HYDROGEOLOGY AND WATER RESOURCES OF THE PLACITAS AREA SANDOVAL COUNTY, NEW MEXICO

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF PLATES

ABSTRACT

The Placitas area straddles the northern flank of the Sandia Mountains and the eastern margin of the Albuquerque Basin of the Rio Grande Rift. The area is geologically complex. Major west-dipping, rift-margin, normal faults, including the San Francisco-Placitas fault zone and numerous subsidiary faults, cut Paleozoic and Mesozoic sedimentary strata that ramp northward below Santa Fe Group basin fill. Faults in the Placitas area behave as both barriers to and conduits for ground-water movement. Surface and subsurface geologic data, well hydrographs, and stable isotope, ion chemistry and trace element data from ground and surface water delineate an assortment of confined and unconfined aquifers with a wide range of water quality and productivity, and varying degrees of hydraulic interconnection, recharge, and residence time. The Placitas area is divided into three major conceptual hydrologic systems: 1) the mountain hydrologic system; 2) the Mesozoic ramp; and 3) the Albuquerque Basin. In general, large supplies of ground water are not available in the mountain system or in the Mesozoic ramp.

The major hydrostratigraphic unit in the mountain system, the Madera Group limestone, forms a dual-porosity, fractured carbonate aquifer with moderate aquifer potential. Ground-water flow is concentrated along discrete fractures, fracture systems, or bedding planes, thus availability of ground water is highly variable and dry holes are relatively common. On a regional scale, the Madera Group limestone possesses very high transmissivity and relatively low storage. Limestone outcrops in the Sandia Mountains form a major ground-water recharge area fed by snowmelt, winter-spring precipitation, and surface water from Las Huertas Creek and other drainages. This recharge water possesses a characteristic water chemistry distinguished by major ions of calcium and bicarbonate, a low TDI concentration (<310 mg/l), temperature less than 16 ^{o}C, a high dissolved oxygen content (≥6 mg/l), no significant trace elements, and ^{2}H/H and ^{18}O/^{16}O ratios similar to local precipitation. Maps of the spatial distribution of TDI, major anions, temperature, dissolved oxygen, and stable isotope ratios identify pathways for ground-water movement, recharge, and hydraulic interconnection or isolation of aquifers.

Ground water in the Mesozoic ramp is limited to compartmentalized sandstone aquifers in the Triassic Agua Zarca Formation, the Jurassic Entrada and uppermost Triassic Petrified Forest Formation, the Westwater Canyon and Jackpile Sandstone members of the Morrison Formation, and the Cretaceous Dakota, Hosta Dalton, and Point Lookout Formations. Rotation of strata to northeast dips of 30 to 65 degrees created subvertical strip aquifers. Each aquifer is stratigraphically isolated by aquitards of mudstone, shale, and siltstone, and by lateral discontinuities produced by north-south faults. Many of the aquifers exhibit elevated temperature (up to 25 ^{o}C), low dissolved oxygen (<1 ppm), and high concentrations of sodium (≤1450 ppm), sulfate (≤3900 ppm), dissolved ions (≤5950 ppm), iron (≤600 ppb), copper (≤270 ppb), manganese (≤ 580 ppb), and zinc (≤1300 ppb). Low concentrations of arsenic (5 to 21 ppb) are typical of ground water from the Triassic Agua Zarca and lower Petrified Forest Formations. This hydrogeochemistry reflects long residence times under semi-confined conditions in low permeability sediments isolated from active recharge. Ground waters with a recharge signature are located near streams and arroyos, along the Caballo-Pomecerro faults, and in permeable units in contact with the Madera Group limestone.

Age determinations on 12 ground-water samples using radiocarbon, tritium, and stable isotopes indicates a variation in ground-water residence time ranging from modern to fossil water over 35,000 years old. Locations with a modern isotopic signature are adjacent to Las Huertas Creek, Arroyo Agua Sarca, and the Caballo-Pomecerro fault. Active recharge to aquifers down-gradient of the San Francisco-Placitas fault zone appears to occur through the Madera Group limestone and across the fault zones via cross-cutting faults, hydraulically continuous permeable units, and as surface water originating from spring discharge and runoff.

I. INTRODUCTION

The Placitas area, situated in the picturesque northern Sandia foothills, has been intensively developed during the past three decades. The region has evolved from a sparsely populated, rural agricultural area, to a mixed suburban environment. Population growth of 85% during the 1970s and 20 to 30% during the 1980s and early 1990s (Middle Rio Grande Council of Governments, 1992) has relied entirely on development of ground water for a domestic water supply. Increased ground-water withdrawals combined with a two-year drought in 1995 and 1996 resulted in numerous dry wells and raised awareness of the potential for over-development of the area's limited ground-water resources. A thorough understanding of the hydrogeology of the Placitas area is essential for sustainable ground-water development, but this understanding has been hampered by a general absence of detailed hydrologic and geologic data, and by the area's geologic complexity. This bulletin presents results of a comprehensive study to characterize the water resources of the Placitas area.

A. Scope and Objectives

This bulletin describes the availability and quality of ground water and surface water in the Placitas area, and its relationship to the region's complex geology. New hydrologic and hydrogeochemical data were collected from aquifers in the Placitas area. Together with recent geologic maps, these data support development of hydrogeologic conceptual models of ground-water flow and occurrence. Funding from the County of Sandoval supported field work and data collection, which were completed by the New Mexico Bureau of Mines and Mineral Resources ("NMBMMR") and a graduate researcher from New Mexico Tech. The study area encompasses the Placitas development area which is located in the southeast corner of Sandoval County, approximately 20 miles north-northeast of Albuquerque (Figure 1). The study area boundaries include Cibola National Forest on the south, the Town of Tejon Grant on the east, San Felipe Pueblo to the north, Santa Ana Pueblo to the northwest, and Town of Bernalillo on the west. The study area is contained within the Placitas and Bernalillo 7.5-minute quadrangles. New data were collected from areas outside the defined study area where it was necessary to understand and illustrate hydrologic conditions within the study area. The principal objectives of the study are:

(1) *Develop a geometric model of the surface and subsurface geology of the Placitas area.* This model relies on existing surface and subsurface geologic data, and illustrates the subsurface position of hydrostratigraphic units (aquifers and aquitards), ground water flow pathways, and hydrogeologic boundaries.
(2) *Develop an accurate, potentiometric surface map of aquifers.* This map provides a quantitative evaluation of hydraulic gradient and ground-water flow direction, and supports qualitative inferences regarding hydrogeologic boundaries, barriers, pathways, and aquifer characteristics.
(3) *Characterize the surface water resources of the Placitas area,* including a map of drainages, perennial springs and streams, and an evaluation of surface-water and ground-water interactions.
(4) *Characterize the spatial distribution of water quality and geochemical parameters in the various aquifers.* Interpretation of hydrogeochemical data permits delineation of recharge areas, ground water flow pathways, hydraulic interconnection or compartmentalization of aquifers, and a relative assessment of ground-water residence times.
(5) *Provide an assessment of ground-water availability and potential impacts of ground-water development.*

The following maps and data are included with this bulletin:

(1) A geologic map of the Placitas area at 1:12,000 scale (Plates 1A and 1B).
(2) A subcrop geologic map of the Placitas area (a geologic map illustrating distribution of underlying bedrock units that constitute the hydrostratigraphic units of the area) at 1:24,000 scale (Plate 2).
(3) Five geologic cross-sections at 1:24,000 scale with 2.5 times vertical exaggeration (Plate 3).
(4) A hydrostratigraphic column showing vertical and time distribution of stratigraphic units, their lithologic character, and aquifer potential (Figures 5 and 6).
(5) An inventory of wells, springs, and data collection sites, presented in database format (Appendices A and B) and on a topographic base at 1:24,000 scale (Plate 4).
(6) Precipitation, stream, and spring discharge data (Appendices C and D) and surface water maps showing distribution of watersheds, springs, streams and arroyos, and perennial stream reaches (Figures 9 and 14).
(7) A hydrogeologic zone map (1:24,000) illustrating the various hydrologic systems (Plate 5 and Table 7).
(8) Water-level elevation data (Appendix E).
(9) A potentiometric surface map of aquifers in the Placitas area (1:24,000 scale) illustrating hydraulic head conditions in April, 1998, water level changes monitored during the course of this study (August 1997 to August 1998), and historical water level changes (Plates 6 and 7 respectively).
(10) Water quality maps showing major ion geochemistry, stable isotope geochemistry, and distribution of total dissolved ions, dissolved oxygen, temperature, arsenic and nitrates (Figures 17 through 33; Appendices F, G, and H).

B. Previous Work

Numerous geologic studies have been conducted in the Placitas area on various aspects of the region's stratigraphy and structure, as well as on the geology of the adjoining Albuquerque Basin, the most significant of which are mentioned here. This study is based primarily on recent geologic maps produced by NMBMMR for the Placitas and Bernalillo 7.5 minute quadrangles (Connell et al., 1995; Connell, 1998) at a scale of 1:24,000. Geologic data are also available on a regional map of the Sandia Mountains at a scale of 1:48,000 (Kelley and Northrop, 1975), and on theses maps covering small areas (Picha, 1982; Menne, 1989; Connell, 1996). Woodward and Menne (1995) provide a structural interpretation of the Placitas area. Subsurface geologic data and interpretation from the Albuquerque Basin are summarized in several studies, including Connell, Koning and Cather (1999), Hawley and Whitworth (1996), Chapin and Cather (1994), Thorn, McAda and Kernodle (1993), Hawley and Haase (1992), and Kelly (1977). Hydrogeologic interpretations for the Albuquerque Basin are found in Hawley and Whitworth (1996), Thorn, McAda and Kernodle (1993), and Hawley and Haase (1992). Titus (1980) completed the only hydrogeologic study of the Sandia Mountains, which includes an assessment of the Placitas area. LeFevre (1999) completed a detailed hydrogeochemical study, funded as part of this project. This thesis describes collection, analysis, distribution, and interpretation of geochemical and stable isotope data from ground water, surface water and precipitation, and a conceptual model of ground-water flow, recharge and residence time.

II. TECHNICAL APPROACH AND DATA COLLECTION

The Placitas area is geologically complex and contains a variety of interconnected and compartmentalized aquifers. Because of this complexity, a multi-disciplinary approach integrating geologic, hydrologic and hydrogeochemical data was used to develop physically based conceptual models of the hydrologic systems. The geologic framework was evaluated based on geologic maps of the Placitas and Bernalillo 7.5 minute quadrangles (Connell et al., 1995; Connell, 1998), and stratigraphic sections measured and described by Picha (1982) and Menne (1989). A hydrogeologic model was developed that describes potential stratigraphic and structural controls on the flow of ground water, the continuity of water-bearing strata, and ground-water surface-water interactions. The geologic data are combined into one geologic map of the Placitas study area at a scale of 1:12,000 (Plate 1). Measured stratigraphic sections and detailed lithologic descriptions from the Placitas area (Menne, 1989) and the nearby Hagan basin (Picha, 1982) are integrated into a single hydrostratigraphic column that describes the sequence, thickness, lithologic character, and aquifer potential of all geologic formations in the Placitas study area (Figure 6). A map of the subcrop geology (Plate 2) facilitates interpretation of subsurface geologic data, and illustrates the spatial distribution of aquifers and aquitards. This map is extremely useful for identifying aquifers of completion for ground-water wells, determining locations of target aquifers, and generally providing a detailed geologic framework for interpreting other hydrologic and geochemical data. The geologic data are also presented in psuedo-three dimensional view in multiple hydrogeologic cross-sections (Plate 3). Subsurface geologic data from water well records were used in construction of both geologic cross-sections and the subcrop geologic map in order to constrain locations of buried faults and stratigraphic contacts. The hydrologic and geochemical data are interpreted within this geologic framework to support hydrogeologic interpretation of the regional ground-water systems.

A. Domestic Well Data and Well-Numbering System

All subsurface geologic, hydrologic and geochemical data collected during this project originated from private domestic and commercial water wells in the Placitas area. Well records from the New Mexico Office of the State Engineer (NMOSE) were reviewed and organized by township, range, and section. Access to private wells was obtained with the permission and cooperation of area landowners. Well owners provided verification of well record, well construction, and well status. Each well was verified through a field check and located using a differential global positioning system (GPS) that provided horizontal coordinates within plus or minus 2 meters, and vertical elevation within plus or minus 7 meters. In a few instances where GPS locations were not feasible, locations were obtained from the U.S. Geological Survey (USGS) 10-meter digital elevation model. Accurate well location data, specifically elevation data, are critical to interpretation of the hydrologic and geochemical data collected from these wells. Because this study relied on access to existing wells, the well coverage tends to be clustered in areas with a greater degree of development, and where access was obtainable. Considerable effort was made to obtain well access in areas with few existing wells to achieve a representative well coverage. All wells utilized during this study are identified with a well identification number (PW- ###), and compiled with their location coordinates in Appendix A (Placitas Data Inventory). All data collection points, including domestic wells, springs, precipitation stations, stream gage stations, and surface water quality stations, are also located on a topographic base map of the Placitas study area at a scale of 1:24,000 (Plate 4), and on the geologic maps (Plates 1A and 2). Well construction and aquifer of completion for each well are compiled in Appendix B (Well and Spring Data).

In addition to providing geographic coordinates for each well, a local identification number is assigned to each well and spring in Appendix B. The system of numbering used for this identifier is based on the common subdivision of land into township, range, and section in the public land-survey system. In land grants, well numbers are based on a projected township, range, and section. The well numbers consist of four parts separated by periods (Figure 2). The first part is the township number, the second part is the range number, the third part is the section number, and the fourth part includes up to four digits that denote, within the section, the particular quarter tract in which the well is located. The method of subdividing quarter tracts within a section is as follows:

- The section is first divided into four quarters, numbered 1 through 4 for the northwest, northeast, southwest, and southeast quarters, respectively. This 160-acre quarter section provides the first digit of the fourth part of the well number.

- Each quarter section is then subdivided in the same manner into progressively smaller quarter tracts, for up to four divisions. If less than four subdivisions are made, then the last digits are occupied by a “0”.

Thus, well 13N.5E.24.1244 is located in the SE1/4 of the SE1/4 of the NE1/4 of the NW1/4 of section 24, Township 13 N., Range 5 E. (Figure 2). This numbering system locates a well within 330 feet in north and east directions.

B. Hydrologic Data

Precipitation, spring and stream data were collected to document the surface-water resources of the Placitas area. Precipitation data for seven historic and one active NOAA (National Oceanic and Atmospheric Administration) weather stations and one private station were compiled. In addition, a network of seven precipitation collection stations was established in and around the Placitas area to monitor and collect precipitation in the local watersheds. Precipitation data are presented in Appendix C. All known perennial springs were mapped and located using differential GPS. Spring discharge data were compiled and are presented in Appendix D (Spring and Stream Discharge Data). Watersheds, and perennial and ephemeral reaches of streams were mapped, and stream discharge was measured at seven locations along perennial reaches of Las Huertas and San Francisco Creeks (Figures 9, 14, Appendix D). These various surface water sites are included in the data inventory (Appendix A and Plate 4) and bear a unique identification number as follows: precipitation collection station (PPT- ##), spring (PS- ##), surface water quality (PSW- ##), and stream discharge station (PGS- ##).

Accurate measurements of depth to ground water in area wells, including repeat measurements of water levels over time, was a primary data objective of this project. Water levels were measured bimonthly in a monitoring network of 51 wells from March 1997 through August 1998. Some wells do not have a full 17 months of water level data as they were added to the network during the course of the project. Locations of wells in the monitoring network were obtained using high-resolution GPS that provided vertical and horizontal accuracy of plus or minus one centimeter. A database of 185 water-level measurements was compiled from the following sources and is presented in Appendix E (Water Level Elevation Data):

- 59 direct measurements taken during this study
- 30 water levels obtained from locations of springs and artesian wells

- 16 measurements taken by private geologists and compiled from unpublished technical reports
- 60 water levels from NMOSE field checked well records
- 20 historic water levels obtained from the USGS Ground Water Sites Inventory (GWSI) database

These water-level data were contoured through an iterative process involving the overlay of water level, geologic, and topographic data, using ArcView and ArcINFO GIS. Where multiple wells with different depths of completion were located adjacent to one another, the measurement from the shallowest well was selected for contouring. The product is a potentiometric-surface map of the area's aquifers that reflects the influence of elevation, aquifer type, and hydrogeologic boundaries (Plates 6 and 7).

Changes in water levels in monitoring wells were evaluated on an annual basis over the time period August 1997 to August 1998. Long-term changes were also evaluated by comparing a water-level measurement taken during this study with a historical water level (from a NMOSE well record or consultant's report) measured during a similar seasonal period at least three years prior. The resulting water level rises or declines are mapped and presented with the potentiometric surface in Plates 6 and 7, respectively. Seasonal water-level changes and other short-term trends are also shown on well hydrographs constructed for each monitoring well, and presented at the end of Appendix E. Seasonal water-level changes reflect the short-term dynamics of an aquifer system, and help define aquifer recharge areas as well as short-term impacts due to drought and ground-water withdrawal. Long-term water-level fluctuations reflect changes in the aquifer that occur over a time interval of three years or longer, but because the data reflect varying periods of time, interpretations of the long-term data require care. Long-term trends help identify geographic areas that consistently reflect a rise or decline in water levels, and thus are a good indicator of aquifers that have been stressed by over-development.

C. Geochemical and Water Quality Data

Another primary data objective of this project was to map the spatial distribution of water quality. These data are used to characterize the overall quality and potability of ground water for domestic and other uses, and to identify aquifers having waters of substandard quality. Also, specific, naturally occurring chemicals in ground water can be used to characterize a chemical signature that may be unique to waters originating from different sources and following distinct flow paths. These ground-water tracers are used to identify recharge sources, confirm ground-water flow paths, and evaluate ground-water residence times in the various aquifers. Water samples were collected from 7 surface-water locations, 83 wells, and 13 springs representing all the major, productive hydrostratigraphic units. A few hydrostratigraphic units with limited well access and productivity are not represented. Water samples were analyzed for field parameters (temperature, conductivity, pH, and dissolved oxygen), major ions, select trace elements, and oxygen and hydrogen isotope ratios. Samples were also collected from 11 wells and one spring for tritium and carbon-14 age determination. Private well owners and the USGS (GWSI database and N. Plummer, unpubl. data 1997) provided geochemical data from an additional 15 well and spring sites. Precipitation samples were also analyzed for oxygen and hydrogen isotope ratios. Sampling and analysis protocols are described in detail in LeFevre (1999). Results of water quality sampling are reported in Appendix F (Major Ion Geochemistry), Appendix G (Stable Isotope Geochemistry and Field Parameters), and Appendix H (Trace Element Geochemistry).

III. HYDROGEOLOGIC FRAMEWORK

A. Geographic, Physiographic, and Geologic Setting.

The Placitas area occupies the northern flank of the Sandia Mountains and the eastern margin of the Albuquerque Basin (Figure 3). It is a region of diverse topography, landforms, vegetation, and climate Elevations range from over 10,000 ft at Sandia Crest to about 5100 ft at the mouth of Las Huertas Creek in the Albuquerque Basin. The most significant topographic relief in the study area occurs along the north-trending limestone salients of Cuchilla Lupe and Crest of Montezuma, which straddle the southern and eastern boundaries. These ridges are separated by Las Huertas Canyon, which drains most of the northern Sandia Mountains. Cuchilla de San Francisco, a northern extension of the Crest of Montezuma, extends along the eastern edge of the study area to the northern boundary with San Felipe Pueblo. Topographic relief along these ridges ranges from 1000 ft on the Crest of Montezuma, to 500 ft on Cuchilla Lupe, and 400 ft on Cuchilla de San Francisco. Over 4000 ft of relief exists between the Village of Placitas and Sandia Crest, the highest elevation landform in the Las Huertas Creek watershed. The central portion of the study area consists of rolling hills and piedmont, dissected by several arroyos. The northern and western portions of the study area lie entirely within the Albuquerque Basin.

Vegetation is sparse in most of the study area, except near springs and along perennial reaches of streams where dense cottonwood, willow, and a variety of wetland vegetation grow. Grasses dominate in the lower altitudes. Piñon, juniper, and scrub oak are found at intermediate elevations on upper piedmont slopes and low elevation foothills. Mixed conifer and aspen forests cover the higher elevations of the Sandia Mountains (Williams and McAllister, 1979).

Placitas has a warm, arid to semi-arid climate with significant seasonal and elevation contrasts. Mean annual temperature ranges from 57 ^{o}F (14 ^{o}C) in the lowest regions, to 50 ^{o}F (10 ^{o}C) in the foothills, and 40 ^{o}F (4 ^{o}C) at Sandia Crest. Average annual precipitation ranges from 8 to 10 inches in lowland areas, 10 to 14 inches in the foothills, and 20 to 25 inches at Sandia Crest (National Climatic Data Center, 2000). Most of the area's precipitation is produced between April and September by convective storms originating from tropical Gulf of Mexico air masses. Winter precipitation is principally caused by orographic uplift of cool, moist polar-Pacific air masses. Precipitation during spring and autumn can be from either source (Dorroh, 1964).

Placitas straddles the eastern margin of the Rio Grande Rift. Rift-margin structures, including the Rincon, Placitas, and San Francisco faults, juxtapose east- and north-tilted blocks of older Proterozoic, Paleozoic, and Mesozoic crystalline and sedimentary rocks against upper Cenozoic sediments of the Albuquerque Basin. Three distinct physiographic zones are identified based on these structural boundaries, each with unique geologic, hydrologic, and topographic characteristics (Figures 3 and 4). The mountain zone encompasses higher elevations in the Sandia Mountains, east of the San Francisco fault and south of the Placitas fault. This region has steep topographic relief, and is composed of fractured Proterozoic crystalline rocks and Pennsylvanian limestones and sandstones. Surface water and springs are both perennial and ephemeral and ground water exists in primarily fractured aquifers. The Sandia Mountains, the Crest of Montezuma, Cuchilla Lupe and Cuchilla de San Francisco are prominent features in this physiographic zone. The Mesozoic ramp occupies the foothills between the Placitas fault zone and the Cretaceous-Tertiary unconformity. This region of complexly faulted, and north- to northeast-tilted blocks of Permian and younger Mesozoic strata is bounded by the Rincon and Ranchos faults on the west, and the Suela and Placitas faults on the east. Streams are ephemeral except where fed by perennial springs, and ground water exists in a complex network of compartmentalized aquifers. The remainder of the study area west of the major rift-margin faults is a part of the Albuquerque Basin. The basin zone includes dissected piedmont slopes that extend to the Rio Grande floodplain. These physiographic areas also define the three major hydrogeologic systems described later in this section.

B. Stratigraphy and Hydrostratigraphic Units

A nearly complete Proterozoic to Holocene stratigraphic section is exposed in or near the Placitas study area. The stratigraphic units are depicted with their time dimension in Figure 5, a composite stratigraphic chart. Extensive faulting exposes only portions of the stratigraphic section at any one location. Menne (1989) and Picha (1982) developed detailed, quantitative descriptions of the bedrock formations in Placitas by measuring and describing sections of exposed rock. Basin-fill deposits have been mapped and described in detail by Connell, Koning and Cather (1999), Connell (1998), Connell et al. (1995), and Kelley (1977). Hydrogeologic interpretation of this stratigraphy is summarized in a detailed hydrostratigraphic column (Figure 6) which describes each formation, the thickness of its component units, its lithologic character, and its aquifer potential. Each hydrostratigraphic unit constitutes a definable body of rock with considerable lateral extent that forms a reasonably distinct aquifer having unique hydrologic properties. The following discussion presents a brief description of each unit, from youngest to oldest, and its hydrogeologic significance in the region.

1. Cenozoic Formations

The Quaternary-Tertiary Santa Fe Group comprises the major basin fill deposit in the Albuquerque Basin and has been variously subdivided into upper (Sierra Ladrones Formation), middle (Middle Red Formation), and lower (Zia Formation) units (see Connell, Koning and Cather (1999) for comparative stratigraphic nomenclature). Santa Fe Group sediments in the Placitas area are derived from three depositional sources, the Sandia uplift, the Jemez uplift, and the ancestral Rio Grande, and are divided into individual mappable units based on age, depositional origin and textural facies (Cather, 1997). Axial-fluvial deposits originated from deposition of channel and floodplain sediments by the ancestral Rio Grande. Piedmont deposits are derived from erosion of Paleozoic and Mesozoic rocks of the Sandia uplift, and redeposition as coarse-grained alluvial fan deposits on the flanks of the Sandia Mountains. The Loma Barbon member of the Arroyo Ojito Formation (Connell, Koning and Cather, 1999) originated from erosion and redeposition of sediments derived from the flanks of the Jemez Mountains and the western margin of the Santo Domingo Basin. Each of these three depositional units has been individually mapped on the surface and is distinguishable in the subsurface based on textural, color, and petrographic qualities. Each depositional unit also possesses unique hydrologic properties and is therefore described separately below.

(a) ***Upper Santa Fe Group axial-fluvial deposits (QTsa)*** occupy a relatively narrow strip along the western margin of the study area (Plate 2). Axial-fluvial deposits consist of variable proportions of sand and gravel, with thin interbeds of mud, and are relatively coarse-grained, well sorted, and weakly cemented. Thickness in the Placitas area is an estimated 2,000 to 2,500 ft. These deposits form the most productive aquifers in the Albuquerque Basin.

(b) ***Santa Fe Group piedmont deposits (QTsp and Tsp)*** occupy a broad zone along the eastern margin of the Albuquerque Basin (Plate 2) and range from local boulder and cobble conglomerate along the basin margin, to interbedded gravelly sandstone,

sandstone, and siltstone to the west. Mudstone is rare. The deposits are divided into four lithofacies (Cather, 1997) based on relative amounts of gravel and sand:

(1) Conglomerate ($QTsp_c$ and Tsp_c), with a conglomerate to sandstone ratio greater than 2, subordinate coarse to very coarse sand, and very rare mudstone;
(2) Conglomerate/sand ($QTsp_{cs}$ and Tsp_{cs}), with subequal proportions of conglomerate and sandstone, and rare mudstone;
(3) Sandstone ($QTsp_s$ and Tsp_s), with a conglomerate to sandstone ratio less than 0.5, and subordinate siltstone; and
(4) Fine-grained deposits ($QTsp_{sm}$) with subequal proportions of siltstone and mudstone.

Tertiary Lower Santa Fe Group piedmont deposits are in contact with Quaternary-Tertiary Upper Santa Fe Group piedmont deposits across the Ranchos, Lomas, and Escala faults. Piedmont deposits generally have lower permeability and porosity than axial-fluvial deposits, but the coarse-grained lithofacies still provide substantial quantities of high quality water. Transitional fluvial-piedmont deposits occupy a zone of overlap between the easternmost outcrops of axial-fluvial deposits and the westernmost outcrops of piedmont sandstone and conglomerate, wherein axial and piedmont deposits interfinger.

(c) ***Loma Barbon member of the Arroyo Ojito Formation (QTob)*** occupies the subsurface beneath the current Rio Grande floodplain and a narrow strip on the western margin of the study area (Plate 2). It consists mostly of fine-grained silty sandstone with interbedded mudstone. It is a fine-grained deposit, well consolidated, and weakly to moderately cemented, and thus it does not produce either as high a quality or quantity of water as other Santa Fe Group deposits.

Other Quaternary deposits are present in the study area, including recent valley-fill and piedmont-slope alluvium, colluvium, landslides and eolian deposits. These units form a thin veneer overlying older rocks, and have no hydrostratigraphic significance. Quaternary travertine deposits up to 50 ft thick are found at the northern end of Cuchilla de San Francisco and record ground-water discharge from paleosprings (Connell et al., 1995).

Three other lower Tertiary formations, the Espinaso (Te), Galisteo (Tg), and Diamond Tail (Td) Formations, are present in the region but are not exposed within the study area. All three formations are well exposed in the Hagan Basin just east of Placitas, where they unconformably overlie the Cretaceous Menefee Formation. Although these formations are believed to exist in the subsurface beneath Tertiary Lower Santa Fe Group piedmont deposits in the northern portion of the study area (Plate 3, cross-sections B-B’, C-C’, D-D’, and E-E’), they are not considered significant hydrostratigraphic units because of their great depth in the subsurface.

A northeast-striking, near vertical, mafic to intermediate dike of Tertiary age is located about 0.6 mi north of the Village of Placitas (Plates 1A, 1B, and 2). The dike intrudes the Lower Mancos, Hosta-Dalton, Upper Mancos, Point Lookout and Menefee Formations, but is buried by Lower Santa Fe Group piedmont conglomerate. Based on a $^{40}Ar/^{39}Ar$ date of 30.9 ±0.5 million years (W.C. McIntosh, unpubl. 1995), the dike also presumably intrudes other lower Tertiary formations that may be present in the subsurface (Plate 3, cross-sections B-B’, C-C’, and E-E’). The volcanic material is relatively impermeable, and acts as a barrier to ground-water movement.

2. Mesozoic Formations

Exposures of Cretaceous, Jurassic and Triassic formations are found in north- and east-tilted blocks in the Mesozoic ramp, north of the Placitas fault zone, and locally as fault-bounded slivers in the major margin-bounding structures (Rincon, Placitas, and San Francisco faults) (Plates 1A and 2). The major Cretaceous units, in descending order (youngest to oldest), are the Menefee Formation (Kmf), the Point Lookout Sandstone (Kpl), the Upper Mancos Shale tongue (Km_2), the Hosta-Dalton Sandstone (Khd), the Lower Mancos Shale (Km_1), and the Dakota Sandstone (Kd). The Cretaceous units are mostly shales and siltstones, with subordinate sandstones, gypsum, and minor limestone, all of which are faulted and dipping toward the north and northeast. The fine-grained units weather easily, and hence are poorly exposed in valley bottoms and on gentle slopes. Interbedded sandstone units form small resistant ledges and ridges. Only four formations within the Cretaceous exhibit moderate aquifer potential, the Harmon Sandstone member of the Menefee Formation, the Point Lookout Sandstone, the Hosta-Dalton Sandstone, and the Dakota Sandstone (Figure 6). Most (75%) of the Cretaceous section consists entirely of shales, mudstones and siltstones, with only thinly interbedded sands. Gypsum, coal, and organic material are disseminated throughout much of the low permeability rock. The fine-grained, low permeability sediments produce little or no ground water, and high organic and gypsum contents result in extremely poor water quality (section VI.C). In addition, low permeability shales and mudstones are rotated to moderately steep dips of 30^o to 70^o and oriented primarily perpendicular to the regional hydraulic gradient, retarding movement of ground water into and through the Cretaceous units. The low permeability units behave as stratigraphic barriers to down-dip ground-water movement. Unless the higher permeability sandstone formations (Harmon, Point Lookout, Hosta-Dalton, and Dakota) are in hydraulic connection with a direct source of recharge, they also have limited aquifer productivity.

The Jurassic section includes the Morrison (Jm), Todilto (Jt), and Entrada (Je) Formations, which are exposed in the center of the Mesozoic ramp (Plates 1A and 2). These formations include a significantly greater proportion of sandstone (over 50%) than the overlying Cretaceous units (Figure 6). The sandstones are typically medium- to coarse-grained, weakly cemented, and have moderate porosity and permeability. The Morrison Formation contains several sandstone units, interbedded between mudstone and shale, that provide moderate to poor aquifer potential. The hydrostratigraphic units with the greatest aquifer potential are the Jackpile Sandstone and Westwater Canyon Sandstone members of the Morrison Formation, sandstone interbeds in the Brushy Basin Shale member of the Morrison Formation, and the Entrada Formation, which is a well-sorted eolian sandstone. The Jackpile Sandstone member of the Morrison Formation and the lower portion of the overlying Dakota Sandstone (Kd) probably function as a single hydrostratigraphic unit with similar hydraulic and chemical properties. The Todilto Formation contains organic-rich, fetid limestone and an upper unit of gypsum, both of which degrade the quality of ground water.

The Triassic formations include the Petrified Forest Formation (T_Rcp), the Agua Zarca Formation (T_Rz), and the Moenkopi Formation (T_Rm), all of which are poorly and incompletely exposed at the head of the Mesozoic ramp and in the Placitas fault zone (Plates 1A and 2). The Triassic section is predominantly mudstone and shale of the Petrified Forest Formation, and only about one-quarter of the section includes sandstones that have a moderate to poor aquifer potential (Figure 6). The uppermost Petrified Forest contains approximately 90 ft of sandstone and siltstone that appear to function as a single hydrostratigraphic unit with the overlying Entrada Formation. The remainder of the upper Petrified Forest and the lower Petrified Forest form a thick (1350 ft) section of extremely low permeability mudstone that does not produce sustainable quantities of water or water of acceptable quality. The middle Petrified Forest consists of a small section of medium-grained, moderately cemented sandstone that is layered between the upper and lower mudstone units. The middle Petrified Forest sandstone is the only unit with aquifer potential in this part of the Triassic section, and as a result it is widely developed. The underlying Agua Zarca and Moenkopi Formations consist primarily of sandstone. The contact between the Agua Zarca and the overlying Petrified Forest Formation is gradational, with Agua Zarca sandstones interfingering with red Petrified Forest mudstone. Sandstones in the Agua Zarca Formation are fine- to medium-grained, and extremely well cemented. As a result, the primary porosity of the unit is limited. However, in and adjacent to the Placitas fault zone, the Agua Zarca is highly fractured, and readily transmits significant quantities of good quality water. The Moenkopi Formation is a relatively thin (45 to 100 ft), medium-grained sandstone with subordinate interbedded mudstone, and is exposed only within the Placitas fault zone. The formation has no hydrologic significance; however, its lithologic character should allow relatively unimpeded movement of ground water through the unit.

3. Paleozoic Formations

Exposures of the Permian, Pennsylvanian, and Mississippian formations are found in the Placitas fault zone, at higher elevations in the Sandia Mountains and on nearby cuchillas, and in the bottom of Las Huertas Canyon. The major Permian units, in descending order (youngest to oldest), are the San Andres, Glorieta, Yeso, and Abo Formations. The San Andres, Glorieta and Yeso Formations crop out as fault-bounded slivers and blocks in the Placitas fault zone and in stratigraphic sequence east of Cuchilla de San Francisco. The San Andres Formation consists of thin- to medium-bedded limestone, interbedded with medium-grained, well-cemented, Glorieta-type sandstone. The Glorieta and San Andres Formations probably function as a single hydrostratigraphic unit. Permeability in these well-indurated formations is variable and depends on the presence of fractures and solution features, both of which are observed in the field. The Yeso formation consists primarily of friable, fine-grained sandstone, and depending on grain size and degree of cementation, has a moderate to poor aquifer potential. Due to their location, none of these upper Permian formations form significant aquifers in the Placitas area; however, they are sufficiently porous and permeable to allow relatively unimpeded through-flow of ground water into down-gradient hydrostratigraphic units in the Mesozoic ramp.

The Permian Abo Formation (Pa) crops out in the Placitas fault zone, the San Francisco fault zone, the bottom of Las Huertas Canyon, and the valleys east of the Crest of Montezuma and Cuchilla de San Francisco (Plates 1A and 2). The formation contains subequal proportions of reddish-brown mudstone/siltstone (70%) and sandstone (30%), with the lower two-thirds consisting primarily of fine-grained mudstone (Figure 6). The lower contact with the Madera Formation is slightly gradational and interfingering, with about 20% limestone units interbedded in reddish-brown mudstone over the lower 80 ft. Due to faulting, the entire formation is never exposed at one locality in the Placitas area. Accordingly, it is difficult to discern where in the section any specific exposure or well is situated. In the southern end of Las Huertas Canyon, geologic logs from well records indicate the last mudstone beds are encountered at 50 to 100 ft below the surface. At the northern end of Las Huertas Canyon, ground-water wells are completed entirely within the Abo Formation. The Abo Formation is in fault contact with the underlying and up-gradient Madera Limestone across the Suela fault, the East and West Las Huertas Canyon faults, and the South Montezuma fault. Because of its low permeability relative to the adjacent Madera Formation, Abo Formation mudstone generally behaves as a stratigraphic barrier, restricting flow of ground water from the Madera Limestone.

The Pennsylvanian Madera Limestone (|Pm) is the dominant unit and aquifer of the Sandia Mountains, and forms the eastern and northern dip slopes of the Sandias, Cuchilla Lupe, Crest of

Montezuma, and Cuchilla de San Francisco (Plates 1A and 2). The Madera Limestone is in fault contact with upper Permian and lower Triassic units across the Placitas fault zone, and is juxtaposed against the Abo Formation at other faults as mentioned above. The formation consists of a lower member of massive limestone, and an upper member of limestone, shale, and arkosic sandstone (Figure 6). The upper member is lithologically more heterogeneous than the lower member, consisting of just over 50% limestone, 30% shale and 15% coarse sandstone. The limestone forms fractured aquifers where ground water moves primarily through solution-enlarged fractures, bedding planes, and fault-related fracture systems. Thick units of shale in the upper member may hydraulically isolate permeable limestone units or limit cross-flow between them. Aquifer tests in the lower limestone member indicate that although the fracture component of the aquifer transmits most of the ground water, the majority of aquifer storage is provided by pore space in the rock matrix (Johnson, 1999). Thus, the character of the Madera aquifer is a unique, dual porosity system, with a component of quick flow through the fractures, and a slower, baseflow component moving through the rock matrix. This dual porosity, fractured character manifests extreme heterogeneity and anisotropy, whereby large volumes of ground water are transmitted through interconnected fractures, sometimes rapidly and over great distances, but dry holes are also common. The Madera Limestone is certainly the most important hydrostratigraphic unit in the study area, and is responsible for transmitting large quantities of young ground water, generated from winter snowpacks high in the Sandia Mountains, to the Placitas area.

The Pennsylvanian Sandia Formation (|Ps) and the underlying Mississippian Arroyo Peñasco Formation (Ma) are relatively thin units, and have limited exposure in the Placitas area (Plates 1A and 2). The Sandia Formation is a sequence of interbedded, well-cemented sandstone, limestone, and shale underlying the Madera Limestone (Figure 6). The formation is likely a fractured aquifer, similar to the Madera, and the two formations probably behave as a single hydrostratigraphic unit. Titus (1980) showed that water from these formations is chemically indistinguishable, supporting such a hydraulic connection. The Mississippian Arroyo Peñasco Formation is a discontinuous unit of sandstone and limestone with little hydrologic significance.

4. Proterozoic Formations

Proterozoic crystalline rocks form the core of the Sandia Mountains, and are exposed in the southern portion of the study area, south of the Placitas fault zone and at the base of the Crest of Montezuma (Plates 1A and 2). The core of the Sandia Mountains consists of mixed metamorphic rocks and the Sandia Granite, which have no primary porosity or permeability. However, faults, fractures, and a weathered zone at the unconformity between the Sandia Granite and the overlying sedimentary rocks, create high permeability zones that may be important in transmitting ground water from higher elevations in the Sandia Mountains to the study area.

