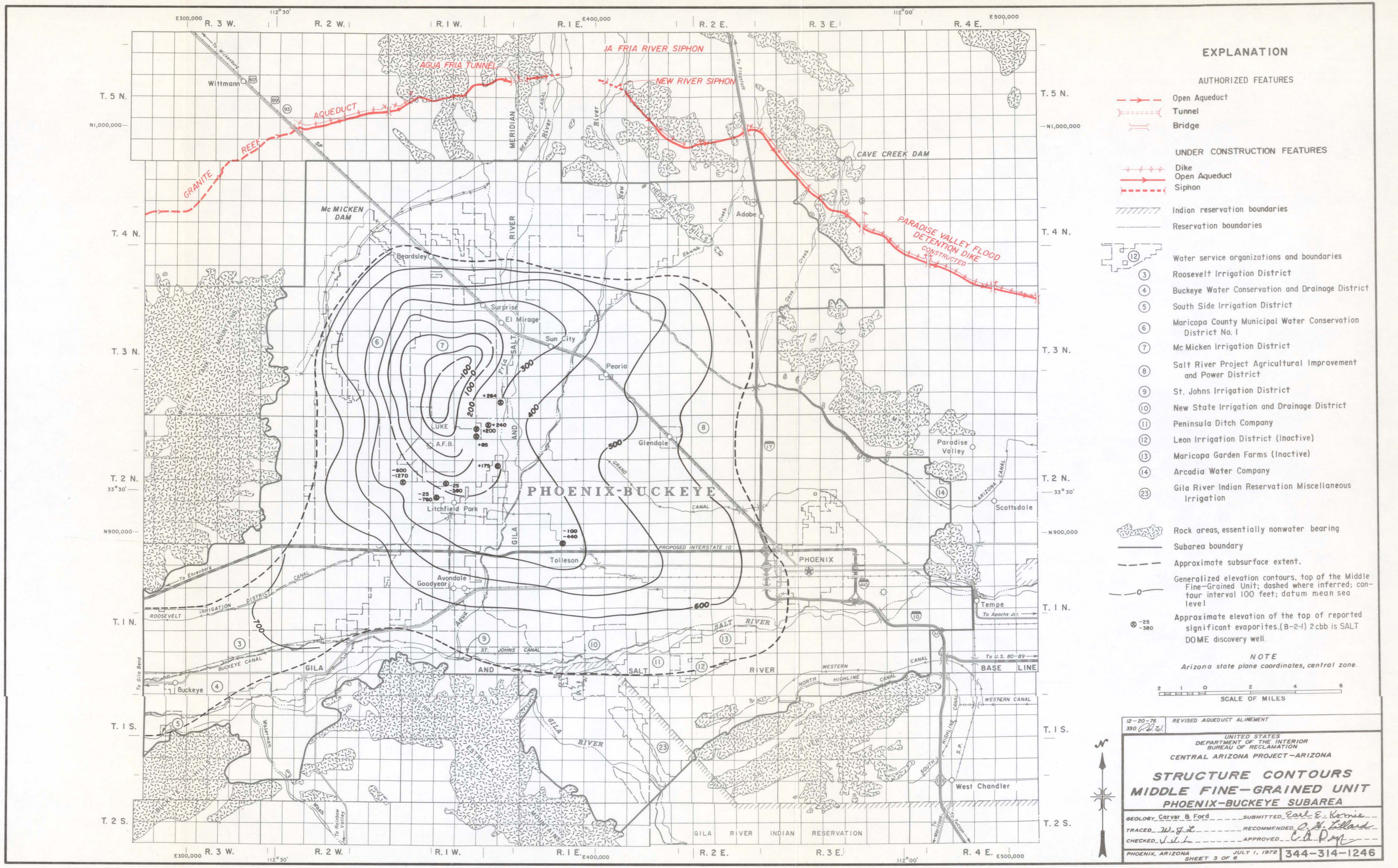

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
UNDER CONSTRUCTION FEATURES
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
Approximate subsurface extent.
Generalized elevation contours, top of the Middle Fine-Grained Unit; dashed where inferred; contour interval 100 feet; datum mean sea level
Approximate elevation of the top of reported significant evaporites. (B-2-1) 2cbb is SALT DOME discovery well.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
STRUCTURE CONTOURS
MIDDLE FINE-GRAINED UNIT
PHOENIX-BUCKEYE SUBAREA
GEOLOGY Carver & Ford
PHOENIX, ARIZONA JULY 1, 1972 SHEET 3 OF 6
344-314-1246
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
BASE LINE
MERIDIAN
AGUA FRIA TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
AQUEDUCT
GRANITE REEF
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE
Mc MICKEN DAM
PHOENIX-BUCKEYE
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Adobe
Paradise Valley
Scottsdale
PHOENIX
Tempe
Tolleson
Avondale
Goodyear
Litchfield Park
LUKE A.F.B.
Buckeye
West Chandler
GILA AND SALT RIVER
SALT RIVER
GILA RIVER
GILA RIVER INDIAN RESERVATION
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ST. JOHNS CANAL
GRAND CANAL
ARIZONA CANAL
WESTERN CANAL
PROPOSED INTERSTATE 10
WHITE TANK MOUNTAINS
ESTRELLA MOUNTAINS

Figure 48

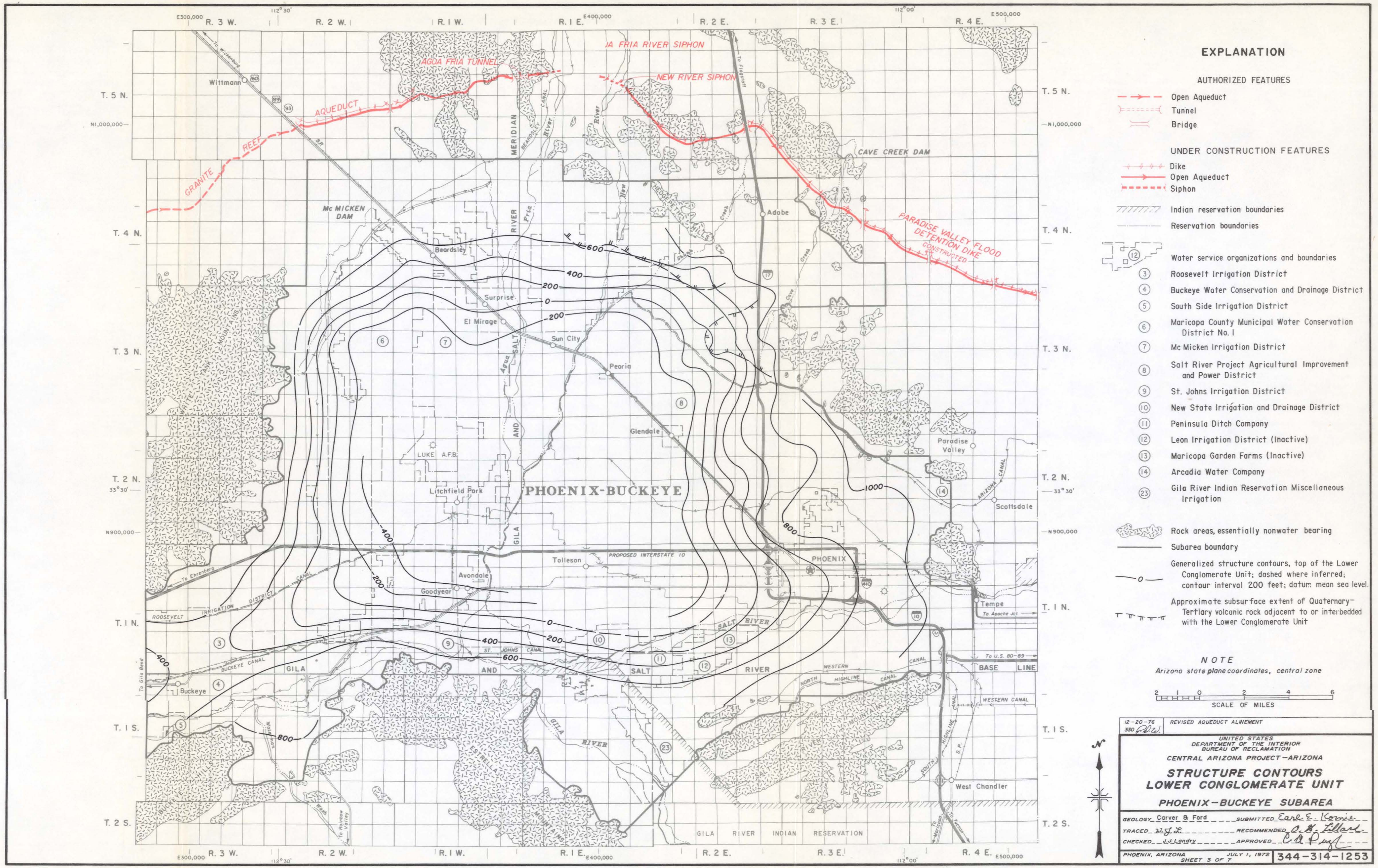
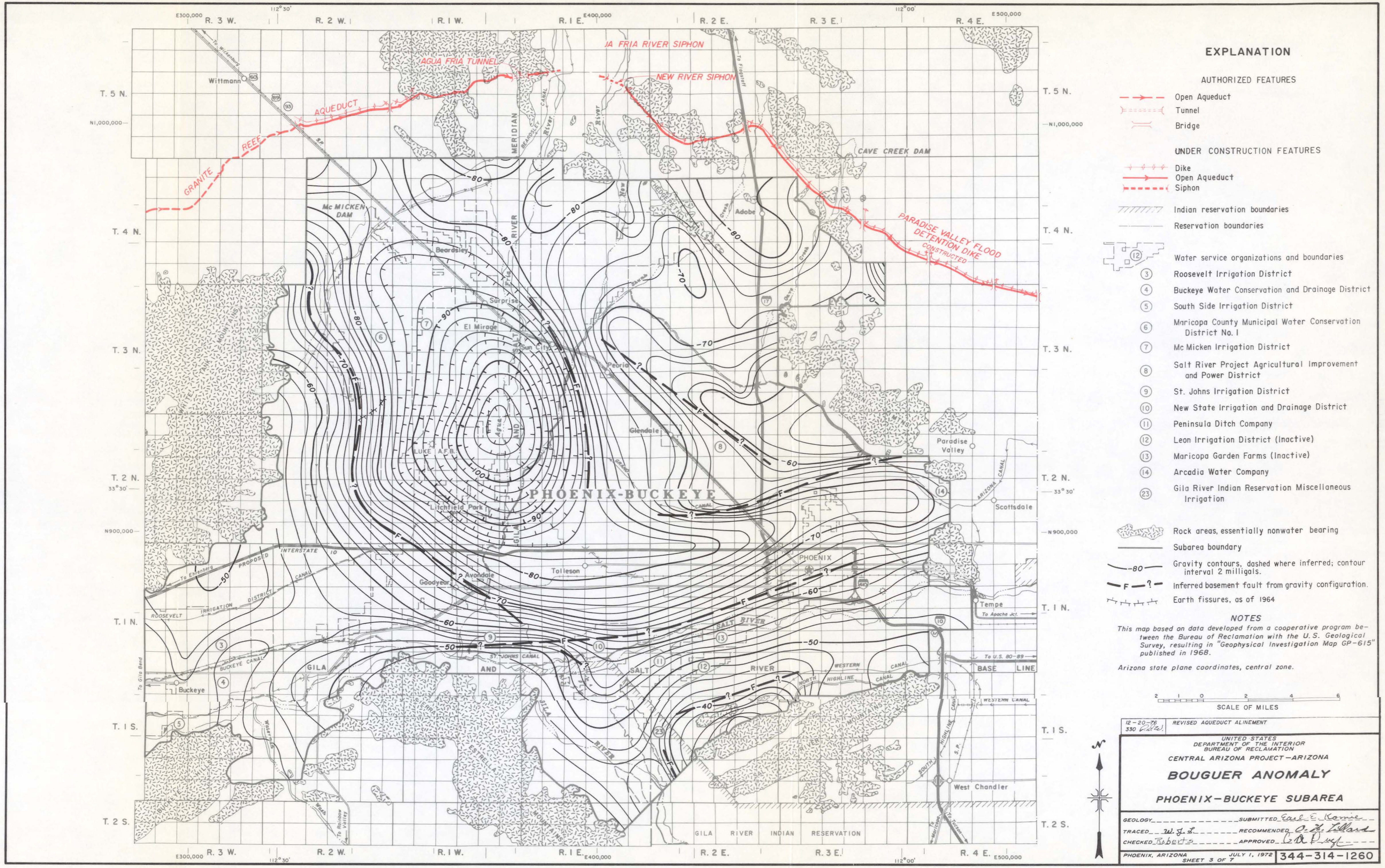

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
UNDER CONSTRUCTION FEATURES
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
Generalized structure contours, top of the Lower Conglomerate Unit; dashed where inferred; contour interval 200 feet; datum mean sea level.
Approximate subsurface extent of Quaternary-Tertiary volcanic rock adjacent to or interbedded with the Lower Conglomerate Unit
NOTE
Arizona state plane coordinates, central zone
SCALE OF MILES
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
STRUCTURE CONTOURS
LOWER CONGLOMERATE UNIT
PHOENIX—BUCKEYE SUBAREA
GEOLOGY Carver & Ford SUBMITTED Earl E. Kornie
TRACED RECOMMENDED
CHECKED J.J. Landry APPROVED
PHOENIX, ARIZONA JULY 1, 1972 SHEET 3 OF 7
344-314-1253
PHOENIX-BUCKEYE
AGUA FRIA TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
GRANITE REEF AQUEDUCT
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE
Mc MICKEN DAM
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Adobe
Paradise Valley
Scottsdale
LUKE A.F.B.
Litchfield Park
Tolleson
Avondale
Goodyear
PHOENIX
Tempe
Buckeye
West Chandler
GILA RIVER INDIAN RESERVATION
SALT RIVER
GILA RIVER
BASE LINE
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.