C. Structural Elements

Over a dozen major faults, including the Rincon, Placitas, and San Francisco faults, and numerous minor faults have been mapped in the Placitas area (Figure 4, Plates 1A and 2). These structures exert significant control on the occurrence, movement, and residence time of ground water in the study area. The following discussion briefly describes the major faults and fault systems present in the area, their characteristics, and their affect on movement of ground water.

1. Hydraulic Effects of Faults

Faults can act as either barriers, non-barriers, or conduits to ground-water flow depending upon whether the fault zones are less permeable, similarly permeable, or more permeable than the adjoining aquifers. In turn, the permeability of fault zones depends on many factors, including fault displacement, rock lithology, and three dimensional fault zone geometry (Caine et al., 1996). Fault zones are composed of a central fault core, where most of the displacement is accommodated, and an adjacent damage zone. The presence, width and distribution of each component control fluid flow within and near the fault zone (Caine et al., 1996). The fault core, when present, can contain a single slip surface, clay-rich gouge zones, breccia zones, and/or extremely well-indurated zones (regions hardened by extreme pressure or cementation). The presence of gouge, breccia, and/or mineral cements generally reduces fluid flow properties (permeability, porosity, and storativity), and creates fault cores with lower porosity and permeability than the adjacent rock. Such faults act as barriers or partial barriers (combined conduit-barrier) to fluid flow.

A damage zone may exist adjacent and parallel to the fault core. Damage zones typically include small faults, fractures, cleavage, and small folds, all of which enhance damage-zone permeability relative to the core and nearby undeformed rock. The presence of a high-permeability damage zone causes the fault to behave as a conduit for fluid flow, channeling fluid movement away from both the fault core and the undeformed rock. Such faults are known as distributed conduit or localized conduit faults, depending on the size of the damage zone relative to the total fault zone width. Fault zones that are dominated by a large damage zone (distributed conduit fault) tend to form in coarse-grained, consolidated sedimentary rocks such as limestones, well-indurated sandstones and conglomerates, and in crystalline rocks. Damage zone fracture permeability is estimated at two to three orders of magnitude (100 to 1000 times) greater than undeformed rock (Caine et al., 1996; Huntoon and Lundy, 1979), and four to six orders of magnitude (10,000 to 1,000,000 times) greater than the fault core (Caine et al., 1996; Smith et al., 1990). Such large permeability contrasts are common within a single fault zone, and together with local topography and ground-water gradients, control the dynamics of ground-water movement in faulted, mountainous terrain such as Placitas.

Faults with significant offset can also affect cross-fault permeability by truncating or locally reducing the thickness of permeable units, or by juxtaposing formations with different permeabilities. Permeable windows in an otherwise impermeable fault may occur locally in areas of minimal displacement and little damage. Permeable windows also exist at fault intersections and splays where damage to the protolith is maximized, and the development of fault gouge is minor compared to the amount of fracturing (i.e., a fault core is non-existent or insignificant relative to the adjacent damage zone) (Smith et al., 1990; Caine et al., 1996).

2. Basin-Margin Faults

The Placitas area straddles the boundary between the northern end of the Sandia Mountains and the Albuquerque Basin. Three major, basin-margin faults or fault systems intersect in the area: the Rincon fault, the Placitas fault zone, and the San Francisco fault (Plates 1A, 2, and 3; Figure 4). These basin-margin structures juxtapose east- and north-tilted blocks of older Proterozoic, Paleozoic, and Mesozoic crystalline and sedimentary rocks in the Sandia Mountains, against upper Cenozoic sediments of the Albuquerque Basin. The Rincon fault is a north- to northeast-striking normal fault that forms the western boundary between the Albuquerque Basin and the northern part of the Sandia Mountains. The fault terminates just south of the study area, where it splays into two major faults, the Valley View fault and the Ranchos fault, which then terminate in the northern Albuquerque Basin. Because the Rincon fault lies south of the study area, it does not have a direct influence on ground water in the study area, and is mentioned here only for regional context.

The San Francisco fault forms the eastern boundary of the Albuquerque Basin from Tecolote northward along Cuchilla de San Francisco in the northeastern part of the study area. There are about 5900 to 6900 ft of stratigraphic separation along this moderate-angle, down-to-the-west, normal fault (Woodward and Menne, 1995). The fault juxtaposes Lower Santa Fe Group piedmont deposits against Madera Formation limestone. Fault slivers and blocks of Permian Abo to Upper Cretaceous formations exist within the fault zone near Tecolote, and to the north near old San Francisco Springs Ranch. The southern termination of the fault near Tecolote splays out in two directions, southward into the Las Huertas fault system, and southwestward into the Placitas fault zone.

The Placitas fault zone is a complex system of steeply dipping normal faults that merge with and connect the San Francisco and Rincon faults. The fault zone, which trends northeast along the northern base of the Sandia Mountains, is composed of numerous fault traces that are mostly down-to-the-northwest, with 330 ft to 1600 ft of stratigraphic separation (Woodward and Menne, 1995). Total offset across the fault zone increases southwest to northeast, with from 2800 to 5600 ft of separation at the northeast end, where the fault zone is reduced to a single trace. The fault places Proterozoic through Pennsylvanian rocks on the south against Mesozoic rocks on the north. Permian and Triassic units form blocks within the fault zone. The Placitas fault zone abuts, or merges with, the Rincon fault under basin-fill sediments.

These large-displacement, basin-margin faults, particularly the San Francisco fault and the Placitas fault zone, play a major role in controlling movement of ground water from recharge areas in the Sandia Mountains into the Placitas area, by several mechanisms. Both faults juxtapose rock units of significantly different lithology and fluid properties, and also truncate the up-gradient aquifer. Ground water moving through the highly transmissive Madera Limestone generally encounters lower permeability Mesozoic sediments across the Placitas fault zone, and Lower Santa Fe Group conglomerates across the San Francisco fault. In each case the Madera aquifer is truncated at the fault. Both fault zones are complex, and locally include visible fault gouge, breccia zones and cemented zones in a highly heterogeneous fault core, all of which reduce cross-fault permeability. However, adjacent damage zones are sometimes exposed, and together with crosscutting faults, may create windows for ground-water movement. Tectonic slivers and fault blocks of a wide variety of deformed protolith are typically caught in broader segments of both faults. Because of the extreme heterogeneity of the faults, they are observed to act as either localized barriers, combined barrier-conduit, or distributed conduit faults, depending on location.

3. Las Huertas Fault System

The north-striking Las Huertas fault system has three splays that define the horst and graben structures forming Las Huertas canyon: the Suela fault, the West Las Huertas fault, and the East Las Huertas fault (Plates 1A and 2, cross-section A-A’ of Plate 3, and Figure 4). The Suela fault, a major north-striking, west down, normal fault, forms the western boundary of the Cuchilla Lupe horst. This fault merges with the Placitas fault zone east and northeast of the Village of Placitas, where it separates Madera Limestone from Permian Abo Formation. The Suela fault extends over 5 mi to the south, at least as far as Capulin Peak, were it contributes to a major fault system that forms the upper part of Las Huertas Canyon. The fault intersects Las Huertas Creek approximately 3.5 mi south-southeast of the Village. The eastern boundary of the Cuchilla Lupe horst is formed by the West Las Huertas fault, a steeply dipping, east down, normal fault that places Madera Limestone against Permian Abo Formation. A small, local fault, antecedent to the West Las Huertas fault, cuts the center of the Cuchilla Lupe horst block and is responsible for most of the relief along the east face of the ridge. The East Las Huertas fault, which separates Las

Huertas canyon and the Crest of Montezuma, is a north-striking, moderately (~ 45^{o}) dipping, down-to-the-west normal fault. Up to 3300 ft of stratigraphic separation place Permian Abo Formation in the canyon against Proterozoic and Paleozoic rocks to the east (Woodward and Menne, 1995).

The north-south faults of the Las Huertas system cut the Madera Limestone aquifer and tend to form large damage zones relative to a smaller or non-existent fault core. Although no data exist concerning fractures along the Suela or West Las Huertas faults, major breccia zones have been mapped along faults that are well exposed elsewhere in the vicinity of Cuchilla Lupe, including the East Las Huertas and Apache Canyon faults (Connell et al., 1995). Significant fault-parallel fracture zones up to 10 feet in width have been mapped elsewhere in the Madera Limestone (Picha, 1982). Faults in the Las Huertas system are oriented parallel to the direction of ground-water movement, and are generally observed to enhance ground-water flow in a fault-parallel direction. However, where the faults juxtapose Abo Formation against Madera Limestone, cross-fault permeability may be reduced by the presence of a fault core as well as adjoining lower permeability sediments. In general, these faults behave as localized conduits, distributed conduits, and combined conduit-barriers for ground-water movement.

4. Caballo, Agua Zarca, and Pomecerro Faults

The Caballo fault, together with the Agua Sarca and Pomecerro faults, forms a north-striking fault system that offsets two major blocks of the Mesozoic ramp (Plates 1A and 2, cross-section A-A' of Plate 3, and Figure 4). The Caballo fault, which appears to be the dominant fault, extends through the entire section of Mesozoic sedimentary rocks in the central part of the study area, then continues northward into Santa Fe Group sediments and dies out. All three faults cut the Placitas fault zone, and terminate to the south in Proterozoic crystalline rock or Pennsylvanian limestone. North of the Placitas fault zone the Agua Sarca and Pomecerro faults intersect the Caballo fault. All three faults exhibit normal, west down movements, dip steeply to the northwest, and have left separation. Stratigraphic separation across the Caballo fault ranges from about 70 ft south of the Placitas fault zone, up to 2300 ft north of highway 165 (Woodward and Menne, 1995). Stratigraphic separation across the Agua Sarca fault is difficult to determine, but is believed to be over 600 ft south of the Placitas fault zone, and between 120 and 660 ft to the north (Woodward and Menne, 1995). Stratigraphic separation across the Pomecerro fault is about 300 to 600 ft south of the Placitas fault zone. North of the Placitas fault zone, the Pomecerro fault has two splays, the westernmost terminating in the Placitas fault zone. The eastern fault has up to 500 ft of stratigraphic separation, which increases north of the Placitas fault zone to about 1600 to 2000 ft at its junction with the Caballo fault (Woodward and Menne, 1995).

The Caballo fault system is the most significant structure affecting ground-water movement within the Mesozoic ramp. This fault system, in combination with the layered stratigraphy, is responsible for the extensive compartmentalization of aquifers in the area. However, because this fault system cuts the Placitas fault zone and joins permeable rock units across the fault at certain locations, it also creates permeable pathways through which ground water can flow from recharge areas in the Sandia Mountains into aquifer units in the Mesozoic ramp. Where the faults cut well-cemented sandstones and limestones such as the Agua Zarca, Moenkopi, Glorieta and San Andres Formations, they are expected to generate well-developed damage zones that also facilitate movement of ground water.

5. Basin Faults

Several moderate angle normal faults cut Santa Fe Group sediments within the Albuquerque Basin, and affect ground-water movement, occurrence and residence time in the basin aquifers. The north-striking Ranchos and Valley View faults are splays of the Rincon fault. The Ranchos fault is the eastern splay of the Rincon, and forms the western boundary of the Mesozoic ramp (Plates 1A and 2, cross-section A-A' of Plate 3, and Figure 4). The Ranchos fault is a low angle (~45^{o}) normal fault, with west down movement. It places Triassic through Tertiary Lower Santa Fe Group sediments on the east against Tertiary-Quaternary Upper Santa Fe piedmont alluvium on the west. The Valley View fault, the western splay of the Rincon, steps out from the Ranchos fault and follows a similar northeast strike through the basin. The small, fault-bounded block of Santa Fe Group piedmont deposits between the Ranchos and Valley View faults is believed to be relatively thin. The Lomas and Escala faults down-drop Upper Santa Fe piedmont deposits against Lower Santa Fe piedmont deposits. The Lomos fault is oriented east-west between the northern ends of the Ranchos and Caballo faults. The Escala fault strikes north from the east end of the Lomos fault along an escarpment in the northeast part of the study area. Large-displacement faults in unconsolidated sediments, like the Valley View and Escala faults, generally act as barriers to ground-water flow (Heynekamp et al., 1999).

6. South Montezuma Fault

The South Montezuma fault is an east-striking, steeply dipping reverse fault that forms the northern boundary of the Crest of Montezuma (Plates 1A and 2, and Figure 4). The fault drops Abo Formation about 300 to 1000 ft down on the north against Madera Limestone on the south. The western end of the South Montezuma fault terminates against the East Las Huertas fault, and/or the San Francisco fault, at Tecolote. The down-dropped block of low permeability Abo Formation on the north side of the South Montezuma fault forms a constriction in the Madera Limestone aquifer east of Tecolote, and may restrict large-scale movement of ground water north along Cuchilla de San Francisco. Intersection of the South Montezuma fault with the Las Huertas fault system and the San Francisco fault at Tecolote, contributes to the complexity of the damage zone in that area.

7. Folds

A structural fold is a curve or bend in a rock unit caused by tectonic deformation. Several minor folds occur in the Placitas area, including the Escala and Lomos synclines, which deform Lower Santa Fe Group deposits in the eastern basin, and smaller scale folds in the Abo and Madera Formations in Las Huertas Canyon and Cuchilla de San Francisco (Plates 1A and 2, cross-section C-C' of Plate 3). Folds, like faults, can either facilitate or restrict the movement of ground water depending on the spatial orientation of the fold relative to ground-water flow direction. Where a fold is oriented perpendicular to the direction of ground-water movement, it may retard flow by orienting bedding planes at oblique to perpendicular angles to ground-water flow direction, thus reducing permeability in the direction of flow. Alternatively, fold deformation also creates fracture systems parallel to the fold axes, and where a fold axis is oriented parallel to the direction of ground-water flow, fracture permeability and ground-water movement are believed to be enhanced (Levens et al., 1994).

D. Hydrologic Systems

Geologic formations and structures constitute the plumbing of a hydrologic system, and a combination of recharge and elevation gradient provides the force that drives ground-water flow through the system from areas of recharge to areas of discharge. Conceptual models of the major aquifer systems in the Placitas area are developed from the stratigraphic and structural elements discussed in the previous two subsections. These conceptual models are simplified, plausible descriptions of the hydrologic systems based on current understanding of hydrogeologic data and knowledge of physical properties. The Placitas study area is divided into three major conceptual hydrologic systems (Figure 7) based on physiographic regions described in section III.A: (1) the mountain hydrologic system, (2) the Mesozoic ramp, and (3) the Albuquerque Basin. Each area possesses unique geologic, hydrologic, and topographic characteristics, and constitutes a unique hydrologic system. Based on hydrologic and hydrogeochemical data presented in subsequent sections, each hydrologic system is further subdivided into hydrogeologic zones with similar types of aquifers, water quality, and ground-water residence times. These hydrogeologic zones are described here for organizational clarity (Plate 5). Conceptual models of the hydrologic systems and hydrogeologic zones describe the hydrostratigraphic units, geologic controls on ground-water flow, continuity or compartmentalization of aquifers and flow pathways, recharge and discharge areas, recharge mechanisms, ground-water residence times, and water quality.

1. Mountain Hydrologic System

The mountain hydrologic system (Figure 7) includes the higher elevations east of the San Francisco fault and south of the Placitas fault zone within the drainage basins of upper Las Huertas Creek and upper Arroyo de San Francisco. The principal aquifer and hydrostratigraphic unit in the mountain system is the Pennsylvanian Madera Formation. Adjacent formations that may or may not be hydraulically connected with the Madera include Precambrian crystalline rocks, and Abo Formation. The Madera Formation is a fractured carbonate aquifer consisting primarily of massive limestone, with minor amounts of sandstone, siltstone and shale (section III.B.3). The Madera Formation caps the top of the Sandia Mountains, and forms the prominent north-trending ridges that extend northward into the Placitas area, including Cuchilla Lupe, the Crest of Montezuma, and Cuchilla de San Francisco. Madera Formation beds generally strike north to northeast, parallel to the ridges, with eastward dips ranging from 7 to 20 degrees. A number of major north-striking faults, including the Suela, Pomecerro, West Las Huertas, East Las Huertas, and Apache Canyon faults (section III.C), cut through the Madera Limestone for significant distances and are responsible for most of the relief between ridges and valleys of the Las Huertas and San Francisco drainages. The formation transmits water derived from infiltration of high elevation snow pack, precipitation, and surface runoff, and constitutes a major recharge area for the Placitas region. Where surface water flows across the Madera Formation in upper Las Huertas Canyon, it is observed to rapidly infiltrate into the formation (J. Brekhus et al., unpubl. report for University of New Mexico, Public Administration 573, 1991). Numerous large springs discharge significant volumes of ground water from faults in Madera Limestone, where the limestone is in contact with lower permeability formations across the Placitas fault zone, such as the Abo or Petrified Forest Formations. Numerous springs also discharge from the Madera Formation at the toe of Cuchilla de San Francisco, where the Madera aquifer is truncated by the San Francisco fault. Extensive Quaternary and Tertiary travertine deposits (QTt) located at the northern end of Cuchilla de San Francisco (Plates 1 and 2), indicate that ground water has been actively discharging from the Madera Formation at this location for millions of years.

Ground-water flow in the Madera Limestone is localized along discrete fractures and bedding planes that have been enlarged by dissolution of the carbonate in ground water. The primary controls for ground-water movement are fracture systems associated with major faults, and to a lesser degree, openings along bedding planes and minor faults. The major fault-related fracture systems are oriented parallel to the regional topographic gradient, the hydraulic gradient, and the strike of the limestone beds, and are continuous for long distances. These fracture systems form highly permeable zones that concentrate ground-water movement through the Madera Formation. Ground-water flow is thus concentrated along discrete fractures in the limestone matrix, rather than occurring uniformly through interconnected pores as in sandstone. The unfractured limestone matrix has negligible permeability and porosity, whereas the fractures have extremely high permeability. The formation transmits large quantities of high-quality water, as evidenced by large-volume springs and wells, but as a whole it has very little storage capacity. High transmissivity and low storage are characteristics of both fractured and carbonate aquifers, and clearly describe the Madera Formation. As a result, the Madera aquifer is particularly difficult to characterize. Both dry holes and wells that produce as much as 100 gal/min are encountered in close proximity when drilling in the Madera Formation.

In summary, Madera Formation limestone controls ground-water movement within and through the mountain hydrologic zone. The limestone forms a fractured aquifer with high transmissivity, and low storativity, where ground-water flow is localized along faults, fracture systems, and bedding planes. Madera Limestone also constitutes the major recharge area of the northern Sandia Mountains, and transmits ground-water recharge to the Placitas area primarily along fault-related fracture networks. Cuchilla Lupe forms the primary fault-controlled, carbonate aquifer system that transmits water on a seasonal basis from high elevation recharge areas to discharge at the Placitas Village springs. Carbonate aquifers underlying the Crest of Montezuma and Cuchilla de San Francisco appear to operate in a similar fashion, but on a much longer flow path, and much longer time scale.

The mountain hydrologic system is further subdivided into four hydrogeologic zones, M1 through M4, according to unique characteristics of hydrostratigraphic units, recharge sources and mechanisms, water quality, and ground-water residence time (Plate 5). Hydrogeologic zone M1 encompasses the north slope of the Sandia Mountains south of the Placitas fault zone, and includes the Madera Limestone of Cuchilla Lupe, Dome Valley, and upper Las Huertas Canyon. Zone M2 encompasses the Crest of Montezuma and Cuchilla de San Francisco, the northernmost limestone salients of the northern slope of the Sandia Mountains, which are disconnected from Cuchilla Lupe by the Las Huertas Canyon and South Montezuma fault systems. A narrow strip of terrain that comprises the San Francisco fault zone north of Tecolote is also included within Zone M2. Zone M3 includes the Abo Formation along Las Huertas Creek and a section of the San Francisco fault near Tecolote. Zone M4 encompasses the area east of Cuchilla de San Francisco (eastern highlands), most of which lies outside the study area.

2. Mesozoic Ramp Hydrologic System

The Mesozoic ramp occupies the foothills between the Placitas fault zone on the south and east, the Ranchos fault on the west, and the Cretaceous-Tertiary unconformity on the north (Figures 4 and 7). This is a region of complexly faulted, north- to northeast-tilted, blocks of Permian to Cretaceous sedimentary strata, where ground water exists in a complex system of compartmentalized aquifers. The principal aquifers are associated with relatively permeable sandstone units within the Triassic Agua Zarca Formation, the Jurassic Entrada and uppermost Triassic Petrified Forest Formations, the Westwater Canyon and Jackpile Sandstone members of the Jurassic Morrison Formation, and the Cretaceous Dakota, Hosta-Dalton, and Point Lookout Sandstones (Figures 5 and 6, Plates 2 and 3). Each of these hydrostratigraphic units possesses moderate to moderate-poor aquifer potential based on a hydrogeologic interpretation of lithology, and the number and productivity of wells completed in each unit (Figure 6). Each aquifer is stratigraphically isolated by aquitards of mudstone, shale, and siltstone, and by lateral discontinuities produced by through-going north-south faults. Other minor aquifers are associated with thin, very fine-grained sandstone and siltstone that are interbedded within thick, impermeable sequences of mudstone or shale. Such minor aquifers are located within the middle portion of the Triassic Petrified Forest Formation, in the Recapture and Brushy Basin Shale members of the Jurassic Morrison Formation, and in the Cretaceous lower and upper Mancos Shale and Menefee Formations (Figure 6). These isolated units possess poor aquifer potential at best, and also have poor water quality (see section VI.C). Older Permian units, including the Yeso, Glorieta, and San Andres Formations, and the Triassic Moenkopi Formation all possess lithologies with moderate aquifer potential, but crop out only in isolated blocks within the Placitas fault zone and outside the study area. Hence they are hydrologically significant only as units that may transmit water from the Madera Limestone, through the Placitas fault zone, and into aquifers in the Mesozoic ramp.

The structural orientation of sedimentary layers dramatically affects movement of ground water into and through geologic formations in the Mesozoic ramp. Tectonic movement along the Placitas fault zone has rotated the Mesozoic strata, so that blocks of strata, and the aquifers and aquitards, exhibit strong north to northeast regional dips (Plates 1 and 3). These layers of sedimentary strata “ramp” down to the northeast, beneath the younger Tertiary sediments of the Albuquerque Basin, hence the name “Mesozoic ramp”. Regional dips range from 20 to 50 degrees to the north-northeast in the Permian, Triassic, and Jurassic units in the south half of the ramp, and from 30 to 65 degrees in the Cretaceous units in the northern ramp. Dips of up to 75 degrees are measured in the Cretaceous upper Menefee Formation near the contact with overlying Santa Fe Group. This subvertical to nearly vertical orientation of strata produces strip aquifers (Plate 3, cross-section D-D’), as opposed to a vertically layered aquifer system that would otherwise occur if the beds retained their original horizontal orientation. Through-going north-south faults that cut the Placitas fault zone, including the Pomecerro, Agua Zarca and Caballo faults, offset major blocks of the Mesozoic ramp, and further isolate aquifers in a single hydrostratigraphic unit (Plate 3, cross-section A-A’). In a few cases, this faulting may actually adjoin aquifers from different hydrostratigraphic units into a continuous, hydrologically connected, aquifer system. In addition, such faulting typically increases the permeability of well-cemented sandstones through fault-related fracturing. Such circumstances are observed to increase both the hydraulic continuity and permeability of aquifers in limited areas of the Mesozoic ramp.

Recharge to aquifers in the Mesozoic ramp occurs by one of two active mechanisms: (1) subsurface through-flow of young, recently recharged water from the Madera Formation across the Placitas fault zone, or (2) infiltration of surface water from perennial and ephemeral streams that flow across one of the permeable hydrostratigraphic units. Subsurface through-flow across the Placitas fault occurs where aquifer units of adequate permeability are adjacent to the Madera Limestone, or where a continuous, high permeability zone is associated with a through-going north-south fault. Hydrogeologic evaluation identifies three potential locations where such a favorable orientation of permeable units may create a preferential ground-water flow pathway (Plate 2). Two locations are near Rainbow Valley in the southeast quarter of section 1 (T. 12 N., R. 4 E.) and the southwest quarter of section 6 (T. 12 N. R. 5 E.) where Triassic Agua Zarca Formation is faulted in close proximity to Jurassic Entrada Formation. A third location is south of Placitas Heights in the southwest quarter of section 5 (T.12 N., R. 5 E.), where a continuous pathway exists from Madera Limestone, through Permian Santa Rosa Formation and Triassic Agua Zarca Formation, and into the Jurassic Morrison Formation in the central Mesozoic ramp. In addition, through-going north-south faults that cut the Placitas fault zone (Pomecerro, Agua

Zarca, and Caballo faults) may potentially create permeable pathways for subsurface recharge to enter the ramp, even though continuity of permeable formations may not be obvious at the surface. The second recharge mechanism, infiltration of surface water, appears to be active in the channels of all the major streams and arroyos where they cross permeable aquifer units, specifically Arroyo Agua Sarca, Arroyo del Ojo del Orno, Arroyo Suela, and Arroyo del Oso.

In summary, the Mesozoic ramp hydrologic system exhibits a high degree of spatial variability in water quantity, water quality, recharge, and residence time. The hydrologic system consists of isolated strip aquifers separated by mudstone and shale aquitards, and further disconnected by through-going north-south faults. All hydrostratigraphic units possess moderate to poor aquifer potential based on lithology, and are limited in their spatial extent. Active recharge mechanisms allow for limited movement of ground water into the Mesozoic ramp via subsurface through-flow across the Placitas fault zone at three locations, and via arroyo-channel infiltration where stream channels cross permeable aquifer units.

The Mesozoic ramp hydrologic system is further subdivided into four hydrogeologic zones, R1 through R4 (Plate 5). Hydrogeologic zone R1 encompasses the foothills of the northern Sandia Mountains immediately south of the Placitas study area, and includes fault-bounded blocks of Permian Abo Formation through Triassic Agua Zarca Formation exposed within the Placitas fault zone. Zone R2 encompasses the lower foothills of the northern Sandia Mountains along the southern boundary of the study area, and includes the Triassic Petrified Forest Formation. Hydrogeologic zone R3 includes a relatively large area in the central portion of the Mesozoic ramp. This zone exemplifies the compartmentalized aquifer system characteristic of the Placitas area, with nine hydrostratigraphic units, from the Jurassic Entrada Formation up-section to the Upper Mancos Shale Formation, forming subvertical strip aquifers separated and isolated by strip aquitards and faults. Zone R4 encompasses the northern-most portion of the Mesozoic ramp, and includes the Cretaceous Menefee Formation.

3. Albuquerque Basin Hydrologic System

The northern and western two-thirds of the Placitas study area, west of the major rift-margin faults, are part of the Albuquerque Basin hydrologic system. The Albuquerque Basin is one of a series of north-south trending structural depressions of the Rio Grande Rift (Chapin and Cather, 1994) (Figure 8). During rift formation over the past 25 million years, sedimentary and volcanic basin fill deposits have filled the basin to a maximum depth of 15,000 feet in the Albuquerque area (Hawley, 1996). These basin fill deposits comprise the Santa Fe Group, which forms the major aquifer in the basin (section III.B.1). The distribution and lithologic characteristics of the various Santa Fe Group sediments determine the quality of the basin aquifers. The best aquifers are found in the coarser grained, permeable deposits that make up the thin upper layers of the Santa Fe Group. These Upper Santa Fe Group sediments, which were deposited within the last 5 million years by a through-flowing axial river system and erosion from adjacent mountains, form layers that range from less than 1000 feet to as much as 2000 feet in saturated thickness (Connell et al., 1995; Hansen and Gorbach, 1997). Underlying Lower and Middle Santa Fe Group form the bulk of the basin fill, but tend to be fine-grained deposits that produce relatively small amounts of poorer quality water. The only aquifers in the Lower and Middle Santa Fe Group that have the potential for production of large amounts of good quality ground water are buried dune sands and coarse-grained fan-delta deposits beneath northern Rio Rancho and Corrales (Hansen and Gorbach, 1997).

The Albuquerque Basin is further divided into five major fault block depressions, which include in the Placitas area, the Cochiti-Bernalillo Depression (Hawley, 1996; Hansen and Gorbach,

1997) (Figure 8). The Cochiti-Bernalillo Depression is the northernmost depression in the Albuquerque Basin complex, and has previously been called the Santo Domingo Basin. This structural depression begins at Cochiti Dam and includes the segment of the Rio Grande Valley downstream as far as Sandia Pueblo and Rio Rancho. Because of its position at the upper end of the system, the coarsest grained sediments carried by the ancestral Rio Grande have been deposited here. Younger coarse-grained sediments deposited by the active Rio Grande directly overlie the Upper Santa Fe Group axial-fluvial deposits. Because both formations consist of coarse, permeable material, the surface-water and ground-water systems are well connected throughout the entire area (Hansen and Gorbach, 1997).

Structural depressions of the Albuquerque Basin are separated by buried bedrock ridges or other structural highs such as horsts or anticlines, which tend to be bounded by faults and have relatively low permeability. The interbasin boundary zone that separates the Cochiti-Bernalillo Depression from the Metro Area Depression to the south is the Ziana-Sandia Pueblo Dividing Ridge (Figure 8). This structure trends northwest southeast across the basin through Angostura and southeast through Placitas along the drainage divide between Las Huertas Creek and Arroyo Agua Sarca (Hawley, 1996). The Ziana-Sandia Pueblo structural high forms a shallow bench beneath Sandia Pueblo south of the Placitas study area. Gaps in dividing ridges provide high permeability pathways through which ground water can move from one depression into the next. The River's Edge Gap forms a saddle between the Zia anticline and the Sandia Pueblo bench, and provides one such pathway for ground-water movement across the Ziana-Sandia Pueblo Ridge into the Metro Area Depression. This narrow gap extends for about five miles between Corrales and Bernalillo, and contains highly conductive aquifer materials up to 1,500 feet thick. The geometry of these structural depressions, dividing ridges, bounding fault zones, and gaps control the movement of ground water within the Albuquerque Basin aquifer system. In short, the Cochiti-Bernalillo Depression forms an underground aquifer that slowly discharges into the Metro Area Depression through the River's Edge Gap in the buried Ziana-Sandia Ridge (Hansen and Gorbach, 1997).

Recharge to the Albuquerque Basin aquifers results either from subsurface through-flow of ground water from bounding uplifts (the Sandia Mountains for example) across the rift-margin faults, infiltration of surface water from perennial and ephemeral streams, or by inflow from the Espanola Basin to the north. The most active recharge mechanism in the Albuquerque Basin aquifer system is infiltration of surface water through stream and arroyo channels. In general, the most extensive recharge corridor in the Albuquerque Basin is the main channel of the Rio Grande and associated canals and drains (Hawley, 1996; Hansen and Gorbach, 1997). In the Placitas area, smaller recharge windows and recharge reaches are associated with Las Huertas Creek, San Francisco Creek and Arroyo Agua Sarca, where coarse-grained channel deposits are in direct contact with coarse-grained Upper Santa Fe deposits (this report section IV.C; Hawley, 1996; Hansen and Gorbach, 1997). Hydrologic data presented in section V.A indicate that subsurface flow moves into the basin across the San Francisco fault at Tecolote and the old San Francisco Springs Ranch north of Cuchilla de San Francisco. These are significant recharge mechanisms at a local scale within the Placitas area. Through-flow at other locations appears to be negligible.

The Upper Santa Fe Group deposits (section III.B.1) include a northeast-trending strip of axial-fluvial deposits (QTsa) that transition into piedmont deposits (QTsp) to the east, and interfinger with sediments shed from the Jemez Mountains (QTob) to the west (Plate 2). The spatial distribution of axial-fluvial deposits, which form the most productive aquifers in the area, is best illustrated in geologic cross-sections of Connell et al. (1995) and in Plate 3 of this report. Immediately west of the Ranchito fault in the vicinity of the Placitas Trails and Placitas West subdivisions, axial-fluvial deposits form a wedge of coarse-grained sand and gravel about one mile wide and 700 to 1100 feet thick. This axial wedge extends southwest to the River's Edge Gap between Corrales and Bernalillo, and north-northeast into San Felipe Pueblo where it trends approximately parallel to and east of the current Rio Grande floodplain. At the northwest corner of the study area, the axial wedge expands to about 2.75 miles wide and between 2000 and 2500 feet thick.

Axial sediments grade eastward into Upper Santa Fe piedmont deposits (QTsp). Between the Ranchito and Valley View faults in the vicinity of Placitas West and Placitas Homesteads subdivisions, piedmont deposits form a block of relatively permeable gravel and sand about 1.5 miles wide and 2000 to 2500 feet thick (Connell et al., 1995, cross-section A-A'). Further east between the Valley View and Ranchos faults, in the vicinity of Vista de Oro subdivison, this block of piedmont sediments thins to between 700 and 1000 feet (Plate 3, cross-section A-A'). In the north-central portion of the study area, a block of piedmont sediments is wedged between axial deposits to the west and the Escala fault on the east. This block of piedmont sediments is up to 1.5 miles wide and from 2500 to 3500 ft thick (Plate 3, cross-section C-C'). Conglomerates and sandstones in these Upper Santa Fe piedmont deposits are in direct contact with coarse-grained sediments associated with the channel of Las Huertas Creek west of the Escala fault and north of the Lomos fault. Stream flow from perennial reaches of Arroyo del Ojo del Orno and Las Huertas Creek below Tecolote (section IV.C) discharges into this reach of lower Las Huertas Creek. This locality is an important recharge area for the shallow aquifers of the Albuquerque Basin in the areas of Cedar Creek, Placitas North, Juniper Hills, and Placitas Ranchettes.

Lower Santa Fe Group piedmont deposits (Tsp) rest unconformably on Cretaceous Menefee Formation, and cover a relatively shallow bench between the San Francisco and Escala faults (Escala bench), and between the Caballo, Ranchos and Lomos faults (Lomos Altos) (Figure 4, Plates 1, 2 and cross-sections B-B', C-C', D-D' and E-E' of Plate 3). Lower Santa Fe piedmont deposits are generally similar in character to Upper Santa Fe piedmont deposits, except that they are slightly more consolidated, have a greater degree of cementation, and are deformed into broad synclines (Lomos syncline and Escala syncline). These sediments cap Lomos Altos beneath the Overlook subdivision, where they form a relatively thin wedge that measures 1.4 miles east to west, and 1 mile north to south. The maximum thickness is 800 to 1000 feet on the footwall of the Lomos fault (Plate 3, cross-section D-D'). Recharge into this piedmont block occurs along the northeast margin by infiltration of perennial stream flow from Arroyo del Ojo del Orno. The Escala bench is formed by a plunging syncline in piedmont deposits between the San Francisco and Escala faults (Plate 3, cross-sections B-B', C-C', and E-E'). The bench varies from 1.3 to 2 miles wide with an estimated sediment thickness of about 800 feet at Las Huertas Creek and 2600 feet or more to the north. Ground-water discharges from this aquifer along a perennial reach of Las Huertas Creek (section IV.C.1). Water levels become very shallow as ground water moves from east to west through Tecolote and across the Escala bench, eventually discharging into the stream channel. Discharge of ground water along this stream reach occurs in response to a reduction in aquifer thickness. The aquifer thins to the west along the rising limb of the Escala syncline, and probably also due to the inferred presence of the buried Tertiary volcanic dike that is mapped in outcrops to southwest (section III.B.1). Gaining and losing sections of this perennial reach are symmetrical about the projection of the Tertiary dike, and strongly support its presence in the subsurface (Plate 3, cross-section B-B', and section IV.C.1).

The Albuquerque Basin hydrologic system is further subdivided into four hydrogeologic zones, B1 through B4, based on lithologic characteristics, aquifer thickness, recharge sources, ground-water residence time, and water quality (Plate 5). Hydrogeologic zone B1 in the northeast Albuquerque Basin consists of Lower Santa Fe Group piedmont deposits, and is divided into two structural regions, the Escala bench between the San Francisco and Escala faults, and Lomos

Altos (zones B1a and B1b respectively). The eastern margin of the Albuquerque Basin consists of a conglomerate-sand facies of Upper Santa Fe Group piedmont deposits. The region is subdivided into two separate hydrogeologic zones, B2a and B2b, based on aquifer thickness, and sources of recharge. Zone B2a is a thick sequence of Upper Santa Fe Group conglomerate and sand deposited adjacent to the Rincon, Ranchos, and Escala faults. Zone B2b is a relatively thin sequence of Upper Santa Fe Group conglomerate and sand wedged between the Ranchos and Valley View faults (the Ranchos block). Hydrogeologic zone B3 consists of a thick sequence of Upper Santa Fe Group axial river deposits that occupies a narrow strip through the center of the Albuquerque Basin, east of the current Rio Grande floodplain. Hydrogeologic zone B4 is a thick sequence of fine-grained Santa Fe Group sediments, known as the Loma Barbon member of the Arroyo Ojito Formation, that occupies the subsurface beneath the current Rio Grande floodplain.

IV. SURFACE WATER HYDROLOGY

This section provides a general description and inventory of surface-water features and related data in the Placitas area, with a focus on drainage basins, climatic data, spring locations and discharges, streamflow, and ground-water surface-water interactions.

A. Drainage Basins

Perennial and ephemeral streams in the Placitas area occupy three major drainage basins, including Las Huertas Creek, Arroyo Agua Sarca, and Arroyo de San Francisco (Figure 9). Las Huertas Creek, the largest basin, drains most of the northern end of the Sandia Mountains. The drainage basin covers 30.6 mi^2, nearly half of which is contained in the study area. The basin traverses terrain from Sandia Crest at an elevation of 10,678 ft, to the Rio Grande at about 5,000 feet. The basin is subdivided into three subbasins, upper Las Huertas Creek (17.7 mi^2), lower Las Huertas Creek (8.2 mi^2), and Arroyo del Ojo del Orno (4.7 mi^2), each of which contain both ephemeral and perennial stream reaches, and large perennial springs. Las Huertas Creek originates from spring discharge on the northwest face of Capulin Peak and from runoff on Sandia Crest. The creek flows north to Tecolote where it crosses the San Francisco fault, turns west-northwest into the lower Las Huertas Creek subbasin, and continues across the Albuquerque Basin to the Rio Grande. Arroyo del Ojo del Orno, the main tributary to lower Las Huertas Creek, joins Las Huertas about 3 miles west of Tecolote, near the Cedar Creek subdivision. Two acequias operate in the drainage, Las Huertas-La Jara Ditch Association in upper Las Huertas Creek, and Las Acequias of the Community of Placitas in the Arroyo del Ojo del Orno subbasin. Las Acequias of the Community of Placitas relies entirely on spring discharge to irrigate and to operate the domestic water supply system for the Village of Placitas.

Arroyo de San Francisco is a small drainage, the southern half of which covers 3.6 mi^2 at the northeast corner of the Placitas study area. The basin captures runoff from the east side of Cuchilla de San Francisco, before entering the Albuquerque Basin in the vicinity of the old San Francisco Springs Ranch. The channel continues north from the study area onto San Felipe Pueblo, where it turns west and continues towards the Rio Grande before being truncated by the San Felipe east-side ditch, north of Algodones. Arroyo de San Francisco contains both ephemeral and perennial stream reaches.

Arroyo Agua Sarca drains a fairly small watershed (6.0 mi^2), the Canon Agua Sarca, at the northwest end of the Sandia Mountains. The arroyo contains an ephemeral stream channel that carries runoff northwest through Rainbow Valley, Ranchos de Placitas, and onward through the Albuquerque Basin to the Rio Grande.

B. Climatic Data

Total annual and mean monthly precipitation data are compiled for active and historic weather stations operated by the National Oceanic and Atmospheric Administration (NOAA) in the vicinity of Placitas (Appendix C, Precipitation Data). Two active and seven historic stations are located in the area (Figure 10, Table 1). Relatively long periods of record are available for the three combined Bernalillo sites (1889-1982), Sandia Park (1946-present), and Sandia Crest (1953-1979). Mean annual precipitation ranges from 8.7 inches in Bernalillo to 23 inches at Sandia Crest. Winter precipitation (December through March) is concentrated at elevations above about 7000 ft, and varies from 8 inches at Sandia Crest to about an inch in the Hagan Basin (Figure 11, Table 1). Mean monthly precipitation data indicate that 40 to 50% of annual precipitation falls as summer monsoon rain during the months June through September (Figure

12, Table 1). Winter precipitation contributes about 30 to 35% of the annual total at higher elevations (Sandia Crest, Sandia Park, and Placitas nr), and 20 to 25% at lower elevations (Bernalillo, Placitas-4W, and PPT-8).

Precipitation data collected by a private observer in the Village of Placitas between May 1991 and December 1999 (Figure 13) indicate that the Village receives an annual average precipitation of 14.7 inches (PPT-8 in Figure 10, Table 1, Appendix C) (J. Fish, unpubl. 1999). Figure 13 also shows below normal precipitation (64% of normal) for the drought year 1995, when the annual total was 9.49 inches. Successive summer and winter dry periods beginning in summer 1995 and continuing through the following winters of 1996 and 1997 caused this drought. However, successive seasonal dry periods are not uncommon, and the drought was not severe in its overall length.

Annual potential evaporation (PE) in the Placitas area ranges from 17.4 inches at Sandia Crest to 30.9 inches in Albuquerque (Tuan et al., 1969), and is several times greater in the summer than in the winter. The moisture deficit, estimated by subtracting precipitation from PE, can provide a useful perspective of the actual water need. Using the monthly evaporation distribution of Hale et al. (1965), and estimates of annual PE of Tuan et al. (1969), monthly and annual moisture deficits and surpluses can be estimated. This approach indicates that a moisture surplus (precipitation exceeding PE) occurs only during January and February in Albuquerque and totals 0.15 inches for that two-month interval. At Sandia Crest, however, a moisture surplus occurs during summer months of July and August, as well as October through March, for an annual moisture surplus of about 5.4 inches. The highest moisture surplus occurs from December through March. This four-month period yields a moisture surplus of 6.6 inches. This moisture surplus also provides a rough estimate of the upper limit of ground-water recharge rates for high elevations in the Sandia Mountains.

C. Springs and Streams

Most streams draining the major basins in the area are intermittent or ephemeral streams and flow primarily in response to spring snowmelt or heavy storm runoff. However, perennial reaches of streams occur along Las Huertas Creek and Arroyo de San Francisco. In all cases, these perennial reaches are fed by ground water discharging from springs in the Madera Limestone or springs and seeps in the stream channel. Spring-fed perennial stream flows are important resources in the surface water system of the Placitas area. These stream reaches support riparian areas and irrigation, redistribute water between the ground-water and surface-water systems and between otherwise unconnected or poorly connected ground-water aquifers. Identifying gaining and losing reaches of streams, and understanding the geologic factors controlling surface-water ground-water interactions is also critical to mapping discharge and recharge areas of the ground-water system. Spring discharge and stream flows are discussed by drainage basin in the following subsections.

1. Las Huertas Creek

Las Huertas Creek is primarily an intermittent stream, but is perennial through spring-fed reaches in upper Las Huertas Creek, lower Las Huertas Creek below Tecolote, and in its tributary Arroyo del Ojo del Orno (Figure 14). Except during periods of snowmelt and runoff, upper Las Huertas Creek derives its flow from springs that discharge above the Las Huertas picnic area in section 33 (township 12 N., range 5 E.). J. Brekhus and others (unpubl. report for University of New Mexico, Public Administration 573, 1991) gathered stream discharge data at six stations along upper Las Huertas Creek (LH-1 through LH-6, Figure 9 and Table 2), and identified a perennial reach of the creek that flows for approximately 3 miles between these springs and the Las Huertas-La Jara Ditch Association diversion. These stream-flow measurements also indicate that 48% of stream flow in the upper reach is lost to infiltration between the Las Huertas picnic area and the ditch association diversion, where the stream flows over Madera Limestone. Infiltration of surface water is an important source of recharge to the ground-water system in the upper part of Las Huertas canyon. A hydrograph of stream discharge in upper Las Huertas Creek is developed from stream-flow data collected about 0.3 miles south of Sandia Man Cave along NM 165, as part of the New Mexico Game and Fish watershed watch program (Figure 15) (D. Shaw, unpubl. 1999). This hydrograph clearly shows the seasonal nature of flow in Las Huertas Creek and the correlation between stream discharge and spring snowmelt. Discharges of up to 30 ft^3/sec are shown for peak runoff in the month of May, but flows during the remainder of the year are typically less than 2 ft^3/sec (898 gal/min) at this location. Continuous stream flow is usually sustained through most of upper Las Huertas Creek by snowmelt from April through June, and summer monsoon rains may extend continuous flow through August or later. During heavy snowpack years, runoff reaches the Rio Grande.

Spring discharge also sustains perennial flow in a 1.25-mile reach of lower Las Huertas Creek, between Tecolote and the Escala fault. Small springs and seeps discharge from Lower Santa Fe Group piedmont deposits into the channel of Las Huertas Creek beginning about 0.5 miles west of the San Francisco fault, and a single large spring, Rosa de la Castilla spring (PS-8), discharges into the creek 1 mile west of the fault. Perennial stream flow is maintained through this reach until at least the Escala fault. The up-gradient reach of Las Huertas Creek, through lower Las Huertas Canyon and Tecolote, is typically dry except during spring snowmelt and runoff. Stream flow measurements were taken at three locations west of Tecolote (PGS-1, PGS-2, and PGS-3) (Figure 14, Table 2) in January 1998 during a period of no snowmelt or runoff and negligible evapotranspiration. These data indicate a maximum stream discharge of 215 gal/min (0.5 ft^3/sec) at Tres Amigos Road, just downstream of Rosa de la Costilla spring (PGS-2), and are consistent with a spring discharge of approximately 100 gal/min. Stream discharge at Camino de las Huertas, approximately 0.7 miles west of the Escala fault, was reduced to 38.6 gal/min, indicating a loss of 82% of streamflow across the Escala fault. Under these base flow conditions, stream flow was completely lost before the confluence of Las Huertas Creek and Arroyo del Ojo del Orno. Infiltration of stream flow from lower Las Huertas Creek into Santa Fe Group sediments is an important source of recharge for this portion of the Albuquerque Basin.

2. Arroyo del Ojo del Orno and the Placitas Village Springs

Arroyo del Ojo del Orno and its two major tributaries, Arroyo del Oso and Arroyo Suela, also contain perennial streams, fed by discharge from five major perennial springs of the Las Acequias of the Community of Placitas (Figure 14). These springs, which discharge from Madera Limestone at the base of Cuchilla Lupe, are one of the most impressive and important surface-water resources of the Placitas area. The springs discharge ground water from the Madera Limestone aquifer, which furnishes the domestic water supply for about 500 users in the Village of Placitas (L.Gonzales, personal commun. 1999), and irrigation for Village gardens and orchards via an acequia system that has been in operation since the mid-1830’s (L. Spencer and J. Cummings, unpubl. report for Anasazi Fields Winery, 1999). Overflow and return flow from the domestic and irrigation systems feed perennial stream flow in Arroyo del Oso and Arroyo Suela. This perennial stream flow is augmented by other small springs discharging in Arroyo del Ojo del Orno (PS-19). Spring-fed perennial stream flow is maintained in Arroyo del Ojo del Orno until the stream crosses the Lomos fault (Figure 14). During periods of normal or subnormal flow, stream discharge is quickly lost to channel-bed infiltration within a few hundred feet of crossing the Lomos fault. However, during periods of higher discharge and runoff, the stream continues all the way to its confluence with lower Las Huertas Creek. A stream discharge measurement taken under baseflow conditions in January 1998 at Cedar Creek Road indicated a discharge of 3.5 gal/min (Table 2), although much higher discharges have been observed. Infiltration of stream flow from Arroyo del Ojo del Orno in the region north of the Lomos fault, and elsewhere along the perennial reach, is an important source of recharge to local aquifers in the Santa Fe Group and older Mesozoic units west of the Village of Placitas.

The hydrology of the Village springs and the Madera aquifer are controlled by faults bounding Cuchilla Lupe (Figure 14). These faults behave as localized conduits, distributed conduits, and combined conduit-barriers for ground-water movement (see section III.C). Openings associated with fault fractures become enlarged over time by dissolution of the limestone in ground water, and contribute to a conduit component of ground-water flow within the Madera aquifer. The two largest springs, Ciruela spring (PS-1) and El Oso spring (PS-4), are located along separate faults in the Madera Formation, where the limestone abuts lower permeability units. Ciruela spring discharges from enlarged fractures adjacent to the Suela fault. El Oso spring discharges at the termination of the small antecedent fault on the east side of Cuchilla Lupe. Numerous other smaller springs, including Placitas springs #3 (PS-2), #5 (PS-3), and #7 (PS-20), emerge from the Abo Formation between the Suela and Placitas faults.

Hydrographs of the Placitas springs (Figure 16) indicate spring discharge fluctuates with a strong seasonal response to spring snowmelt. Recent data gathered during August 1999 further suggests that spring discharge also responds to large-scale rain events. However, detailed analyses of precipitation and discharge data for summer and fall of 1998 showed no response to local summer thunderstorms (Johnson, 1999). Hydrographs for 1997 and 1998 show a dramatic rise in discharge rates in mid April. The springs maintain a relatively constant discharge for four to eight weeks, then decrease slowly to a relatively constant winter base flow by mid September to late October. The hydrograph from El Oso spring (Figure 16A) has a steep rising limb, a short response time, a narrow peak, and a moderate recession to a very constant winter base flow. During the rising limb of the April 1997 hydrograph, discharge increased from 70 to 184 gal/min (163%) in just one day, and to over 260 gal/min (370%) in six days. This curve reflects a large component of fracture or conduit flow (Johnson, 1999). Spring #3 and Ciruela spring hydrographs exhibit more moderate springtime discharge peaks and are nearly identical in form (Figure 16B-C). Discharge during the rising limbs of the two 1998 hydrographs increases 140% over the same seven-week period (from April 1 to May 20), and the recession curves have comparable shapes. The hydrograph form indicates a system dominated by diffuse flow with a subordinate component of fracture flow (Johnson, 1999).

Spring hydrographs can be separated into components of quick flow and base flow in a manner analogous to separation of stream-flow hydrographs. Ground-water flow during a hydrograph rise and peak derives from quick flow, which is rapidly percolating water moving through well-developed networks of conduits, fissures and large fractures. During hydrograph recession and base flow, discharge derives predominantly from diffuse flow through pervasive fractures and smaller openings. Hydrograph separation is approximate because all methods are partly subjective. The simplest hydrograph separation technique, and the one applied here, is to draw a line connecting the point at the beginning of the rising limb with the point at the base of the recession curve (Viessman and Lewis, 1996; Atkinson, 1977). Hydrographs of the Placitas springs (Figure 16) are separated into quick flow and base flow components, and the volume of each discharge component is obtained by computing the area beneath each curve (Table 3). Hydrograph separation suggests that over half of the annual discharge of El Oso spring is comprised of quick flow, whereas 70 to 80% of annual discharge from spring #3 and Ciruela spring is comprised of base flow.

3. Arroyo de San Francisco

Arroyo de San Francisco originates on the east side of Cuchilla de San Francisco (Figure 14). The arroyo maintains intermittent flow where it crosses the Abo and Madera Formations from its headwaters north and west to the San Francisco fault. Stream flow through this reach occurs only in response to storm runoff. Perennial springs discharging from the Madera Formation adjacent to the San Francisco fault (PS-18 and PS-21) contribute flow to a perennial reach of stream known as San Francisco Creek. This perennial stream flow is augmented by discharge from at least three additional springs discharging from Santa Fe Group deposits on the Wessely property (PS-10, PS-12, and PS-13), and flows for an unknown distance onto San Felipe Pueblo. Three springs discharging in this area (PS-10, PS-11, and PS-12) also provide the domestic, stock and irrigation water supply for two residences. Instantaneous discharge measurements were taken for two springs, PS-10 and PS-11, in July and September 1997, and at three stream locations along the perennial reach of San Francisco Creek (PGS-5, PGS-6, and PGS-7) during January and August, 1998 (Table 2). These data indicate that spring discharge at PS-10 and PS-11 was relatively uniform over this two-month time period, with an increase of about 15% from July to September (a portion of which may also reflect the uncertainty in the method of measurement). Observations of the spring owners also support that discharge from PS-10 and PS-11 does not vary appreciably over time. This is not true, however, for other springs discharging from the Madera Formation east of the San Francisco fault. Based on physical observation of spring PS-18, discharge at this location varied significantly over the course of this study. Stream discharge measurements (Table 2) indicate a maximum base flow discharge of 200 gal/min for this perennial reach of stream during January, 1998, and show a moderate stream loss to channel-bed infiltration of about 29% between PGS-5 and PGS-7 at the study area boundary with San Felipe Pueblo. Infiltration of stream flow from San Francisco Creek is an important source of recharge to this area of the Santa Fe Group aquifer. Repeat stream flow measurements at the same locations during August 1998 indicate approximately a 60 to 70% seasonal reduction of stream flow, as well as greater variability of flow over the perennial reach of stream. This seasonal fluctuation in discharge is likely due primarily to seasonal variation in evapotranspiration and also to natural variation in spring discharge at PS-18 and PS-21.

V. GROUND-WATER HYDROLOGY -- POTENTIOMETRIC SURFACE AND CHANGES IN WATER LEVELS

A potentiometric-surface map depicts the distribution of hydraulic head in an aquifer system. Measurements of hydraulic head, obtained by measuring the depth that water stands in wells, are converted to elevation, and lines or contours are drawn that connect points of equal hydraulic head. These lines, called equipotential lines, produce a map of the altitude, slope, and shape of the ground-water surface and illustrate flow conditions and stresses on the aquifer. A potentiometric-surface map of shallow water in the Placitas area, representing flow conditions in April 1998, is illustrated on Plates 6 and 7. Supporting data are presented in Appendix E.

A potentiometric-surface map is used to define the direction of ground-water movement. Generally speaking, the direction of ground-water flow is perpendicular to the equipotential lines. The red arrows in Plates 6 and 7 indicate the direction of ground-water flow, and the location of preferential ground-water flow paths. A second application of the map is to infer aquifer transmissivity and evaluate heterogeneity in the aquifer. In the Placitas area, the map aids in determining how ground water moves across a fault or stratigraphic boundary. In Darcy's law of ground-water flow (**q = -Ki**), hydraulic gradient (**i**) is inversely proportional to hydraulic conductivity (**K**). Where the equipotential lines are closely spaced, a steep hydraulic gradient exists. A steep gradient reflects low hydraulic conductivity, and indicates the presence of relatively low permeability material or some other constriction that is impeding or restricting ground-water movement through the area. In general, ground-water flow is concentrated into areas of the aquifer where the potentiometric-surface map indicates a relatively low hydraulic gradient. Although a water level gradient is an essential condition for subsurface flow, flow direction cannot be deduced from gradient alone. The potentiometric surface presented here was developed with overlays of geologic and topographic data. Hence the potentiometric surface and interpretations of ground-water flow direction and preferential pathways are consistent with topographic, hydrologic, and geologic data, and are further supported by geochemical data discussed in subsequent sections.

The construction and interpretation of a potentiometric-surface map relies on several assumptions. First, a potentiometric map is assumed to relate to a single aquifer. Deeper or shallower aquifers will often have a different hydraulic head than the aquifer of interest. Second, ground-water flow in the aquifer is assumed to be horizontal, that is, upper and lower confining layers exist and flow is parallel to them. Hydrogeologic conditions in Placitas do not always meet these assumptions. This fact should be understood when applying or interpreting the map, but does not render it inapplicable or inappropriate. Aquifers in the area are not horizontal. Flow in the Madera Formation aquifer, for example, is subhorizontal, moving down dip and roughly parallel to bedding under a steep elevation gradient. Unconfined conditions generally prevail and hydraulic head does not appear to vary significantly with depth (see for example wells PW-70 and PW-100). Aquifers in the Mesozoic ramp are generally subvertical strip aquifers separated by subvertical aquitards, an orientation that produces hydrologic conditions ranging from unconfined to semi-confined. Truly confined conditions are a local phenomenon and relatively rare. Hydraulic head does not vary appreciably with depth within a single aquifer, at a given location. Hydraulic head does vary within a single aquifer in a down-dip direction as one moves laterally and deeper in the same formation. Similarly, hydraulic heads in wells completed at the same location but in different strip aquifers, and at different depths, vary 8 to 12 feet (see for example wells PW-129 (Kd) and PW-148 (Jm); wells PW-117 (Jm) and PW-172 (Km_l)). This small variation in head is negligible in the context of 50 to 100-ft equipotential contours and does not affect the shape of the potentiometric surface. Generally speaking the Placitas area shows a prevailing regional gradient that does not vary appreciably with depth, despite the high degree of heterogeneity and anisotropy, and thus the guiding assumptions of a potentiometric map are met.

The potentiometric surface in the Placitas area generally follows topography, sloping north and west from the northern Sandia Mountains to the Rio Grande floodplain, and is generally consistent with the map of Titus (1980). However, the higher density of water level measurements shown here produces a higher resolution map that reflects the complexity of the hydrologic systems. The combination of steep topography and extreme permeability contrasts across faults and stratigraphic boundaries produces a potentiometric surface with many inflections, ridges, troughs, and local changes in gradient and flow direction. In addition, drawdown depressions are present around specific wells and in certain areas where pumping has lowered water levels.

In a natural (undeveloped) aquifer system, changes in water levels reflect the response of an aquifer over time to changes in recharge. A seasonal rise and fall in water levels indicate that the aquifer is actively connected with, and responding to, a seasonal source of recharge such as spring snowmelt, precipitation, irrigation, or stream flow. The lag time between the recharge input and aquifer response, and/or dampening of the signal, indicate how well connected the recharge source and aquifer may be. Because water-level monitoring for this study began at the end of the 1995-1996 drought, many wells reflect a steady rise in water levels, in addition to a seasonal fluctuation, as the hydrologic systems recovered from the drought. For a developed aquifer, water level changes also reflect changes in discharge. For example, a dramatic rise in water levels that is not coincident with recharge may reflect cessation of pumping in a nearby well. Similarly, a continuous, long-term, decline in water levels may reflect withdrawal of water by pumping, in excess of the amount of water added by recharge. Water level hydrographs for 48 wells monitored between March 1997 and August 1998 are presented at the end of Appendix E, and organized by township, range, section. The wells are distributed throughout the three hydrologic systems, although the Mesozoic ramp contains the greatest number of monitor wells due to the extreme variability of aquifers in that region. In addition, changes in water levels between August 1997 and August 1998 are depicted on Plate 6, and changes over annual periods of three years or longer are depicted on Plate 7. Interpretations of the water-level hydrographs (Appendix E, Figures E-1 through E-25), the potentiometric-surface map, and water-level changes over time are discussed for each hydrologic system.

A. Mountain Hydrologic System

The shape of the potentiometric surface in the Madera Limestone of the mountain hydrologic system is largely controlled by the presence of faults. North trending ground-water mounds (water-level highs) are coincident with the major limestone ridges of Cuchilla Lupe and Cuchilla de San Francisco. Ground-water troughs (water-level lows) are associated with some of the north striking faults, such as the small, unnamed fault along the east face of Cuchilla Lupe and the Spillway fault east of the Crest of Montezuma. The ground-water troughs indicate that these faults are behaving as drains by capturing ground water from the surrounding area and directing flow along the fault. Suela fault probably also behaves similarly, but there are insufficient water level data to show this effect. (Data are limited to the areas of Cuchilla Lupe, Las Huertas Canyon, Tecolote, and Cuchilla de San Francisco.)

PW-66 and PW-83, completed along the unnamed fault bounding the east face of Cuchilla Lupe, reflect nearly identical hydrographs (when isolated measurements perturbed by pumping in PW-83 are ignored) even though the wells are 0.8 miles apart (Figure E-1). These hydrographs indicate that the Madera aquifer adjacent to this fault has a very high degree of hydraulic connection. By comparison, the hydrograph for PW-37, located 500 feet east of the fault, shows a similar but significantly dampened water-level trend compared with wells immediately adjacent to the fault. These three hydrographs indicate the localized nature of ground-water flow in the vicinity of faults in the Madera, the high degree of anisotropy in the aquifer, and the seasonality of recharge.

Aquifers in the Abo and Madera Formations in Las Huertas Canyon are recharged by infiltration of stream flow in Las Huertas Creek and/or snowmelt. Dramatic water level increases occurred in all wells in Las Huertas Canyon between April and June 1998 when runoff from snowmelt increased flow in Las Huertas Creek. The magnitude of springtime water-level rises varied from 12 to 15 feet in the southern canyon (PW-70 and PW-100 (Figure E-2)), to over 30 ft in the northern canyon (PW-50, PW-155, PW-156 (Figure E-3), PW-93 (Figure E-4), and PW-88, PW-92 (Figure E-5)). A widespread water-level rise of over 10 feet occurred in mid Las Huertas canyon between August 1997 and August 1998 (Plate 6). Wells in close proximity reflect very similar hydrographs and indicate local continuity of the aquifer system. An exception is well PW-76, which is located in the San Francisco fault zone near Tecolote and far from the Creek. This well shows no seasonal fluctuation in water level, and is disconnected from the Las Huertas Canyon aquifers. These data indicate that Las Heurtas Creek is a significant source of annual recharge for the Abo and other formations in Las Huertas Canyon at least as far north as Tecolote. If stream flow in Las Huertas Creek is are be immediately impacted. However, these same aquifers recover quickly when stream flow returns, as shown by water level rises that began in spring of 1997 following the 1995-1996 drought.

Water level fluctuations in the Madera aquifer north of Tecolote are quite variable, the timing and magnitude of which are significantly different from hydrographs in Las Huertas Canyon and Dome Valley. The nearest well north of Tecolote, PW-89, is completed in the Madera aquifer in the footwall of the San Francisco fault. The hydrograph for PW-89 (Figure E-8) shows a definite seasonal fluctuation of 2 to 3.5 feet, with peak levels in September and lowest levels in about May. This fluctuation has a much lower magnitude and is slightly lagged compared with Las Huertas Canyon hydrographs, suggesting that the well is connected to a seasonal source of recharge, but through a longer, and probably distinct flow path. Several springs also discharge from the Madera Formation immediately adjacent to the San Francisco fault, including (from south to north) PS-7, PS-17, PS-21, PS-18, and PS-16. These springs and PW-89 likely discharge ground water from the damage zone adjacent to the San Francisco fault, and may also be connected to aquifers adjacent to the East Las Huertas Canyon fault (a southern splay of the San Francisco fault). These data are consistent with the presence of a continuous, fault-parallel preferential flow path, in Madera Limestone adjacent to the San Francisco fault, which transmits ground water from east of Las Huertas Canyon through the Madera Formation to its truncation at the north end of Cuchilla de San Francisco.

The hydrograph for well PW-91 (Figure E-7) at the northern end of Cuchilla de San Francisco, also has a slight seasonal fluctuation of 0.65 feet, with a peak in April and a trough in August. Limited data from well PW-96 to the southeast show a very similar trend. Both wells are completed in the same interval of the upper Madera Formation (Figure 6). A nearby well, PW-71, is completed in a lower interval of the upper Madera, but reflects a similar annual fluctuation (Figure 6, Figure E-10). The magnitude of the fluctuation is quite small and is not in phase with wells in Las Huertas Canyon or with PW-89 adjacent to the San Francisco fault. Annual fluctuations in the upper Madera of Cuchilla de San Francisco suggest that this portion of the aquifer is connected to a seasonal recharge source, such as snowmelt or runoff, but is so far removed from the recharge input that the resulting signal is significantly attenuated and time-lagged. One would also expect that actual travel time for ground water to flow from a recharge area in the Sandias to a discharge area at the north end of Cuchilla de San Francisco is significant. These various hydrographs suggest that the upper Madera aquifer underlying Cuchilla de San Francisco is isolated from the fault-zone pathway, and from Madera aquifers near Cuchilla Lupe and Las Huertas Canyon. Ground-water movement in the upper Madera of Cuchilla de San Francisco appears to be concentrated along bedding planes and in units with lateral continuity.

Ground water in the Abo Formation east of Cuchilla de San Francisco does not appear to be connected to the adjacent Madera Formation aquifer, or to a short-term, annual source of recharge. A limited hydrograph from well PW-95 (Figure E-11), completed in the Abo Formation northeast of Cuchilla de San Francisco, reflects a minimal change in water level over one year of monitoring, with no apparent annual fluctuation. These data suggest that the aquifer in this part of the Abo Formation is isolated from other aquifers in the Madera Formation to the west, and from common sources of annual recharge. Ground-water movement under natural gradients in low permeability portions of the Abo Formation is expected to be fairly limited.

A relatively steep, irregular hydraulic gradient exists across the Placitas fault zone (Plate 6). The gradient suggests that the fault zone generally has a lower permeability than adjacent Madera Limestone, and that the permeability contrast between the two zones is also quite variable. For example, the gradient across the faults bounding Cuchille Lupe varies from 0.5 at the northwest corner of Cuchilla Lupe, to 0.2 near Ciruela Spring, to 0.05 between the east side of Cuchilla Lupe into Las Huertas Canyon. The highest gradient of 0.5 reflects the lowest permeability material associated with the lower Mancos Formation on the north side of the Village. The potentiometric surface indicates that ground water flows from the Madera Formation on Cuchilla Lupe northwest across the Placitas fault zone into the Morrison Formation south of the Village, and north-northeast into the Abo Formation in Las Huertas Canyon. Minimal ground-water movement occurs across the Placitas fault zone at the north and northwest boundaries of Cuchilla Lupe, where Madera Formation is adjacent to steeply dipping, low permeability shales and siltstones of the Mancos Formation.

The hydraulic gradient across the San Francisco fault is also somewhat variable, ranging from a relatively steep gradient of 0.75 just north of Tecolote to about 0.4 at Old San Francisco Springs Ranch, and 0.08 at the tip of Cuchilla de San Francisco where the Madera Formation aquifer is truncated. The hydraulic gradient at Tecolote is 0.025. Because ground-water flow is concentrated into areas with the lowest hydraulic gradient, this potentiometric surface is consistent with preferential ground-water movement across the San Francisco fault through Tecolote and at the north end of Cuchilla de San Francisco. Flow across the intermediate section of the San Francisco fault, between Tecolote and old San Francisco Ranch appears to be minimal.

Ground water discharges from the Madera Formaton at the northern end of Cuchilla de San Francisco where the San Francisco fault truncates the aquifer, then flows northwest into Santa Fe Group sediments. The northern end of Cuchilla de San Francisco is an area of shallow ground water. Numerous springs, including PS-10, PS-11, PS-12, PS-13, PS-14, and PS-15, discharge on the west side of the fault in Santa Fe Group sediments. The hydrograph from PW-90 (Figure E-9), completed in the Santa Fe Group aquifer, has no seasonal fluctuation in water level, but does show a minimal, continuous rise in water levels between August 1997 and August 1998. There is no indication that the Santa Fe Group aquifer in the vicinity of San Francisco Ranch is connected to any source of annual or short-term recharge. This aquifer is replenished totally by discharge from the Madera Formation aquifer beneath Cuchilla de San Francisco.

Limited historic water level data, reflecting periods of three years or longer, suggest that there have been no long-term water level declines in the mountain aquifer system (Plate 7). Limited data from six wells in Las Huertas Canyon and near old San Francisco Springs Ranch show no long-term trends for the mountain aquifer system. Water levels measured in 1997 and 1998 are approximately the same as documented historic levels, and suggest that there has been no long-term impact due to drought or over-development of the aquifers.

B. Mesozoic Ramp Hydrologic System

The potentiometric surface in the Mesozoic ramp slopes generally to the north at a moderate gradient of 0.04. Ground water moving northward encounters north to northeast dipping, low permeability strata (see section III.D.2). A wide range of hydraulic conductivity, estimated at seven or more orders of magnitude, exists between the various aquifers and aquitards, and localized fracturing or gouge along faults may produce even greater conductivity contrasts. The steeply dipping, layered strata compartmentalize the aquifer system, and produce a potentiometric surface characterized by numerous inflections, ridges, and troughs. In many areas, the resolution of water-level data is sufficient to illustrate refraction of equipotential lines across stratigraphic contacts, and deflection of ground water into permeable strips of aquifer. Ground water moves parallel to the strike of permeable units, including the Agua Zarca, Entrada, Morrison (Jackpile and Westwater Canyon members), Point Lookout and Hosta Dalton Formations. In general, ground water is deflected around the extremely low permeability formations, including the Petrified Forest, upper Mancos Shale, and Menefee Formations. Ground-water flow also appears to concentrate along the Pomecerro fault as it cuts through the Placitas fault zone and into the center of the Mesozoic ramp. Ground-water flow lines shown on Plates 6 and 7 illustrate these pathways. The overall pattern of the potentiometric surface is consistent with a system of compartmentalized aquifers, which are connected, partially connected, or in some cases totally isolated from one another. There are no data to support appreciable ground-water flow through the Mesozoic ramp and into the Albuquerque Basin.

Ground-water availability is limited in low permeability units, including the Petrified Forest, Lower Mancos,Upper Mancos, and Menefee Formations. Hydrographs from numerous wells in these units in T. 12 N., R. 5 E., sections 5 and 6 and T. 13 N., R. 5 E., sections 31 and 32 show similar trends of short-term and/or long-term water-level declines. Negligible or no seasonal fluctuations are observed, indicating that these areas are isolated from sources of annual recharge. In many cases, wells in these formations can not sustain pumping without severe drawdowns, or in some cases pumping dry. See hydrographs for wells PW-30 (Figure E-13), PW-10 (Figure E-14), PW-21 and PW-31 (Figure E-16), PW-33 and PW-80 (Figure E-17), PW-13 (Figure E-18), PW-112 and PW-113 (Figure E-22), and PW-44 and PW-172 (Figure E-23).

Ground water moves into the Mesozoic ramp along preferential flow paths associated with the Pomecerro/Caballo fault system. Hydrographs from PW-141 (Figure E-22) completed near a splay of the Pomecerro fault in Placitas Heights, and from PW-75 (Figure E-13) located adjacent to the Caballo fault near Tunnel Springs, both show moderate seasonal fluctuations as well as significant increases in water level over the 1997-1998 monitoring period. PW-141 underwent a water level rise of 31 feet between August 1996 and August 1998, in response to increased recharge along the Pomecerro fault following the 1995-1996 drought. Although not as dramatic, the water-level rise of 4 feet in PW-75 is notable when compared with dramatic declines in water levels in nearby wells completed in low permeability formations (for example, PW-10 and PW-40), and is consistent with localized ground-water flow along the Caballo fault. Localization of ground-water movement along fault related fracture networks is one mechanism responsible for the highly variable and localized nature of ground-water occurrence in this hydrologic system. However, not all faults concentrate ground-water flow. Only the Pomecerro-Caballo fault system appears to exhibit this character.

Ground water moves across the Placitas fault zone at locations where there is continuity of permeable units, and concentrates in the Entrada/upper Petrified Forest, Morrison, Hosta Dalton, and Point Lookout hydrostratigraphic units. Hydrographs from wells completed in these units (for example, PW-85 (Figure E-20), and PW-17, PW-18, and PW-28 (Figure E-24)) show similar trends of continuous water level rises throughout the 1997-1998 monitoring period. Small seasonal fluctuations occurred, but were largely masked by a steady rise in water levels. Annual increases from August 1997 to August 1998 vary from 2 to 6 feet in the Entrada (PW-17, PW-18, and PW-28), to about 10 feet in the Morrison. These water level increases reflect response of the aquifers to increased recharge following the 1995-1996 drought, and are consistent with the preferential flow paths shown on Plates 6 and 7. Limited data from the Point Lookout Formation near Quail Meadow (T. 12 N., R. 5 E., section 6) indicate that water levels in this unit have maintained, or risen over the past 20 years (see PW-127 in Appendix E, and Plate 7), suggesting that ground water moving across the Placitas fault zone along the Caballo-Agua Zarca faults may concentrate in this hydrostratigraphic unit. Wells completed in the Hosta Dalton in La Vina Viejo to the north (PW-25 and PW-27) are good producers capable of sustained discharges of 20 to 50 gallons/minute. However, hydrographs from these wells (Figure E-18) show water-level declines of about 2 feet between August 1997 and August 1998. Aquifers in the Hosta Dalton and Point Lookout Formations at the northeast end of the Mesozoic ramp (T. 13 N., R. 5 E., section 32) may not be able to withstand increased development, as recharge in this area is very limited.

Infiltration of surface runoff in arroyos is an important recharge mechanism on the Mesozoic ramp. Shallow aquifers in the Mesozoic ramp receive local recharge from both ephemeral and perennial flow in arroyos. Hydrographs from wells adjacent to Arroyo Agua Sarca in Rainbow Valley (Figures E-19 and E-21) and Arroyo del Oso near the Village (Figure E-25) show water level trends that are linked with flow in the arroyos. In the case of Arroyo Agua Sarca, shallow wells less than 100 feet in depth near the arroyo (PW-55, PW-56) showed a dramatic rise in water levels between April and June when the arroyo was flowing with snowmelt. Water level rises are sudden, dramatic, and vary in magnitude from 10 to 18 feet. Wells that are further away from the arroyo (PW-86 (Figure E-19), and PW-171 (Figure E-15)), and/or completed at deeper intervals (PW-99 (Figure E-20)), show a limited or time lagged response to this recharge flux. In Arroyo Agua Sarca, the effects of arroyo channel recharge appear to be limited to a fairly small zone adjacent to the arroyo. A similar response is observed in PW-12 (Figure E-25), completed adjacent to Arroyo del Oso. Perennial flow in this reach of Arroyo del Oso is fed by flow from El Oso Spring (see section IV.C.2). During summer most of the flow is diverted for irrigation, but from October to April in the non-irrigation season, stream discharge is much higher. The hydrograph for PW-12 shows a low in October, a steady rise through the fall and winter, and a high in April. This trend is out of phase with snowmelt-derived recharge, but precisely mirrors flow in Arroyo del Oso.

C. Albuquerque Basin Hydrologic System

The potentiometric surface in the Albuquerque Basin has a low to moderate gradient (0.07 to 0.004) and a more uniform character, relative to the other hydrologic systems in the Placitas area. These characteristics reflect the higher permeability and homogeneity of Santa Fe Group sediments when compared to layered and fractured bedrock formations. Depth to water in the Upper Santa Fe Group west of Placitas varies from 170 to 360 feet depending on topographic location. In the northern portion of the study area, depth to water can be as much as 400 feet or more. The potentiometric surface of the Santa Fe Group slopes west and northwest from the foothills toward the inner valley of the Rio Grande. Gradient changes and inflections in the potentiometric surface are associated with intrabasin faults, synclinal folds, lithologic or facies changes in Santa Fe Group deposits, recharge from Las Huertas Creek and Arroyo Agua Sarca, and buried geologic structures.

Shallow, fault-bounded benches in the Santa Fe Group adjacent to the rift margin have relatively limited ground-water storage. The block of Santa Fe Group piedmont deposits wedged between the Ranchos and Valley View faults (T. 13 N., R. 4 E., sections 35 and 36 and T. 12 N., R. 4 E., section 1)) has a total thickness of about 600 to 1000 feet, a saturated thickness of 300 to 500 feet, and limited recharge from ephemeral flow in Arroyo Agua Sarca. Similarly, the block of Lower Santa Fe Group piedmont deposits beneath Lomos Altos (T. 13 N., R. 5 E., sections 30 and 31) has an estimated thickness of 400 to 800 feet, and a saturated thickness ranging from 0 to 400 feet. This fault bounded block, wedged between the Ranchos, Lomos and Caballo faults and the Cretaceous-Tertiary unconformity, also receives fairly limited recharge via infiltration from Arroyo del Ojo del Orno in the northwest corner of the area. These two areas have limited aquifer thickness, limited lateral extent, and limited recharge relative to other areas. Consequently, associated aquifers in the vicinity of Vista de Oro and the Overlook have a finite capacity. The notable depression in the potentiometric surface around wells PW-179 and PW-180 near Vista de Oro (Plate 7) suggest that ground-water withdrawals in this area may be exceeding recharge.

The major arroyos entering the Albuquerque Basin provide significant sources of recharge to the Santa Fe Group aquifer west of the Ranchos and Escala faults. Water-level highs are associated with the three major arroyos that enter the Albuquerque Basin in the Placitas area. Ground-water mounds exist beneath Arroyo Agua Sarca west of the Ranchos and Valley View faults, beneath Arroyo del Ojo del Orno north of the Lomos fault, and beneath Las Huertas Creek west of the Escala fault (see also section IV.C). Las Huertas Creek appears to be the most significant source of recharge. A substantial ground-water mound starts at the Escala fault and extends at least 0.75 miles north of the creek beneath Indian Flats, and a short distance south of the creek in the vicinity of Cedar Creek. Water levels in wells completed at different depths beneath Indian Flats (PW-169, PW-196 and PW-214, PW-219 on Plates 6 and 7) indicate a strong, vertically downward gradient of about 0.5, which is consistent with this region being a major recharge area for aquifers in the eastern Albuquerque Basin. Hydrographs from shallow wells adjacent to Las Huertas Creek west of Tecolote illustrate that the shallow aquifer here is closely linked with flow in the creek, and is seasonally recharged by infiltration from the arroyo or creek channel (PW-88 and PW-92, Figure E-5). Hydrographs from wells completed further from the Creek and at greater depths (PW-24 and PW-29, Figure E-6) indicate that the effects of arroyo recharge are limited in the short-term to areas near the arroyo.