Figure 49



EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
UNDER CONSTRUCTION FEATURES
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
-80- Gravity contours, dashed where inferred; contour interval 2 milligals.
-F-?- Inferred basement fault from gravity configuration.
Earth fissures, as of 1964
NOTES
This map based on data developed from a cooperative program between the Bureau of Reclamation with the U. S. Geological Survey, resulting in "Geophysical Investigation Map GP-615" published in 1968.
Arizona state plane coordinates, central zone.
SCALE OF MILES
REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
BOUGUER ANOMALY
PHOENIX—BUCKEYE SUBAREA
GEOLOGY
TRACED
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
PHOENIX, ARIZONA JULY 1, 1972
SHEET 3 OF 7
344-314-1260
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
E300,000
E400,000
E500,000
N1,000,000
N900,000
112°30'
112°00'
33°30'
AGUA FRIA TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
AQUEDUCT
GRANITE REEF
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE CONSTRUCTED
Wittmann
Mc MICKEN DAM
Beardsley
Surprise
El Mirage
Sun City
Peoria
Adobe
Glendale
Paradise Valley
LUKE A.F.B.
PHOENIX-BUCKEYE
Litchfield Park
Scottsdale
Avondale
Goodyear
Tolleson
PHOENIX
Tempe
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
Buckeye
GILA AND SALT RIVER BASE LINE
ST. JOHNS CANAL
WESTERN CANAL
HIGHLINE CANAL
ARIZONA CANAL
SALT RIVER
GILA RIVER
MERIDIAN
West Chandler
GILA RIVER INDIAN RESERVATION
To Apache Jct.
To U.S. 80-89
PROPOSED INTERSTATE 10

Figure 50

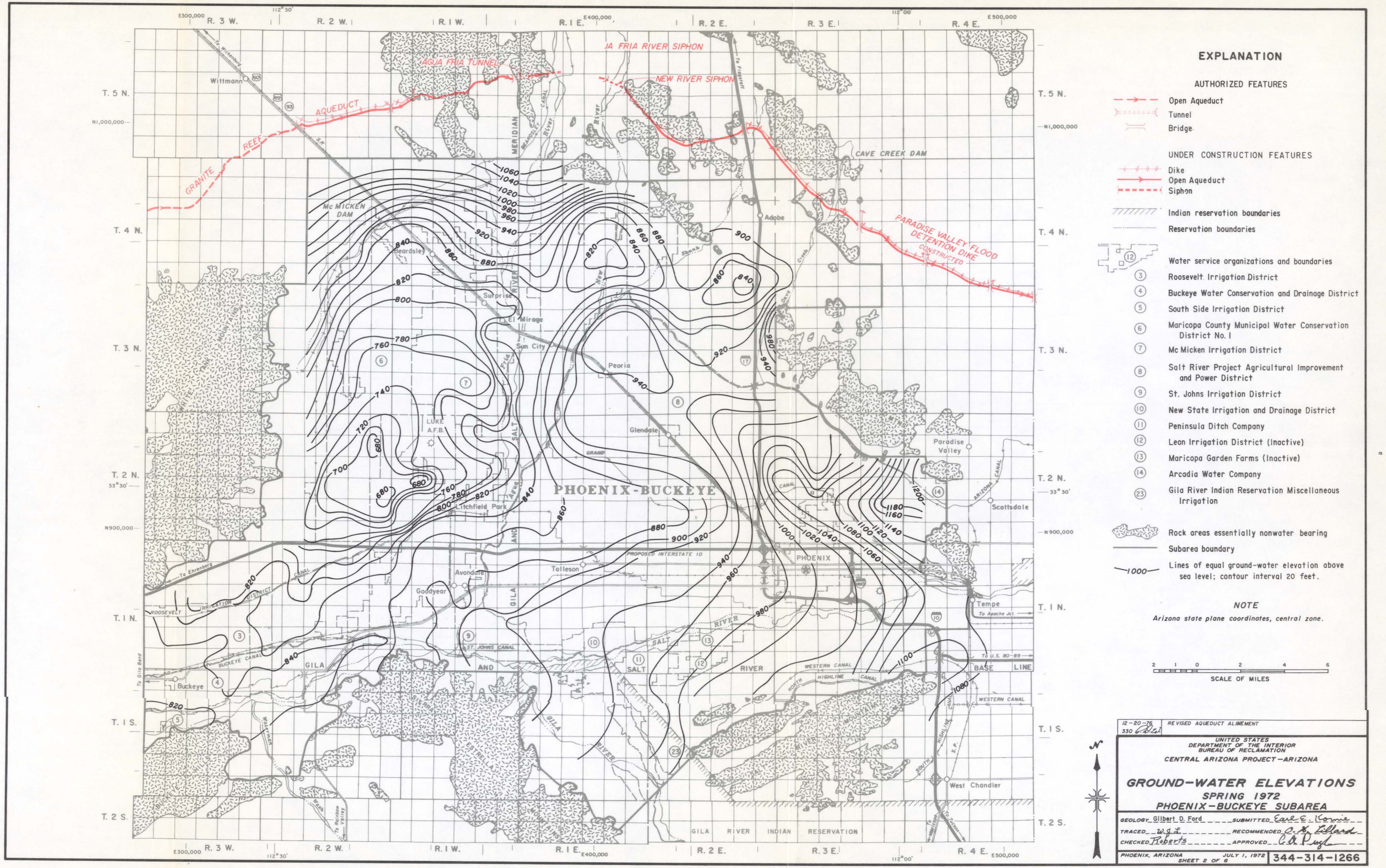

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
UNDER CONSTRUCTION FEATURES
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas essentially nonwater bearing
Subarea boundary
1000 Lines of equal ground-water elevation above sea level; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
PHOENIX-BUCKEYE
AGUA FRIA TUNNEL
NEW RIVER SIPHON
AQUEDUCT
GRANITE REEF
PARADISE VALLEY FLOOD DETENTION DIKE
CAVE CREEK DAM
Mc MICKEN DAM
GILA RIVER INDIAN RESERVATION
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Adobe
Paradise Valley
Scottsdale
Phoenix
Tempe
Tolleson
Avondale
Goodyear
Litchfield Park
Buckeye
West Chandler
12-20-76 330 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1972
PHOENIX-BUCKEYE SUBAREA
GEOLOGY Gilbert D. Ford SUBMITTED Earl E. Kornie
TRACED W.J.L. RECOMMENDED O. K. Lillard
CHECKED Roberts APPROVED C. A. Pugh
PHOENIX, ARIZONA JULY 1, 1972 SHEET 2 OF 6
344-314-1266

Figure 51

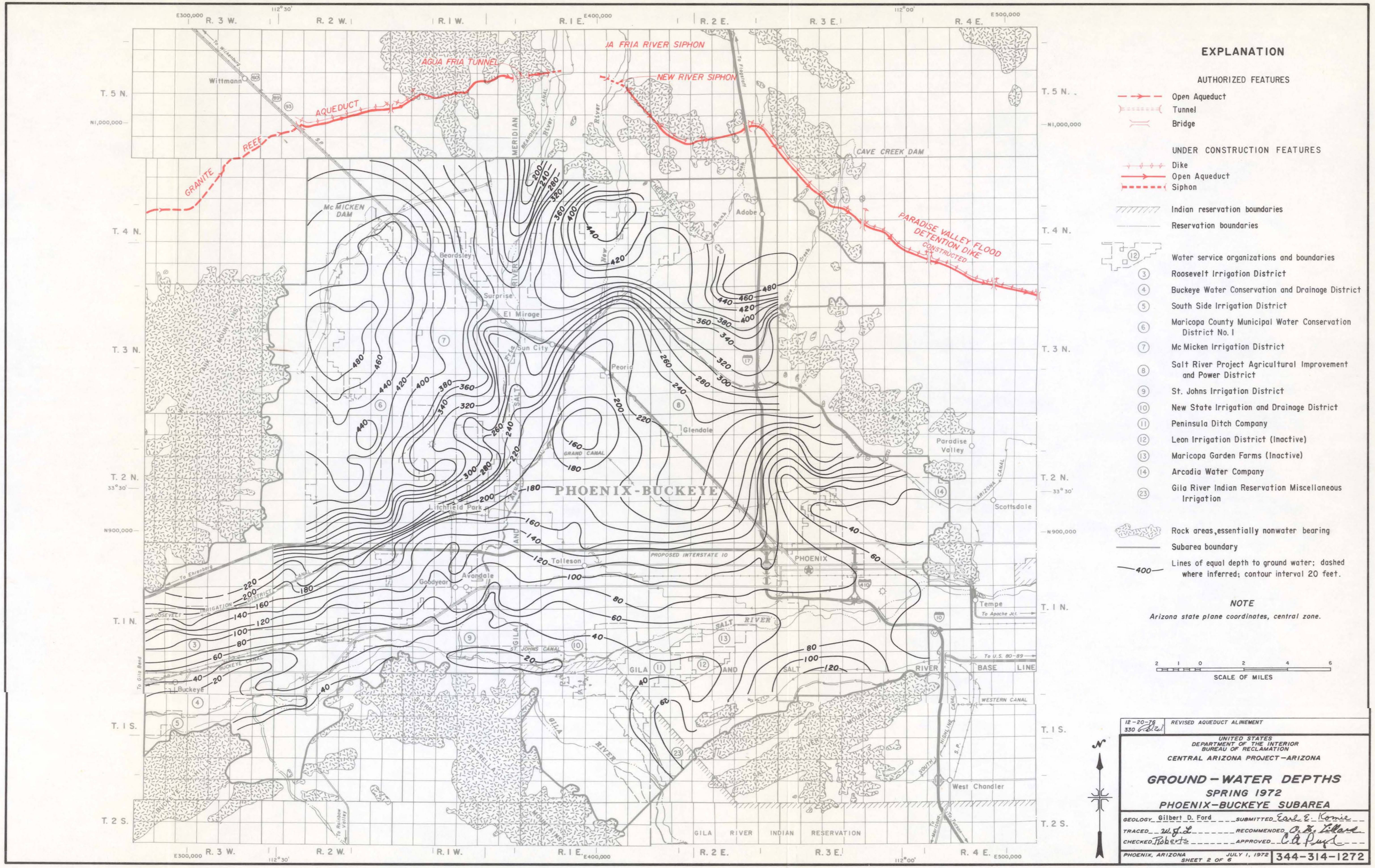

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
UNDER CONSTRUCTION FEATURES
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal depth to ground water; dashed where inferred; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
PHOENIX-BUCKEYE
12-20-76 330 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER DEPTHS
SPRING 1972
PHOENIX-BUCKEYE SUBAREA
GEOLOGY Gilbert D. Ford SUBMITTED Earl E. Komie
TRACED W.J.L. RECOMMENDED O. K. Tillard
CHECKED Roberts APPROVED C.A. Pugh
PHOENIX, ARIZONA SHEET 2 OF 6 JULY 1, 1972
344-314-1272

Figure 52

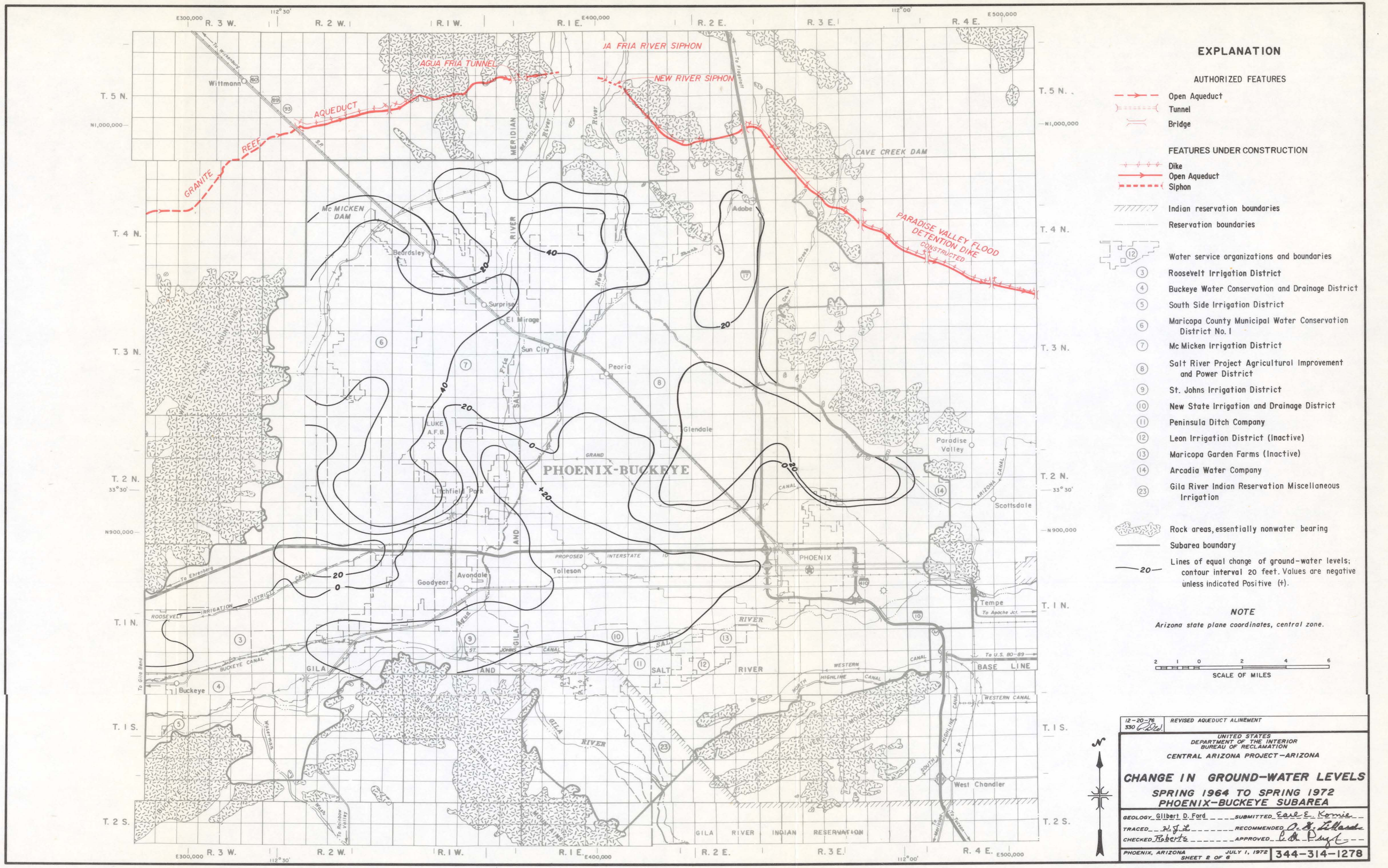

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Tunnel
Bridge
FEATURES UNDER CONSTRUCTION
Dike
Open Aqueduct
Siphon
Indian reservation boundaries
Reservation boundaries
Water service organizations and boundaries
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
6 Maricopa County Municipal Water Conservation District No. 1
7 Mc Micken Irrigation District
8 Salt River Project Agricultural Improvement and Power District
9 St. Johns Irrigation District
10 New State Irrigation and Drainage District
11 Peninsula Ditch Company
12 Leon Irrigation District (Inactive)
13 Maricopa Garden Farms (Inactive)
14 Arcadia Water Company
23 Gila River Indian Reservation Miscellaneous Irrigation
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal change of ground-water levels; contour interval 20 feet. Values are negative unless indicated Positive (+).
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 330
REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
CHANGE IN GROUND-WATER LEVELS
SPRING 1964 TO SPRING 1972
PHOENIX-BUCKEYE SUBAREA
GEOLOGY Gilbert D. Ford
SUBMITTED Earl E. Kornie
TRACED W. J. L.
CHECKED Roberts
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 2 OF 6
344-314-1278
PHOENIX-BUCKEYE
AGUA FRIA TUNNEL
AGUA FRIA RIVER SIPHON
NEW RIVER SIPHON
AQUEDUCT
GRANITE REEF
CAVE CREEK DAM
PARADISE VALLEY FLOOD DETENTION DIKE
CONSTRUCTED
Mc MICKEN DAM
Wittmann
Beardsley
Surprise
El Mirage
Sun City
Peoria
Glendale
Luke A.F.B.
Litchfield Park
Goodyear
Avondale
Tolleson
PHOENIX
Tempe
Scottsdale
Paradise Valley
Adobe
Buckeye
West Chandler
GILA RIVER INDIAN RESERVATION
BASE LINE
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
N1,000,000
N900,000
E300,000
E400,000
E500,000
112°30'
112°00'
33°30'