Ground water moving west through Tecolote from the mountain aquifer system encounters two subsurface geologic features, the Escala syncline and the buried Tertiary dike, that restrict or attenuate westward movement of ground water into the Albuquerque Basin (see section III.D.3) . Cross-section B-B’ (Plate 3) shows the effects of the Escala syncline and the buried Tertiary dike on movement of ground water. Both features produce thinning of the aquifer and force ground water to rise to shallow depths. The rising limb of the Escala syncline forces ground water to move through Santa Fe Group sediments at an oblique angle to bedding. Because the sediments have reduced permeability in this cross-bedding direction, ground-water movement is also attenuated to some degree. This phenomenon is observed in the change of gradient between the axis and the rising limb of the Escala syncline. Where the hydraulic gradient is not sufficient to move water through the formation, then ground water may be totally stagnant, such as along the western limb of the syncline north of Las Huertas Creek. Ground-water residence time in the Santa Fe Group aquifer along the Escala syncline, except in the recharge area immediately west of Tecolote and adjacent to Las Huertas Creek, is probably on the order of 1000s of years to more than 10,000 years (see section VI.D.1).

VI. WATER QUALITY AND GROUND-WATER TRACERS

The quality of water describes both its potability for drinking and its specific chemical characteristics, which are governed by the original composition of precipitation, chemical conditions in the aquifer, and impacts of human development. Mapping the distribution of water quality and geochemical parameters in aquifers of the Placitas area is important to an overall understanding of the hydrologic systems and management of the water resources. Hydrogeochemistry in the three hydrologic systems is quite variable, and primarily influenced by the diversity of aquifer materials, localization of active recharge, and ground-water residence time. This study includes a detailed evaluation of water quality, hydrogeochemistry, and ground-water tracers in all the major hydrostratigraphic units. Water quality and the spatial distribution of important hydrogeochemical parameters is summarized for each hydrologic system, aquifer, and hydrogeologic zone (section III.D and Plate 5).

A. Hydrogeochemical Methods and Results

The spatial distribution of certain hydrogeochemical parameters provides useful information about a ground-water flow system, including general water quality and water type, recharge and discharge areas, recharge mechanisms, depth of ground-water circulation, degree of hydraulic interconnection, length and continuity of ground-water flow paths, and a relative sense of ground-water residence time. The most useful chemical parameters include total dissolved ions (TDI), major ions, temperature, dissolved oxygen, select trace elements, and stable isotopes of oxygen and hydrogen. Ground water in recharge areas in the Madera Limestone has a characteristic water chemistry distinguished by major ions of calcium and bicarbonate, a low TDI of less than 310 mg/l, temperature less than 16 ^{o}C, a relatively high dissolved oxygen content of approximately 6 or more mg/l, and no significant trace elements. In addition, Madera recharge waters have $^{2}H/H$ and $^{18}O/^{16}O$ ratios that are either similar to local precipitation or slightly enriched by evaporation. Ground waters beneath Cuchilla Lupe, in upper Las Huertas Canyon, and at Tunnel Spring are representative of this recharge water.

As ground water moves along its flow path, changes in this characteristic chemistry occur. In general, shallow ground water in recharge areas is lower in TDI than water deeper in the aquifer or water isolated from active flow paths, and lower in TDI than shallow ground water in discharge areas. In addition, anion evolution occurs along a ground-water flow path, as water moves from shallow zones of active ground-water movement into deeper or isolated zones where flow is attenuated and residence time is longer. The anion content, which delineates chemical facies of ground water, increases and evolves progressively from bicarbonate toward sodium, sulfate, and eventually chloride. The temperature of ground water increases as it follows a long or deep circulation pathway and accrues a long residence time. Although the dissolved oxygen content of ground water is not conservative and can be reduced dramatically within a short time of recharge, it is generally found to be higher in recharge areas and to decrease along a flow path. The stable isotopes of ^{2}H and ^{18}O are ideal, conservative hydrologic tracers as they are a part of the water molecule. Ratios of $^{2}H/H$ and $^{18}O/^{16}O$ are not chemically altered in low temperature, shallow ground water environments once the water molecule is isolated from the atmosphere, and always reflect the isotopic content of the recharge water. Accordingly, the spatial distribution of TDI, major ions, temperature, dissolved oxygen, and stable isotope ratios provides valuable information concerning the ground water systems, and addresses many issues of water quality, recharge, hydraulic interconnection, and relative residence time.

1. Total Dissolved Ions (TDI), Temperature, and Dissolved Oxygen

The TDI content of ground water in the Placitas area ranges from 220 to nearly 6000 mg/l (Appendix G). Water with less than about 1000 mg/l TDI is considered potable. Ground water with greater TDI is moderately to highly saline, requires treatment for domestic use, and may have limited application for irrigation. Elevated TDI concentrations are generally caused by increases in dissolved sulfate and sodium. The spatial distribution of TDI (Figure 17) indicates that low TDI ground water is found in the Madera Limestone, in the Abo Formation of Las Huertas Canyon, and in most Albuquerque Basin deposits. The freshest bicarbonate ground water, with less than 300 mg/l TDI, is restricted to the Madera Formation, and to the shallow subsurface adjacent to Las Huertas Creek, Arroyo Agua Sarca, and other ephemeral arroyos where ground water is actively recharged. In addition, anion evolution from bicarbonate to sulfate (Figure 18) occurs as ground water moves away from these recharge areas into deeper or isolated portions of the ground water system. Ground water with a higher TDI and sulfate content is disconnected from sources of active recharge and has a longer residence time, although no quantitative age estimates can be made without considering specific hydrochemical processes.

Temperature data closely reflect hydrological conditions and three thermal types of ground water are distinguished in the Placitas area. Ground water that belongs to the shallow, active water cycle, with circulation limited to the upper 300 to 500 ft of subsurface, typically reflects the local average surface temperature (Mazor, 1991). In the Placitas area, the average non-winter (March through November) surface temperature is approximately 16 ^{o}C (61 ^{o}F). Ground water colder than 16 ^{o}C occurs at higher altitudes, or is recharged primarily by snowmelt. Ground water with a temperature more than about 6 ^{o}C above the local average circulates to appreciable depths, implying a long ground water flow path and a relatively long residence time (Mazor, 1991). Ground-water temperatures in the Placitas area vary from 11.7 to 28.8 ^{o}C (Appendix G) and reflect these three hydrothermal regimes (Figure 19). Ground water temperatures in much of the area indicate shallow circulation controlled by the average surface temperature. Ground water colder than 16 ^{o}C is restricted to higher elevations in the Madera Formation, including Cuchilla Lupe and Las Huertas Canyon, and to aquifers recharged by snowmelt, perennial spring discharge or subsurface through-flow from the Madera Formation. Ground water warmer than 21 ^{o}C, indicating deep circulation and a long residence time, is concentrated primarily in the Albuquerque Basin west of the Rincon and Valley View faults, and in spring discharge from the northern end of Cuchilla de San Francisco.

The spatial distribution of dissolved oxygen in ground water (Figure 20) presents a pattern similar to TDI and temperature. Dissolved oxygen ranges from 0.5 to 11 mg/l (Appendix G), with concentrations greater than 5.6 mg/l restricted primarily to the Madera Formation or aquifers adjacent to lower Las Huertas Creek. These are regions in which TDI and temperature data also indicate active recharge by snowmelt runoff, subsurface through-flow or perennial spring discharge.

2. Environmental Isotopes

Stable isotope ratios $^{18}O/^{16}O$ and $^{2}H/H$ (reported as $\delta^{18}O$ and $\delta^{2}H$) are ideal hydrologic tracers as they are measured as part of the water molecule. Stable isotope ratios in ground water are affected by meteorological processes that provide a characteristic fingerprint of the water's origin. Each step of the hydrologic cycle, evaporation from the oceans, condensation and rain, re-evaporation, snow accumulation and melting, and runoff, partitions the heavier isotopes of ^{18}O and ^{2}H amongst the different freshwater reservoirs. On a global scale, $\delta^{2}H$ and $\delta^{18}O$ in fresh waters correlate along a "global meteoric water line" (Figure 21). The equation for this line is approximately $\delta^2H = 8\delta^{18}O + 10\ ^o/_{oo}$. The meteoric water line ("MWL") is the key to interpretation of ^2H and ^{18}O data. Water with an isotopic composition falling close to the MWL generally originates as precipitation and is unaffected by other isotopic processes.

Various processes produce deviations from the MWL, but do so in unique ways. Figure 21 illustrates these processes and the resulting compositional trends away from the MWL. The most important of these processes to ground water provenance studies are evaporation and paleoclimate effects. When meteoric waters undergo evaporation, the remaining reservoir is enriched in heavy isotopes. The result is a deviation from the MWL along a line with a lower slope, which depends primarily on temperature and relative humidity. For a normal range of humidity values the slope of an evaporation line varies between 3 and 5, with a lower slope corresponding to lower humidity. The isotopic composition of recharge waters lies in a region along the evaporation line, and the intersection of the evaporation line with the MWL usually reflects the mean composition of annual precipitation. Fossil ground water recharged during late Pleistocene (more than 10,000 years ago) reflects the effect of a cooler, more humid pluvial climate. The temperature effect is expressed by depletion of pluvial-climate ground water with respect to modern water and a shift along the MWL towards more negative values. Pleistocene age ground water from the San Juan Basin reveals depletions of 25 $^o/_{oo}$ in ^2H and 3 $^o/_{oo}$ in ^{18}O (Phillips et al., 1986). In arid climates, the relative decrease in humidity also causes a displacement of fossil ground water below the modern, local MWL. Fossil ground water manifesting a paleoclimate shift (Figure 21) is not a part of an actively recharged flow system, and hence represents a very finite resource. Mixing of modern and fossil ground water produces an intermediate isotopic composition.

On a local or regional scale, a meteoric water line differs from the global line in both slope and deuterium intercept due to varying climatic and geographic conditions. For local or regional investigations, it is therefore important to compare surface water and ground water data with a local MWL. In the Placitas area, a local MWL was established from precipitation samples collected quarterly at seven regional locations (Figure 10 and Plate 4) (LeFevre, 1999). The isotopic composition of precipitation and the resulting MWL are shown on Figure 22 and in Table 4. The volume-weighted, mean annual composition of precipitation falls mid-way along the Placitas MWL, with a δ^2H of -79 $^o/_{oo}$ and $\delta^{18}O$ of -10.8 $^o/_{oo}$. For comparison, the weighted mean winter-spring precipitation is depleted in δ^2H and $\delta^{18}O$ by 17.3 $^o/_{oo}$ and 2.0 $^o/_{oo}$ respectively. Such seasonal differences in isotopic composition are typical of inner continental regions where greater seasonal extremes in temperature generate strong seasonal variations in isotopes of precipitation. Further, the weighted mean of El Nino precipitation monitored between April 1997 and May 1998 is enriched with respect to mean annual precipitation and is shifted on the Placitas MWL towards more positive values, reflecting warmer sea surface temperatures in the source area in the eastern Pacific.

The meteoric ^2H-^{18}O signal in precipitation is transferred to ground water during recharge as water moves from the surface to the water table. Mixing during recharge attenuates large seasonal variations in the ^2H and ^{18}O content of precipitation, so that ground water in temperate regions often has an isotopic value close to the weighted average of annual precipitation. In arid regions however, the time it takes for recharge to occur varies from days to years, decades or longer, and the meteoric signal in ground water can be significantly modified. Evaporation or other processes shown in Figure 21 can modify ground water composition, and where there is a seasonal bias to recharge, for example preferential recharge of spring snowmelt, then the isotopic composition of ground water will be depleted compared with that of annual precipitation.

Three groups of ground water representing modern to Holocene recharge, fossil ground water, and mixed modern-fossil ground water are evident in Placitas data (Figure 23), as are effects of seasonal biases in recharge, evaporative enrichment during recharge, and a paleoclimate shift. Three surface water, 29 ground water and three spring samples are tightly clustered near the Placitas MWL in the region between -83 and -95 $^{o}/_{oo}$ ^{2}H and -11.1 and -12.7 $^{o}/_{oo}$ ^{18}O. Ground water in this isotopic range and within the 99% confidence interval are recharged by modern to Holocene precipitation that is unaffected by any alteration process. These data are significantly depleted relative to mean annual precipitation, indicating a strong seasonal bias in ground water recharge toward snowmelt and winter-spring precipitation events. Indeed, the mean composition of winter-spring precipitation, $\delta^{2}H$ of -96 $^{o}/_{oo}$ and $\delta^{18}O$ of -12.8 $^{o}/_{oo}$, closely reflects the most depleted composition of unaltered ground-water recharge. A second cluster of 23 ground water, three surface water and three spring samples plot outside the 99% confidence interval, below the Placitas MWL, and within an evaporation envelope defined by a lower boundary line with a slope of 3. Ground water plotting within the 99% confidence interval and evaporation envelope represents modern to Holocene recharge. A second group of five ground water samples plots well below the MWL, with depletions up to 38 $^{o}/_{oo}$ ^{2}H and 3.5 $^{o}/_{oo}$ ^{18}O relative to modern mean annual precipitation. This composition reflects a dramatic paleoclimate shift, indicating fossil ground water. A third group of 24 ground water samples and one spring sample possesses an intermediate composition that lies between the modern and fossil ground water facies, suggesting that these waters are a mixture of fossil and modern sources. Sample locations and the spatial distribution of isotopic facies are illustrated on Figure 24.

Ground-water age or mean residence time refers to the amount of time elapsed since water in the aquifer has been recharged. Residence time is evaluated using interpretations of stable isotope ratios, $^{18}O/^{16}O$ and $^{2}H/H$, and the radioisotopes ^{14}C and ^{3}H. Determining the age of ground water can be enigmatic, as methods other than tritium rely on dissolved constituents whose amount is affected by physical, chemical, and biological processes. In addition, ground water mixing and convergence of flow paths integrate waters of different origin and age. Hence the "age" determined is only an approximation of the mean residence time in a localized portion of the aquifer. The suite of isotopes applied here permits identification of four age groups of ground water: modern, submodern, Holocene, and fossil. Modern ground waters, those recharged since about 1950, are identified by their tritium content (Table 5). These waters are also part of the active hydrologic cycle, which can be determined by other methods such as hydrogeological mapping and seasonal fluctuations in water level. Submodern ground waters, those recharged in the 50 to 1000 year range, are difficult to identify. A tritium concentration close to the detection limit of 1 TU indicates either recharge during the early 1950's prior to aboveground nuclear testing, or a mixture of fossil, Holocene, or submodern ground water and modern recharge. An intermediate stable isotope signature (see discussion in this section) can further identify ground water of mixed fossil and modern origin. Carbon-14, a lack of tritium, and an undepleted deuterium signature ($\delta\,^{2}H \geq -95$) identify Holocene ground water, recharged from 1000 to 10,000 years ago. An old carbon-14 age and a depleted stable isotope signature indicating a paleoclimate shift ($\delta\,^{2}H \leq -100$) identify fossil ground water which is recharged more than 10,000 years ago during Pleistocene pluvial climate conditions.

Results of age determination on eleven ground water samples and one spring sample from the Placitas area are shown in Table 6 and on Figure 24. These results indicate a tremendous variation in ground water residence time, ranging from modern water to fossil water with a residence time of more than 35,000 years. Only three sites (PW-73, PW-163, PW-109) are identified as modern ground water receiving active recharge. These sites are located adjacent to active streams or arroyos, or major fault systems that are otherwise identified as active ground-water flow paths. Three sites (PW-103, PW-143, PW-149) are identified as fossil water and the spring PS-10 discharges water of Holocene age. These localities are in geologic environments that are hydrologically isolated, of low permeability, and/or far removed from an area of recharge. Five sites are mixtures of modern recharge and either fossil water (PW-39, PW-41, PW-71) or Holocene water (PW-5, PW-89). The age of ground water has important implications for water resource management and development. Depleting ground water that is not actively recharged constitutes mining of the resource. Whereas this practice may be necessary in certain circumstances, it is certainly not sustainable, and is associated with other harmful consequences including water-table declines, drying of wetlands and springs, and land subsidence. On the other hand, ground waters that are actively recharged are part of the modern hydrologic cycle and are constantly being renewed. Exploitation of these sources is potentially sustainable.

B. Water Quality in the Mountain Hydrologic System.

Ground water in the mountain aquifers is generally of high quality, free of elevated mineral concentrations, odor, color, turbidity, and objectionable taste, and hence very suitable for domestic purposes. Ground water in most of the mountain system has a TDI concentration under 400 parts per million (ppm) (Figure 17). The predominant chemical species are calcium and bicarbonate (Figure 18), which impart the quality of “hardness” to the water. Ground water from the Madera Formation typically has between 200 and 270 mg/l equivalent calcium carbonate, a result that is categorized as “very hard”. Three groups of chemically similar water are evident that vary slightly in TDI and composition depending on geologic formation and ground-water residence time. The Madera aquifers of Cuchilla Lupe and Dome Valley in hydrogeologic zone M1 (section III.D.1 and Plate 5), and the Abo aquifer in Las Huertas Canyon (hydrogeologic zone M3), have chemically identical calcium-bicarbonate water. Ground and surface water from these two zones are clustered in a characteristic region of a major ion ternary plot or Piper diagram (Figures 25 and 26). These waters also have relatively low TDI of less than 320 ppm (Figure 17), a low temperature of less than 14 ^{o}C (Figure 19), and a high dissolved oxygen concentration of greater than 5 ppm (Figure 20). These chemical characteristics indicate that the Madera Limestone in zone M1 and Las Huertas Canyon are active ground-water recharge areas. Water-level (Appendix E, section V.A) and temperature data also indicate that ground water in these areas is recharged on a seasonal basis from spring snowmelt. Stable isotope ratios further show that ground water originates from both unaltered and evaporated modern to Holocene precipitation that is biased toward winter-spring precipitation and snowmelt.

The Madera Formation along Cuchilla de San Francisco (hydrogeologic zone M2) also yields calcium-bicarbonate water, but with a slightly higher TDI between 330 and 490 ppm, and higher sodium and magnesium concentrations (Figures 18 and 25) compared with zones M1 and M3. Ground-water temperature is slightly higher, between 18 and 19 ^{o}C (Figure 19), and dissolved oxygen is less than 3.2 mg/l. This composition is consistent with geochemical evolution of Madera recharge water originating upgradient in zones M1 and M3. Ground water beneath Cuchilla de San Francisco follows a long flow path from recharge areas in upper Las Huertas Canyon. Both hydrogeochemical and water-level data (section V.A) indicate that the flow system along Cuchilla de San Francisco is detached from Cuchilla Lupe and Las Huertas Canyon, and has a much longer residence time. Age determination of ground water from this zone yields ages on the order of 8,000 to 12,000 years (PW-89 and PW-71in Table 6 and Figure 24). The stable isotope data (Figure 25) also indicate a mix of modern-Holocene and Holocene-fossil waters.

Ground water from hydrogeologic zone M4 in the Abo Formation east of Cuchilla de San Francisco has the highest sodium, magnesium, and sulfate concentrations in the mountain system

(Figures 18 and 26). TDI in the Abo aquifer of zone M4 varies from about 500 to over 1,000 ppm, and also increases south to north, in the direction of ground-water flow. This regional variability in TDI reflects differences in residence time and proximity to active sources of recharge. Stable isotope data from samples in remote portions of the eastern highlands indicate a mix of fossil (PW-119) or entirely fossil (PW-95) ground water.

C. Water Quality in the Mesozoic Ramp Hydrologic System.

The quality of ground water in the Mesozoic ramp is highly variable and generally poor, as expected from the variety and type of aquifer materials present and the area's geologic complexity. Ground water from different locations in the same geologic formation possesses different hydrogeochemistry and a wide range of TDI concentrations depending primarily on proximity to sources of recharge and aquifer characteristics. Ground water from hydrogeologic zone R1 in the Placitas fault zone, and in permeable units in zones R2 and R3 which are contiguous with the Madera Limestone, has a calcium-bicarbonate composition identical to Madera recharge water from hydrogeologic zone M1 (Figures 27 and 28). Ground water in proximity of the Caballo-Pomecerro fault system is significantly fresher than in the same geologic units located away from the fault. Ground water in wells adjacent to arroyos possesses a chemical signature similar to the surface water, and is also significantly fresher than water in the same geologic unit away from an arroyo. Ground-water residence time and proximity to sources of recharge appear to be the primary controls on water quality in the Mesozoic ramp, with geologic formation exerting a subordinate role.

In general, water from the central part of the Mesozoic ramp near the Caballo-Pomecerro and Placitas fault systems is a calcium-sodium-bicarbonate-sulfate water with various amounts of magnesium and a relatively low TDI of less than 810 ppm (Figures 17 and 18). This water also has an intermediate temperature of 12.9 to 20.1 ^{o}C (Figure 19) and low to intermediate dissolved oxygen of 1.35 to 5.26 ppm (Figure 20). Samples collected away from these faults have extremely high TDI (up to 3250 ppm) caused by high sulfate concentrations.

Ground water in the eastern Mesozoic ramp has the most variable geochemistry in the study area. Total dissolved ions range in concentration from 260 to 7540 ppm (Figure 17), temperature varies from 12.5 to 21 ^{o}C (Figure 19), and dissolved oxygen varies from 1.0 to 7.2 ppm (Figure 20). Ground water from low permeability units including the Petrified Forest, Menefee and Lower Mancos typically has a high TDI with elevated sodium and/or sulfate. Total dissolved ions in ground water from the Menefee and Petrified Forest Formations range from 2000 to 6000 ppm, and in the Lower Mancos from 1000 to 3000 ppm. Where these same units are in close proximity to arroyos, the TDI concentrations drop as low as 1100 ppm in the Menefee and between 400 and 800 ppm in the Mancos. Because of low permeability, poor water quality, and significant thicknesses in the Petrified Forest and Menefee Formations, these hydrostratigraphic units have been designated as separate hydrogeologic zones, R2 and R4 respectively. Ground water from permeable units contiguous with the Madera aquifer, such as the Abo, Dakota, and Morrison Formations, has much lower TDI concentrations of 260 to 800 ppm. However, where permeable units are isolated from sources of recharge, ground water still has elevated TDI. One example is PW-212 in the Point Lookout Formation, which has a TDI of 3140 ppm.

Ground water in the western Mesozoic ramp is of relatively higher quality than other sectors, but is still highly variable. Ground water is produced primarily from the Dakota, Morrison, Hosta-Dalton, and Point Lookout Formations in hydrogeologic zone R3. Ground water in this area has TDI concentrations ranging from 230 to 2250 ppm (Figure 17), temperatures from 16 to 25 ^{o}C (Figure 19), and dissolved oxygen concentrations from 0.66 to 2.0 ppm (Figure 20). Most ground water in this area has consistently high sulfate with variable calcium and sodium. As in other areas, the variability in water quality reflects proximity to sources of recharge, residence time, and geologic formation.

Residence time of ground water in the Mesozoic ramp is also highly variable, and reflects compartmentalization of aquifers in this system. Water-level data indicate that ground water along the Pomecerro/Caballo fault system is locally recharged on an annual basis, and ground water in permeable units contiguous with the Madera also receives relatively young recharge (Appendix E, section V.B). Age determination of ground water from various aquifers in the Mesozoic ramp indicates residence times varying from modern to over 30,000 years (Table 6, PW-5, PW-41, PW-73, PW-103, PW-109, PW-149). The youngest ground water is located in permeable units adjacent to the Pomecerro/Caballo fault system (PW-109 in Jackpile Sandstone member of the Morrison Formation) and adjacent to Arroyo Agua Sarca (PW-73 in the middle Petrified Forest Formation). The oldest ground water, located in the Menefee Formation in both eastern and western sectors of the ramp, yields radiocarbon ages of 27,400 to 31,710 years. Ground water from other moderately permeable formations across the Mesozoic ramp varies from about 2,000 to over 23,000 years. Stable isotope data are consistent with interpretations of radioisotope and general chemistry data, and confirm that modern to Holocene ground waters are located adjacent to arroyos, and in permeable units along previously identified flow pathways. Fossil stable isotope signatures are found in low permeability units in the Menefee Formation in zone R4. Mixed stable isotope signatures are associated with the Petrified Forest Formation in zone R2, and with isolated portions of the Morrison, Lower Mancos, Point Lookout, and Menefee Formations (Figures 27 and 28).

D. Water Quality in the Albuquerque Basin Hydrologic System

Ground water in Albuquerque Basin aquifers is generally of good quality with low TDI concentrations (Figure 17), but exhibits a range of chemical compositions from calcium to sodium bicarbonate with various amounts of sulfate and magnesium (Figure 18). This variability in ion geochemistry reflects depositional heterogeneity in Santa Fe Group sediments, structural compartmentalization of aquifers by intrabasin faults, and proximity to sources of recharge. Hydrogeochemical data and interpretations of ground-water flow are discussed for the four basin hydrogeologic zones, B1 through B4 (Plate 5), in the Placitas area.

1. Northeast Albuquerque Basin, Escala Bench and Lomos Altos

The aquifer in the northeastern Albuquerque Basin between the Escala and San Francisco faults, hydrogeologic zone B1a, consists of a relatively thin block of Lower Group piedmont deposits which is referred to as the Escala bench (section III.D.3). Hydrogeochemical characteristics of ground water in the Escala bench vary moderately, with TDI concentrations between 280 and 500 ppm (Figure 17), temperature ranging from 14.6 to 23.5 ^{o}C (Figure 19), and dissolved oxygen from 0.5 to 8 ppm (Figure 20). Ground water flows generally west and northwest, driven by recharge from Las Huertas Creek and Tecolote on the south, and recharge from the northern end of Cuchilla de San Francisco and San Francisco Creek. Each recharge area produces unique water chemistry. The north-northeast trending Escala syncline, which extends between these two recharge areas, appears to restrict east-to-west ground-water movement. Ground water near Las Huertas Creek is calcium-bicarbonate water with slightly higher sodium and sulfate concentrations than typical Madera Formation water (Figure 18 and Figure 29, PS-8, PSW-7, and PW-97). Moderate temperature (~17.5 ^{o}C), elevated dissolved oxygen (> 5 mg/l), and an evaporated stable isotope signature in these waters are consistent with recent ground-water recharge from Las Huertas Creek (Figures 19, 20, and 29). Water entering the basin from the northern end of Cuchilla de San Francisco is calcium-sodium-bicarbonate water, with various amounts of sulfate (Figure 18, 29), locally elevated temperature (Figure 19), and depleted dissolved oxygen (Figure 20). Ground water along the eastern limb of the Escala syncline adjacent to the San Francisco fault has similar ion chemistry, but moderate to high dissolved oxygen and temperatures similar to the mean surface temperature of 16 ^{o}C. This chemical signature suggests that ground water in these Santa Fe Group piedmont deposits adjacent to the San Francisco fault may originate from the Madera Formation on Cuchilla de San Francisco, but is redistributed by spring discharge and recharged via surface water pathways rather than subsurface through-flow across the fault. Ground water in the western portion of the Escala bench has unique sodium-sulfate-bicarbonate water with high TDI, high temperature, and low dissolved oxygen relative to other locations in the basin. One well, PW-143, completed in this region adjacent to the Escala fault has the longest residence time of any ground water dated during this study (>35,250 years). This long residence time reflects structural compartmentalization of water in the western limb of the Escala syncline and isolation from sources of recharge.

A relatively small, fault-bounded aquifer exists in Lower Santa Fe Group piedmont facies beneath Lomos Altos in hydrogeologic zone B1b (section III.D.3). Ground water in this region south of Las Huertas Creek and north of the Tertiary unconformity, exhibits unique chemistry with higher TDI (530 ppm), calcium-magnesium-sulfate-bicarbonate water characteristic of recharge from Arroyo del Ojo del Orno (see PW-184 and PSW-1; Figures 18 and 29). Temperature (16.8 ^{o}C) and dissolved oxygen (5.5 mg/l) data from well PW-184 are also consistent with recharge from a surface water source. Stable isotope ratios further indicate that both surface and ground water originate from modern, evaporated meteoric water (Figure 29). Together these data strongly support the interpretation that ground water beneath Lomos Altos originates from recharge of surface water from Arroyo del Ojo del Orno, and not throughflow across the Caballo fault or other subsurface pathways. Ground water in the Albuquerque Basin aquifer immediately north of the Lomos fault also reflects mixing of this higher TDI, magnesium sulfate water from Arroyo del Ojo del Orno (see wells PW-130, PW-131, PW-163, PW-169, PW-202, and PW-214; Figures 17 and 18).

2. Eastern Albuquerque Basin

Aquifers in the eastern Albuquerque Basin (hydrogeologic zone B2), north of the Lomos fault and west of the Escala fault, and along the basin margin near the Ranchos, Rincon, and Valley View faults, consist primarily of Upper Santa Fe Group piedmont deposits. Ground water in this zone has low TDI of 213 to 290 ppm (Figure 17), temperature varying from 15 to 22 ^{o}C (Figure 19), and dissolved oxygen concentrations between 2.7 and 7.5 ppm (Figure 20). Major ion chemistry in this part of the basin varies from calcium-bicarbonate to calcium-sodium-bicarbonate-sulfate with various amounts of magnesium (Figure 18). Aquifers adjacent to Las Huertas Creek and Arroyo Agua Sarca yield calcium-bicarbonate water, whereas adjacent to Arroyo del Ojo del Orno and other arroyos draining Lomos Altos the ground water has signficant concentrations of magnesium and sometimes sulfate (see section D.1, Figure 18). Ground water with high dissolved oxygen (>5.6 ppm) is constrained to an area adjacent to Las Huertas Creek and Arroyo del Ojo del Orno immediately west of the Escala fault (Figure 20). This area delineates the recharge corridor and flow paths for ground-water recharge from Las Huertas Creek. Radiocarbon and tritium age determination of ground water in this pathway indicates a ground-water age of about 5 to 10 years (Table 6, PW-163). Stable isotope contents indicate that of most ground water in this zone originated from evaporated modern to Holocene meteoric water (Figure 30). This hydrogeochemistry indicates that recharge along these arroyo corridors has a significant local impact on shallow ground-water quality.

3. Central Albuquerque Basin Axial-Fluvial Deposits

The major aquifers in the central Albuquerque Basin (hydrogeologic zone B3), west of the East Valley View fault, consist primarily of Upper Santa Fe Group axial and transitional axial-piedmont deposits. Water quality here is excellent with less than 380 ppm TDI (Figure 17), 21.4 to 25.6 ^{o}C temperature (Figure 19), and 1.6 to 5.4 ppm dissolved oxygen (Figure 20). Slight differences in water chemistry are centered along the Valley View fault. Ground water east of the fault is calcium-bicarbonate to intermediate calcium-sodium-bicarbonate water with a relatively lower temperature, lower TDI, lower sodium and chloride, and higher dissolved oxygen. This chemical signature is consistent with active recharge from Las Huertas Creek, and also probably from Arroyo Agua Sarca. West of the Valley View fault ground water shows increasing concentrations of sodium, sulfate, chloride, silica and arsenic, a higher temperature, higher TDI and lower dissolved oxygen. Stable isotope contents of most ground water west of the Valley View fault indicate a mixed fossil-modern signature (Figure 31). These geochemical data indicate mixing of older ground water present in the axial river facies of the central Albuquerque Basin with modern mountain-front recharge.

4. Western Albuquerque Basin

Aquifers in the western Albuquerque Basin (hydrogeologic zone B4) consist of a thick sequence of fine-grained Santa Fe Group sediments, known as the Loma Barbon member of the Arroyo Ojito Formation. These deposits are located beneath the active Rio Grande floodplain and include a narrow strip along the western margin of the Placitas study area. These fine-grained deposits of silty sandstone and mudstone are not expected to produce as high a quantity or quality of ground water as other Santa Fe Group deposits, but production is still adequate for domestic purposes. One sample from this zone (PW-198) yields unique sodium-calcium-bicarbonate-chloride water with a TDI of 310 ppm, an elevated temperature of 25.6 ^{o}C, and a mixed fossil-modern stable isotope signature (Figures 18 and 31). The boundary between the fine-grained deposits of the Loma Barbon in zone B4 and the axial river deposits in zone B3 is transitional and interfingering. Accordingly, wells located near the B3-B4 zone boundary shown on Plate 5 (for example, PW-198, PW-201, PW-205) may have characteristics of either hydrogeologic zone.

E. Metal and Trace Element Concentrations in Ground Water

The occurrence and concentration of arsenic (As), iron (Fe), manganese (Mn), and nitrate (NO_3) affect water quality and potability. Concentrations of some of these parameters exceed New Mexico and U. S. Environmental Protection Agency (USEPA) drinking water standards at specific locations in the Placitas area, and together with high TDI concentrations, compromise the potability of ground water in limited areas around Placitas.

Of greatest significance is the presence of arsenic, which ranges in concentration from undetectable to 64 parts per billion (ppb), but is generally less than 20 ppb (Figure 32). All samples from the Upper Santa Fe axial and transitional facies, and about one third of samples from Santa Fe piedmont facies contained detectable arsenic. Low concentrations of arsenic were also detected in isolated portions of the Abo, Agua Zarca, Petrified Forest, Morrison and Point Lookout Formations. The highest concentrations (36 to 64 ppm) are found in Upper Santa Fe axial and transitional facies west of the Valley View fault. Arsenic concentrations between 10 ppm and 20 ppm are found in Santa Fe Group sediments west of the Ranchos Fault, adjacent to the Escala fault, and in the Agua Zarca and Petrified Forest Formations on the Mesozoic ramp. Where the Morrison Formation is in fault contact with the Agua Zarca and Petrified Forest Formations, it also contains arsenic in this concentration range. Low concentrations of arsenic were also detected in isolated samples from the Point Lookout and Abo Formations at locations where these formations receive little or no fresh recharge. No samples exceeded the New Mexico domestic water standard (100 ppb), and only one sample from Upper Santa Fe Group axial deposits (PW-205) exceeded the USEPA drinking water standard (50 ppb). These standards are currently under review and may be lowered to or below 20 ppb. If standards are lowered to 10 ppb, several private and community water supply systems would be affected.

Nitrate was detected in 87% of samples, and in samples from all but one geologic formation. Concentrations range from less than 1.0 to 15 ppm, but rarely greater than 5 ppm (Figure 33). Only two samples showed concentrations greater than the New Mexico and U.S. EPA drinking water standard of 10 ppm, one from Lower Santa Fe piedmont deposits east of the Escala fault, and one from the Lower Mancos Formation adjacent to Arroyo del Oso. There is no evidence of anthropogenic impact to ground-water or surface-water quality in Placitas from nitrate contamination. Naturally occurring nitrate concentrations less than 5 ppm are common in many environments.

The concentration of iron in ground water ranges from undetectable to 6070 parts per billion (ppb), but is generally less than 1,000 ppb. Iron was detected in all but one geologic formation. Iron concentrations in excess of 1,000 ppb (New Mexico drinking water standard) were detected in six samples from fine-grained, distal piedmont deposits in the Santa Fe Group, and from the Point Lookout, Dakota, Morrison, and Agua Zarca Formations. Ten additional samples from low permeability zones in the Point Lookout, Lower Mancos, Menefee, Morrison, and Petrified Forest Formations exceeded the U.S. EPA aesthetic standard of 300 ppb.

Manganese was detected in all geologic formations except Upper Santa Fe axial deposits at concentrations ranging from 1.4 to 580 ppb, but typically less than 50 ppb. Only the Petrified Forest, Morrison, and Point Lookout Formations produced ground water with manganese concentrations in excess of the U.S. EPA aesthetic standard of 50 ppb. Fifteen ground-water samples exceeded 50 ppb, and three of those also exceeded New Mexico’s aesthetic standard of 200 ppb.

VII. SUMMARY AND DISCUSSION

The three major hydrologic systems in the Placitas area, the mountain hydrologic system, the Mesozoic ramp, and the Albuquerque Basin hydrologic system (section III.D, Figure 7), each possess unique geologic and hydrologic characteristics. However, as demonstrated in sections V and VI, each system also exhibits significant variability in aquifer geometry, hydraulic properties, water quality, ground-water residence time, and accordingly, in ground-water availability. To effectively describe water availability by geographic area, each hydrologic system has been further divided into zones that possess similar hydrogeologic characteristics. These hydrogeologic zones are illustrated in Plate 5 and summarized in Table 7. The characteristics of each hydrogeologic zone, the major hydrostratigraphic units (aquifers and aquitards), aquifer potential, recharge, residence time, water quality, and representative wells and springs are also described in detail in the following subsections.

A. Hydrogeologic Zones in the Mountain Hydrologic System

The mountain hydrologic system (section III.D.1) is divided into four hydrogeologic zones, M1 through M4, according to unique combinations of hydrostratigraphic units, recharge sources and mechanisms, ground-water residence time, and water quality.

1. Zone M1, Sandia North Slope, Cuchilla Lupe and Upper Las Huertas Canyon

Hydrogeologic zone M1 encompasses the north slope of the Sandia Mountains south of the Placitas fault zone, and includes the areas of Cuchilla Lupe, Dome Valley, and upper Las Huertas Canyon. The major hydrostratigraphic unit and aquifer in this zone is the Madera Formation (section III.B.3), which forms a dual-porosity, fractured limestone aquifer with moderate aquifer potential (Figure 6, Plate 2). Because ground-water flow and occurrence in the Madera Formation is concentrated along discrete fractures, fracture systems, or bedding planes, the availability of ground water is highly variable and dry holes are relatively common. On a formation scale, the Madera Limestone possesses very high transmissivity and relatively low storage properties. However, hydraulic properties in the Madera Limestone are expected to vary between the matrix and fractures by up to eight orders of magnitude in hydraulic conductivity and one order of magnitude in specific yield. Hydraulic conductivities of 0.1 to 100 ft/d and storativity of 0.01 have been documented in a fault-related fracture system in the Madera (Johnson, 1999). But hydraulic conductivity as low as 10^{-4} ft/d and a storage coefficient of 0.005 or less are expected for unfractured limestone matrix.

Because of its high elevation and its large infiltration capacity, the Madera Limestone in zone M1 is a recharge area. Madera aquifers in this zone are recharged by infiltration of snowmelt, precipitation, and surface water in Las Huertas Creek and other small drainages that capture and focus runoff. As surface water crosses fractured Madera Limestone, it rapidly infiltrates into the subsurface and concentrates primarily along fault-related fracture systems (sections IV.C.1 and V.A). This recharge process is quite active and replenishes the aquifers on an annual basis in response to melting snow pack (Plate 6). Integrated residence time of ground water in the fractures and matrix of the Madera Limestone in this zone is on the order of 10 years or less. However, these aquifers are also susceptible to drought and experience water level declines in years following low or no high-elevation snow pack. Several major springs located along fault-related fracture systems, including the Placitas Village springs, discharge ground-water from the Madera Formation, and could be susceptible to impact from up-gradient and/or local well development (section IV.C.2).

Water quality in the Madera Limestone in zone M1 is excellent and typically has a TDI concentration of less than 300 ppm, with calcium and bicarbonate constituting the major ions. Because of its fractured character and little to no soil cover, the Madera Limestone in this zone is also particularly susceptible to water quality degradation from surface or near surface contamination such as might originate from septic systems, contaminant spills, large concentrations of animals or feedlots, or contaminated surface water.

2. Zone M2, Cuchilla de San Francisco and the Crest of Montezuma

Hydrogeologic zone M2 encompasses the Crest of Montezuma and Cuchilla de San Francisco, the northernmost limestone salients of the northern slope of the Sandia Mountains. Most of this zone is contained on national forest land, or has such steep topographic relief as to be unsuitable for development. The northernmost tip of the zone includes developing areas associated with San Francisco Hills, and proposed future phases of the Diamond Tail subdivisions. A narrow strip of terrain that comprises the San Francisco fault zone north of Tecolote is also included in this zone. As in zone M1, the major hydrostratigraphic unit in this zone is the Madera Formation (section III.B.3, Figure 6, Plate 2). The entire formation is exposed along the Crest of Montezuma, but further north along Cuchilla de San Francisco only the upper Madera Formation is reasonably accessible to shallow water wells (Plate 3, cross-sections A-A', B-B', and C-C'). Zone M2 shares many hydrogeologic characteristics with zone M1, but also differs in two significant ways. This area lacks multiple north-south faults that create pervasive fracture systems, and Zone M2 is isolated from major sources of recharge such as Las Huertas Creek (section V.A).

Ground-water flow and occurrence in the Madera Formation of Zone M2 appears to be concentrated primarily along a fracture system associated with the damage zone east of the San Francisco fault, and in minor fractures and bedding planes in the limestone. The San Francisco fault (section III.C.2) is a major north-south fault that forms the boundary between older bedrock units (primarily Madera Formation) on the east and the Albuquerque Basin to the west. The San Francisco fault generally does not form a single fault trace or fault plane. Rather it consists of a broad zone of deformation that ranges from roughly 100 to 1000 ft or more in cross-section, and includes fault gouge, breccia, fault slivers, and deformed blocks of older stratigraphic units (Plate 2, cross-sections B-B' and C-C' of Plate 3). In general, the hydraulic conductivity of the fault core is expected to be dramatically less than the undeformed material on either side of the fault (section III.C.1). Hydrologic data suggest that permeable windows exist along segments of the otherwise low-permeability fault near Tecolote and Old San Francisco Springs Ranch. In these areas the fault zone is broad, intersects with other faults, and incorporates large fault slivers and blocks of various materials. Because ground water in the vicinity of the fault zone is concentrated along discrete fractures and in slivers of permeable material, the availability of water is extremely variable. Both dry holes and wells of low to moderate productivity are documented (for example PW-207, PW-157, PW-92, PW-93, and PW-94).

The availability of ground water from the Madera Formation east of the fault zone is also highly variable and the aquifers here, as in zone M1, possess relatively high transmissivity, and low storage properties (paragraph 1, this section). The Madera Formation in zone M2 is recharged primarily through interaquifer flow from areas at higher elevation in the Sandia Mountains, with only minor contributions from local infiltration of precipitation. No recharge appears to originate from Las Huertas Creek. Accordingly, ground water in the Madera Formation along Cuchilla de San Francisco is recharged through a very long flow path and reflects a residence time of 1000s of years (Table 6, PW-71 and PW-89). Water quality in this zone is good, with TDI of 300 to 500 ppm, and calcium, sodium, and bicarbonate constituting the major ions. Higher concentrations of total dissolved solids, specifically sodium and magnesium, relative to ground water in zone M1 reflects this long residence time.

Because of its fractured character and little to no soil cover, the Madera Limestone in this zone is also particularly susceptible to water quality degradation from surface or near surface contamination such as might originate from septic systems, contaminant spills, or large concentrations of animals or feedlots. Zone M2 also contains several major springs located east of and adjacent to the San Francisco fault that could be particularly susceptible to impact from up-gradient and/or local well development in the same fracture network or bedding interval (section IV.C.3).

3. Zone M3, Las Huertas Canyon

Hydrogeologic zone M3 includes the valley bottom along Las Huertas Creek south of Tecolote. The major hydrostratigraphic unit is the Abo Formation (section III.B.3). Only about 30% of the Abo Formation consists of material with a moderate to poor aquifer potential; the remaining 70% consists of mudstone with little or no water producing capability (Figure 6, Plate 2). Accordingly, ground-water production from the Abo Formation is variable, limited to relatively thin sandstone units, and generally dependent on local sources of recharge. Ground water from the Abo Formation along Las Huertas Creek is primarily recharged by surface water infiltrating through the creek channel (section V.A), and to lesser extents from direct infiltration of precipitation, and interaquifer flow from the up-gradient Madera Formation. Ground water in the canyon is actively replenished on an annual basis in response to melting snow pack and runoff in Las Huertas Creek. However, these aquifers are also susceptible to drought and experience water level declines in years following low or no high-elevation snow pack and spring runoff (see for example PW-50, PW-88, PW-92, PW-93 on Figures E-3, E-4, and E-5). Water quality in the Abo Formation of zone M3 is excellent, with a TDI concentration of less than 300 ppm, and calcium and bicarbonate constituting the major ions (Figures 17 and 18). The quality of ground water in Mesozoic Formations adjacent to Las Huertas Creek in the San Francisco fault zone is slightly degraded, however, with TDI up to 420 ppm and increased concentrations of sodium, magnesium, and sulfate.

4. Zone M4, Highlands East of Cuchilla de San Francisco

Hydrogeologic zone M4 encompasses all of the area east of Cuchilla de San Francisco, most of which lies outside the study area. Much of the area also lies within the region of planned development by current and future phases of the Diamond Tail subdivision. A number of hydrostratigraphic units are present in this zone, and include the entire stratigraphic section from the Permian Abo Formation through the Triassic Petrified Forest Formation (section III.B.2 and III.B.3). These bedrock units generally form subvertical, subparallel strip aquifers and aquitards oriented in a north-south direction. Only 25% of the zone consists of material with a moderate to poor aquifer potential; the remaining 75% contains mudstone and siltstone with little or no water producing capability (Figure 6, Plate 2). Accordingly, the availability of ground water in zone M4 is highly variable, and generally poor. There are insufficient hydrologic data available in the zone to adequately characterize or define the aquifers. Aquifers in zone M4 are recharged primarily through interaquifer flow from areas at higher elevation in the Sandia Mountains, with only minor contributions from local arroyo channel infiltration. Accordingly, ground waters in the various aquifers are probably emplaced through a very long flow path and likely reflect a residence time of 1000s of years or more. Stable isotope analyses from well PW-95 in the Abo Formation reflect a fossil ground-water signature. Ground water in the various aquifers of zone M4 is of moderate quality, with a TDI concentration of 400 to 1000 ppm, and sodium, calcium, bicarbonate, and sulfate constituting the major ions.

B. Hydrogeologic Zones in the Mesozoic Ramp Hydrologic System

The Mesozoic ramp hydrologic system (section III.D.2) is divided into four hydrogeologic zones, R1 through R4, according to unique combinations of hydrostratigraphic units, recharge sources and mechanisms, ground-water residence time, and water quality. Each hydrogeologic zone is discussed in detail in the following subsections.

1. Zone R1, Placitas Fault Zone

Hydrogeologic zone R1 encompasses the foothills of the northern Sandia Mountains immediately south of the Placitas study area and a small area along the western base of Cuchilla Lupe. The major hydrostratigraphic units in this zone are fault-bounded blocks of Permian Abo Formation through Triassic Agua Zarca Formation (section III.B.1 and III.B.2) exposed in the Placitas fault zone. Most of these units possess a moderate to poor aquifer potential (Figure 6) that is enhanced by fault-related fracturing. The Placitas fault (section III.C.2) is a major northeast-trending fault at the base of the northern Sandia Mountains. The fault does not form a single fault trace, rather it consists of a complex system of steeply dipping normal faults (Plate 2). The geometry and orientation of faults and fault blocks within the fault zone control movement of ground water from the up-gradient Madera Limestone into down-gradient areas of the Mesozoic ramp. The fault juxtaposes rock units of significantly different lithology and fluid properties, often impeding ground-water movement across the fault zone. Tunnel Spring (PS-5), for example, discharges ground water from a block of Madera Limestone within the fault zone. Several other springs are located along fault-related fracture systems and stratigraphic barriers (section IV.C.2). Subsurface through-flow of ground water across the Placitas fault zone can only occur where aquifer units of adequate permeability are adjacent to the Madera Limestone, or where a continuous, high permeability zone is associated with a through-going north-south fault. The movement of ground water into and through zone R1 is believed to actively occur at three, high permeability locations (section III.D.2) on a time scale of a few years to a few tens of years. In low permeability areas where the movement of ground water is restricted, this recharge process may take 100s or 1000s of years. Ground water in a fault block of Abo Formation along the western base of Cuchilla Lupe is probably recharged by a combination of interaquifer flow from up-gradient Madera Formation, and infiltration of surface water in acequia channels. As a result of these multiple recharge mechanisms, ground water in this area of zone R1 reflects a complicated recharge history and residence time, with components of both modern and fossil water (Table 6, PW-39). Ground-water quality in this zone is excellent to good, with TDI concentrations of 260 to 340 ppm, and calcium and bicarbonate constituting the major ions.

2. Zone R2, Southern Mesozoic Ramp

Hydrogeologic zone R2 encompasses the lower foothills of the northern Sandia Mountains along the southern boundary of the Placitas study area. Roughly half of this hydrogeologic zone is contained on national forest land. The other half includes the developed areas of La Puerta, Tunnel Springs, and Placitas Heights, and additional undeveloped areas to the east. The major hydrostratigraphic unit in this zone is the Triassic Petrified Forest Formation (section III.B.2, Plate 2). The lower and upper units of this formation comprise 85% of zone R2, and consist of very fine-grained mudstone and shale that possess extremely poor to no aquifer potential (Figure 6). Many wells completed in these units are unable to sustain a production sufficient to fulfill domestic needs. The middle Petrified Forest forms an isolated, thin, sandstone strip aquifer with a moderate to poor aquifer potential (Figure 6). This aquifer is recharged primarily by interaquifer flow across the Placitas fault zone (see section III.D.2 and paragraph 1 above), and to a lesser extent by infiltration from Arroyo Agua Sarca. Recharge is thus spatially limited, localized along through-going, north-south faults or active arroyos, and occurs on a highly variable time scale ranging from 10s to 1000s of years depending on location (PW-73, Table 6). A few isolated tracts reflect water-level fluctuations consistent with annual recharge (for example, PW-141; Plate 6). Low permeability portions of the upper and lower units of the Petrified Forest are probably recharged on a time scale ranging from 100s of years to more than 10,000 years. A portion of zone R2 near Tunnel Spring has experienced historic water level declines of more than 50 ft (Plate 7), indicating that the aquifer in this area has been overdeveloped.

The quality of ground water in zone R2 reflects this large variation in residence time. Water quality in the middle sandstone aquifer varies from good to very poor, with TDI concentrations of 390 to 3230 ppm, and sodium, bicarbonate, and sulfate constituting the major ions. Ground water in the upper and lower units varies in quality from moderate to very poor, with TDI concentrations of 560 to 5950 ppm, and sodium, calcium, and sulfate as the major ions. Extremely high TDI concentrations (more than 2000 ppm) documented in many of the wells completed in this zone reflects a combination of long residence time, little or no fresh recharge, and the occurrence of soluble gypsum disseminated throughout the mudstone and shale.

3. Zone R3, Mid Mesozoic Ramp

Hydrogeologic zone R3 includes a relatively large area in the central portion of the Mesozoic ramp hydrologic system. Most of the residential development in the study area, including the Village of Placitas, is contained in this hydrogeologic zone. This zone exemplifies the compartmentalized aquifer system characteristic of the Placitas area, with subvertical strip aquifers separated and isolated by strip aquitards and faults (section III.D.2). Nine hydrostratigraphic units occur in this zone from the Jurassic Entrada Formation up-section to the Upper Mancos Shale Formation (section III.B.2, Figure 6, Plate 2). Roughly 60% of the hydrostratigraphic units in zone R3 have poor to no aquifer potential and generally behave as aquitards that neither produce adequate volumes of good quality water nor allow ground water to move across them into other more permeable units. The remaining 40% of zone R3 consists of isolated, thin strips of sandstone aquifers that range in thickness from 20 ft or less to a maximum of about 300 ft. Because these sandstones are generally fine-grained and moderately to well cemented, they have relatively low porosity and permeability and thus possess only moderate to poor aquifer potential. These aquifers are not only isolated from each other, but with few exceptions are also isolated from significant sources of fresh ground-water recharge. Recharge to aquifers in this zone occurs either by subsurface, interaquifer flow from the Madera Limestone across the Placitas fault zone (through zone R1), or by infiltration of surface water from perennial or ephemeral streams that cross one of the permeable sandstone units (section V.B). Recharge is thus limited to very specific areas and also limited by availability of snowmelt and runoff. Aquifers in zone R3 that are accessible to recharge are replenished on a scale of a few years to tens of years (Table 6, PW-109), although very isolated tracts reflect water-level fluctuations consistent with annual recharge (for example, PW-12, PW-85, PW-56, PW-18; Plate 6). Most aquifers in zone R3 are isolated, and probably recharged on a time scale of 1000s of years to 10,000 years or more (Table 6, PW-41). Much of the area around Quail Meadow has experienced historic water level declines of 5 to 25 ft, and locally up to 170 ft, indicating that aquifers in a large portion of the zone have been overdeveloped (Plate 7).

Because of the extreme variability in aquifer material, and amount and location of recharge, water quality in zone R3 is also extremely variable. Aquifers accessible to active recharge can have excellent water quality with less than 300 ppm total dissolved solids, and calcium-bicarbonate type water. These wells are the exception and are typically located in clean sand aquifers immediately adjacent to an active source of arroyo-channel recharge such as along Arroyo Agua Sarca in Rainbow Valley, or at shallow depths adjacent to Arroyo del Oso. Aquifers receiving recharge through interaquifer flow mechanisms typically have moderate water quality with total dissolved solids between 500 and 1000 ppm, and higher concentrations of sodium and sulfate. Much of the ground water in zone R3 is categorized as poor (TDI of 1000 to 2000 ppm) or very poor (TDI greater than 2000 ppm), with elevated concentrations of sulfate and other undesirable trace elements.

4. Zone R4, Northern Mesozoic Ramp

Hydrogeologic zone R4 encompasses the northern-most portion of the Mesozoic ramp, and includes the developed areas of Lomas de Placitas, El Cerro Negro, and portions of Puesta del Sol, and Ranchos de Placitas. The major hydrostratigraphic unit in this zone is the Cretaceous Menefee Formation (III.B.2, Plate 2), a 1200-foot thick shale unit that has virtually no aquifer potential (Figure 6). The lower half of this formation contains the Harmon Sandstone, which provides about 130 ft of aquifer material with lithologic characteristics that should possess a moderate aquifer potential. However, several wells have been drilled into this portion of the formation without encountering water (for example PW-182), or encountering water of such poor quality as to be unpotable. Wells that produce from this formation obtain their water from very thin, fine-grained sandstone beds that vary in thickness from less than 10 ft to no more than 30 ft, and possess only poor aquifer potential. The Menefee Formation also contains coal and peat seams, and a very high organic content, features that lead to extremely poor water quality (section VI.C). The permeable portions of this formation receive only minimal, localized recharge by infiltration from Arroyo del Ojo del Orno or smaller ephemeral channels. Up-gradient, subvertical aquitards probably completely restrict ground-water movement into the formation through interaquifer flow. Ground-water residence times measured in this formation are among the longest monitored in the Placitas area, indicating ages in the range of 25,000 to 30,000 years (Table 6, PW-103, PW-149). Water quality in zone R4 is typically poor to very poor. Portions of the formation immediately adjacent to arroyos produce the best water quality, with TDI concentrations ranging from 850 to 1640 ppm, and high concentrations of either or both sulfate and/or sodium (for example, PW-23, PW-147, PW-149, PS-19). Water from elsewhere in the formation typically has TDI concentrations much greater than 2000 ppm and as much as 3800 ppm (for example PW-78, PW-103).

C. Hydrogeologic Zones in the Albuquerque Basin Hydrologic System

The Albuquerque Basin hydrologic system (section III.D.3) is divided into four hydrogeologic zones, B1 through B4. Two of these zones are further divided into subzones, based on lithologic characteristics, aquifer thickness, recharge sources, ground-water residence time, and water quality. Each hydrogeologic zone is discussed in detail in the following subsections.

1. Zone B1, Northeast Albuquerque Basin

Two regions in the northeast Albuquerque Basin and the northern portion of the Placitas study area consist entirely of Lower Santa Fe Group piedmont deposits. These regions are the Escala bench, between the San Francisco and Escala faults, and Lomos Altos. The regions are designated as separate hydrogeologic zones B1a and B1b respectively (Plate 5).

Hydrogeologic zone B1a consists of a fairly thick sequence of Lower Santa Fe Group conglomerate piedmont deposits that make up the Escala bench, located between the San Francisco and Escala faults. Zone B1a incorporates several developed and newly developing residential and agricultural areas, including Tres Amigos, western portions of Tecolote, Linda Placitas, Mountain View Acres, and San Francisco Hills. Piedmont deposits on the Escala bench consist primarily of large cobble and boulder conglomerates, with lesser amounts of gravel, gravelly sandstone, and coarse sandstone (section III.B.1(b)). These sediments are more consolidated and cemented than sediments elsewhere in the Albuquerque Basin, but still possess moderately high hydraulic properties (0.1 to 4 ft/d hydraulic conductivity and 0.1 storage coefficient) and can produce significant volumes of good quality water (P.Johnson, unpubl. report for Sandoval County, 1999). Depth to ground water in zone B1a varies from the land surface, along perennial reaches of Las Huertas and San Francisco Creeks (sections IV.C.1, IV.C.3), to as much as 650 ft adjacent to the Escala fault, 500 ft in Tres Amigos, 300 to 400 ft in Linda Placitas and Mountain View Acres, and 150 to 200 ft in San Francisco Hills. Total thickness of the Lower Santa Fe Group piedmont deposits in this zone varies from about 800 ft near Las Huertas Creek to an estimated 2600 ft beneath Mountain View Acres. The sediments in this zone are deformed into a broad plunging syncline called the Escala syncline (Plate 2; Plate 3, cross-sections B-B', C-C', and E-E'). This synclinal structure restricts ground-water movement from east to west in the zone, resulting in an extremely long ground-water residence time in portions of the zone not being actively recharged (Table 6, PW-143; section V.C). The aquifer in zone B1a is recharged from two sources: (1) subsurface through-flow of ground water across the San Francisco fault at Tecolote and the northern end of Cuchilla de San Francisco, and (2) infiltration of surface water from San Francisco Creek and Las Huertas Creek. Recharge by infiltration along the creek channels is an active process and replenishes the aquifers in the immediate vicinity of the creek channels on an annual or continual basis. Recharge by subsurface flow across the San Francisco fault is limited and operates on a much longer time scale, probably on the order of 10s to 100s of years near Tecolote and 100s to 1000s of years at the northern end of Cuchilla de San Francisco (Table 6, PS-10). Zone B1a contains several major springs and perennial stream reaches that are susceptible to impact by local ground-water development. These springs include Rosa de la Costilla spring on Las Huertas Creek (section IV.C.1), and springs on the Wessley property along San Francisco Creek (section IV.C.3).

Water quality in zone B1a is excellent to good depending on location, proximity to sources of recharge, and ground-water residence time (section VI.D.1). Shallow aquifers receiving recharge from Las Huertas Creek have excellent water quality, with a TDI concentration of less than 300 ppm, and calcium-bicarbonate type water. The portion of aquifer receiving recharge from San Francisco Creek and the northern end of Cuchilla de San Francisco has good water quality, with a TDI concentration of 300 to 420 ppm, and calcium, sodium, and bicarbonate as the major ions. Ground water from deeper portions of zone B1a that are not a part of the active recharge system (for example, PW-186 and PW-143) still have good water quality, but higher TDI concentrations of 450 to 500 ppm, and sodium, bicarbonate, and sulfate as the major dissolved ions.

Hydrogeologic zone B1b encompasses Lomos Altos, and consists of a relatively thin sequence of Lower Santa Fe piedmont deposits. Zone B1b includes the Overlook subdivision, City of Albuquerque open space, and several newly developing areas. This zone is bounded on three sides by major faults, and on its southern boundary by an erosional contact with the upper Cretaceous Menefee Formation (section III.D.3), all of which are believed to form hydrologic boundaries. The piedmont deposits on Lomos Altos are similar to those comprising the Escala bench in zone B1a, but based on limited subsurface geologic data from PW-184 also appear to have a slightly greater proportion of mudstone, and accordingly a slightly lower range of hydraulic properties. Only two wells are currently completed in this hydrostratigraphic unit, and both produce adequate volumes of good quality water. Depth to ground water in the center of zone B1b varies from about 350 to 450 ft below land surface, depending on elevation of the well head. Total thickness of the Lower Santa Fe Group piedmont deposits in this zone varies from about 300 ft along the southern edge of the zone to about 800 ft at the Lomos fault. The sediments in zone B1b are also deformed into a broad plunging syncline called the Lomos syncline (Plate 2). This synclinal structure probably also restricts ground-water movement from east to west in the zone, resulting in long ground-water residence time in the western portion of the zone not being actively recharged (section V.C). The aquifer in the eastern half of zone B1b receives fairly limited recharge via infiltration from Arroyo del Ojo del Orno in the northwest corner of the zone. Recharge by infiltration along the creek channel is an active process and replenishes the aquifers in the immediate vicinity of the creek channel on a continual basis. Because the aquifer in the western half of the zone lacks any active recharge, ground-water residence time here is probably much longer, probably on the time scale of 100s to 1000s of years. The perennial stream reach along Arroyo del Ojo del Orno is sensitive to impact by local ground-water development. Water quality in zone B1b is good and reflects the quality of surface water in Arroyo del Ojo del Orno (see PW-184 and PSW-1). Ground water has a TDI concentration of about 530 ppm, with calcium, sulfate, and bicarbonate as the major dissolved ions.

2. Zone B2, Eastern Albuquerque Basin

The eastern margin of the Albuquerque Basin consists entirely of a conglomerate-sand facies of Upper Santa Fe Group piedmont deposits. This margin region encompasses a northeast trending strip through the center of the Placitas study area. The region is subdivided into two separate hydrogeologic zones, B2a and B2b (Plate 5), based on aquifer thickness, and sources of recharge.

Hydrogeologic zone B2a consists of thick sequences of Upper Santa Fe Group conglomerate and sand that were deposited adjacent to the Rincon, Ranchos, and Escala faults. This zone incorporates the fastest developing areas in the vicinity of Placitas and includes Placitas Small Tracts, Placitas Homesteads, Tres Vidas, Cedar Creek, Placitas Ranchettes, Placitas North, Juniper Hills, and Windfall subdivisions. Piedmont deposits in zone B2a form a block of relatively permeable gravel and sand about 1.5 miles wide. The sediments also contain mudstone, which is generally rare, but increases proportionally to the west (sections III.B.1(b) and III.D.3). Total thickness of the Upper Santa Fe Group sediment in zone B2a varies from about 2000 to 2500 ft in the southern half, and up to 3500 ft in the northern half of the zone. These sediments possess moderate values of transmissivity (7 ft/d hydraulic conductivity) and produce sufficient quantity and quality of water for domestic purposes (P.Johnson, unpubl. report for Sandoval County, 1999). Depth to productive ground water in zone B2a varies from 550 to 650 ft below land surface in the southern part of the zone, from 350 to 450 ft in Cedar Creek, and from 250 to 400 ft in the area north of Las Huertas Creek. A deeper production zone is located adjacent to the Escala fault near the boundary of San Felipe Pueblo, where ground water is encountered at about 500 ft below land surface. The aquifers in zone B2a are recharged by infiltration of surface water through arroyo channels. Perennial stream flow from Las Huertas Creek and Arroyo del Ojo del Orno contributes significant recharge to the area encompassed by Cedar Creek, Tres Vidas, Placitas Ranchettes, Placitas North, Juniper Hills, and Windfall subdivisions. Stream-channel infiltration is an active recharge mechanism and replenishes the shallow ground-water system in this vicinity on a continual basis. Ground-water residence time in this area is on the order of a few years to 10s of years (Table 6, PW-163). The aquifer in the southern portion of zone B2a has no significant, local source of recharge, and ground-water residence times are probably much longer, on the order of 100s to 1000s of years.

Water quality in zone B2a ranges from excellent to good depending on location. Ground water in the southern portion of the zone has TDI concentrations varying from 260 to 380 ppm, with calcium and bicarbonate as the major dissolved ions. Wells on the western edge of this zone, where the piedmont sediments transition into axial river sediments, contain higher TDI concentrations and higher concentrations of sodium, sulfate, and chloride. Ground water in the northern portion of the zone has TDI concentrations varying from 220 to 420 ppm depending on location and source of recharge. In the vicinity of Cedar Creek, recharge originating from Arroyo del Ojo del Orno influences the quality of ground water, resulting in higher TDI concentrations (390 to 420 ppm) and a greater portion of sulfate in the water. North of Las Huertas Creek water quality is consistently excellent, with TDI concentrations less than 300 ppm, and calcium and bicarbonate as the major dissolved ions.

Hydrogeologic zone B2b consists of a relatively thin sequence of Upper Santa Fe Group conglomerate and sand wedged between the Ranchos and Valley View faults. This zone includes most of the Vista de Oro, Ranchos de Placitas, and North Ranchos developments. The piedmont sand and gravel deposits in zone B2b are lithologically similar to those described above for zone B2a, but form a relatively thin wedge estimated to be only 700 to 1000 ft thick. This fault-bounded block of sediments also possesses moderate permeability and storage properties, but a relatively lower transmissivity due to much thinner saturated thickness than the aquifers in zone B2a. Historic water level declines in the vicinity of PW-191 of about 20 ft between 1971 and 1995 suggest that ground-water resources in some areas of zone B2a may be over-developed (Plate 7). Depth to productive ground water in zone B2b varies from about 800 ft in the southern half of the zone, to about 350 to 600 ft in the northern part of the zone, depending on elevation of the well head. Infiltration of ephemeral stream flow in Arroyo Agua Sarca is probably the only source of recharge to the aquifer in zone B2b. This is not an active recharge mechanism that can transmit a significant volume of recharge to a water table 350 ft below the channel. Although no age determination data were gathered in this hydrogeologic zone, the working model of the ground-water system in this zone is consistent with a residence time on the order of at least 1000s of years, and possibly more than 10,000 years. Water quality in zone B2b is excellent, with less than 300 ppm of total dissolved solids, and calcium, sodium, and bicarbonate as the major dissolved ions.

3. Zone B3, Central Albuquerque Basin

Hydrogeologic zone B3 consists of a thick sequence of Upper Santa Fe Group axial river deposits that occupies a narrow strip through the center of the Albuquerque Basin, east of the current Rio Grande floodplain. These axial deposits form a block of highly permeable sand and gravel varying from about 1 mile to 3 miles in width and from 700 to 2,500 ft in thickness (sections III.B.1(a) and III.D.3). This zone incorporates the developed areas of Vista de la Montana Sur, Placitas Trails, Placitas Trails North, Tierra Madre, La Mesa, and Sundance Mesa. The aquifers in zone B3 have very high permeability and storage values (hydraulic conductivity up to 450 ft/d), and are among the most productive aquifers in the Albuquerque Basin (P.Johnson, unpubl. report for Sandoval County, 1999). These aquifers have the capacity to support large municipal supplies. Depth to productive ground water in this zone varies from 350 ft to 550 ft depending on elevation of the well head. The aquifers in zone B3 are recharged by infiltration of surface water from ephemeral and perennial stream channels, including the Rio Grande and its associated system of canals and drains, and by deep subsurface inflow of ground water from the Espanola Basin to the north. Ground-water residence time in this system is believed to vary with depth and location from a few years or 10s of years to many 1,000s of years. Based on water quality and hydrologic data it appears that recharge originating from Las Huertas Creek, Arroyo del Ojo del Orno, and Arroyo Agua Sarca in hydrogeologic zones to the east may contribute to the shallow ground-water system in zone B3 on a relatively short time scale. Water quality in zone B3 is generally excellent, with concentrations of total dissolved solids less than 300 ppm, and calcium, sodium, and bicarbonate as the major dissolved ions. Some wells completed in zone B3 in the northwest corner of the study area have concentrations of arsenic approaching or in excess of the maximum contaminant level established by the U.S. Environmental Protection Agency (for example, PW-205).

4. Zone B4, Western Albuquerque Basin

Hydrogeologic zone B4 consists of a thick sequence of fine-grained Santa Fe Group sediments, known as the Loma Barbon member of the Arroyo Ojito Formation. This zone occupies the subsurface beneath the current Rio Grande floodplain and includes a narrow strip along the western margin of the Placitas study area. Placitas Trails South and newly developing areas immediately east of Interstate 25 are included in the zone. Although these fine-grained deposits of silty sandstone and mudstone are not expected to produce as high a quantity or quality of water as other Santa Fe Group deposits, production should still be sufficient for domestic purposes. The boundary between the fine-grained deposits of the Loma Barbon in zone B4 and the axial river deposits in zone B3 is transitional and interfingering. Accordingly, wells located near the B3-B4 zone boundary shown on Plate 5 (for example, PW-198, PW-201, PW-205) may have characteristics of either hydrogeologic zone. Because very limited water quality and water level data, and no aquifer test data, were available from this zone, a more detailed description of the aquifer characteristics for zone B4 is not possible.

VIII. ACKNOWLEDGMENTS

The authors gratefully acknowledge William J. LeFevre for his many contributions to the understanding of the water quality and geochemistry of ground and surface water in the Placitas area, which were provided through graduate research at New Mexico Tech.. We also thank Debbie Hayes, Sandoval County Manager, and Jim Service, former Sandoval County Planner, for funding and defining the scope of this project. Bill Dealy of W.C. Dealy Pump and Well Service, formerly with Murray Drilling Co., provided in depth knowledge of wells, water levels, and water quality in the area. Many Placitas property owners graciously provided access to wells, well records, and property during the course of this study, and without their interest and support the work product would not have been possible. While all the participants are too numerous to mention, the following individuals provided exceptional support during the course of the study: Ed Newville, Jim Fish, Dana Army, Bob Wessely, George Shaffer, Jean Johnson, Len and Fran Stephens, Joe Neas, Stan Dieker, Cynthia Schoen, Marianne Davidson, Jean Eichberger, Bruce and Wilda Maclauchlan, Lois Gonzales, Jackie Ericksen, John Shomaker and Assoc. (for Diamond Tail, Inc.), Rebecca Summer, Jeff Watson, and Tony Lucero. We also thank the Range for its nourishment and the Placitas Supermart for its facilities.

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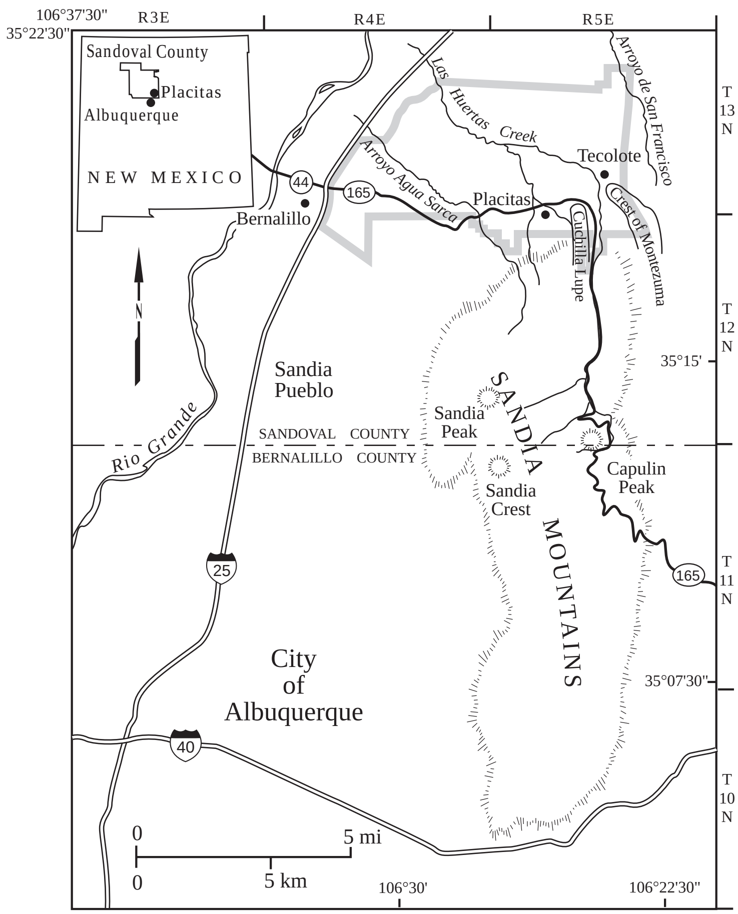


Figure 1. Location of the Placitas study area, Sandoval County, New Mexico.

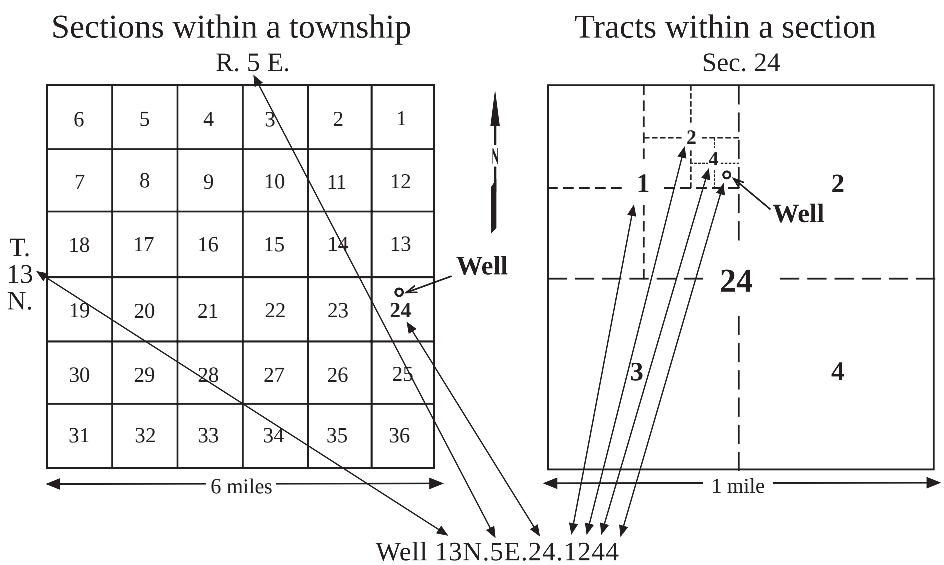


Figure 2. System of numbering wells and springs.