Figure 53

GILA BEND AND WATERMAN WASH SUBAREAS

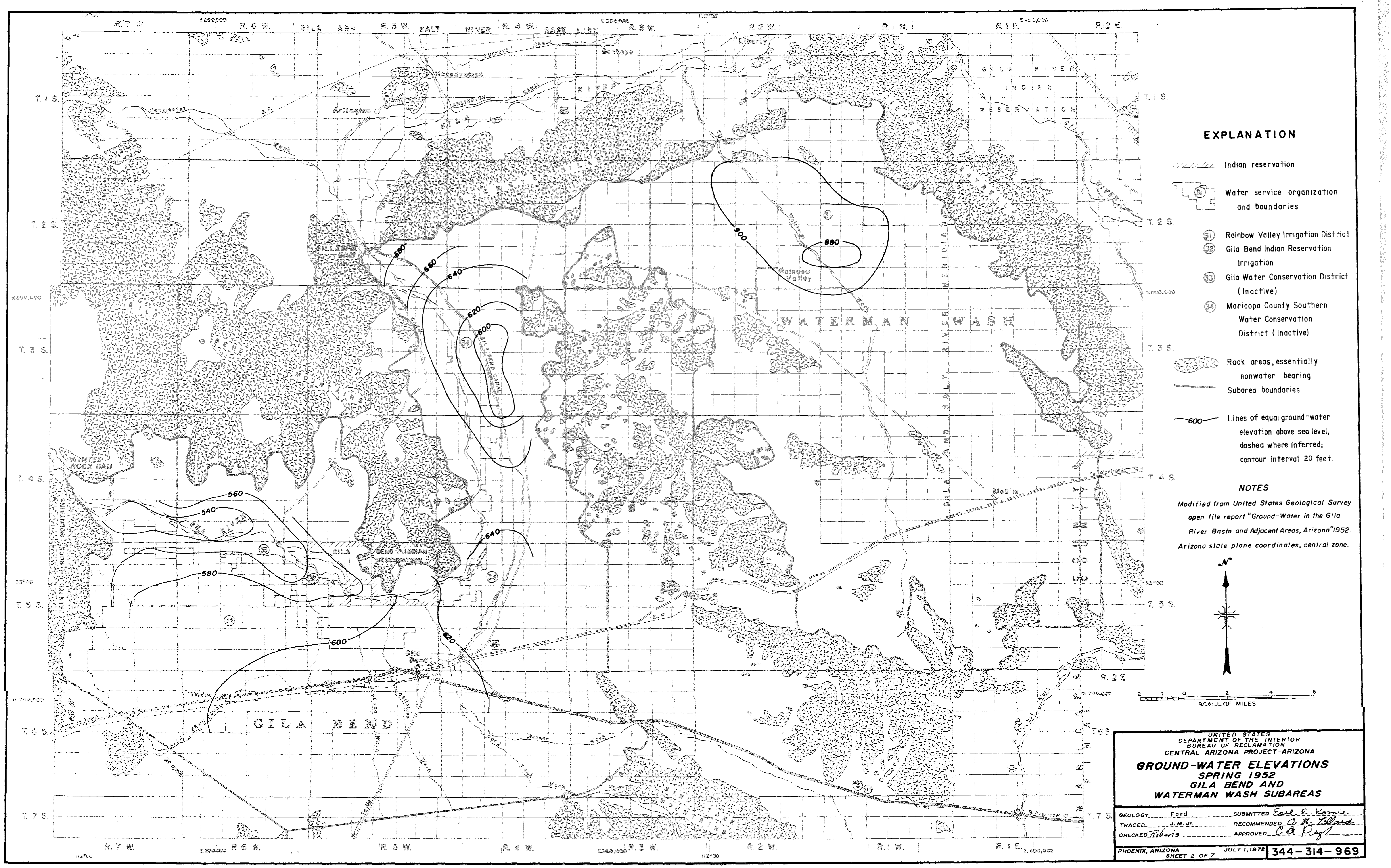

EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
600 Lines of equal ground-water elevation above sea level, dashed where inferred; contour interval 20 feet.
NOTES
Modified from United States Geological Survey open file report "Ground-Water in the Gila River Basin and Adjacent Areas, Arizona" 1952.
Arizona state plane coordinates, central zone.
SCALE OF MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1952
GILA BEND AND
WATERMAN WASH SUBAREAS
GEOLOGY Ford
TRACED J. M. Jr.
CHECKED Roberts
SUBMITTED Earl E. Kimie
RECOMMENDED O. H. Dillard
APPROVED C. A. Pugh
PHOENIX, ARIZONA
SHEET 2 OF 7
JULY 1, 1972
344-314-969
GILA AND SALT RIVER BASE LINE
GILA AND SALT RIVER MERIDIAN
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
GILA RIVER INDIAN RESERVATION
GILA BEND INDIAN RESERVATION
WATERMAN WASH
GILA BEND
MARICOPA COUNTY
PINAL COUNTY
Liberty
Buckeye
Hassayampa
Arlington
Rainbow Valley
Gillespie Dam
Painted Rock Dam
Gila Bend
Mobile
BUCKEYE CANAL
ARLINGTON CANAL
GILA BEND CANAL
900
880
660
640
620
600
580
560
540

Figure 54

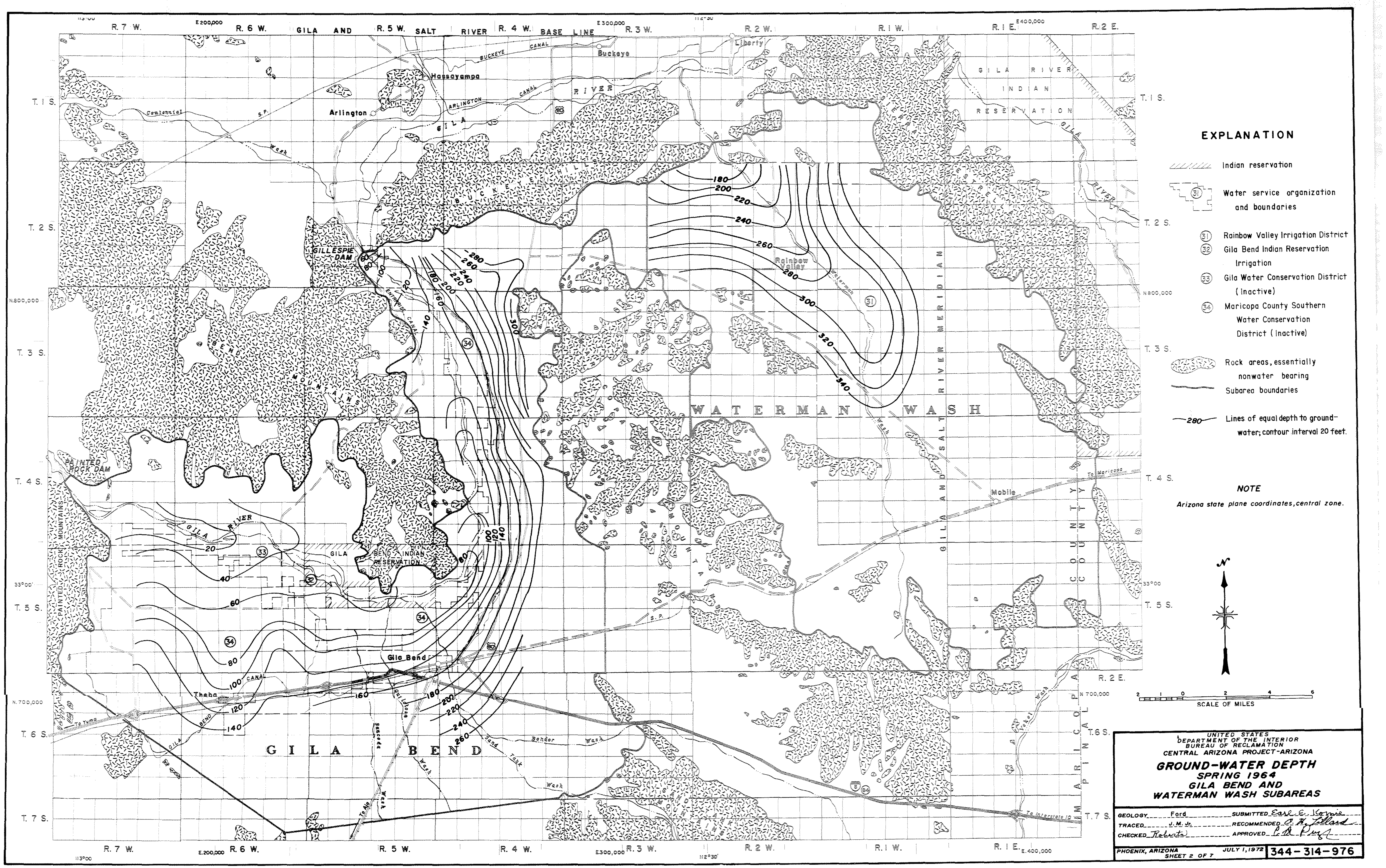

EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
280 Lines of equal depth to ground-water; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER DEPTH
SPRING 1964
GILA BEND AND
WATERMAN WASH SUBAREAS
GEOLOGY Ford
SUBMITTED Earl E. Kornie
TRACED J. M. Jr.
RECOMMENDED O. H. Lillard
CHECKED Roberts
APPROVED C. A. Pugh
PHOENIX, ARIZONA
SHEET 2 OF 7
JULY 1, 1972
344-314-976
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
GILA AND SALT RIVER BASE LINE
GILA AND SALT RIVER MERIDIAN
Buckeye
Hassayampa
Arlington
Liberty
GILA RIVER INDIAN RESERVATION
GILLESPIE DAM
PAINTED ROCK DAM
Rainbow Valley
WATERMAN WASH
Mobile
GILA BEND INDIAN RESERVATION
Gila Bend
Theba
GILA BEND
MARICOPA COUNTY
PAINTED ROCK MOUNTAINS
Bender Wash
Sand Tank Wash

Figure 55

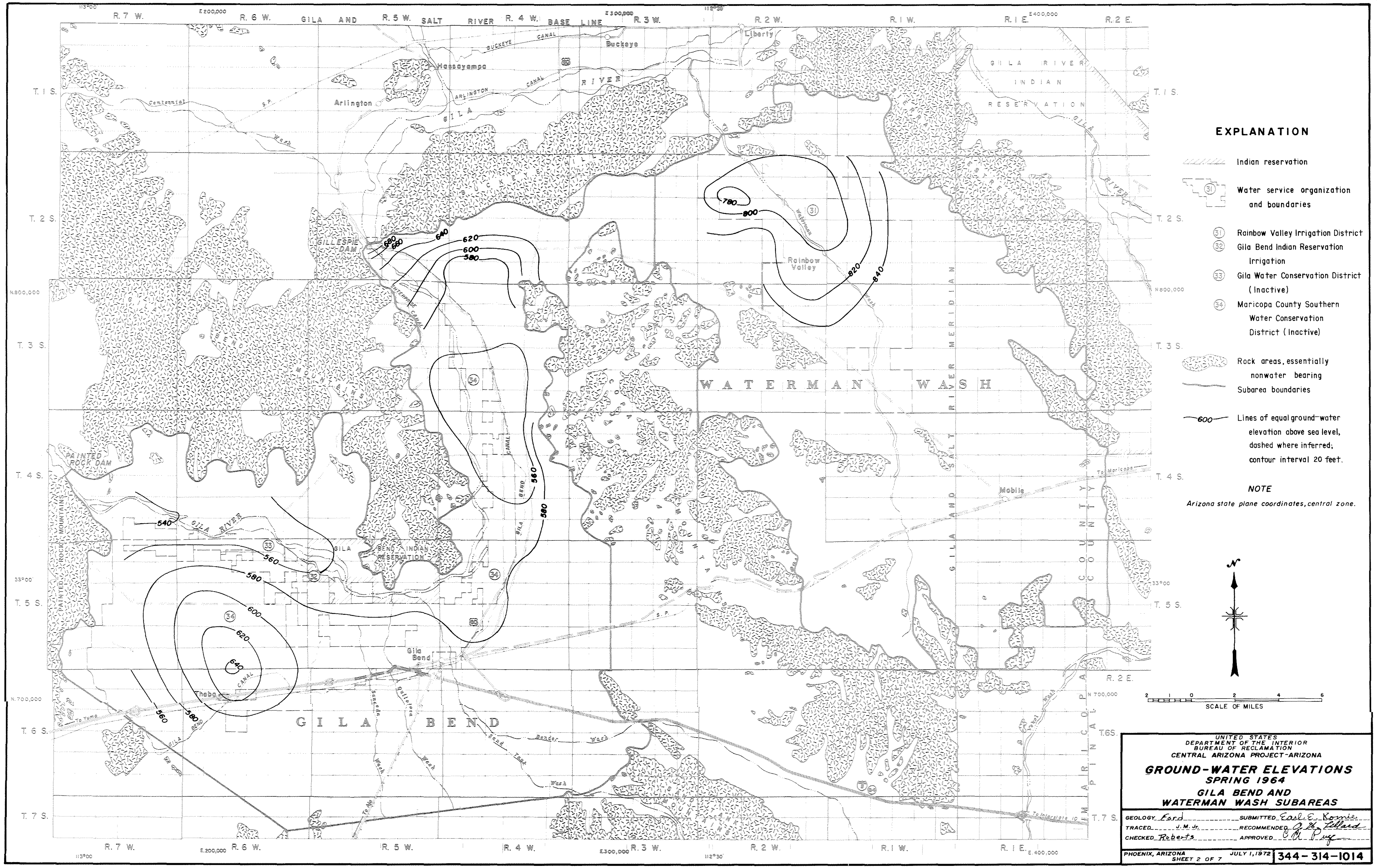

EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
600 Lines of equal ground-water elevation above sea level, dashed where inferred; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1964
GILA BEND AND
WATERMAN WASH SUBAREAS
GEOLOGY Ford
TRACED J. M. Jr.
CHECKED Roberts
SUBMITTED
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
SHEET 2 OF 7
JULY 1, 1972
344-314-1014
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
GILA AND SALT RIVER BASE LINE
GILA AND SALT RIVER MERIDIAN
MARICOPA COUNTY
PINAL COUNTY
GILA RIVER INDIAN RESERVATION
Buckeye
Liberty
Hassayampa
Arlington
BUCKEYE CANAL
ARLINGTON CANAL
GILA RIVER
GILLESPIE DAM
PAINTED ROCK DAM
PAINTED ROCK MOUNTAINS
Rainbow Valley
WATERMAN WASH
GILA BEND INDIAN RESERVATION
Gila Bend
Theba
Mobile
GILA BEND
Bender Wash
Sand Tank Wash
To Yuma
To Maricopa
To Interstate 10
780
800
820
840
680
660
640
620
600
580
560
540