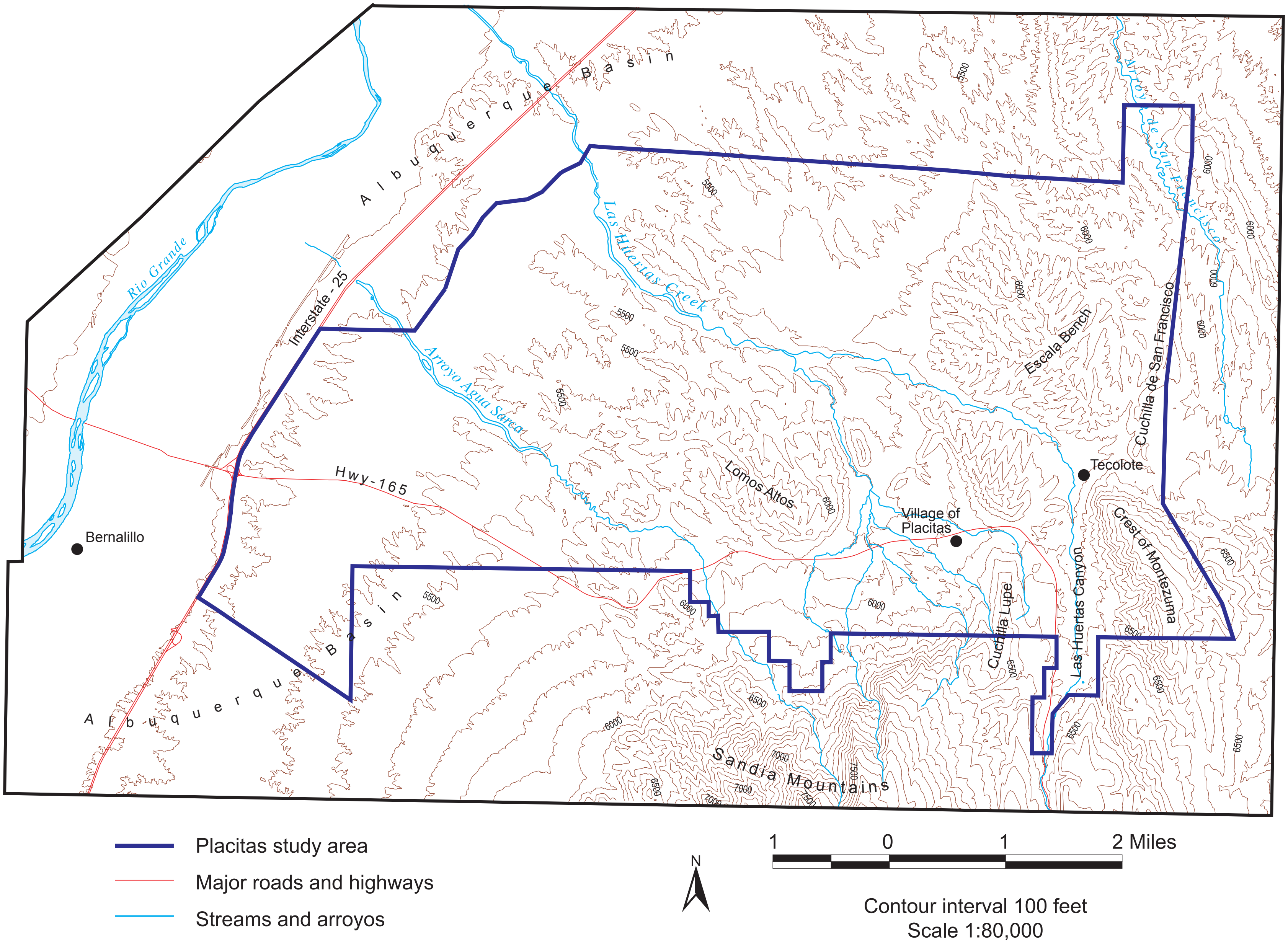
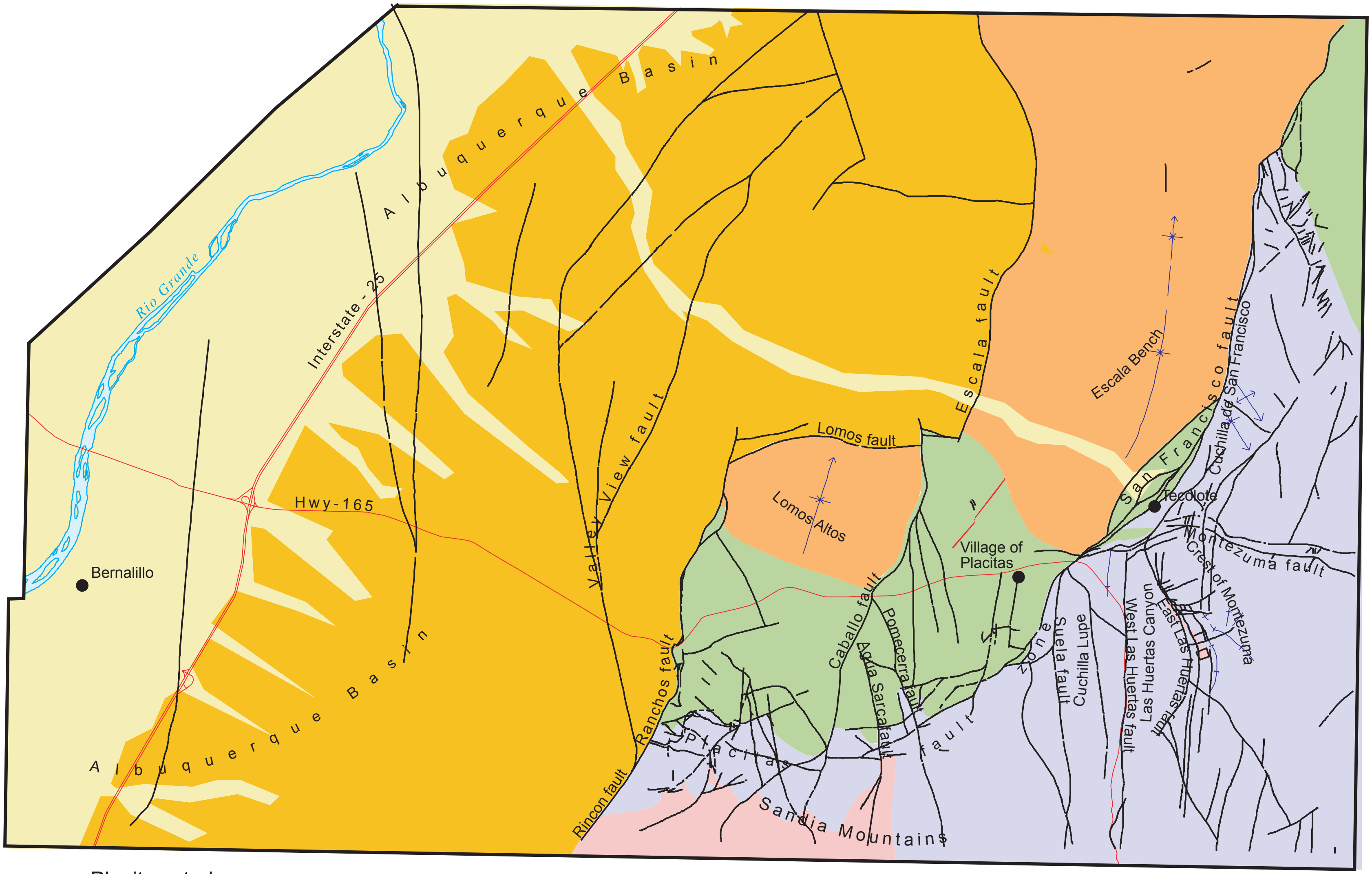


Figure 3. Physiographic and geographic features of the Placitas area.



Placitas study area
Major roads and highways
Streams and arroyos
Fault
Fold

N

Generalized stratigraphic units

Valley fill alluvium
Upper Santa Fe Fm.
Lower Santa Fe Fm.
Teriary dike
Mesozoic Sedum
Paleozoic sedim
Precambrian

1 0 1 2 Miles

Contour interval 100 feet

Scale 1:80,000

Figure 4. Generalized geologic map of the Placitas area (modified from Connell et al. (1995) and Connell (1998)).

Figure 5. Composite stratigraphic chart for the Placitas area (after Anderson et al., 1995)

Age (ma)	Period	Epoch	Stratigraphic Units	Approx. Thickness (ft)	Location of Measured Section in Figure 6 (T.R.S.1/4,1/4,1/4)	Thickness Data Source
0.01	Quaternary	Holocene	Valley-fill alluvium-Qal, Qv	0-20	none	Connell et al., (1995)
0.25		Pleistocene: late, middle	Piedmont-slope alluvium- Qaf, Qf, Qp; Travertine-QTtv	0-120		
0.7		Pleistocene: early				
1.6	Tertiary	Pliocene	Santa Fe Group: Upper Santa Fe Group QTsa, QTst, QTspcs, QTspc	600-4000		
5.3		Miocene	Santa Fe Group: Lower Santa Fe Group Tsps, Tspcs, Tspc	~400-2400		
23.7		Oligocene	Espinaso Fm. Te; Mafic Dike, Tmi	≤1300	none- not exposed	Smith et al., (1991)
36.6		Eocene	Galisteo Fm. Tg	≤2800	none- not exposed	Gorham and Ingersoll, (1979)
57.8		Paleocene	Diamond Tail Fm. Td	≤1450	none- not exposed	Lucas et al., (1997)
66.4	Cretaceous	Upper	Mesa Verde Grp.: Upper Menefee Fm. / Harmon Sandstone / Lower Menefee Fm. — Kmf	740 / 140 / 324	13.5.33.110	Menne, 1989
			Mesa Verde Grp.: Point Lookout Sandstone Kpl	240-315	13.5.32.220	Menne, 1989; Picha, 1982
			Mesa Verde Grp.: Upper Mancos Shale Km_2	240-360	12.4.1.120; 13.6.32.220	Menne, 1989; Picha, 1982
			Mesa Verde Grp.: Hosta Dalton Sandstone Khd	210-370	13.5.32.210; 13.6.32.320	Menne, 1989; Picha, 1982
			Lower Mancos Shale Km_1	850-1850	12.4.1.120; 13.6.32	Menne, 1989; Picha, 1982
			Dakota Fm. Kd	25-75	12.4.1.240	Picha, 1982; Menne, 1989
		Lower				
144	Jurassic	Upper	Morrison Fm. Jm: Jackpile Sandstone Mbr.	70	13.5.32.430	Menne, 1989
			Morrison Fm. Jm: Brushy Basin Mbr.	240		
			Morrison Fm. Jm: Westwater Cyn/Saltwash	215		
		Middle	Morrison Fm. Jm: Recapture Sh/Summerville	325		
			San Rafael Grp.: Todilto Fm. Jt	50-65	12.5.6.320; 13.5.24.140	Picha, 1982; Menne, 1989
			San Rafael Grp.: Entrada Fm. Je	120	12.5.6.320	Menne, 1989
208	Triassic	Upper	Chinle Grp.: Petrified Forest Fm. T̄Rcp	1590	13.5.24.140	Picha, 1982
			Chinle Grp.: Agua Zarca Fm. T̄Rz	220	12.5.6.330	Menne, 1989
		Middle-Lower	Moenkopi Fm. T̄Rm	45-100	12.4.5.320; 12.6.19.200	Menne, 1989; Picha, 1982
245	Permian	Guadalupian	San Andres Fm. Ps	80-130	12.4.5.320	Menne, 1989; Picha, 1982
			Glorieta Ss. Pg	50	West of Pomecerro Cyn	Menne, 1989
		Leonardian	Yeso Fm. Py: San Ysidro Mbr. / Meseta Blanca Mbr. / Lower Yeso Mbr.	680	13.5.26	Picha, 1982
		Wolfcampian	Abo Fm. Pa	1070	Cuchilla de San Francisco	Picha, 1982
286	Pennsylvanian	Upper	Madera Fm. IPm: Upper Arkosic Ls.	614	Crest of Montezuma	Picha, 1982
		Middle	Madera Fm. IPm: Lower Gray Ls.	646		
		Lower	Sandia Fm. IPs	193	Crest of Montezuma	Picha, 1982
320	Mississippian		Arroyo Peñasco Grp Ma.	103	13.5.34.140	Menne,1989
360						
1,400	Proterozoic	Middle	Sandia Granite	–	none	
		Early	Various Supracrustal Rocks	–	none	

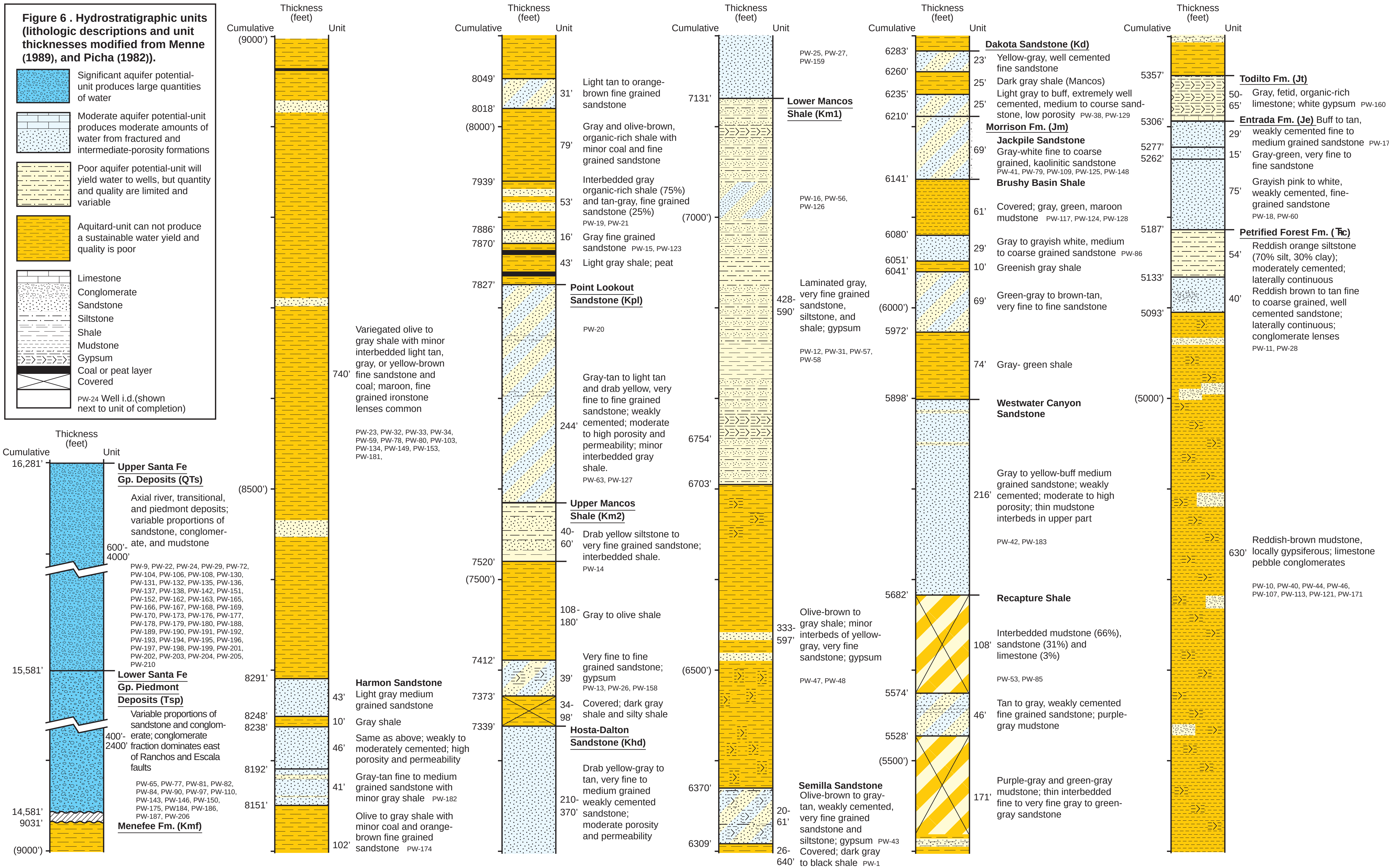
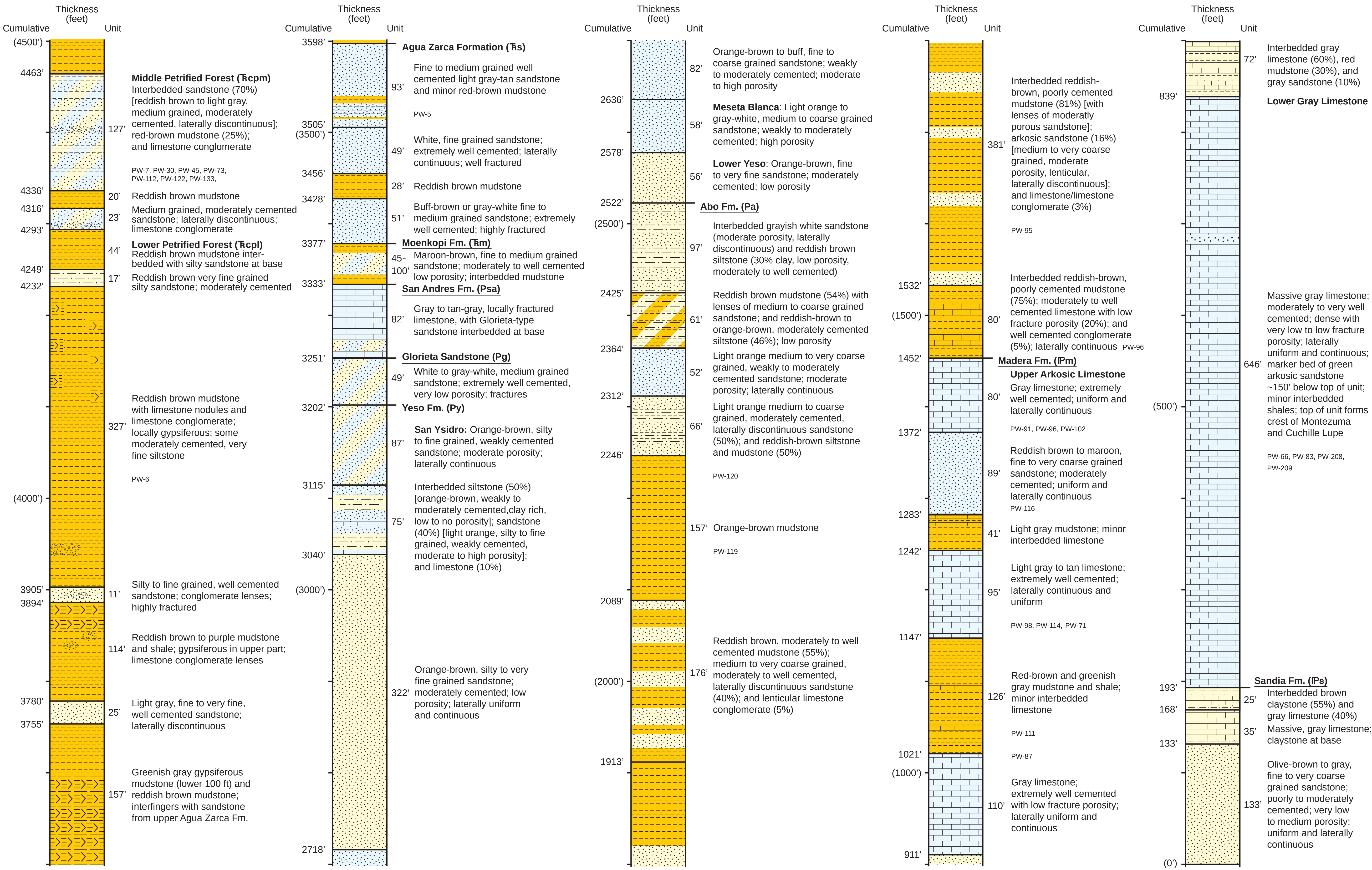


Figure 6 . Hydrostratigraphic units (lithologic descriptions and unit thicknesses modified from Menne (1989), and Picha (1982)).



Thickness (feet)
Cumulative
Unit
(4500')
4463'
Middle Petrified Forest (ŦRcpm)
Interbedded sandstone (70%) [reddish brown to light gray, medium grained, moderately cemented, laterally discontinuous]; red-brown mudstone (25%); and limestone conglomerate
127'
PW-7, PW-30, PW-45, PW-73, PW-112, PW-122, PW-133,
4336'
20'
Reddish brown mudstone
4316'
23'
Medium grained, moderately cemented sandstone; laterally discontinuous; limestone conglomerate
4293'
Lower Petrified Forest (ŦRcpl)
44'
Reddish brown mudstone interbedded with silty sandstone at base
4249'
17'
Reddish brown very fine grained silty sandstone; moderately cemented
4232'
327'
Reddish brown mudstone with limestone nodules and limestone conglomerate; locally gypsiferous; some moderately cemented, very fine siltstone
PW-6
(4000')
3905'
11'
Silty to fine grained, well cemented sandstone; conglomerate lenses; highly fractured
3894'
114'
Reddish brown to purple mudstone and shale; gypsiferous in upper part; limestone conglomerate lenses
3780'
25'
Light gray, fine to very fine, well cemented sandstone; laterally discontinuous
3755'
157'
Greenish gray gypsiferous mudstone (lower 100 ft) and reddish brown mudstone; interfingers with sandstone from upper Agua Zarca Fm.
3598'
Agua Zarca Formation (ŦRs)
93'
Fine to medium grained well cemented light gray-tan sandstone and minor red-brown mudstone
PW-5
3505'
(3500')
49'
White, fine grained sandstone; extremely well cemented; laterally continuous; well fractured
3456'
28'
Reddish brown mudstone
3428'
51'
Buff-brown or gray-white fine to medium grained sandstone; extremely well cemented; highly fractured
3377'
Moenkopi Fm. (ŦRm)
45-100'
Maroon-brown, fine to medium grained sandstone; weakly to moderately to well cemented low porosity; interbedded mudstone
3333'
San Andres Fm. (Psa)
82'
Gray to tan-gray, locally fractured limestone, with Glorieta-type sandstone interbedded at base
3251'
Glorieta Sandstone (Pg)
49'
White to gray-white, medium grained sandstone; extremely well cemented, very low porosity; fractures
3202'
Yeso Fm. (Py)
87'
San Ysidro: Orange-brown, silty to fine grained, weakly cemented sandstone; moderate porosity; laterally continuous
3115'
75'
Interbedded siltstone (50%) [orange-brown, weakly to moderately cemented,clay rich, low to no porosity]; sandstone (40%) [light orange, silty to fine grained, weakly cemented, moderate to high porosity]; and limestone (10%)
3040'
(3000')
322'
Orange-brown, silty to very fine grained sandstone; moderately cemented; low porosity; laterally uniform and continuous
2718'
82'
Orange-brown to buff, fine to coarse grained sandstone; weakly to moderately cemented; moderate to high porosity
2636'
58'
Meseta Blanca: Light orange to gray-white, medium to coarse grained sandstone; weakly to moderately cemented; high porosity
2578'
56'
Lower Yeso: Orange-brown, fine to very fine sandstone; moderately cemented; low porosity
2522'
Abo Fm. (Pa)
(2500')
97'
Interbedded grayish white sandstone (moderate porosity, laterally discontinuous) and reddish brown siltstone (30% clay, low porosity, moderately to well cemented)
2425'
61'
Reddish brown mudstone (54%) with lenses of medium to coarse grained sandstone; and reddish-brown to orange-brown, moderately cemented siltstone (46%); low porosity
2364'
52'
Light orange medium to very coarse grained, weakly to moderately cemented sandstone; moderate porosity; laterally continuous
2312'
66'
Light orange medium to coarse grained, moderately cemented, laterally discontinuous sandstone (50%); and reddish-brown siltstone and mudstone (50%)
PW-120
2246'
157'
Orange-brown mudstone
PW-119
2089'
176'
Reddish brown, moderately to well cemented mudstone (55%); medium to very coarse grained, moderately to well cemented, laterally discontinuous sandstone (40%); and lenticular limestone conglomerate (5%)
(2000')
1913'
381'
Interbedded reddish-brown, poorly cemented mudstone (81%) [with lenses of moderatly porous sandstone]; arkosic sandstone (16%) [medium to very coarse grained, moderate porosity, lenticular, laterally discontinuous]; and limestone/limestone conglomerate (3%)
PW-95
1532'
(1500')
80'
Interbedded reddish-brown, poorly cemented mudstone (75%); moderately to well cemented limestone with low fracture porosity (20%); and well cemented conglomerate (5%); laterally continuous PW-96
1452'
Madera Fm. (IPm)
Upper Arkosic Limestone
80'
Gray limestone; extremely well cemented; uniform and laterally continuous
PW-91, PW-96, PW-102
1372'
89'
Reddish brown to maroon, fine to very coarse grained sandstone; moderately cemented; uniform and laterally continuous
PW-116
1283'
41'
Light gray mudstone; minor interbedded limestone
1242'
95'
Light gray to tan limestone; extremely well cemented; laterally continuous and uniform
PW-98, PW-114, PW-71
1147'
126'
Red-brown and greenish gray mudstone and shale; minor interbedded limestone
PW-111
PW-87
1021'
(1000')
110'
Gray limestone; extremely well cemented with low fracture porosity; laterally uniform and continuous
911'
72'
Interbedded gray limestone (60%), red mudstone (30%), and gray sandstone (10%)
839'
Lower Gray Limestone
646'
Massive gray limestone; moderately to very well cemented; dense with very low to low fracture porosity; laterally uniform and continuous; marker bed of green arkosic sandstone ~150' below top of unit; minor interbedded shales; top of unit forms crest of Montezuma and Cuchille Lupe
PW-66, PW-83, PW-208, PW-209
(500')
Sandia Fm. (IPs)
193'
25'
Interbedded brown claystone (55%) and gray limestone (40%)
168'
35'
Massive, gray limestone; claystone at base
133'
133'
Olive-brown to gray, fine to very coarse grained sandstone; poorly to moderately cemented; very low to medium porosity; uniform and laterally continuous
(0')

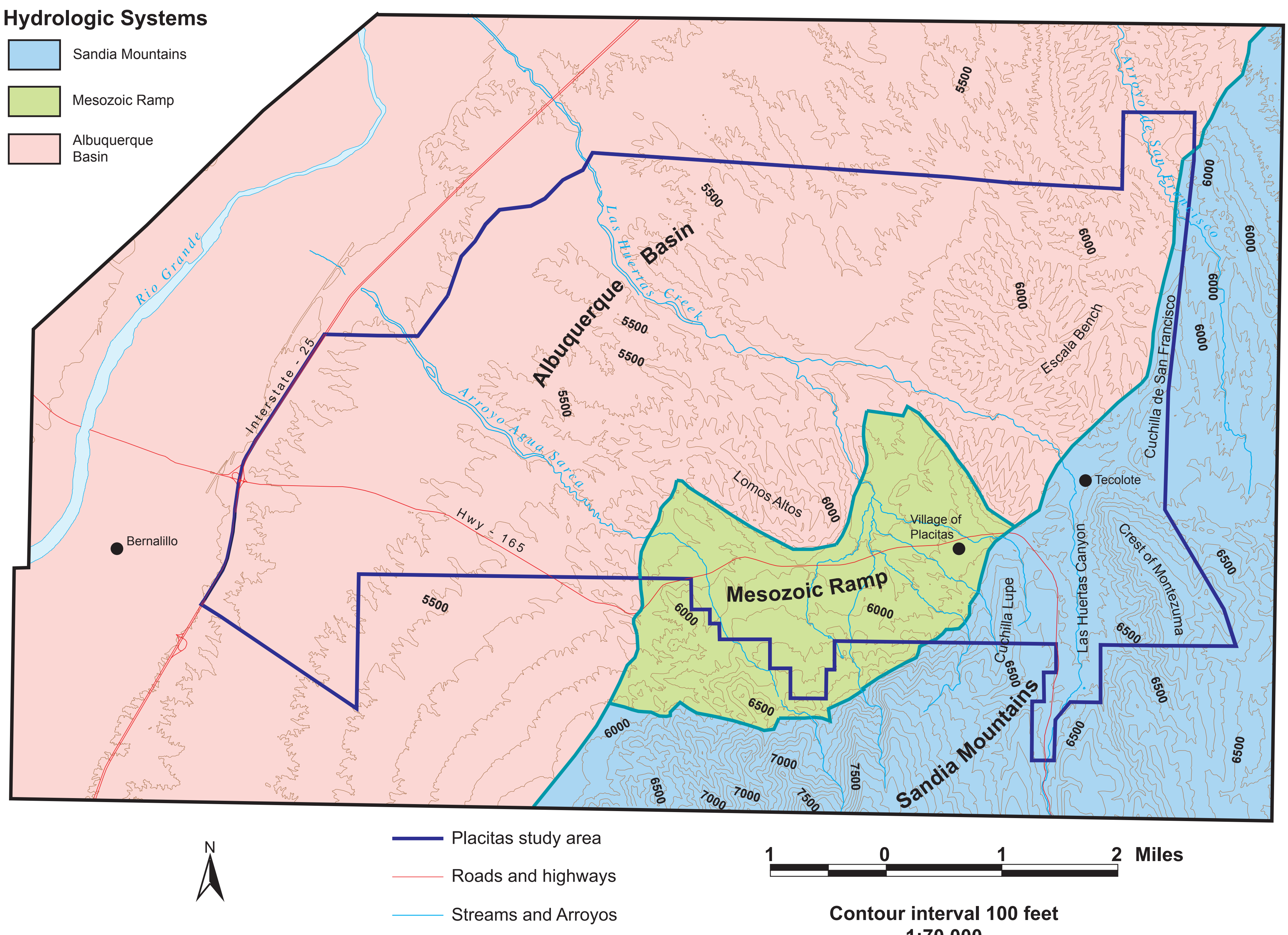


Figure 7. Hydrologic systems in the Placitas area.

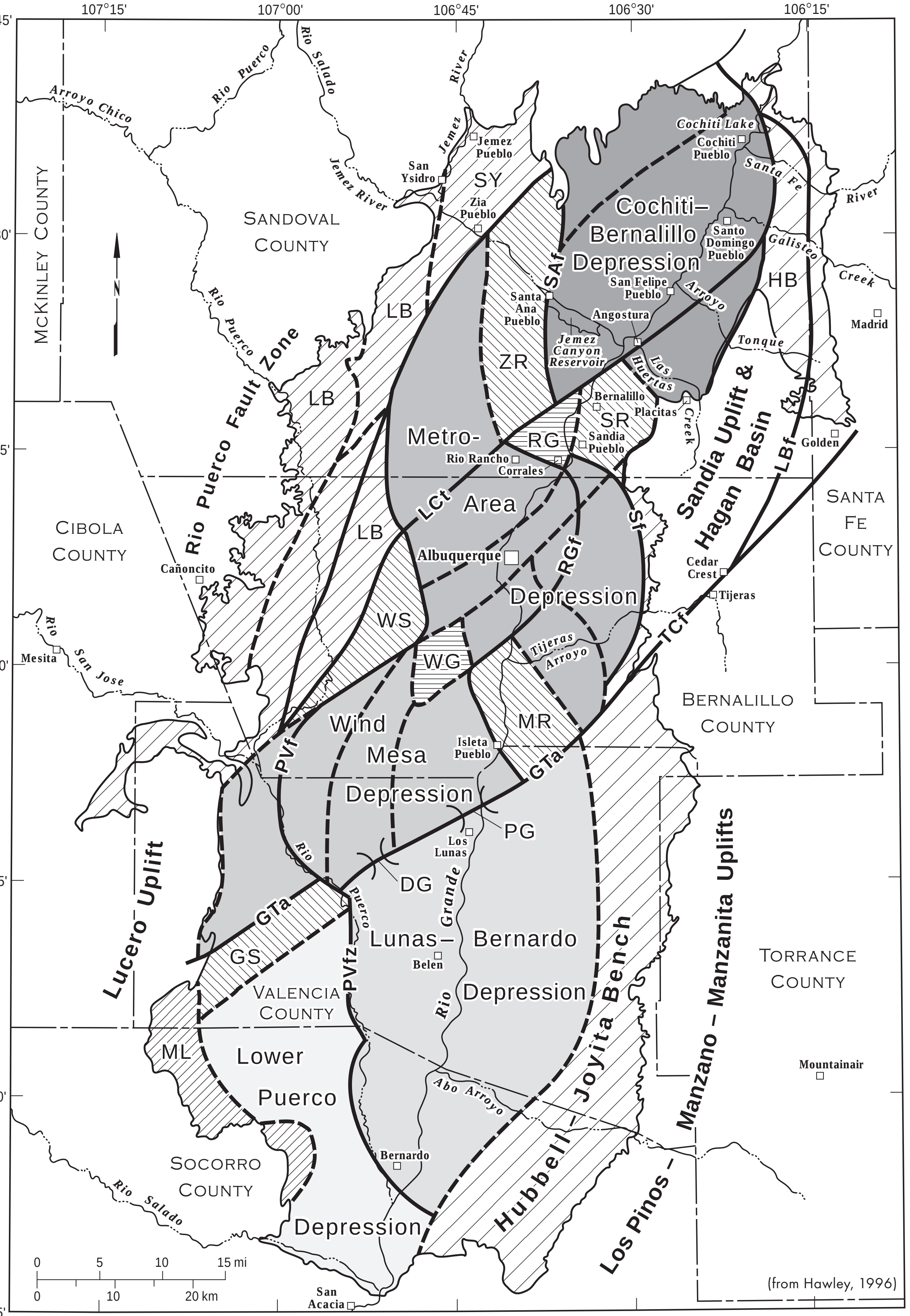


Figure 8. Generalized tectonic map of the Albuquerque area showing structural depressions, structural highs, and fault zones

Explanation

First-order structures, including major basin-margin and intra-basin faults, transfer and accommodation zones: Tijeras–Cañoncito (TCf); Gabaldon–Tijeras (GTa); Loma Colorada (LCt); La Bajada (LBf); Puerco Valley (PVf); Rio Grande (RGf); Santa Ana (SAf); and Sandia (Sf).

Major structures, including significant intra-basin faults, transition zones, and flexures.

Major gaps in dividing ridges and other buried structural highs: Dalies (DG); Peralta (PG); River's Edge (RG); and Westgate (WG).

Structural depressions and subbasins: shading denotes approximate extent of selected basins.

Major structural depressions:

- Cochiti–Bernalillo
- Metro-Area
- Wind Mesa
- Lunas–Bernardo
- Lower Puerco

Basin margin structural bench: Monte Largo (ML); Hubbell–Joyita bench; Laguna bench (LB); San Ysidro embayment (SY); and Hagan bench and embayment (HB). Hachure spacing denotes approximate extent of benches.

Inter-depression structural highs: Westland Salient (WS); Mountainview Prong (MR); Ziana Anticline (ZR); Sandia Pueblo Bench (SR); and Gabaldon Salient (GS).

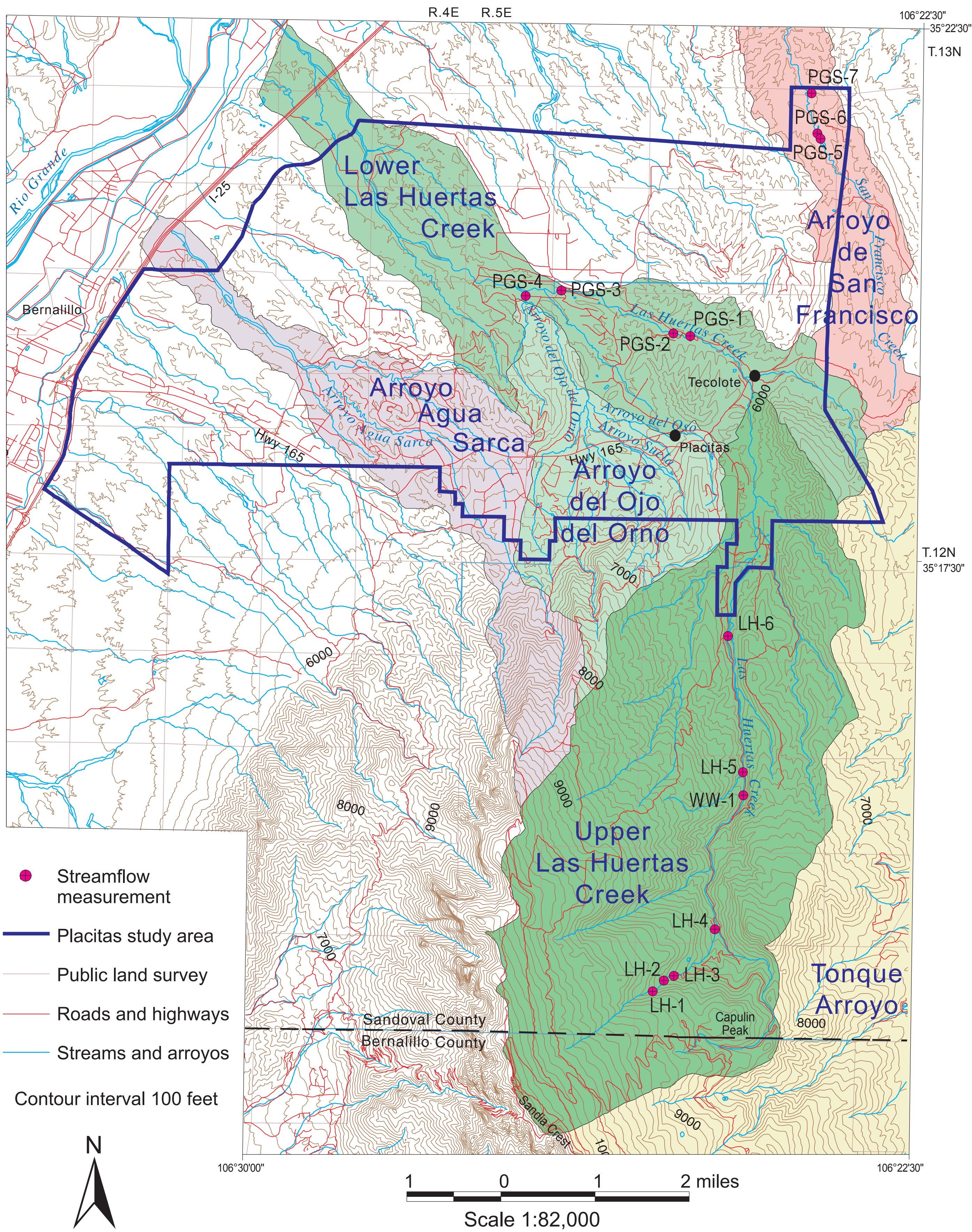


Figure 9. Surface water drainages and streamflow measurements in the Placitas area.

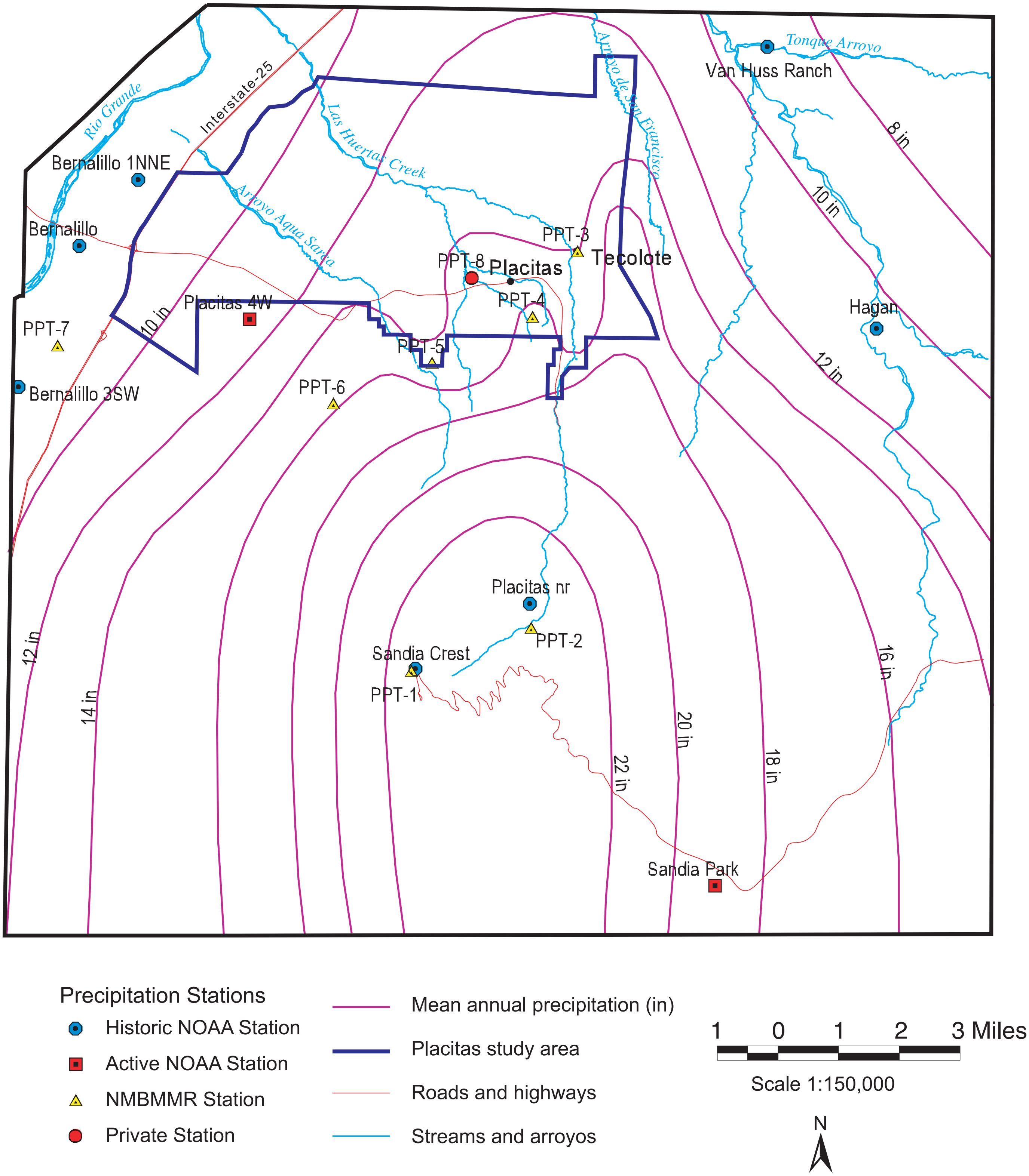


Figure 10. Mean annual precipitation in the Placitas area and northern Sandia Mountains.