Figure 56

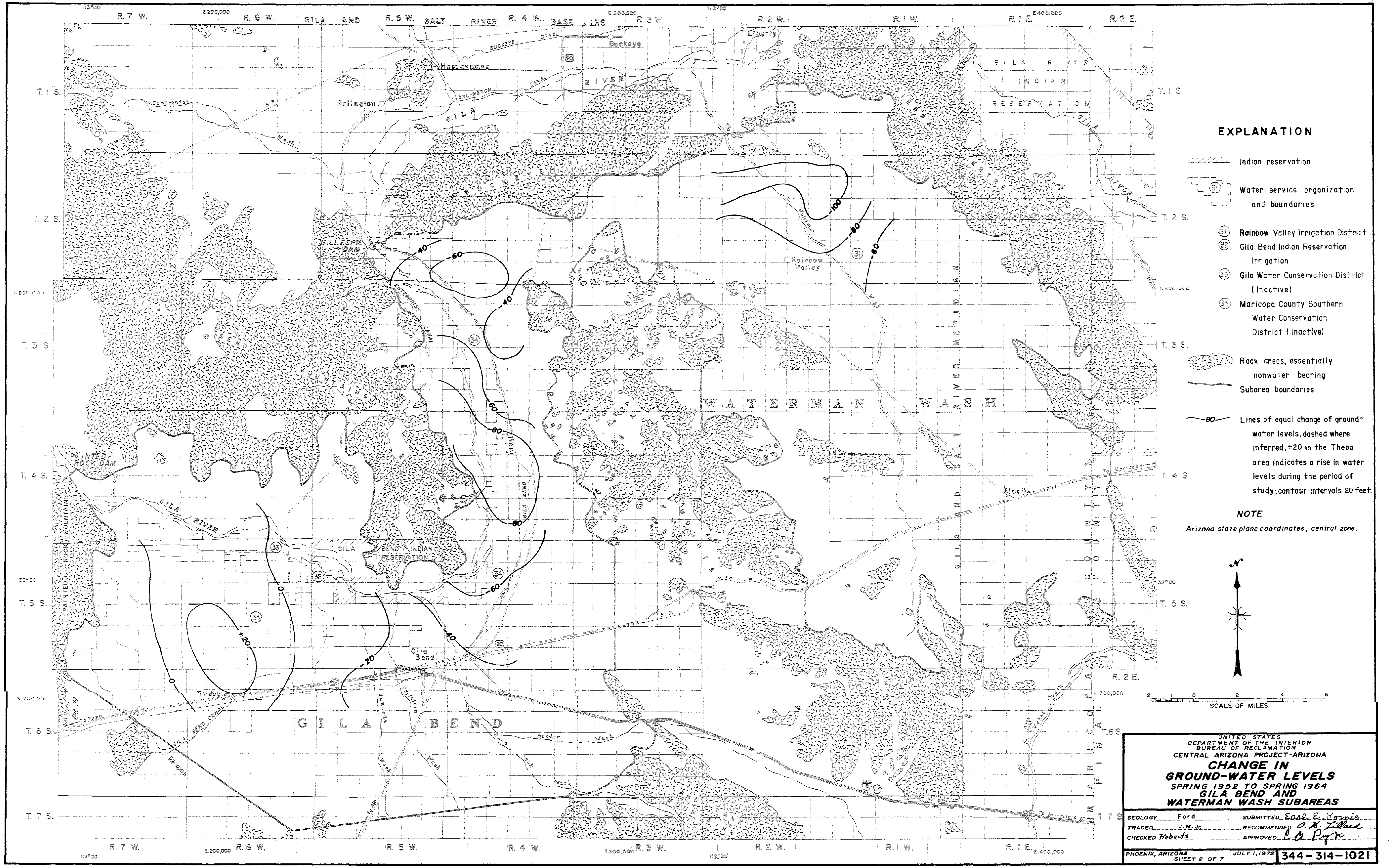
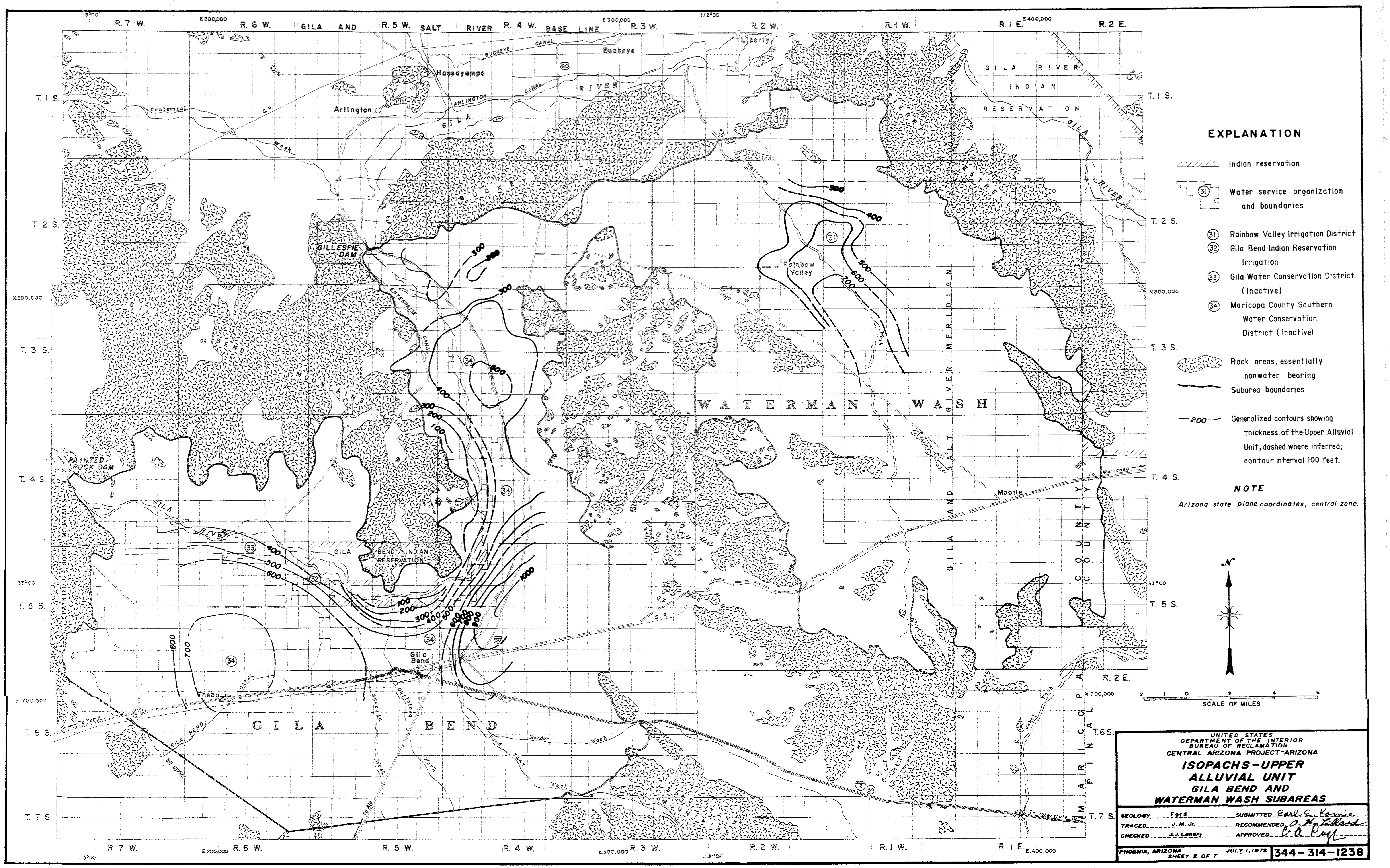

EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
Lines of equal change of ground-water levels, dashed where inferred, +20 in the Theba area indicates a rise in water levels during the period of study; contour intervals 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
CHANGE IN
GROUND-WATER LEVELS
SPRING 1952 TO SPRING 1964
GILA BEND AND
WATERMAN WASH SUBAREAS
GEOLOGY Ford
TRACED J. M. Jr.
CHECKED Roberts
SUBMITTED Earl E. Kornis
PHOENIX, ARIZONA
SHEET 2 OF 7
JULY 1, 1972
344-314-1021
GILA AND SALT RIVER BASE LINE
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
Buckeye
Hassayampa
Liberty
Arlington
GILA RIVER INDIAN RESERVATION
GILLESPIE DAM
Rainbow Valley
WATERMAN WASH
GILA AND SALT RIVER MERIDIAN
MARICOPA COUNTY
PINAL COUNTY
Mobile
PAINTED ROCK DAM
PAINTED ROCK MOUNTAINS
GILA RIVER
GILA BEND INDIAN RESERVATION
Gila Bend
GILA BEND
GILA BEND CANAL
-100
-80
-60
-40
-20
0
+20

Figure 57



EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
200 Generalized contours showing thickness of the Upper Alluvial Unit, dashed where inferred; contour interval 100 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
WATERMAN WASH
GILA BEND
GILA AND SALT RIVER BASE LINE
GILA AND SALT RIVER MERIDIAN
MARICOPA COUNTY
PINAL COUNTY
GILA RIVER INDIAN RESERVATION
GILA BEND INDIAN RESERVATION
GILLESPIE DAM
PAINTED ROCK DAM
Buckeye
Liberty
Hassayampa
Arlington
Rainbow Valley
Mobile
Gila Bend
Theba
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
ISOPACHS-UPPER ALLUVIAL UNIT
GILA BEND AND WATERMAN WASH SUBAREAS
GEOLOGY Ford
TRACED J. M. Jr.
CHECKED J. J. Landry
SUBMITTED Earl E. Kornie
RECOMMENDED
APPROVED
PHOENIX, ARIZONA SHEET 2 OF 7
JULY 1, 1972
344-314-1238

Figure 58

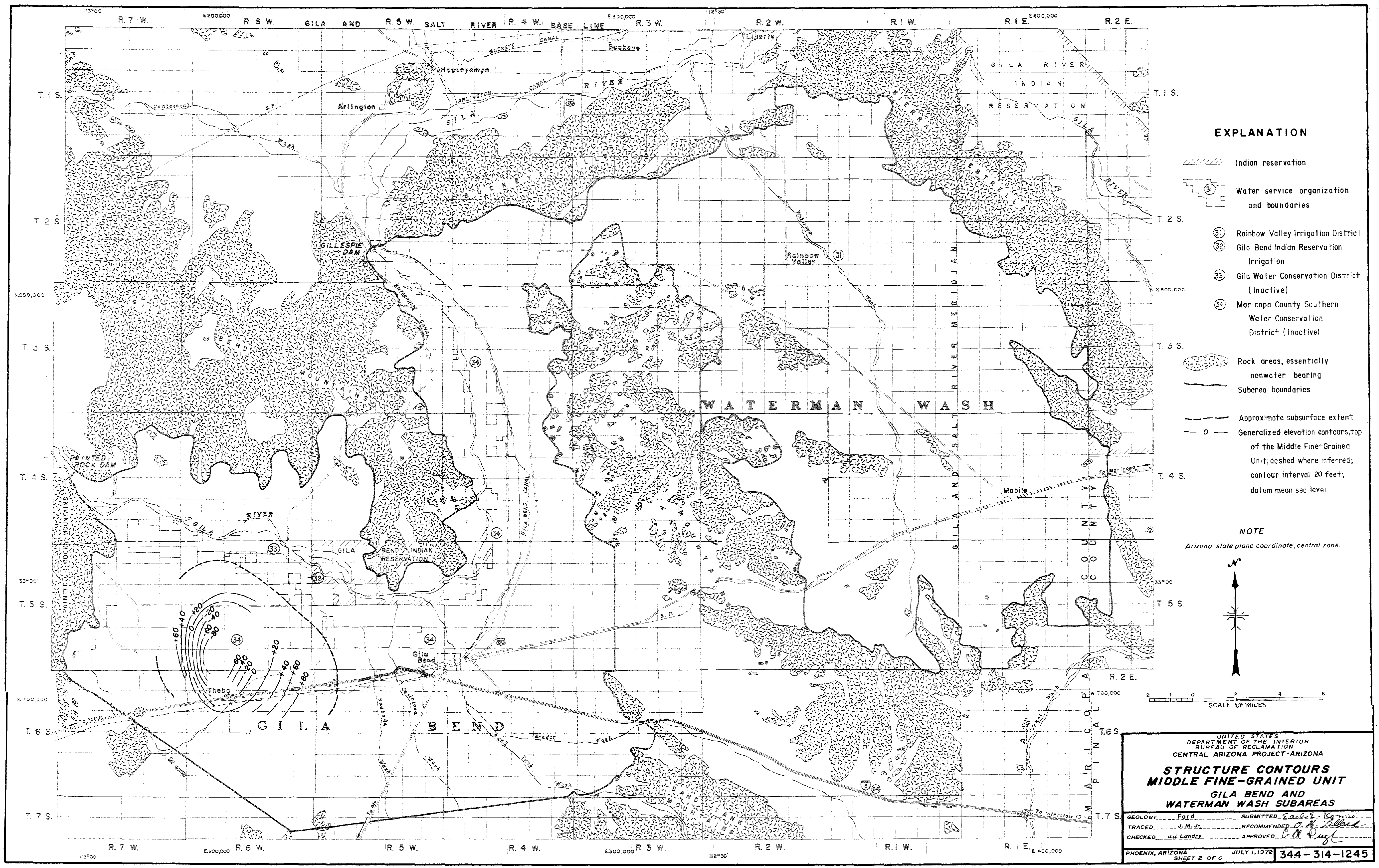

EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
Approximate subsurface extent
Generalized elevation contours, top of the Middle Fine-Grained Unit; dashed where inferred; contour interval 20 feet; datum mean sea level.
NOTE
Arizona state plane coordinate, central zone.
SCALE OF MILES
GILA AND SALT RIVER BASE LINE
GILA RIVER INDIAN RESERVATION
WATERMAN WASH
GILA BEND
GILLESPIE DAM
PAINTED ROCK DAM
GILA BEND INDIAN RESERVATION
Buckeye
Liberty
Hassayampa
Arlington
Rainbow Valley
Mobile
Gila Bend
Theba
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
STRUCTURE CONTOURS
MIDDLE FINE-GRAINED UNIT
GILA BEND AND
WATERMAN WASH SUBAREAS
GEOLOGY Ford
SUBMITTED Earl E. Kosmic
TRACED J. M. Jr.
RECOMMENDED O. K. Lillard
CHECKED J.J. Landry
APPROVED C. A. Ruyl
PHOENIX, ARIZONA
SHEET 2 OF 6
JULY 1, 1972
344-314-1245

Figure 59

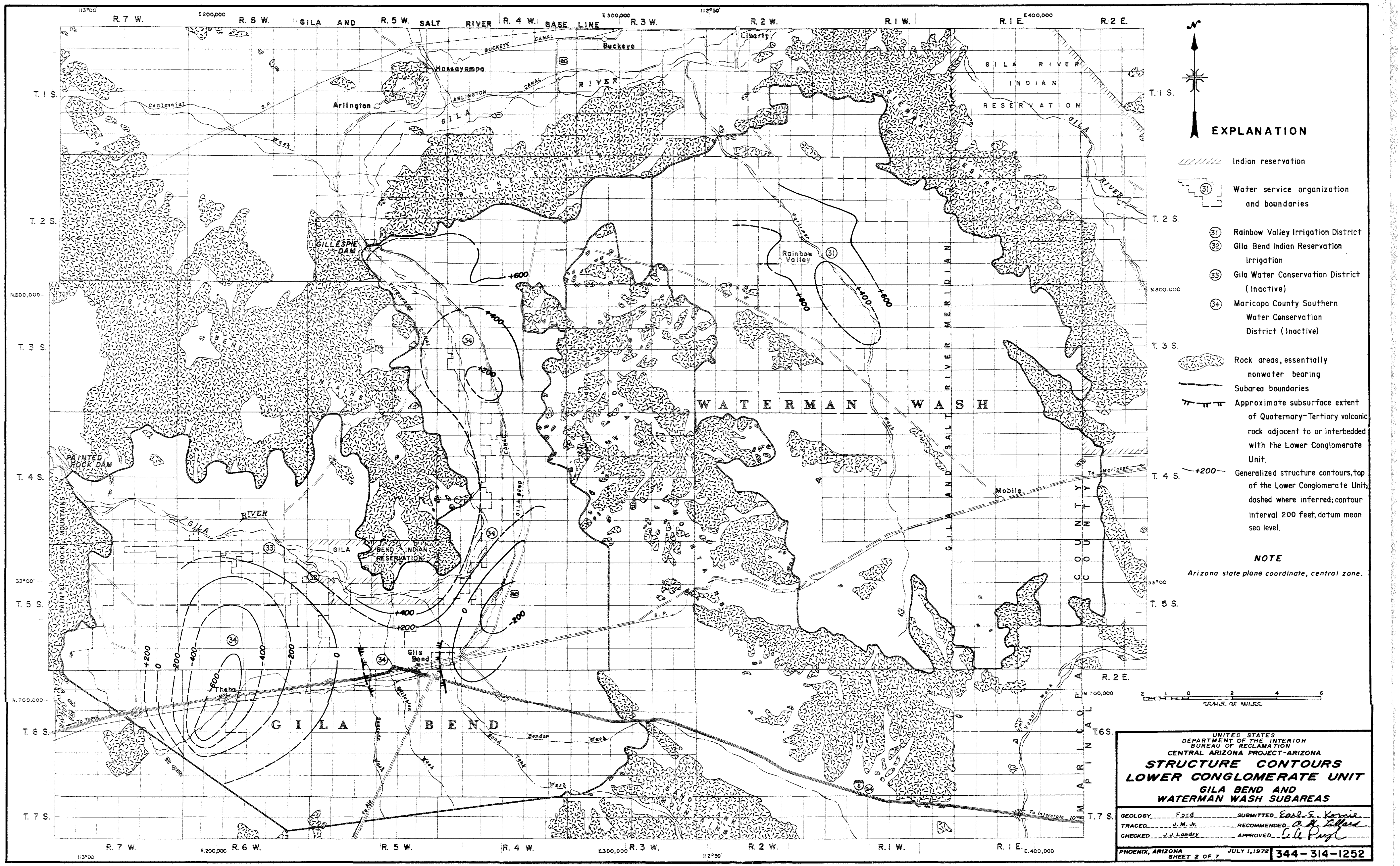

EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
Approximate subsurface extent of Quaternary-Tertiary volcanic rock adjacent to or interbedded with the Lower Conglomerate Unit.
+200 Generalized structure contours, top of the Lower Conglomerate Unit; dashed where inferred; contour interval 200 feet, datum mean sea level.
NOTE
Arizona state plane coordinate, central zone.
SCALE OF MILES
GILA AND SALT RIVER BASE LINE
GILA AND SALT RIVER MERIDIAN
GILA RIVER INDIAN RESERVATION
WATERMAN WASH
GILA BEND
MARICOPA COUNTY
PINAL COUNTY
Buckeye
Liberty
Hassayampa
Arlington
GILLESPIE DAM
PAINTED ROCK DAM
Rainbow Valley
Mobile
Gila Bend
Theba
GILA BEND INDIAN RESERVATION
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
STRUCTURE CONTOURS
LOWER CONGLOMERATE UNIT
GILA BEND AND
WATERMAN WASH SUBAREAS
GEOLOGY Ford
TRACED J. M. Jr.
CHECKED J. J. Landry
SUBMITTED Earl E. Kornie
RECOMMENDED O. H. Tillard
APPROVED C. A. Pugh
PHOENIX, ARIZONA SHEET 2 OF 7 JULY 1, 1972
344-314-1252

Figure 60

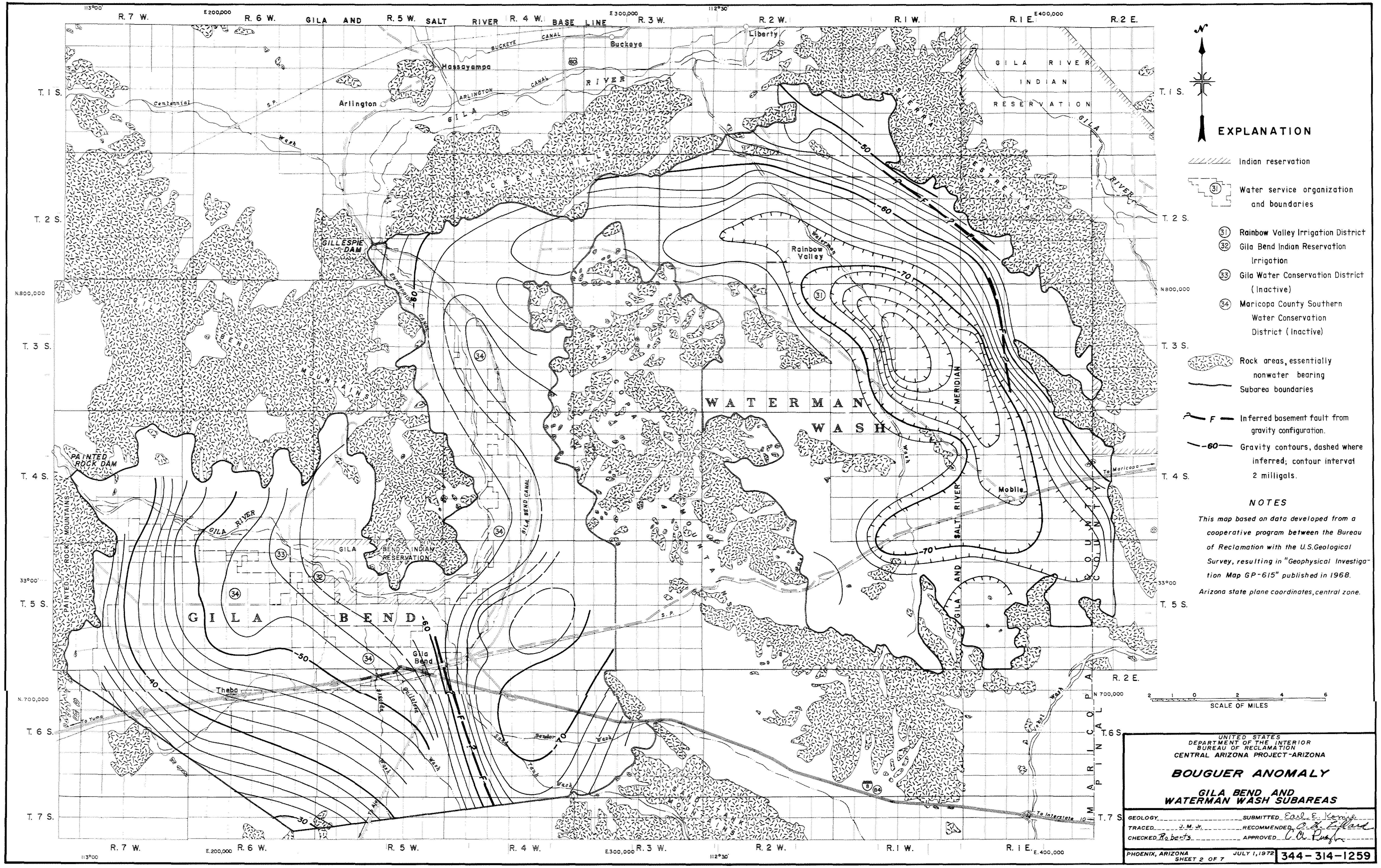

EXPLANATION
Indian reservation
Water service organization and boundaries
31 Rainbow Valley Irrigation District
32 Gila Bend Indian Reservation Irrigation
33 Gila Water Conservation District (Inactive)
34 Maricopa County Southern Water Conservation District (Inactive)
Rock areas, essentially nonwater bearing
Subarea boundaries
F Inferred basement fault from gravity configuration.
-60 Gravity contours, dashed where inferred; contour interval 2 milligals.
NOTES
This map based on data developed from a cooperative program between the Bureau of Reclamation with the U.S.Geological Survey, resulting in "Geophysical Investigation Map GP-615" published in 1968.
Arizona state plane coordinates, central zone.
SCALE OF MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
BOUGUER ANOMALY
GILA BEND AND WATERMAN WASH SUBAREAS
GEOLOGY
TRACED J. M. Jr.
CHECKED Roberts
SUBMITTED Earl E. Komie
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
SHEET 2 OF 7
JULY 1, 1972
344-314-1259
GILA AND SALT RIVER BASE LINE
WATERMAN WASH
GILA BEND
GILA RIVER INDIAN RESERVATION
GILA BEND INDIAN RESERVATION
PAINTED ROCK DAM
GILLESPIE DAM
Rainbow Valley
Gila Bend
Buckeye
Hassayampa
Arlington
Liberty
Mobile
Theba
GILA AND SALT RIVER MERIDIAN
MARICOPA COUNTY
PINAL COUNTY
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.

Figure 61

TONAPAH — ARLINGTON AND HARQUAHALA VALLEY SUBAREAS

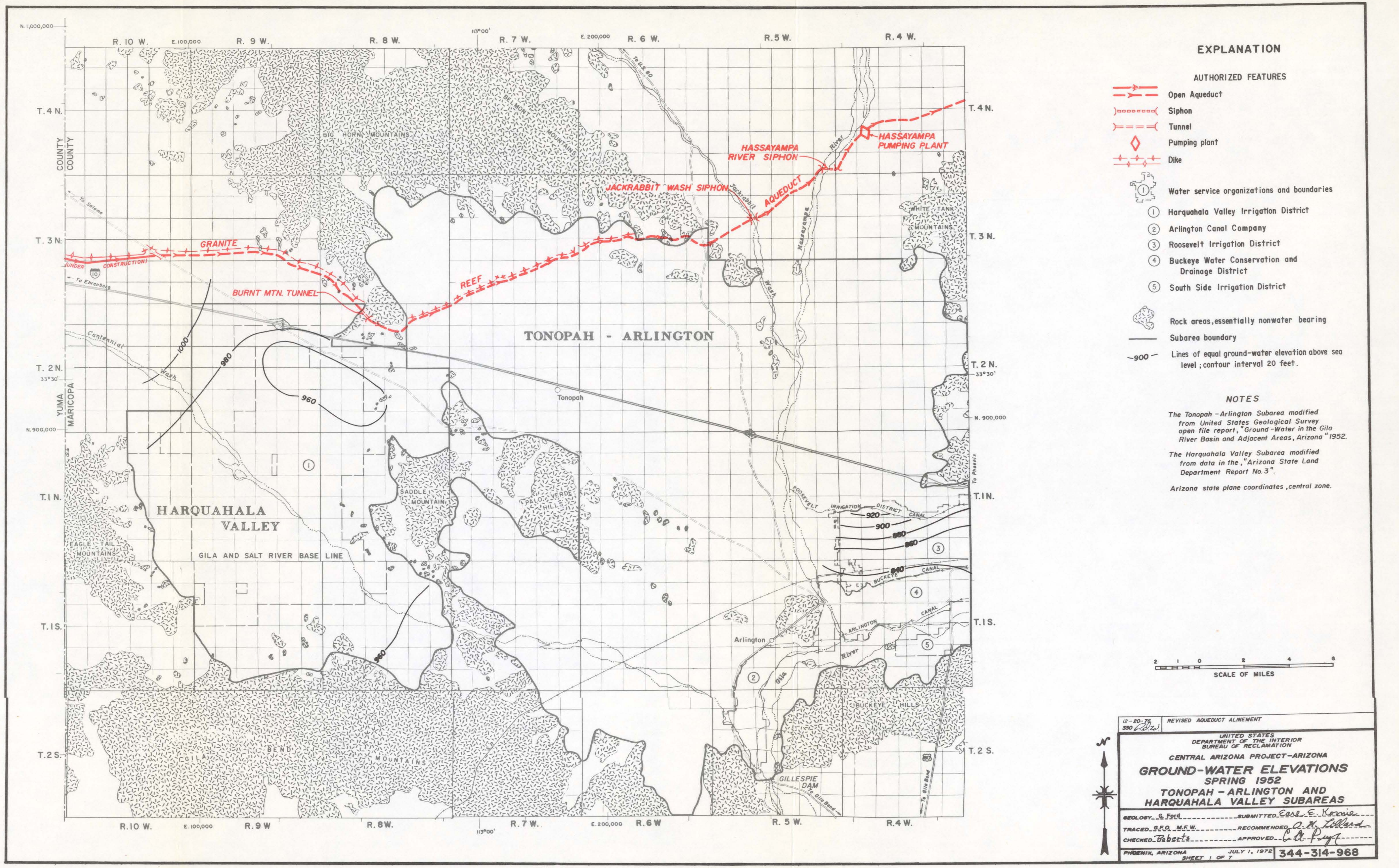

R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
BIG HORN MOUNTAINS
BELMONT MOUNTAINS
WHITE TANK MOUNTAINS
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
JACKRABBIT WASH SIPHON
AQUEDUCT
GRANITE
REEF
(UNDER CONSTRUCTION)
BURNT MTN. TUNNEL
TONOPAH - ARLINGTON
Tonopah
HARQUAHALA VALLEY
GILA AND SALT RIVER BASE LINE
SADDLE MOUNTAIN
PALO VERDE HILLS
EAGLE TAIL MOUNTAINS
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
Arlington
Gila River
BUCKEYE HILLS
GILA BEND MOUNTAINS
GILLESPIE DAM
Centennial Wash
Hassayampa River
YUMA COUNTY
MARICOPA COUNTY
1000
980
960
920
900
880
860
840
EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping plant
Dike
Water service organizations and boundaries
(1) Harquahala Valley Irrigation District
(2) Arlington Canal Company
(3) Roosevelt Irrigation District
(4) Buckeye Water Conservation and Drainage District
(5) South Side Irrigation District
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal ground-water elevation above sea level; contour interval 20 feet.
NOTES
The Tonopah - Arlington Subarea modified from United States Geological Survey open file report, "Ground-Water in the Gila River Basin and Adjacent Areas, Arizona" 1952.
The Harquahala Valley Subarea modified from data in the, "Arizona State Land Department Report No. 3".
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76 330
REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1952
TONOPAH - ARLINGTON AND
HARQUAHALA VALLEY SUBAREAS
GEOLOGY G. Ford
TRACED G.F.O. M.F.W.
CHECKED Roberts
SUBMITTED
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 1 OF 7
344-314-968

Figure 62

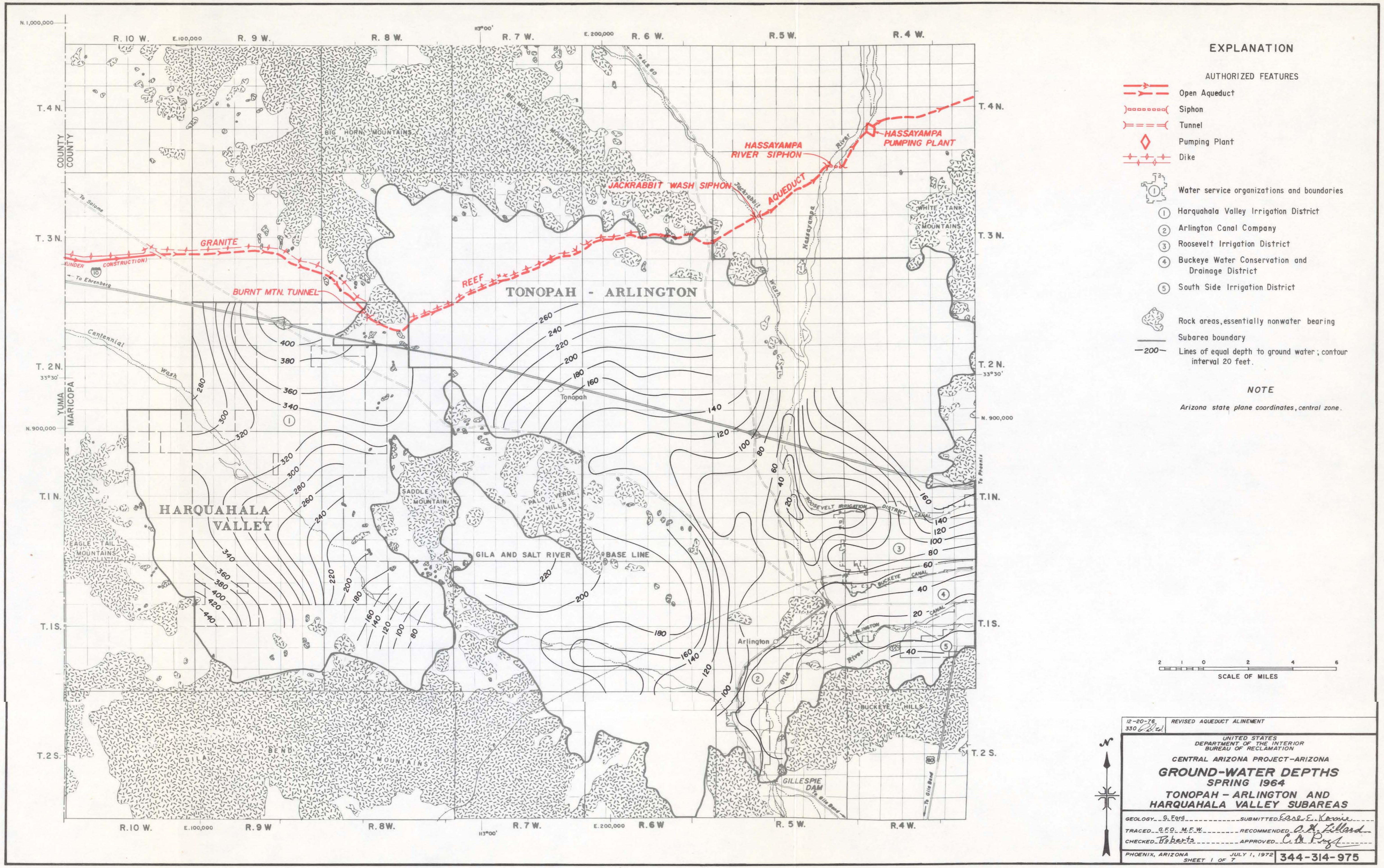

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping Plant
Dike
Water service organizations and boundaries
1 Harquahala Valley Irrigation District
2 Arlington Canal Company
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
Rock areas, essentially nonwater bearing
Subarea boundary
—200— Lines of equal depth to ground water; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
N. 1,000,000
N. 900,000
E. 100,000
E. 200,000
113°00'
33°30'
YUMA COUNTY
MARICOPA COUNTY
BIG HORN MOUNTAINS
BELMONT MOUNTAINS
WHITE TANK MOUNTAINS
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
JACKRABBIT WASH SIPHON
AQUEDUCT
GRANITE
REEF
(UNDER CONSTRUCTION)
BURNT MTN. TUNNEL
TONOPAH - ARLINGTON
HARQUAHALA VALLEY
Centennial Wash
Hassayampa Wash
To Salome
To Ehrenberg
To Phoenix
Tonopah
SADDLE MOUNTAIN
PALO VERDE HILLS
EAGLE TAIL MOUNTAINS
GILA AND SALT RIVER BASE LINE
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
Arlington
Gila River
BUCKEYE HILLS
GILA BEND MOUNTAINS
GILLESPIE DAM
To Gila Bend
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER DEPTHS
SPRING 1964
TONOPAH - ARLINGTON AND HARQUAHALA VALLEY SUBAREAS
GEOLOGY G. Ferg
TRACED G.F.O. M.F.W.
CHECKED Roberts
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 1 OF 7
344-314-975