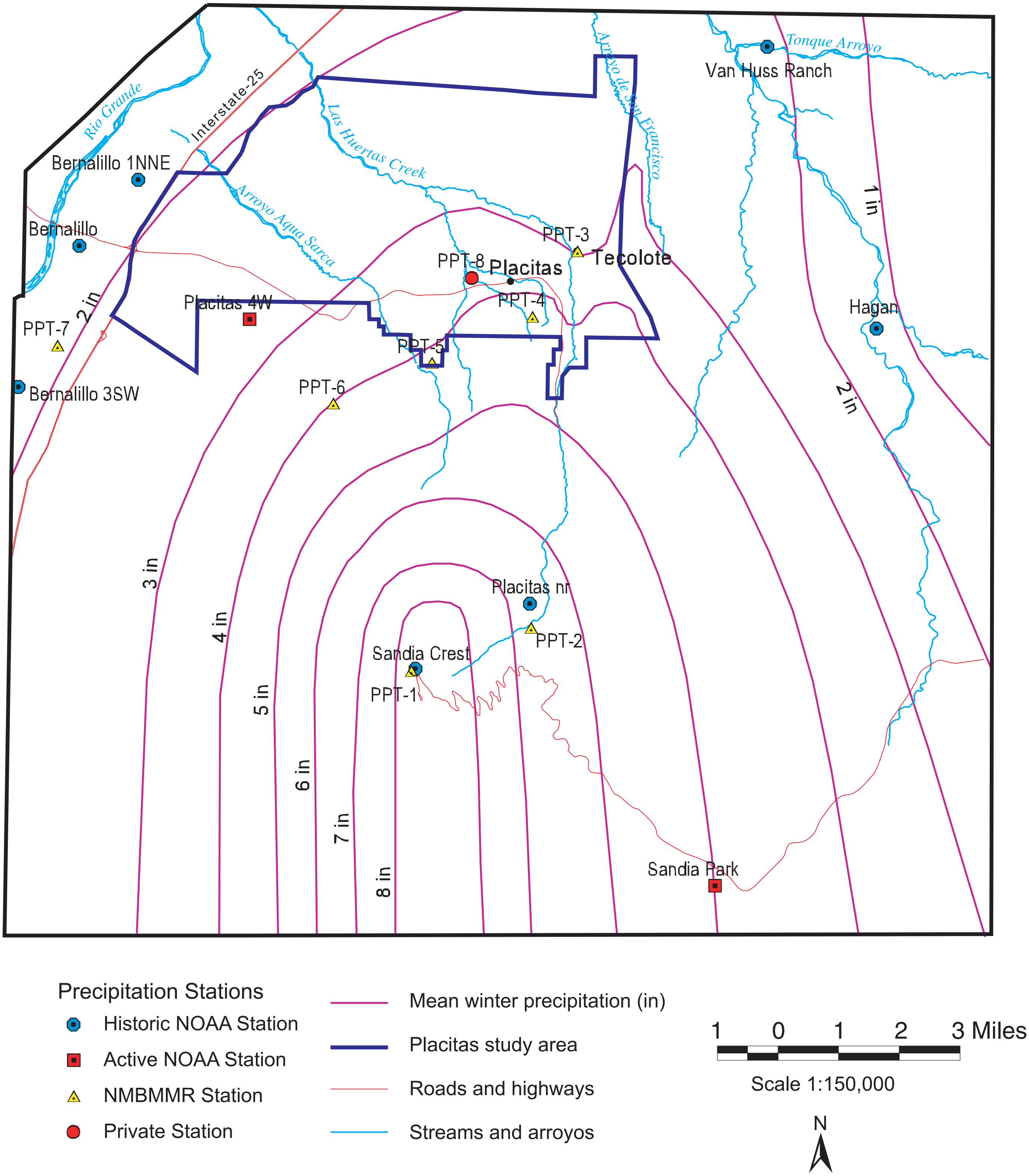


Figure 11. Mean winter precipitation (December-March) in the Placitas area and northern Sandia Mountains.

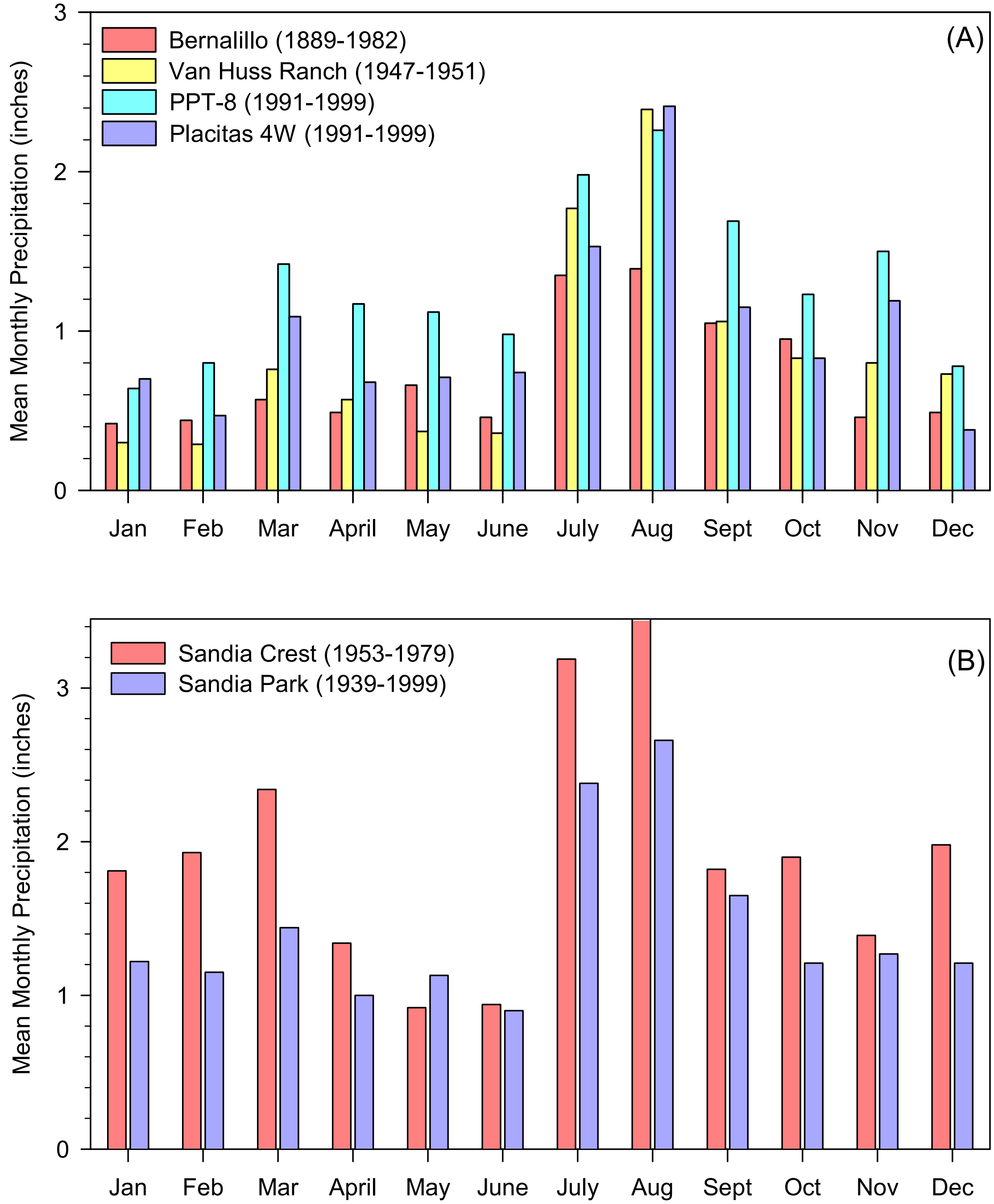
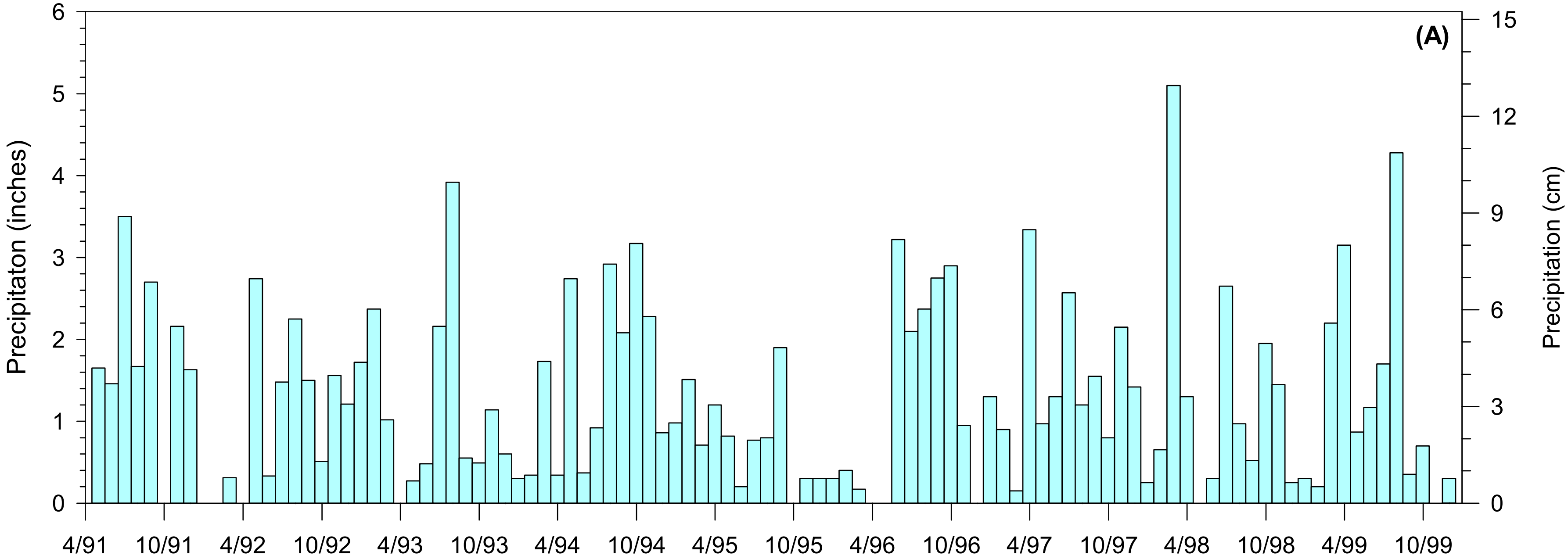
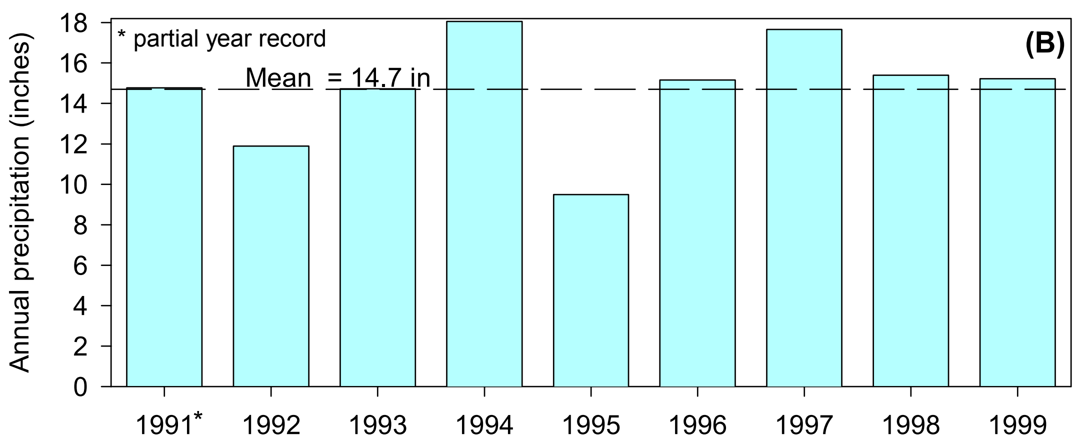


Figure 12. Mean monthly precipitation from weather stations at (A) elevations less than 7000 ft, and (B) elevations greater than 7000 ft in Sandia Mountains (see Figure 10 for locations).

Figure 13. (A) Monthly precipitation in the Village of Placitas (PPT-8 in Figure 10, Table 1, and Appendix C), May 1991 through December 1999; and (B) Annual precipitation 1991 through 1999 (J. Fish, unpubl. 1999).





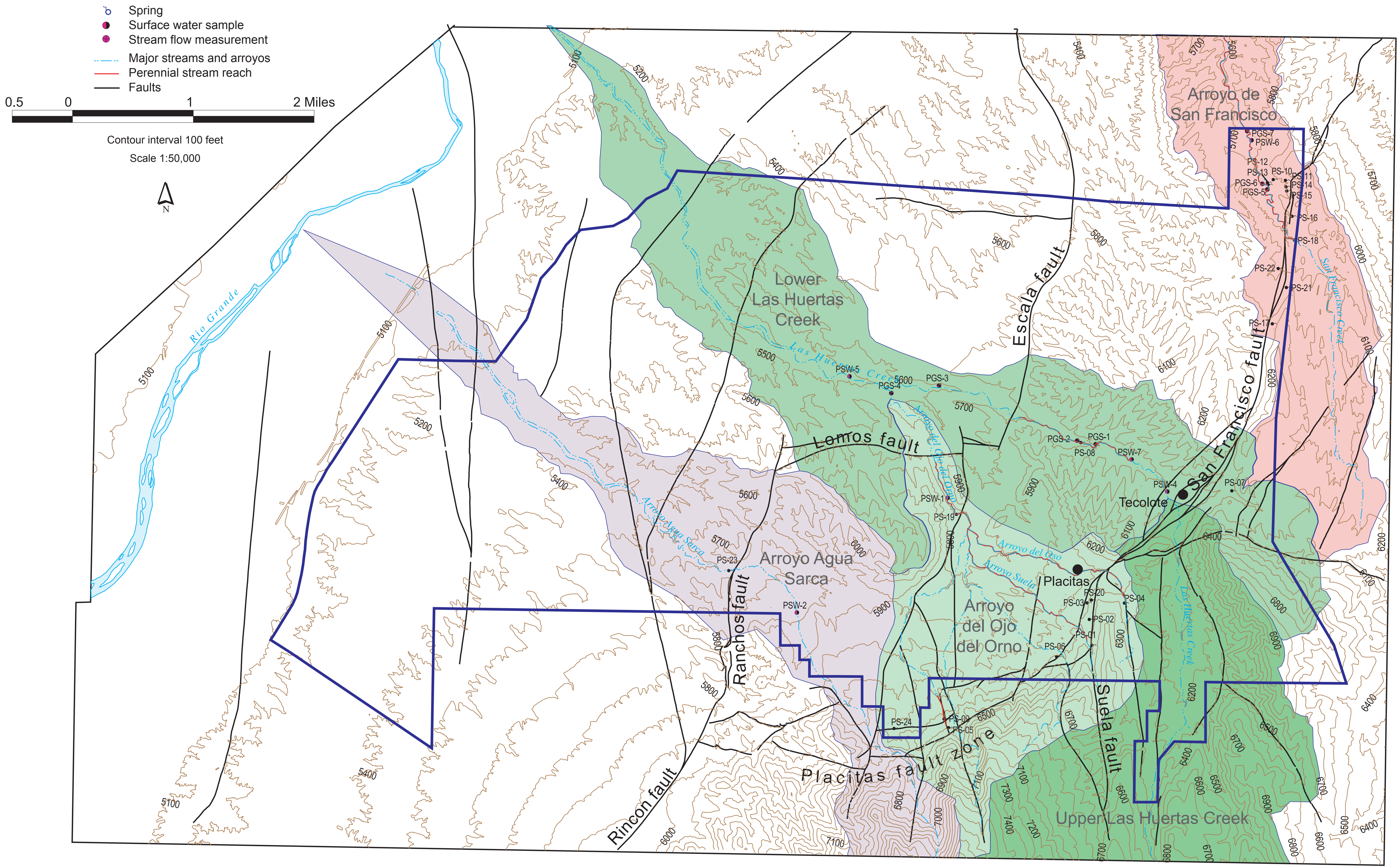


Figure 14. Streams and springs in the Placitas area.

Figure 15. Stream hydrograph for upper Las Huertas Creek near Sandia Man Cave (WW-1 in Figure 9, Table 2) (D. Shaw, unpubl. 1999).

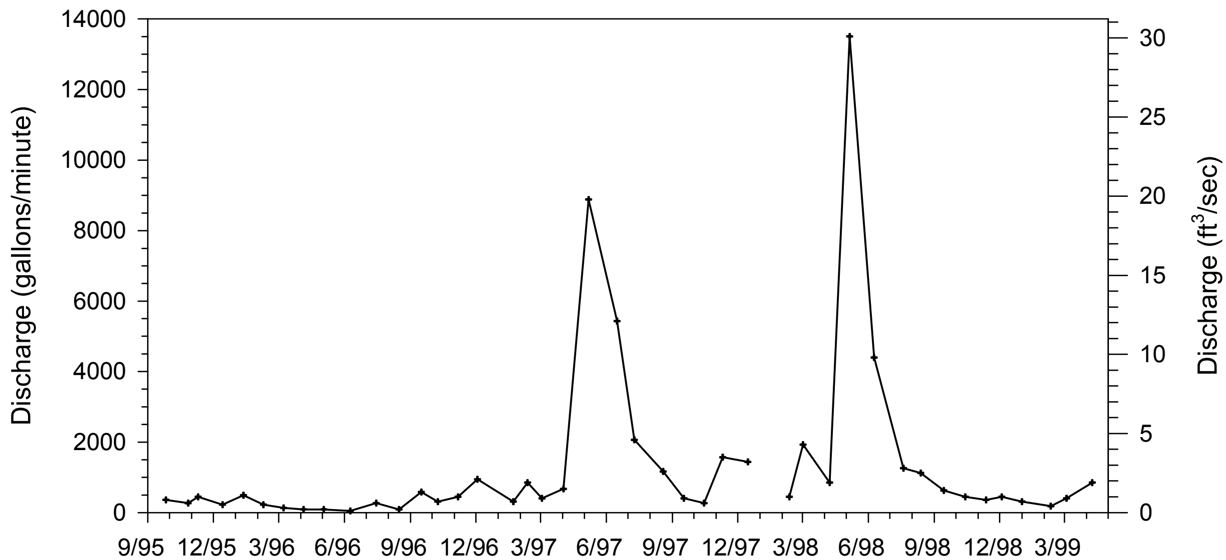
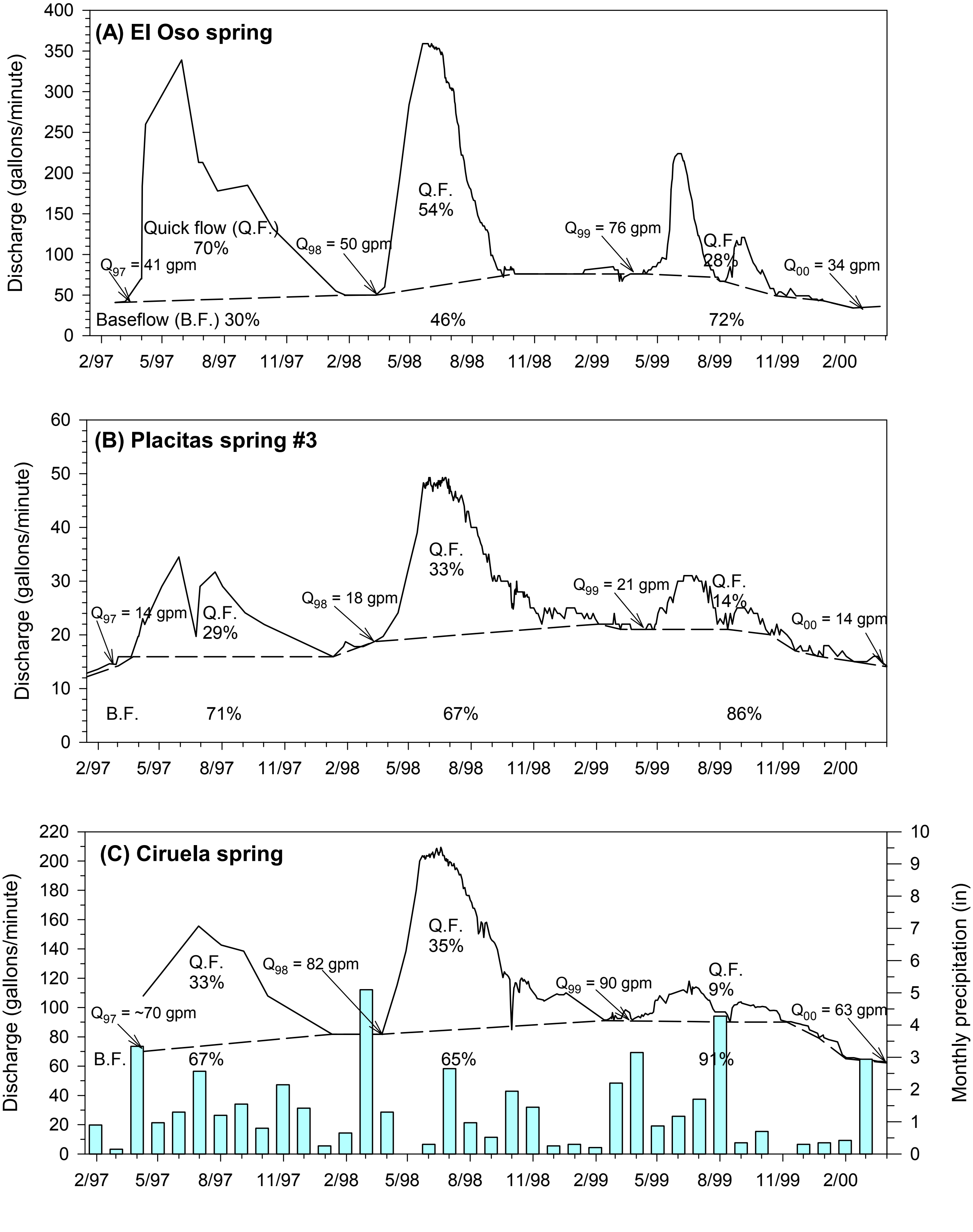


Figure 16. Spring hydrographs for (A) El Oso Spring, (B) Placitas Spring #3, and (C) Ciruela Spring (Johnson, 1999), and monthly precipitation for the Village of Placitas, February 1997 through April 2000 (J.Fish, unpubl. 1999).



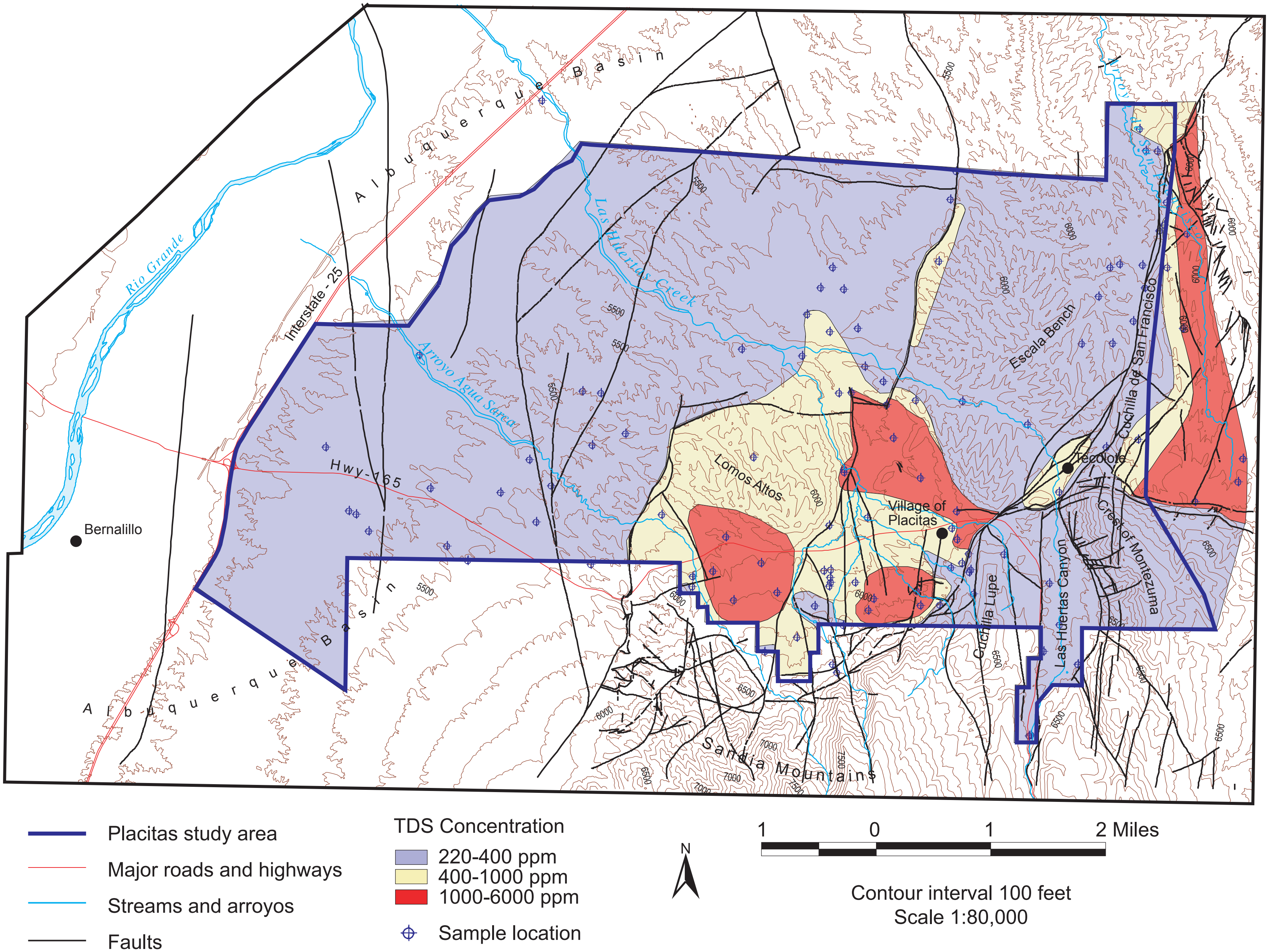


Figure 17. Distribution of total dissolved ions (TDI) in ground water.

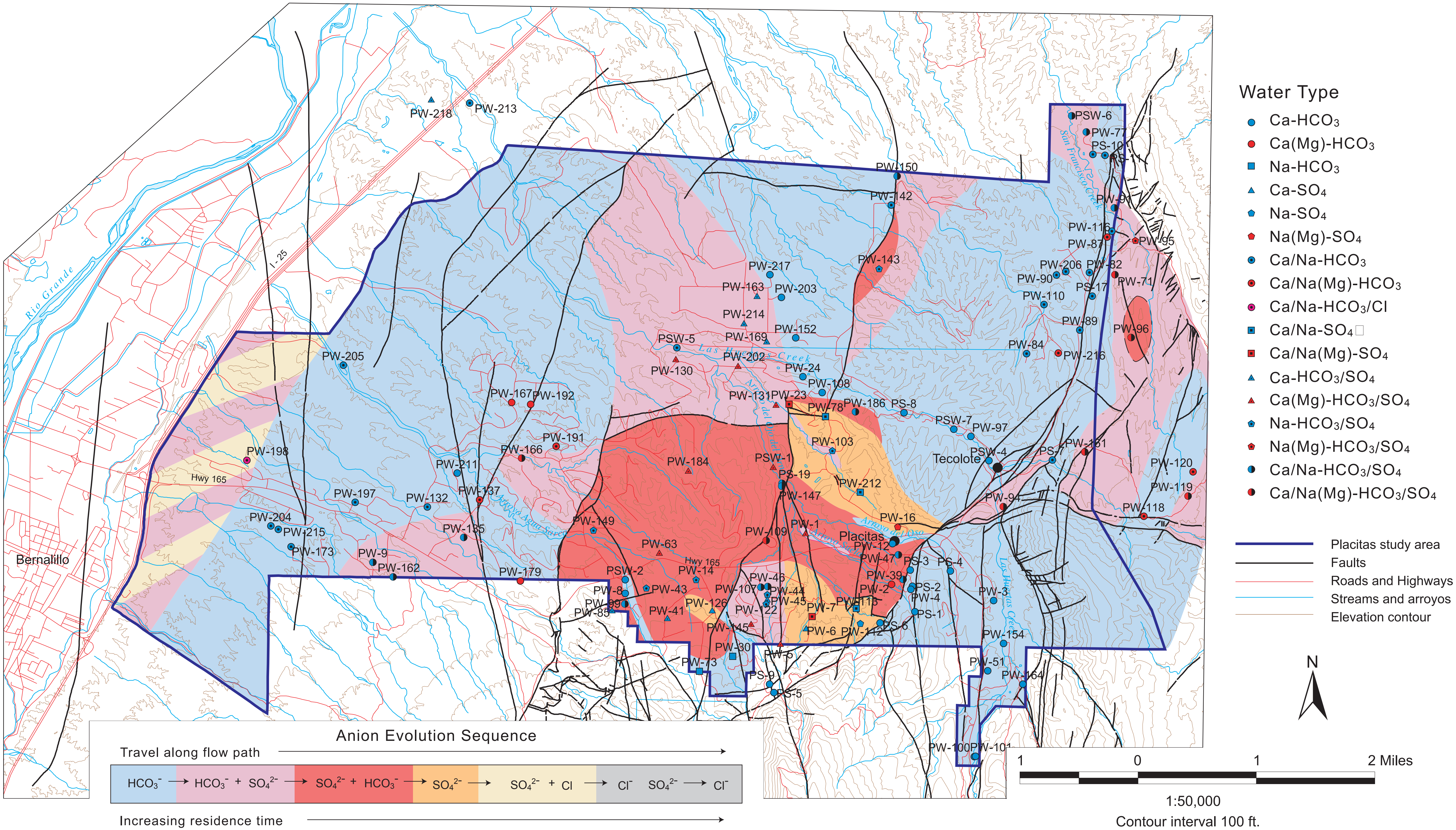


Figure 18. Major ion geochemistry and anion facies in ground water.

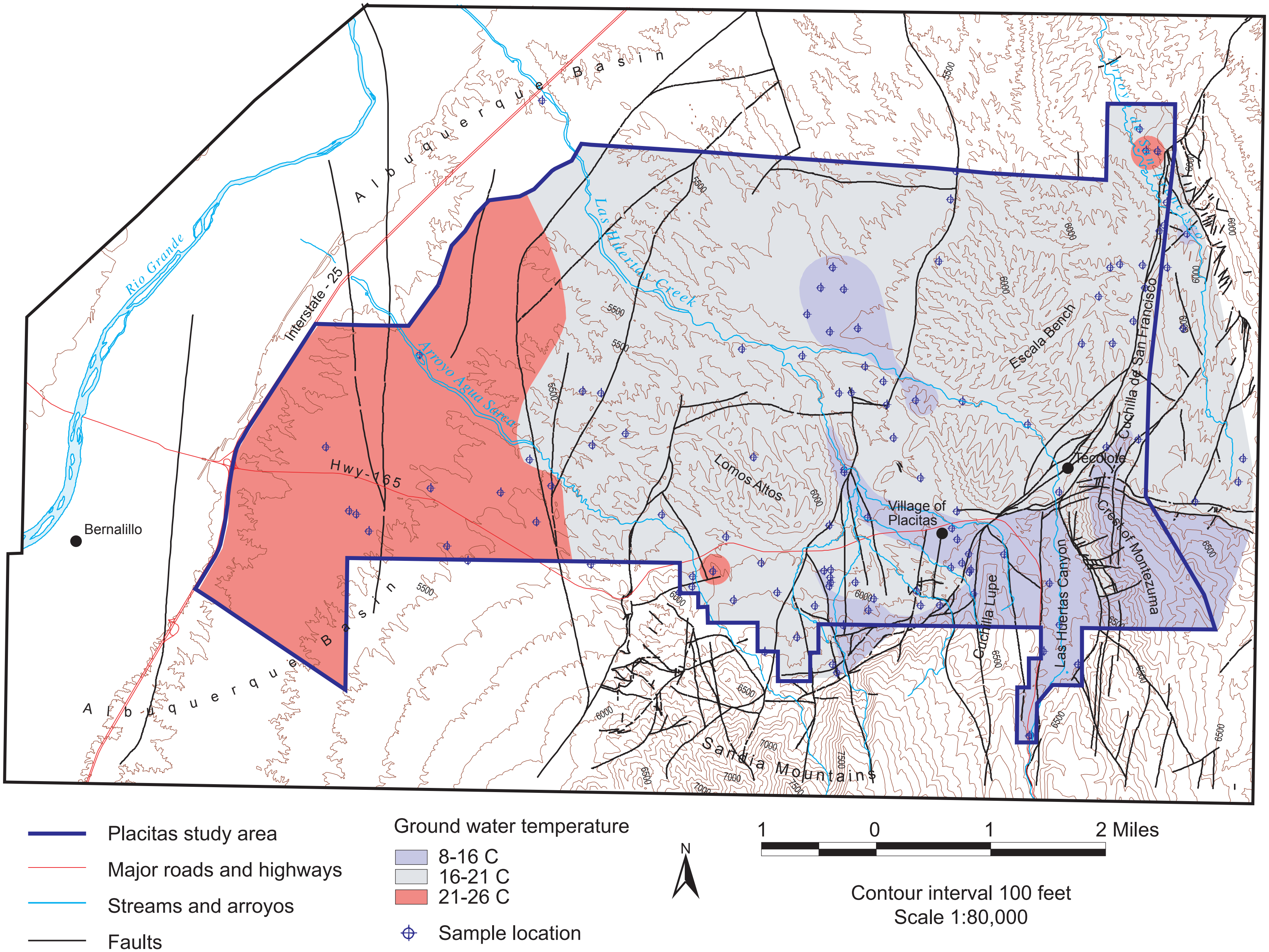


Figure 19. Variability of temperature in ground water.

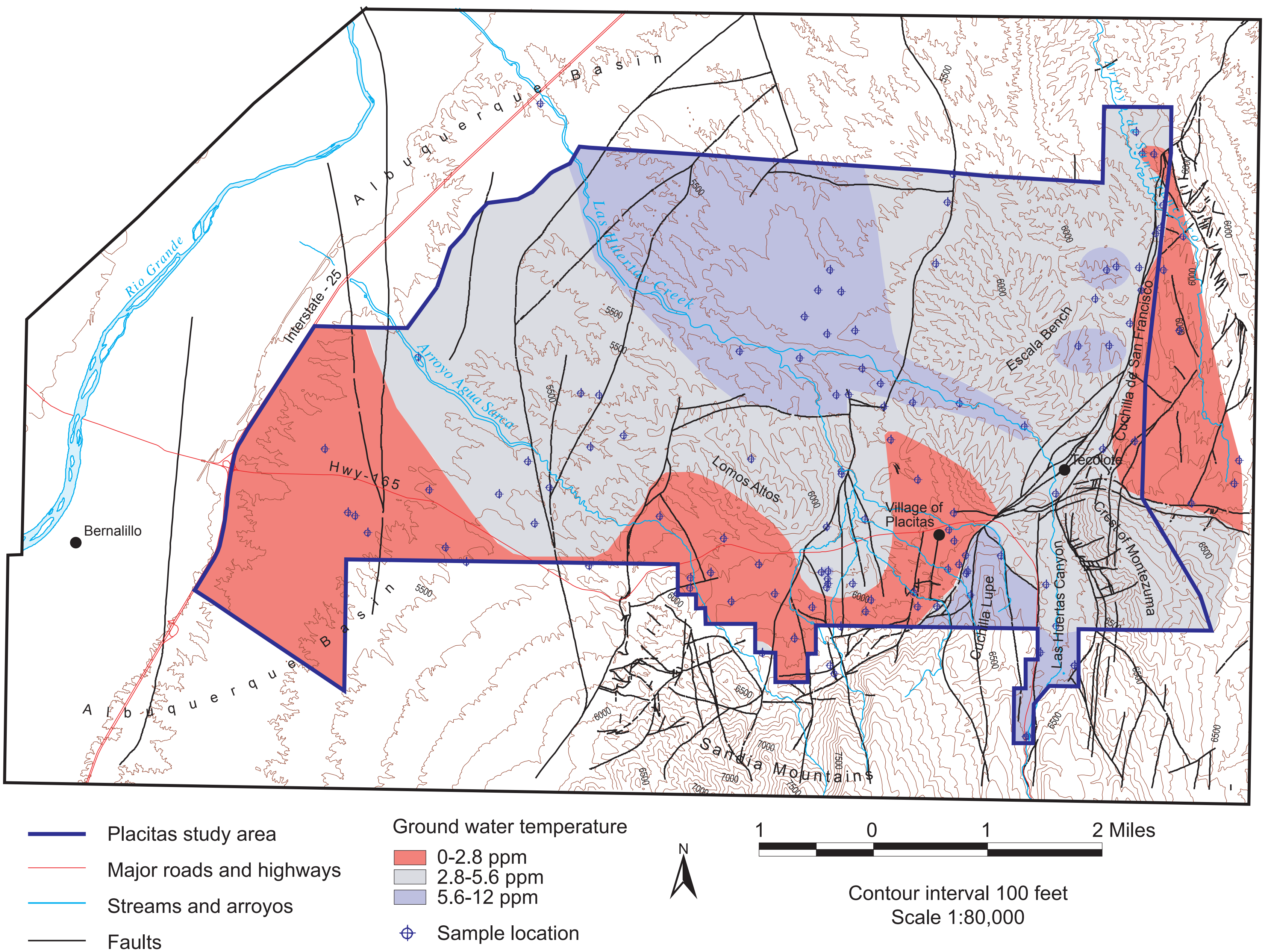


Figure 20. Distribution of dissolved oxygen in ground water.