Figure 63

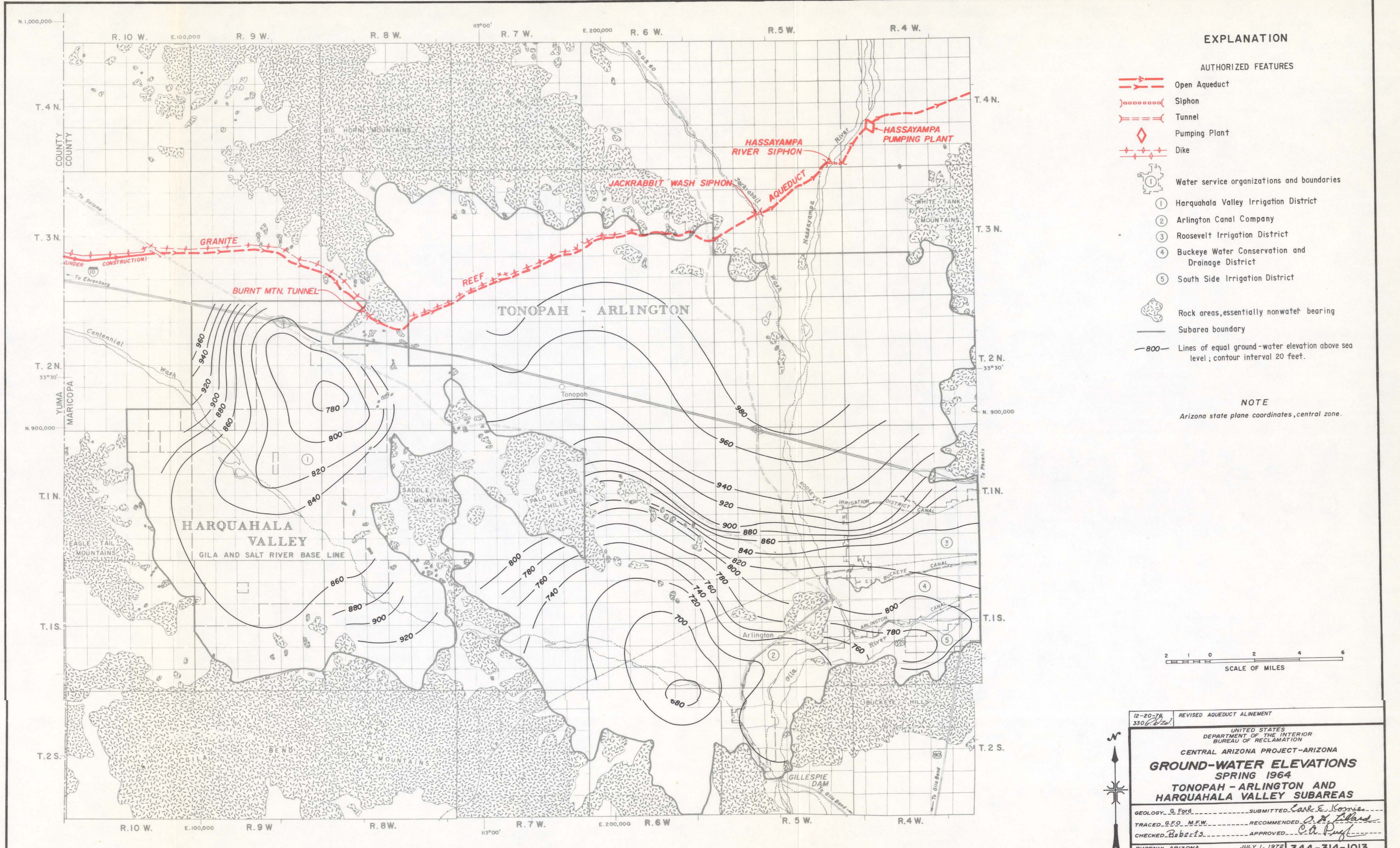

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping Plant
Dike
Water service organizations and boundaries
1 Harquahala Valley Irrigation District
2 Arlington Canal Company
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
Rock areas, essentially nonwater bearing
Subarea boundary
800 Lines of equal ground-water elevation above sea level; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
JACKRABBIT WASH SIPHON
AQUEDUCT
GRANITE
REEF
BURNT MTN. TUNNEL
(UNDER CONSTRUCTION)
BIG HORN MOUNTAINS
WHITE TANK MOUNTAINS
TONOPAH - ARLINGTON
Tonopah
HARQUAHALA VALLEY
GILA AND SALT RIVER BASE LINE
SADDLE MOUNTAIN
PALO VERDE HILLS
EAGLE TAIL MOUNTAINS
GILA BEND MOUNTAINS
BUCKEYE HILLS
GILLESPIE DAM
Arlington
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
Gila River
Hassayampa Wash
Centennial Wash
YUMA COUNTY
MARICOPA COUNTY
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1964
TONOPAH - ARLINGTON AND
HARQUAHALA VALLEY SUBAREAS
GEOLOGY G. Ford
TRACED G.F.O. M.F.W.
CHECKED Roberts
SUBMITTED
RECOMMENDED
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 1 OF 7
344-314-1013

Figure 64

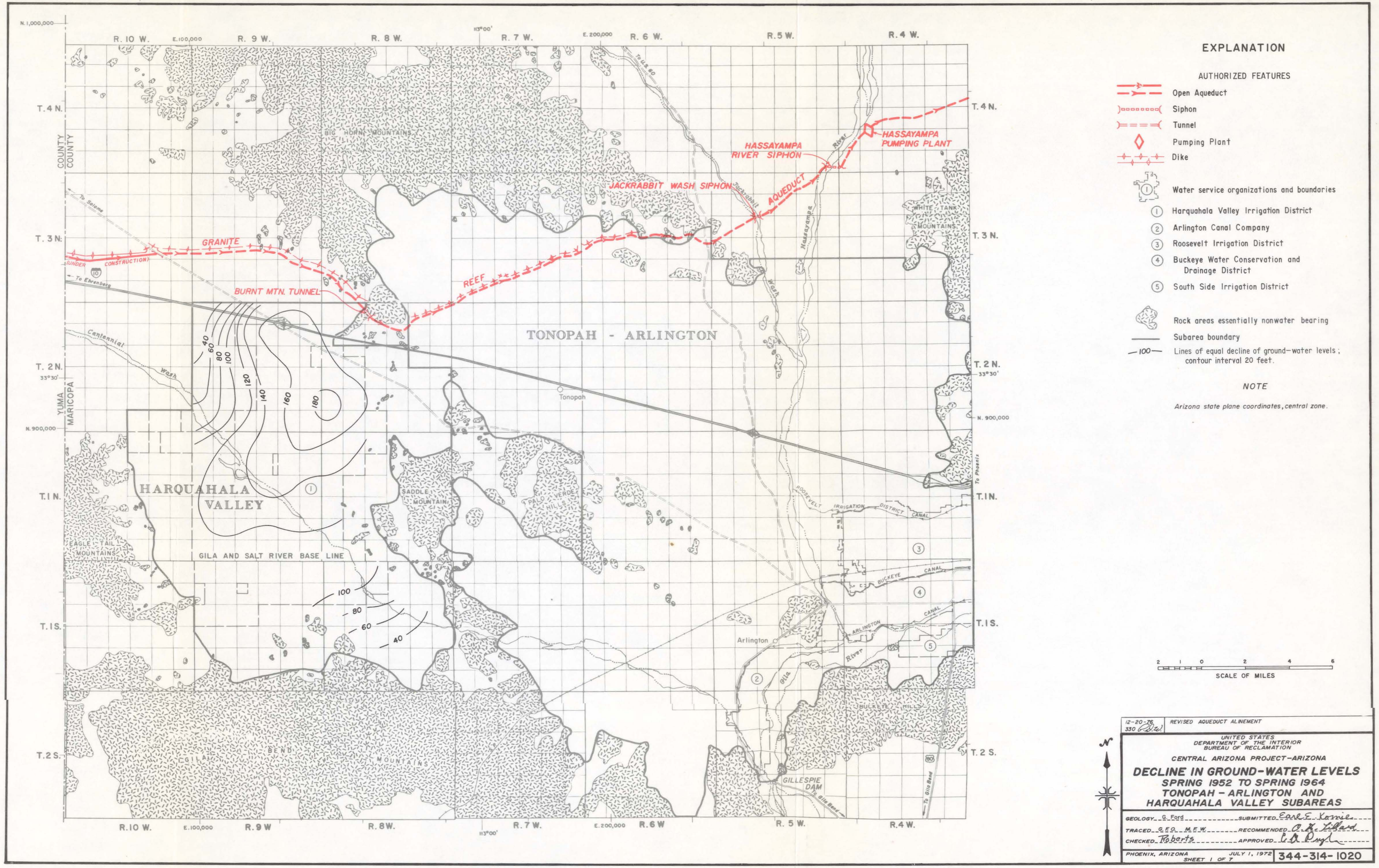
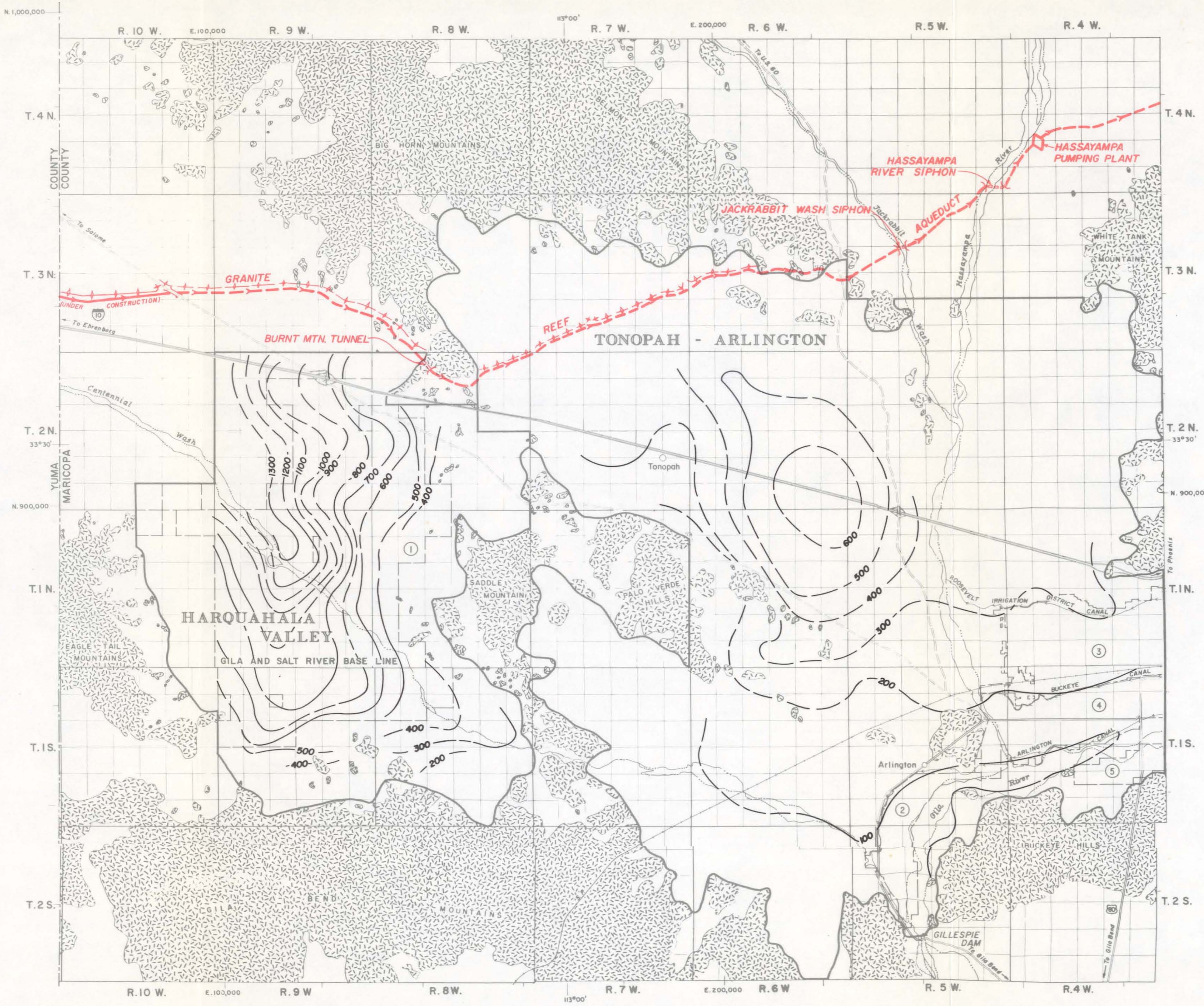

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping Plant
Dike
Water service organizations and boundaries
1 Harquahala Valley Irrigation District
2 Arlington Canal Company
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
Rock areas essentially nonwater bearing
Subarea boundary
Lines of equal decline of ground-water levels; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
N. 1,000,000
N. 900,000
E. 100,000
E. 200,000
113°00'
33°30'
YUMA
MARICOPA
COUNTY
COUNTY
BIG HORN MOUNTAINS
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
JACKRABBIT WASH SIPHON
AQUEDUCT
GRANITE
REEF
(UNDER CONSTRUCTION)
BURNT MTN. TUNNEL
To Salome
To Ehrenberg
WHITE TANK MOUNTAINS
Hassayampa
Wash
River
Centennial
TONOPAH - ARLINGTON
Tonopah
HARQUAHALA VALLEY
SADDLE MOUNTAIN
PALO VERDE HILLS
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
EAGLE TAIL MOUNTAINS
GILA AND SALT RIVER BASE LINE
Arlington
Gila River
GILA BEND MOUNTAINS
BUCKEYE HILLS
GILLESPIE DAM
To Gila Bend
To Phoenix
40
60
80
100
120
140
160
180
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT—ARIZONA
DECLINE IN GROUND-WATER LEVELS
SPRING 1952 TO SPRING 1964
TONOPAH - ARLINGTON AND
HARQUAHALA VALLEY SUBAREAS
GEOLOGY G. Ford
SUBMITTED Earl E. Yarnie
TRACED
RECOMMENDED
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 1 OF 7
344-314-1020

Figure 65



EXPLANATION

AUTHORIZED FEATURES

- Open Aqueduct
- Siphon
- Tunnel
- Pumping Plant
- Dike

Water service organizations and boundaries

1. Harquahala Valley Irrigation District
2. Arlington Canal Company
3. Roosevelt Irrigation District
4. Buckeye Water Conservation and Drainage District
5. South Side Irrigation District

Rock areas, essentially nonwater bearing

Subarea boundary

—300— Generalized contours showing thickness of the Upper Alluvial Unit, dashed where inferred; contour interval 100 feet.

NOTE

Arizona state plane coordinates, central zone.

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED AQUEDUCT ALINEMENT

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT–ARIZONA

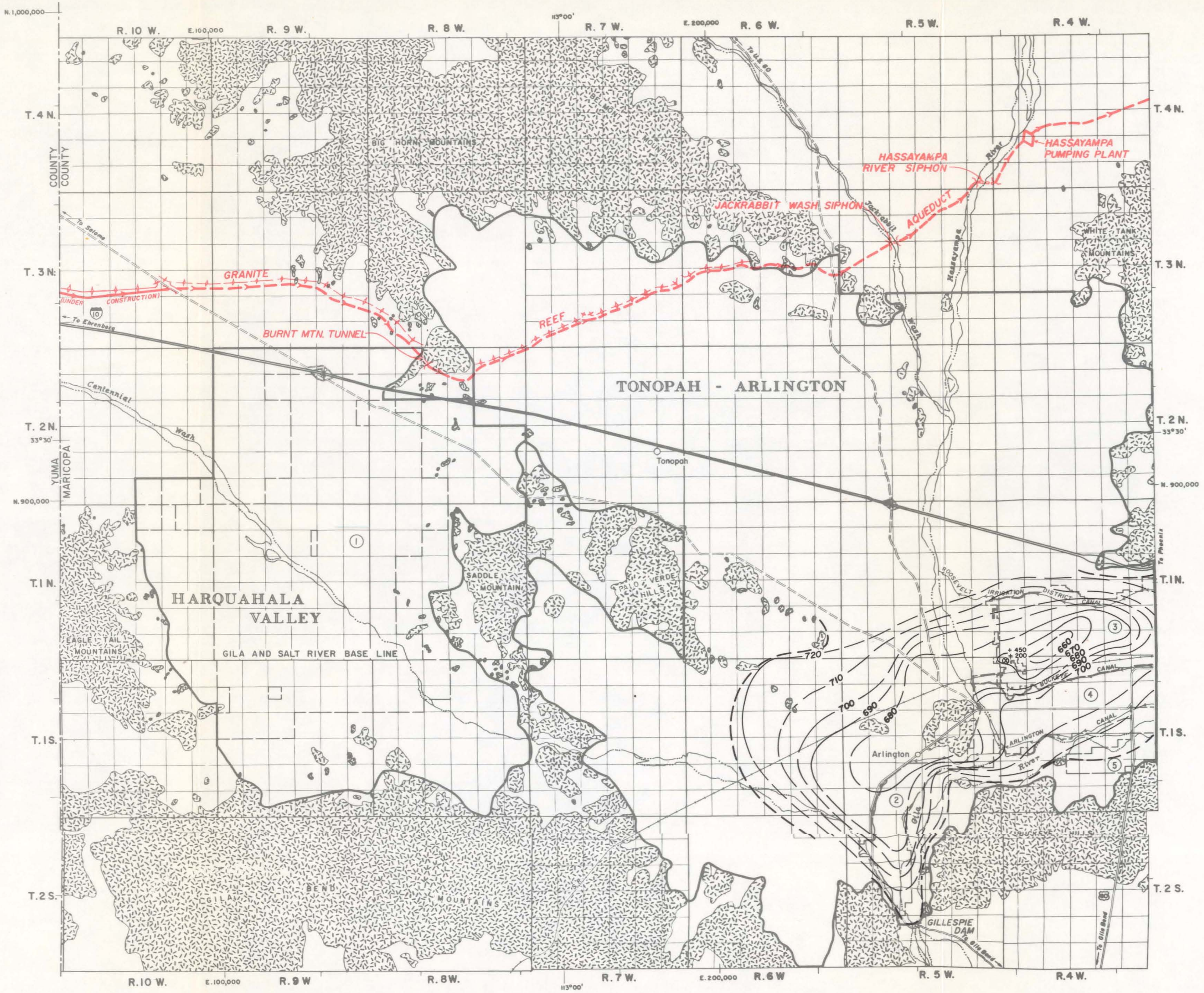
ISOPACHS–UPPER ALLUVIAL UNIT

TONOPAH – ARLINGTON AND HARQUAHALA VALLEY SUBAREAS

GEOLOGY G. Ford — SUBMITTED Earl E. Konie
TRACED G.F.O. M.F.W. — RECOMMENDED O. X. Lillard
CHECKED J.J. Landry — APPROVED C.A. Pugh

PHOENIX, ARIZONA — JULY 1, 1972 — SHEET 1 OF 7 — 344-314-1237

Figure 66



EXPLANATION

AUTHORIZED FEATURES

- Open Aqueduct
- Siphon
- Tunnel
- Pumping Plant
- Dike

Water service organizations and boundaries

1. Harquahala Valley Irrigation District
2. Arlington Canal Company
3. Roosevelt Irrigation District
4. Buckeye Water Conservation and Drainage District
5. South Side Irrigation District

Rock areas essentially nonwater-bearing

Subarea boundary

Approximate subsurface extent.

—700— Generalized elevation contours, top of the Middle Fine-Grained Unit, dashed where inferred; contour interval 10 feet; datum mean sea level.

⊗ + 450 + 200 Approximate elevation of the top of reported significant evaporites.

NOTE

Arizona state plane coordinates, central zone.

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED AQUEDUCT ALINEMENT

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT-ARIZONA

STRUCTURE CONTOURS
MIDDLE FINE-GRAINED UNIT
TONOPAH - ARLINGTON AND HARQUAHALA VALLEY SUBAREAS

GEOLOGY G. Ford — SUBMITTED Earl E. Kornie
TRACED G.F.O. M.F.W. — RECOMMENDED O. H. Tillard
CHECKED J.J. Landry — APPROVED C. A. Pugh

PHOENIX, ARIZONA — JULY 1, 1972 — SHEET 1 OF 6 — 344-314-1244

Figure 67

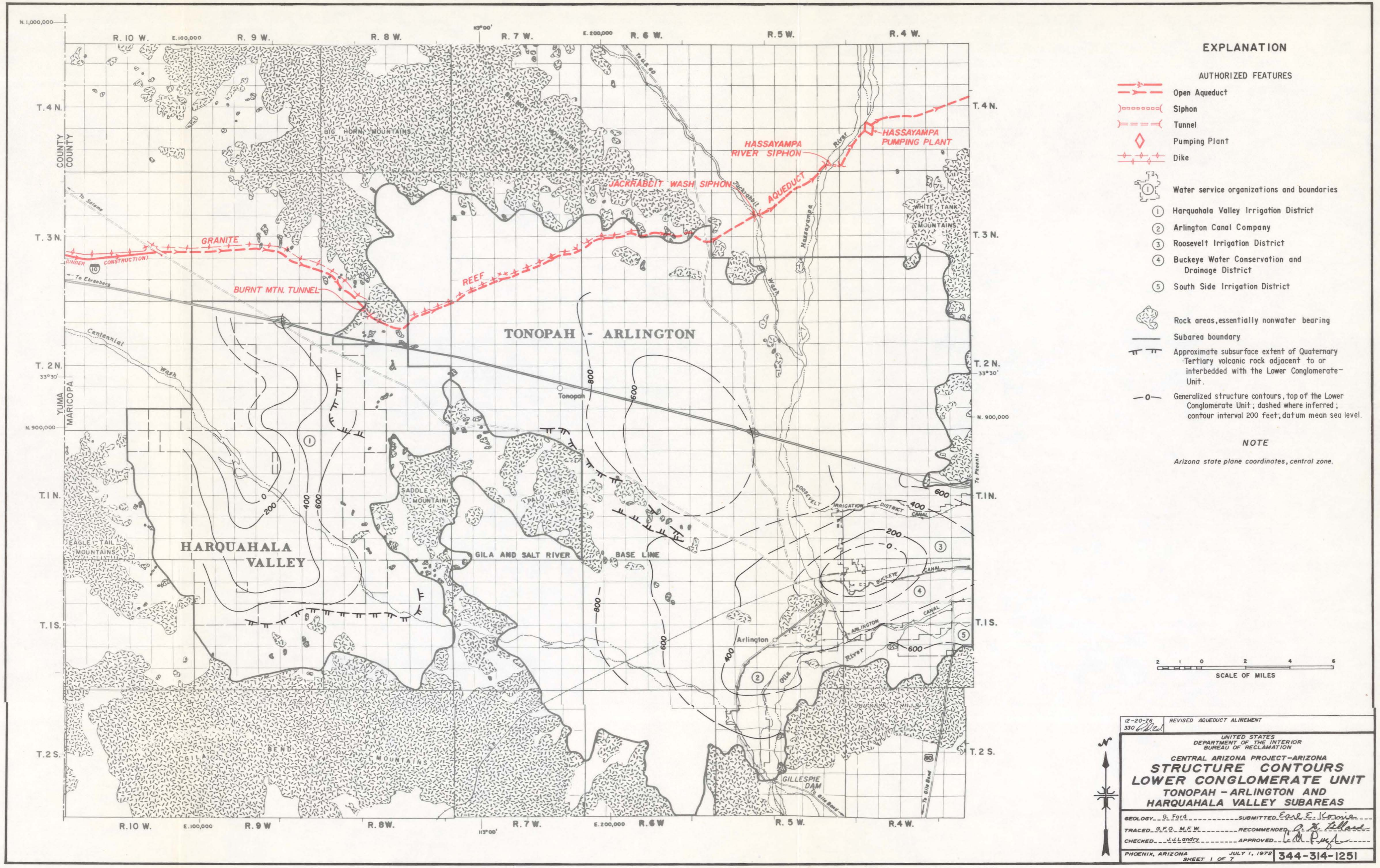
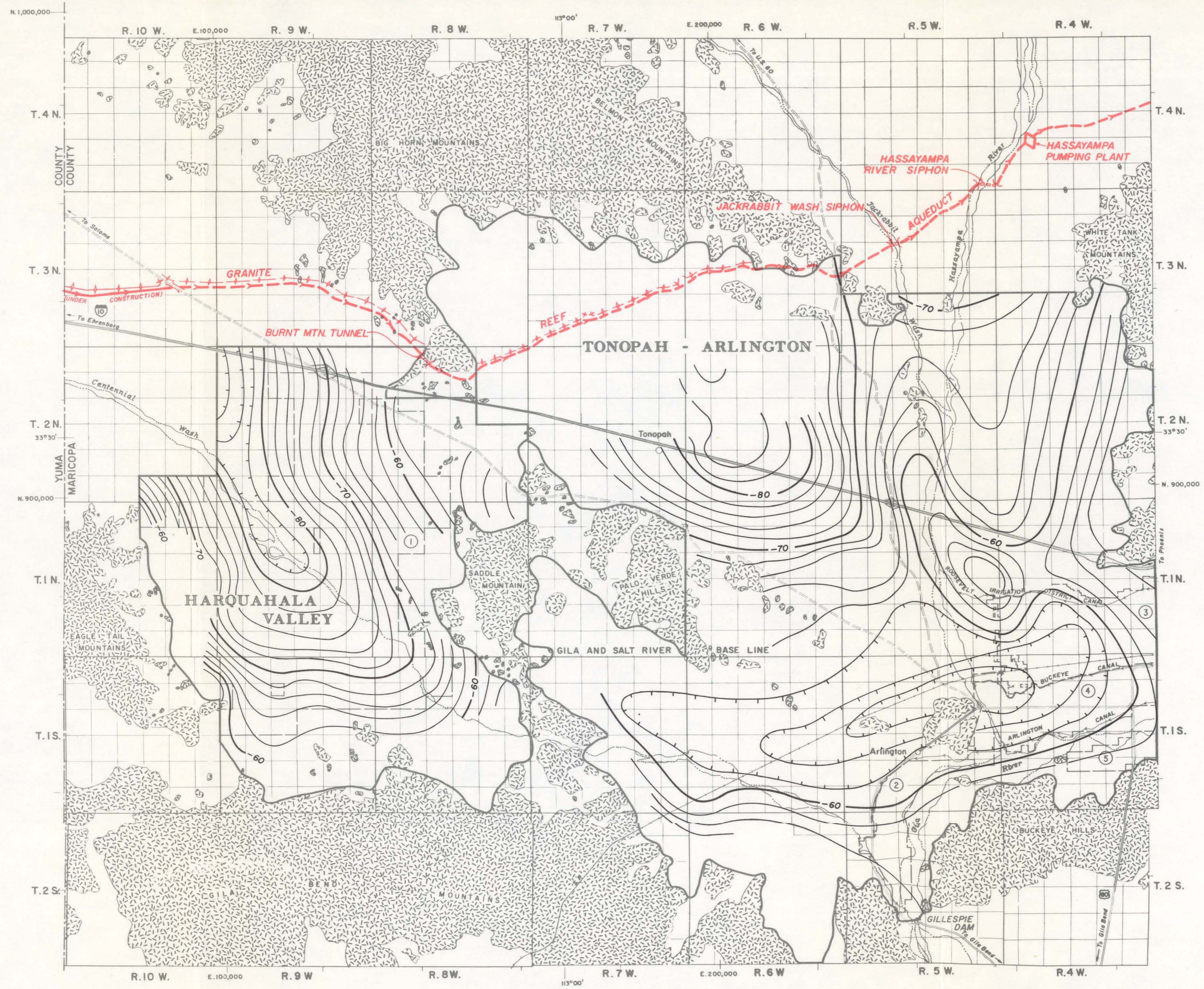

R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
N. 1,000,000
N. 900,000
E. 100,000
E. 200,000
113°00'
33°30'
COUNTY
COUNTY
YUMA
MARICOPA
BIG HORN MOUNTAINS
BELMONT MOUNTAINS
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
JACKRABBIT WASH SIPHON
AQUEDUCT
GRANITE
REEF
(UNDER CONSTRUCTION)
BURNT MTN. TUNNEL
To Salome
To Ehrenberg
Centennial Wash
WHITE TANK MOUNTAINS
TONOPAH - ARLINGTON
Tonopah
HARQUAHALA VALLEY
SADDLE MOUNTAIN
PALO VERDE HILLS
EAGLE TAIL MOUNTAINS
GILA AND SALT RIVER BASE LINE
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
Gila River
Hassayampa Wash
Arlington
GILA BEND MOUNTAINS
GILLESPIE DAM
To Phoenix
To Gila Bend
EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping Plant
Dike
Water service organizations and boundaries
1 Harquahala Valley Irrigation District
2 Arlington Canal Company
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
Rock areas, essentially nonwater bearing
Subarea boundary
Approximate subsurface extent of Quaternary Tertiary volcanic rock adjacent to or interbedded with the Lower Conglomerate Unit.
Generalized structure contours, top of the Lower Conglomerate Unit; dashed where inferred; contour interval 200 feet; datum mean sea level.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
12-20-76
330
REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT–ARIZONA
STRUCTURE CONTOURS
LOWER CONGLOMERATE UNIT
TONOPAH – ARLINGTON AND
HARQUAHALA VALLEY SUBAREAS
GEOLOGY G. Ford
SUBMITTED Earl E. Kornie
TRACED G.F.O. M.F.W.
RECOMMENDED
CHECKED J.J. Landry
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 1 OF 7
344-314-1251

Figure 68



EXPLANATION

AUTHORIZED FEATURES

- Open Aqueduct
- Siphon
- Tunnel
- Pumping Plant
- Dike

Water service organizations and boundaries

1. Harquahala Valley Irrigation District
2. Arlington Canal Company
3. Roosevelt Irrigation District
4. Buckeye Water Conservation and Drainage District
5. South Side Irrigation District

- Rock areas, essentially nonwater bearing
- Subarea boundary
- -80 Gravity contours, dashed where inferred; contour interval 2 milligals.

NOTES

This map based on data developed from a cooperative program between the Bureau of Reclamation with the U.S. Geological Survey, resulting in "Geophysical Investigation Map GP-615" published in 1968.

Arizona state plane coordinates, central zone.

2 1 0 2 4 6

SCALE OF MILES

12-20-76 330	REVISED AQUEDUCT ALINEMENT

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT–ARIZONA

BOUGUER ANOMALY

TONOPAH – ARLINGTON AND HARQUAHALA VALLEY SUBAREAS

GEOLOGY ________ SUBMITTED Earl E. Komie
TRACED G.F.O. M.F.W. ________ RECOMMENDED O. H. Tillard
CHECKED Roberts ________ APPROVED C. A. Pugh

PHOENIX, ARIZONA JULY 1, 1972 SHEET 1 OF 7 | 344-314-1258

Figure 69

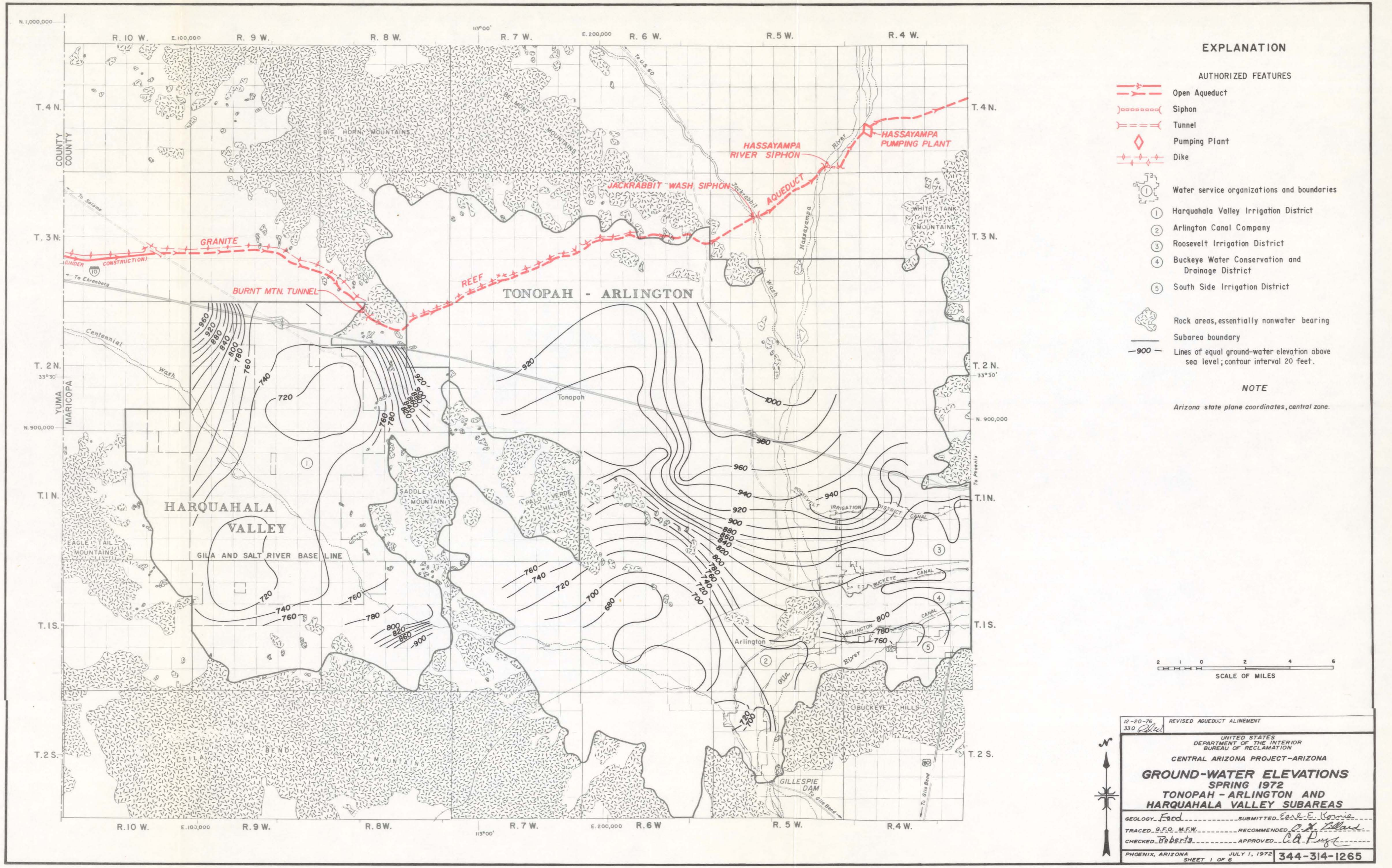

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping Plant
Dike
Water service organizations and boundaries
1 Harquahala Valley Irrigation District
2 Arlington Canal Company
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
Rock areas, essentially nonwater bearing
Subarea boundary
900 Lines of equal ground-water elevation above sea level; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
TONOPAH - ARLINGTON
HARQUAHALA VALLEY
GILA AND SALT RIVER BASE LINE
BIG HORN MOUNTAINS
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
JACKRABBIT WASH SIPHON
AQUEDUCT
GRANITE
REEF
BURNT MTN. TUNNEL
WHITE TANK MOUNTAINS
SADDLE MOUNTAIN
PALO VERDE HILLS
EAGLE TAIL MOUNTAINS
GILA BEND MOUNTAINS
BUCKEYE HILLS
Tonopah
Arlington
GILLESPIE DAM
Centennial Wash
Hassayampa Wash
Gila River
YUMA COUNTY
MARICOPA COUNTY
12-20-76 330 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER ELEVATIONS
SPRING 1972
TONOPAH - ARLINGTON AND
HARQUAHALA VALLEY SUBAREAS
GEOLOGY Ford SUBMITTED Earl E. Kornie
TRACED G.F.O. M.F.W. RECOMMENDED
CHECKED Roberts APPROVED
PHOENIX, ARIZONA JULY 1, 1972
SHEET 1 OF 6
344-314-1265

Figure 70

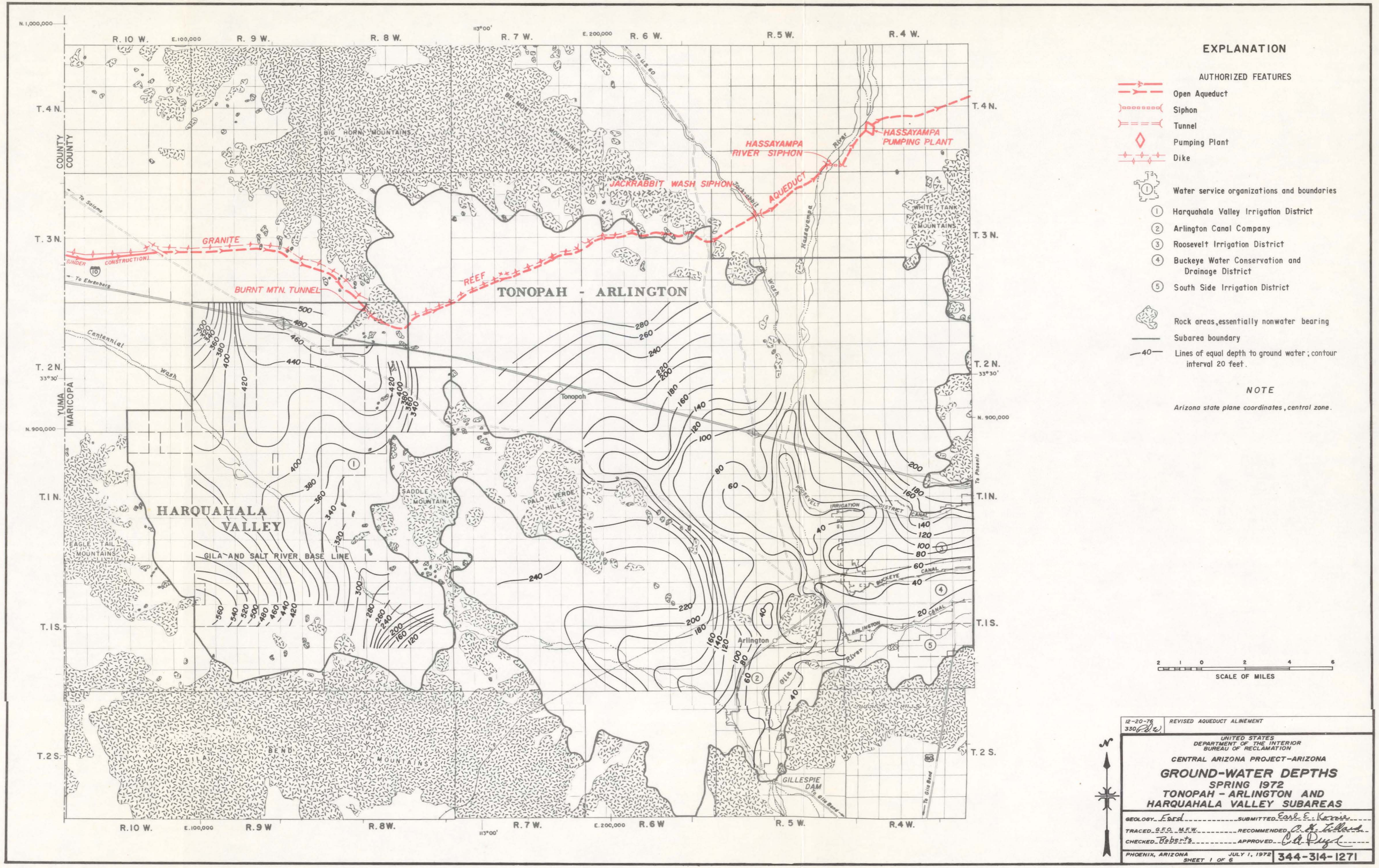

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping Plant
Dike
Water service organizations and boundaries
1 Harquahala Valley Irrigation District
2 Arlington Canal Company
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
Rock areas, essentially nonwater bearing
Subarea boundary
Lines of equal depth to ground water; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
N. 1,000,000
N. 900,000
E. 100,000
E. 200,000
113°00'
33°30'
YUMA COUNTY
MARICOPA COUNTY
BIG HORN MOUNTAINS
BELMONT MOUNTAINS
WHITE TANK MOUNTAINS
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
JACKRABBIT WASH SIPHON
AQUEDUCT
GRANITE
REEF
BURNT MTN. TUNNEL
TONOPAH - ARLINGTON
HARQUAHALA VALLEY
SADDLE MOUNTAIN
PALO VERDE HILLS
EAGLE TAIL MOUNTAINS
GILA AND SALT RIVER BASE LINE
GILA BEND MOUNTAINS
Tonopah
Arlington
GILLESPIE DAM
Centennial Wash
Hassayampa
Gila River
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
To Phoenix
To Gila Bend
To Ehrenberg
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
GROUND-WATER DEPTHS
SPRING 1972
TONOPAH - ARLINGTON AND
HARQUAHALA VALLEY SUBAREAS
GEOLOGY Ford
SUBMITTED Earl E. Kovvis
TRACED
RECOMMENDED
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 1 OF 6
344-314-1271

Figure 71

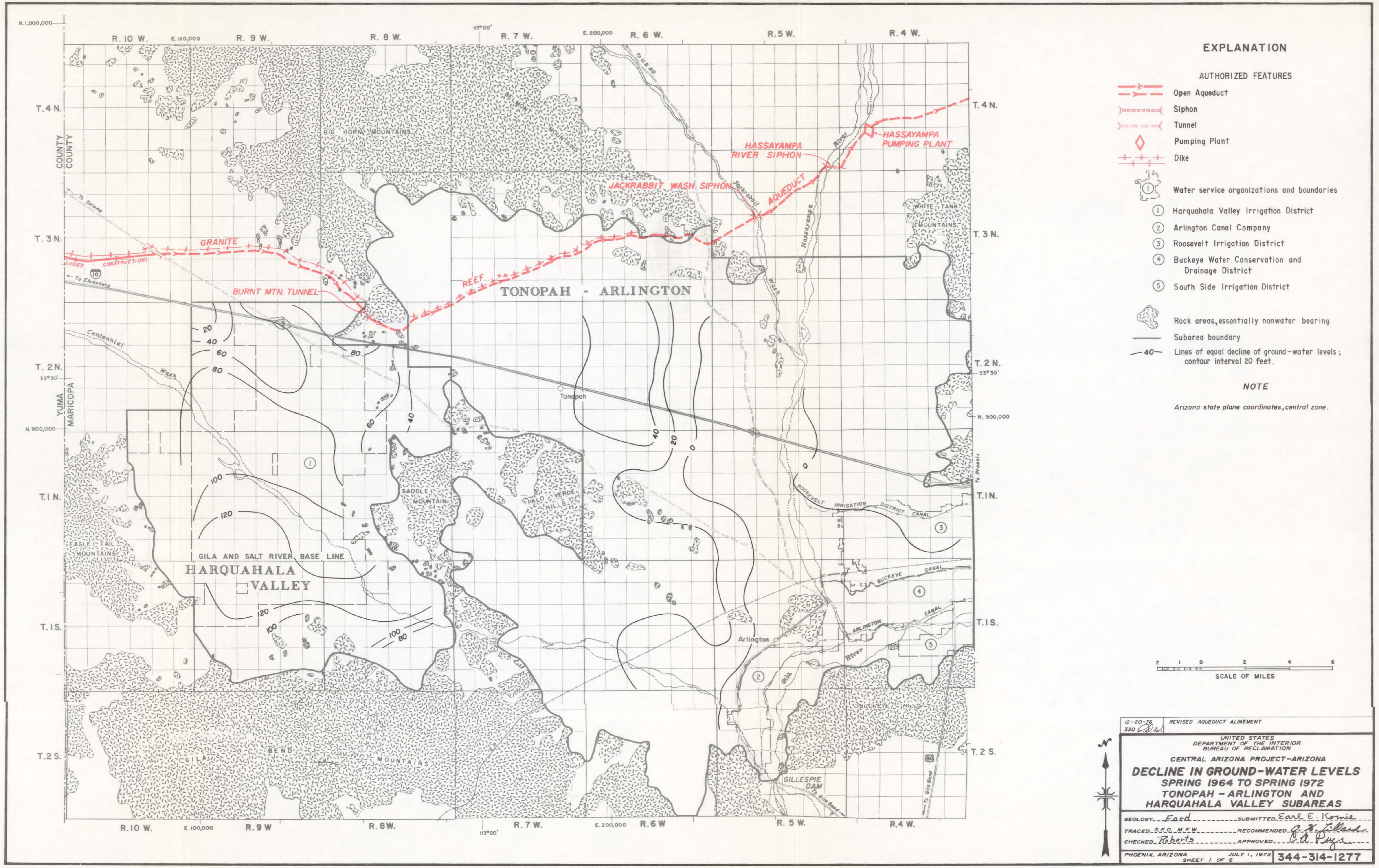

EXPLANATION
AUTHORIZED FEATURES
Open Aqueduct
Siphon
Tunnel
Pumping Plant
Dike
Water service organizations and boundaries
1 Harquahala Valley Irrigation District
2 Arlington Canal Company
3 Roosevelt Irrigation District
4 Buckeye Water Conservation and Drainage District
5 South Side Irrigation District
Rock areas, essentially nonwater bearing
Subarea boundary
40 Lines of equal decline of ground-water levels; contour interval 20 feet.
NOTE
Arizona state plane coordinates, central zone.
SCALE OF MILES
R. 10 W.
R. 9 W.
R. 8 W.
R. 7 W.
R. 6 W.
R. 5 W.
R. 4 W.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
N. 1,000,000
N. 900,000
E. 100,000
E. 200,000
113°00'
33°30'
YUMA COUNTY
MARICOPA COUNTY
BIG HORN MOUNTAINS
BELMONT MOUNTAINS
WHITE TANK MOUNTAINS
SADDLE MOUNTAIN
PALO VERDE HILLS
EAGLE TAIL MOUNTAINS
GILA BEND MOUNTAINS
BUCKEYE HILLS
GRANITE
REEF
AQUEDUCT
(UNDER CONSTRUCTION)
BURNT MTN. TUNNEL
JACKRABBIT WASH SIPHON
HASSAYAMPA RIVER SIPHON
HASSAYAMPA PUMPING PLANT
TONOPAH - ARLINGTON
HARQUAHALA VALLEY
GILA AND SALT RIVER BASE LINE
Centennial Wash
Jackrabbit Wash
Hassayampa River
Gila River
ROOSEVELT IRRIGATION DISTRICT CANAL
BUCKEYE CANAL
ARLINGTON CANAL
GILLESPIE DAM
Tonopah
Arlington
To Salome
To Ehrenberg
To Phoenix
To Gila Bend
To U.S. 60
10
80
20
40
60
80
100
120
0
12-20-76 REVISED AQUEDUCT ALINEMENT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT–ARIZONA
DECLINE IN GROUND-WATER LEVELS
SPRING 1964 TO SPRING 1972
TONOPAH – ARLINGTON AND
HARQUAHALA VALLEY SUBAREAS
GEOLOGY Ford
SUBMITTED Earl E. Kernie
TRACED G.F.O. M.F.W.
RECOMMENDED
CHECKED Roberts
APPROVED
PHOENIX, ARIZONA
JULY 1, 1972
SHEET 1 OF 6
344-314-1277

Figure 72