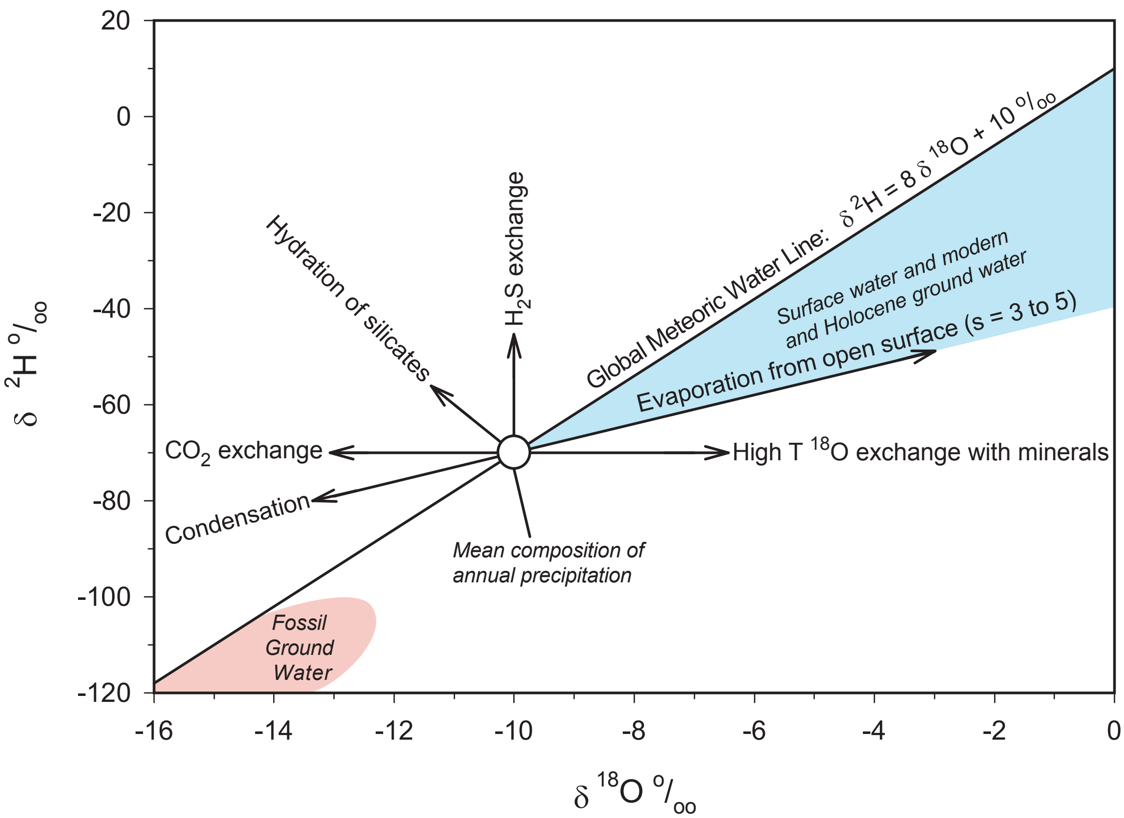


Figure 21. Deviations in isotopic composition away from the meteoric water line (Craig, 1961) as a result of various processes (modified from IAEA Report No. 288, 1983).

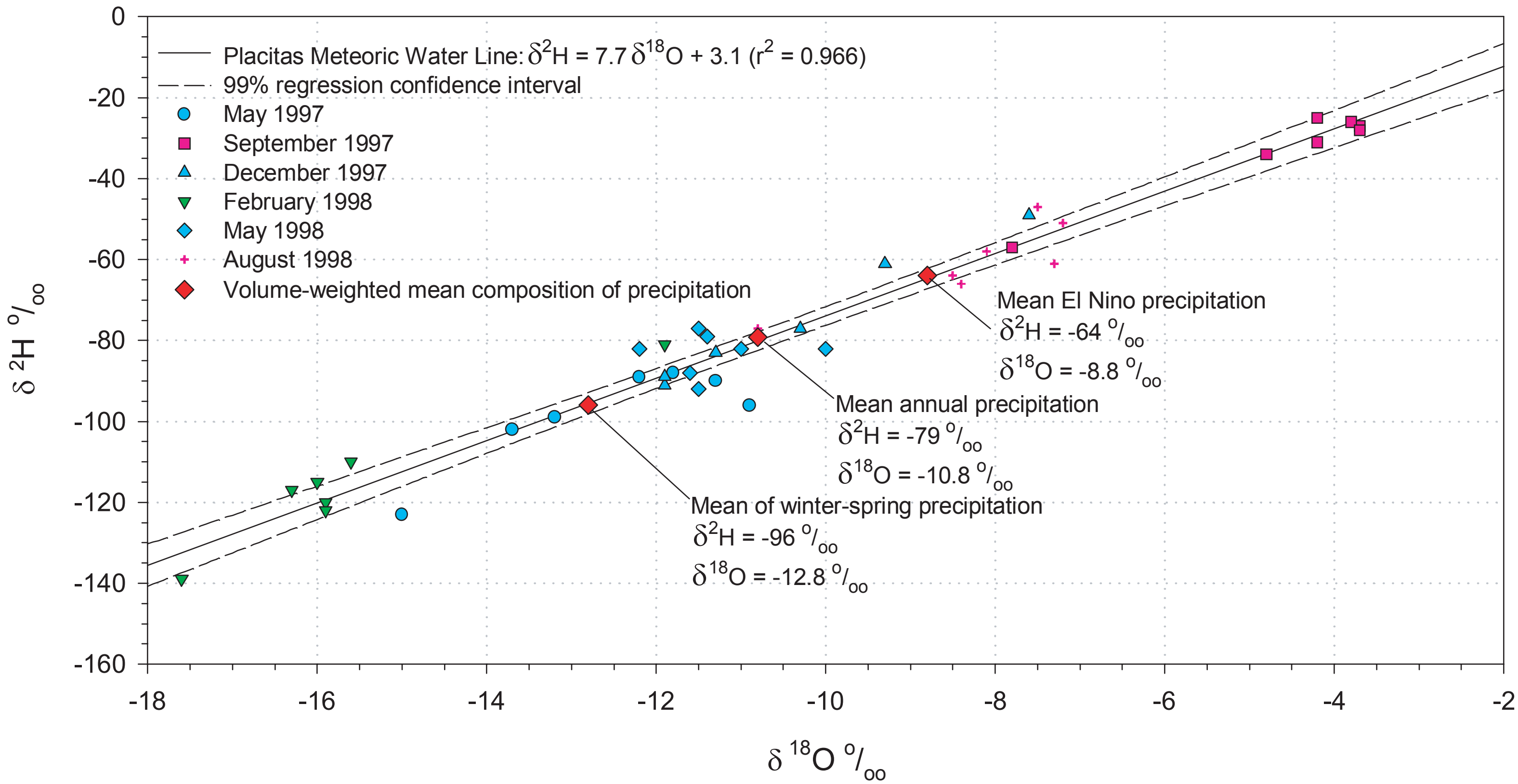


Figure 22. Stable isotope composition of precipitation and the Placitas meteoric water line. Blue reflects spring and fall precipitation, pink reflects summer precipitation, and green reflects winter precipitation.

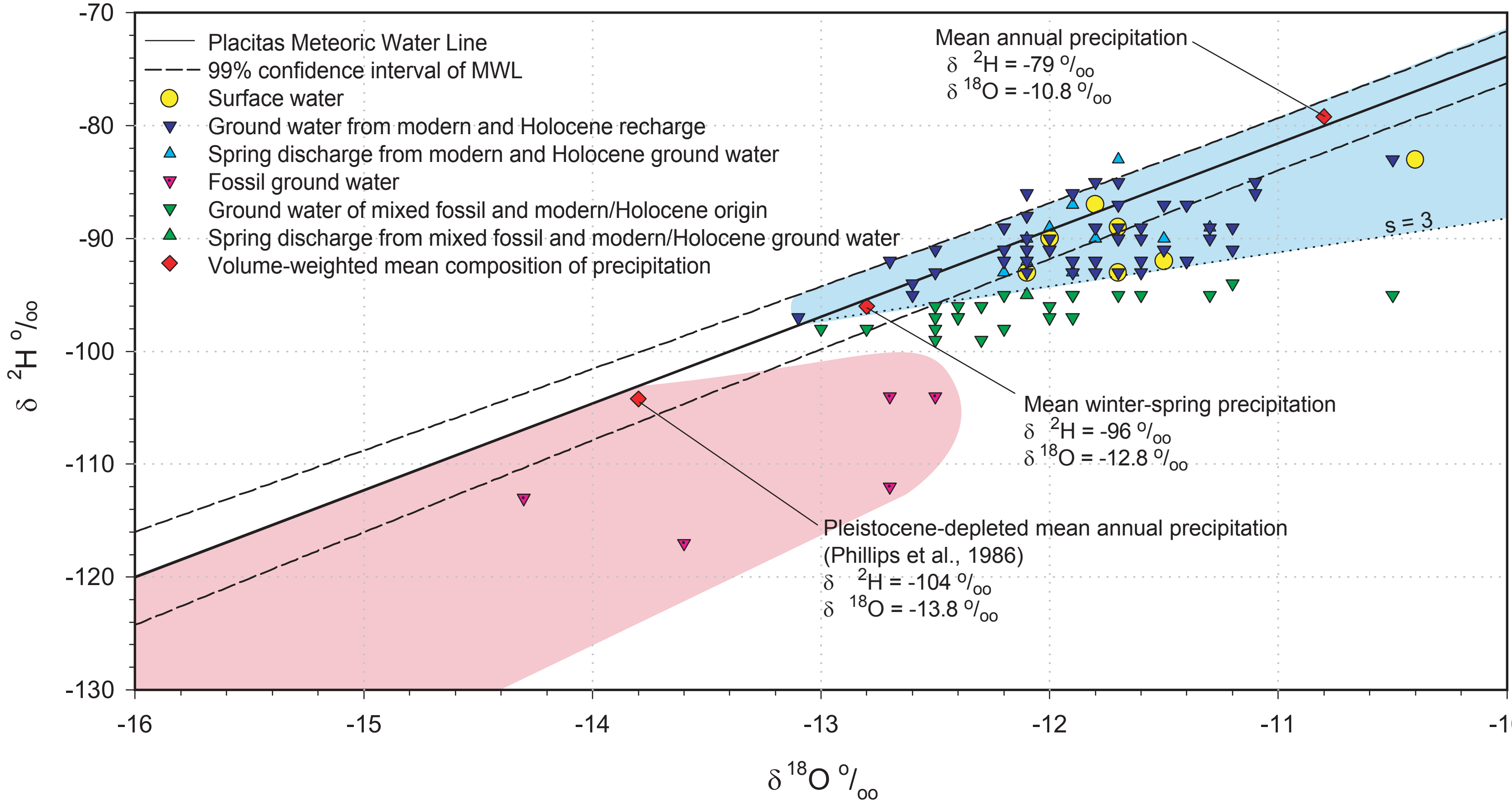


Figure 23. Stable isotope composition of ground water and surface water and delineation of isotopic facies in ground water.

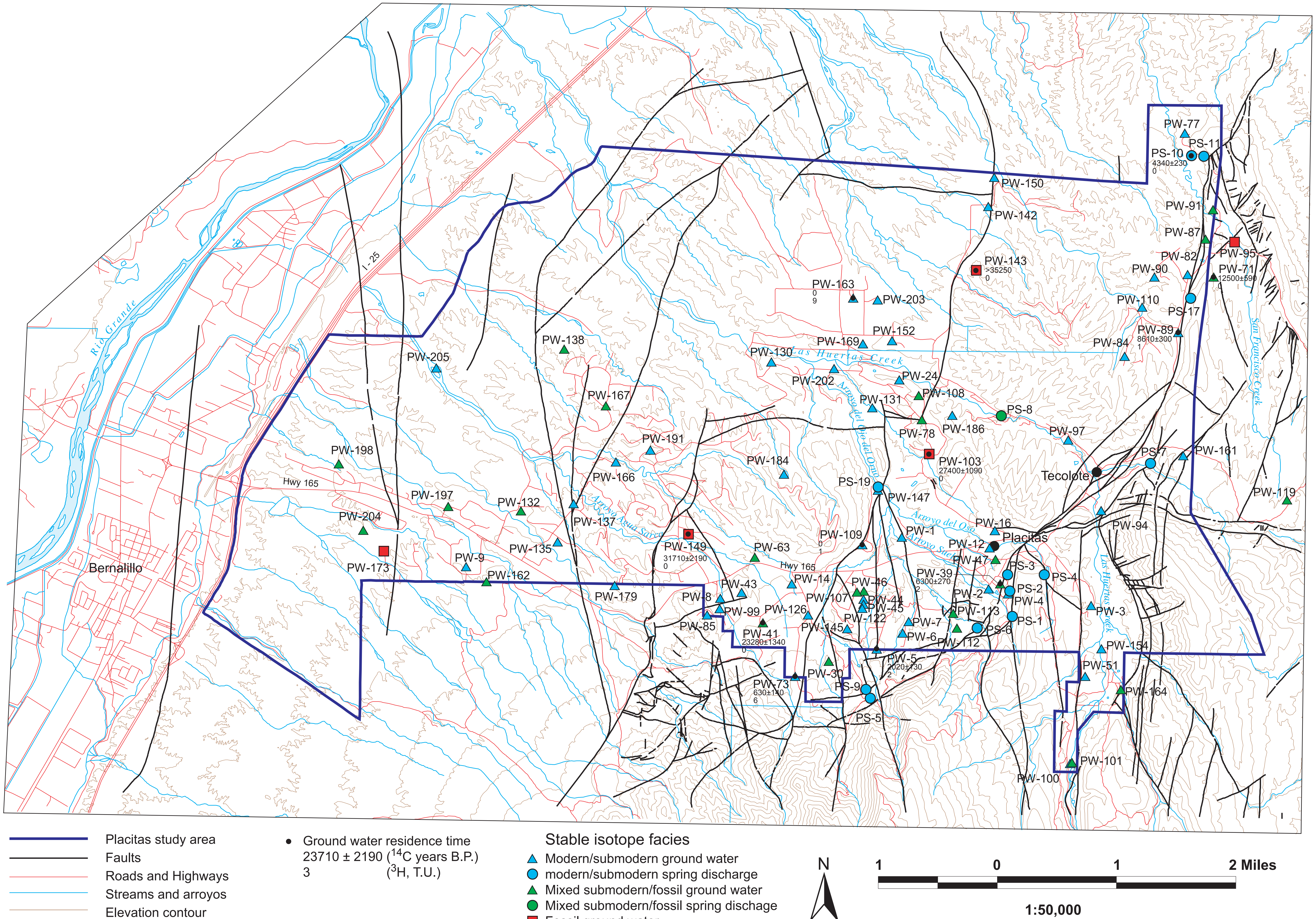
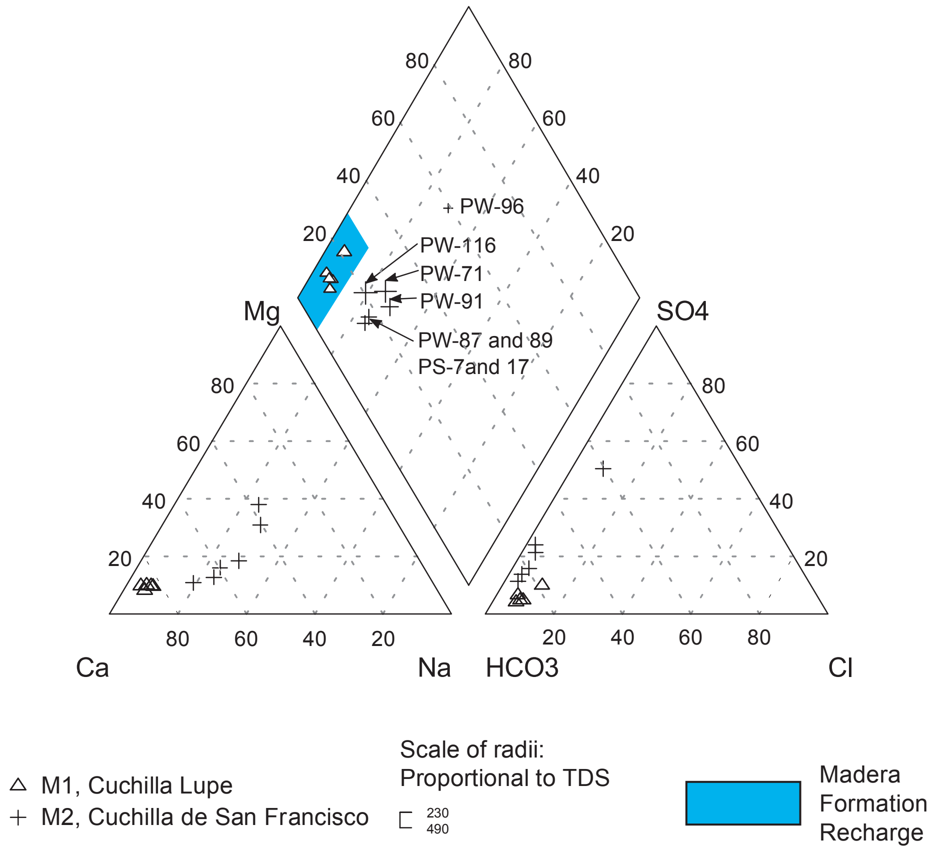


Figure 24. Mean residence times and stable isotope facies.



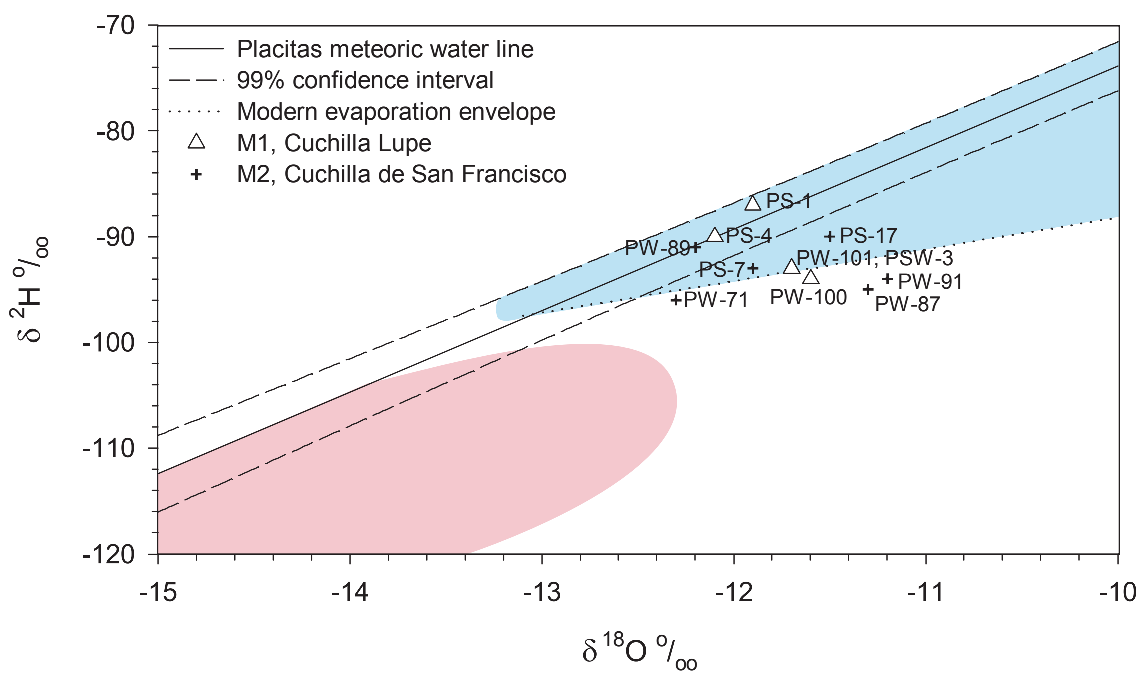
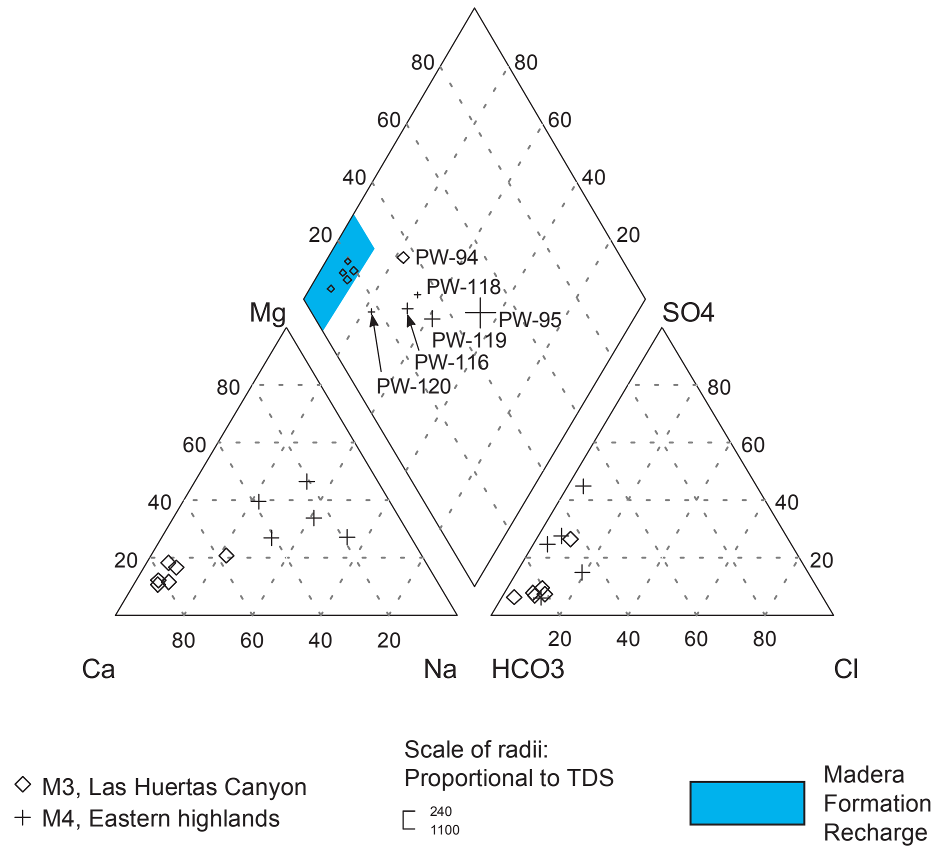


Figure 25. Major ion and stable isotope geochemistry of samples from mountain hydrogeologic zones M1and M2.



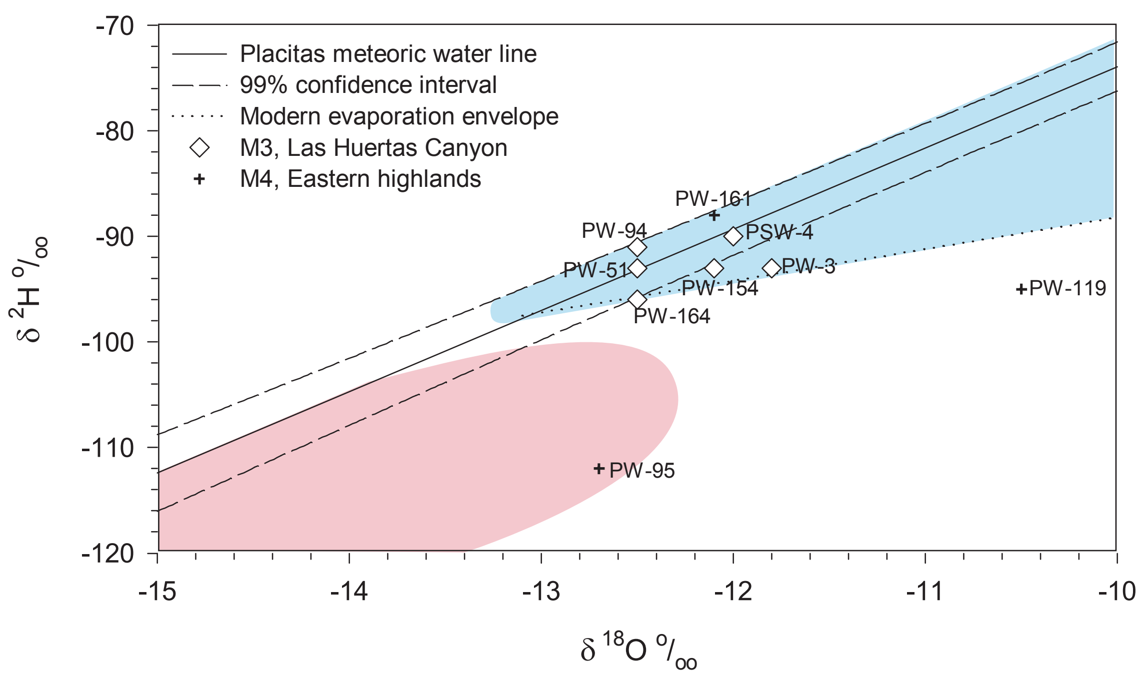


Figure 26. Major ion and stable isotope geochemistry of samples from mountain hydrogeologic zones M3 and M4.

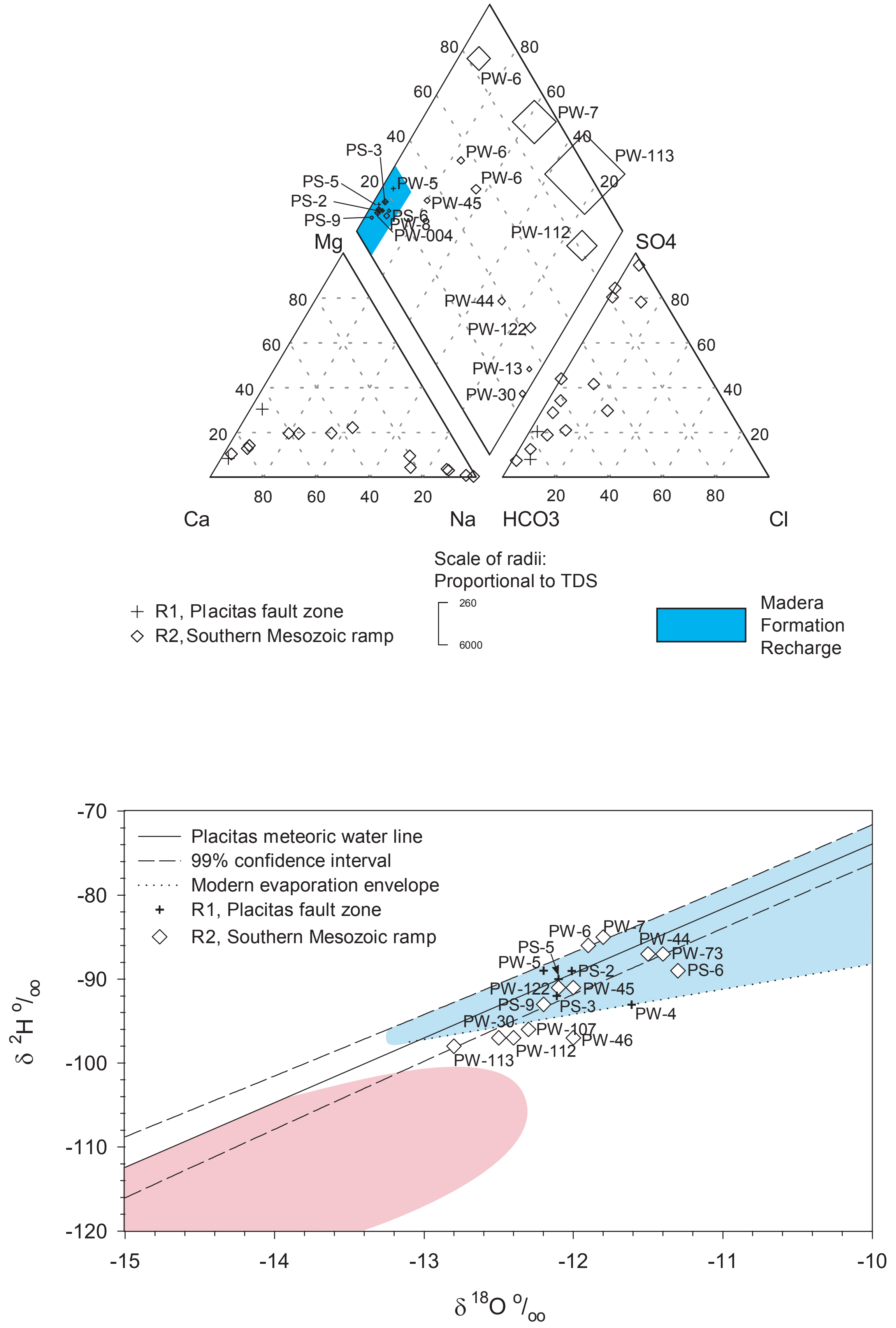


Figure 27. Major ion and stable isotope geochemistry of samples from Mesozoic ramp hydrogeologic zones R1 and R2.

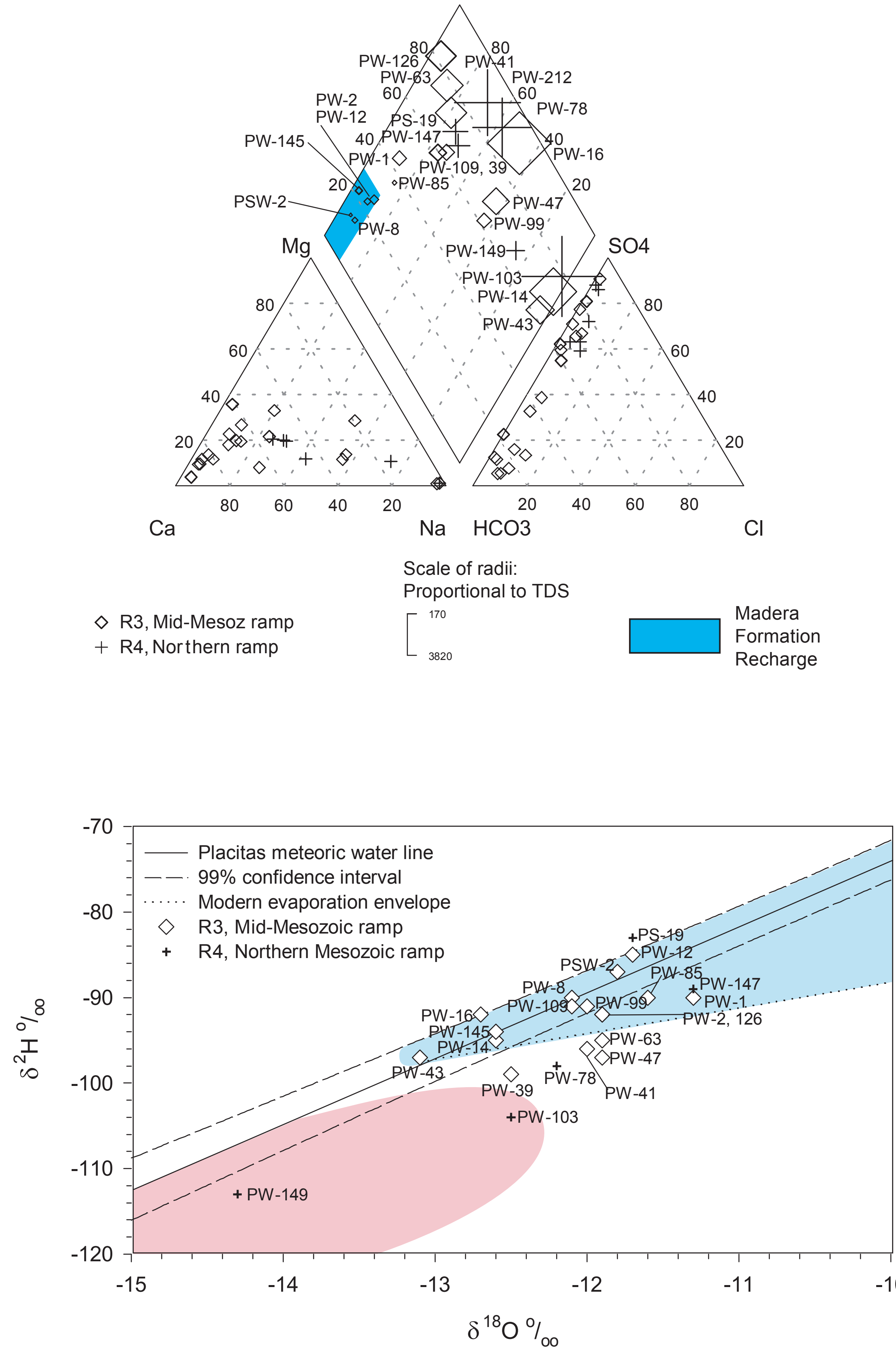


Figure 28. Major ion and stable isotope geochemistry of samples from Mesozoic ramp hydrogeologic zones R3 and R4.

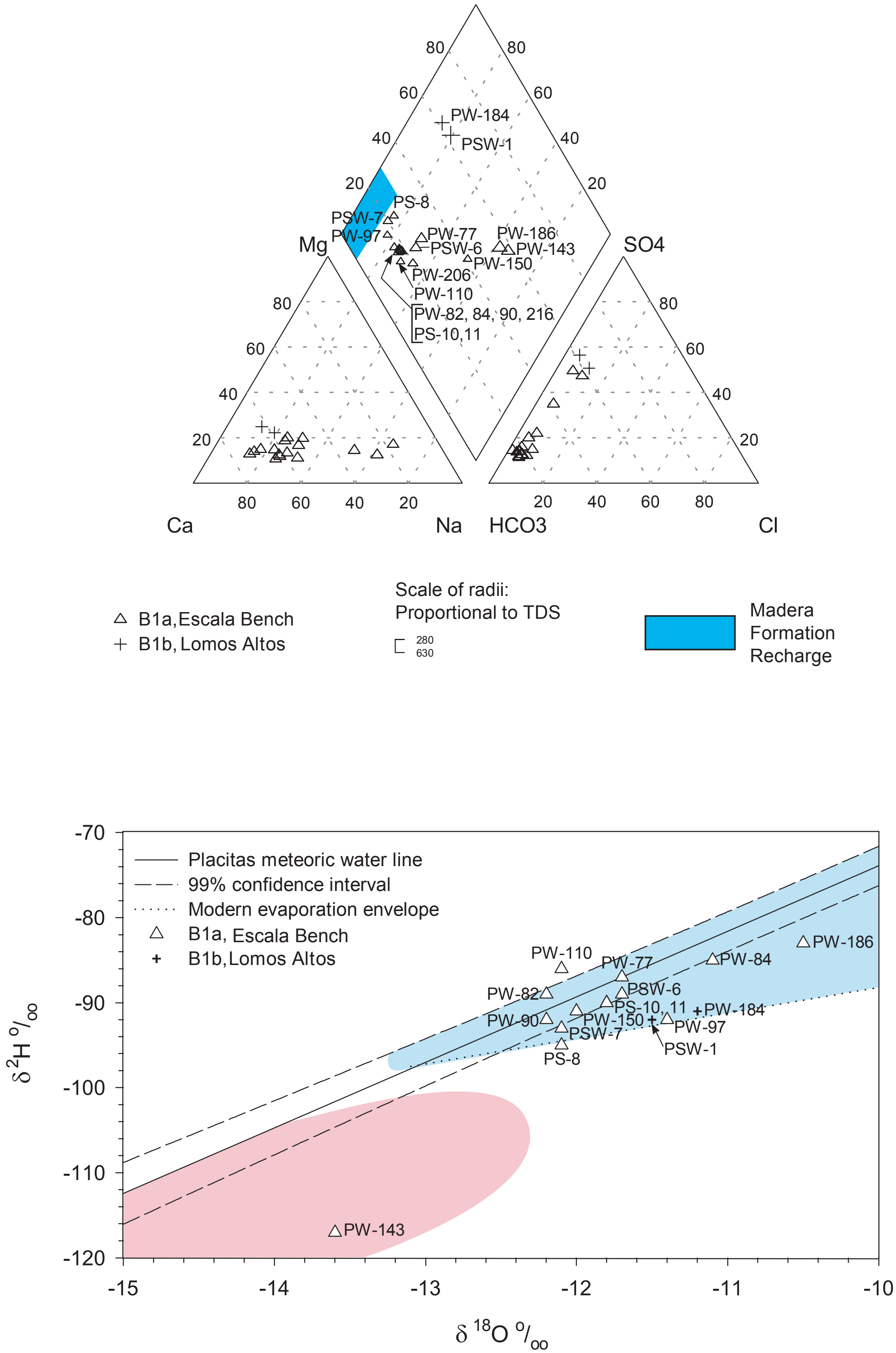
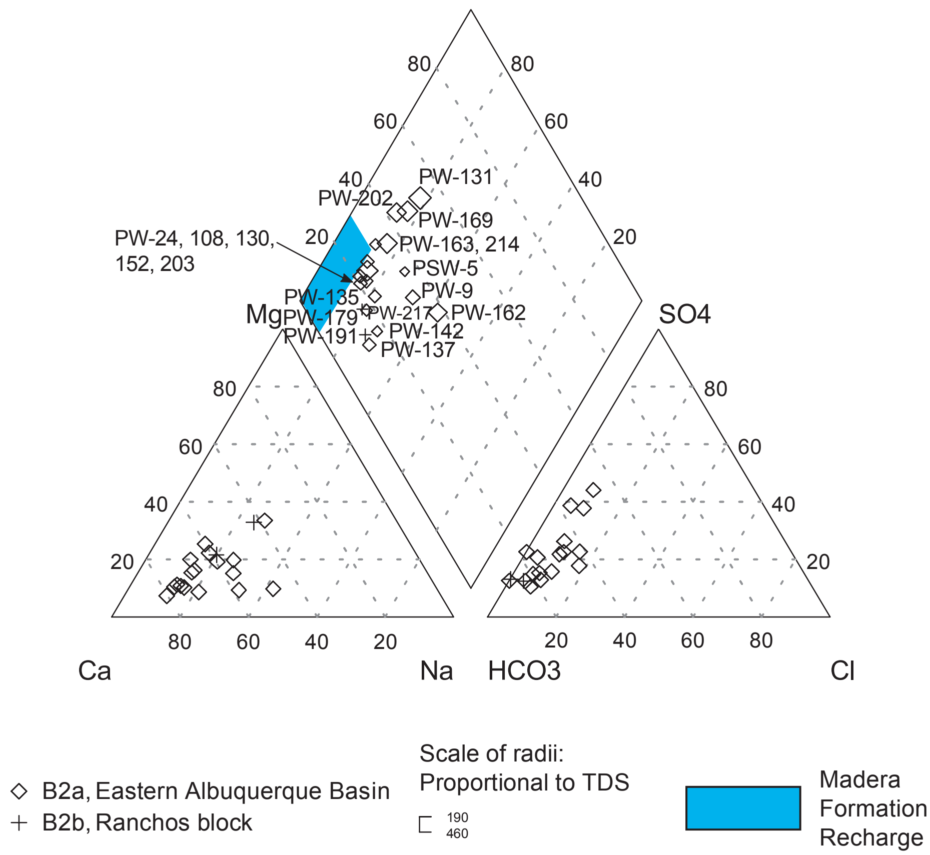


Figure 29. Major ion and stable isotope geochemistry of samples from basin hydrogeologic zones B1a and B1b.



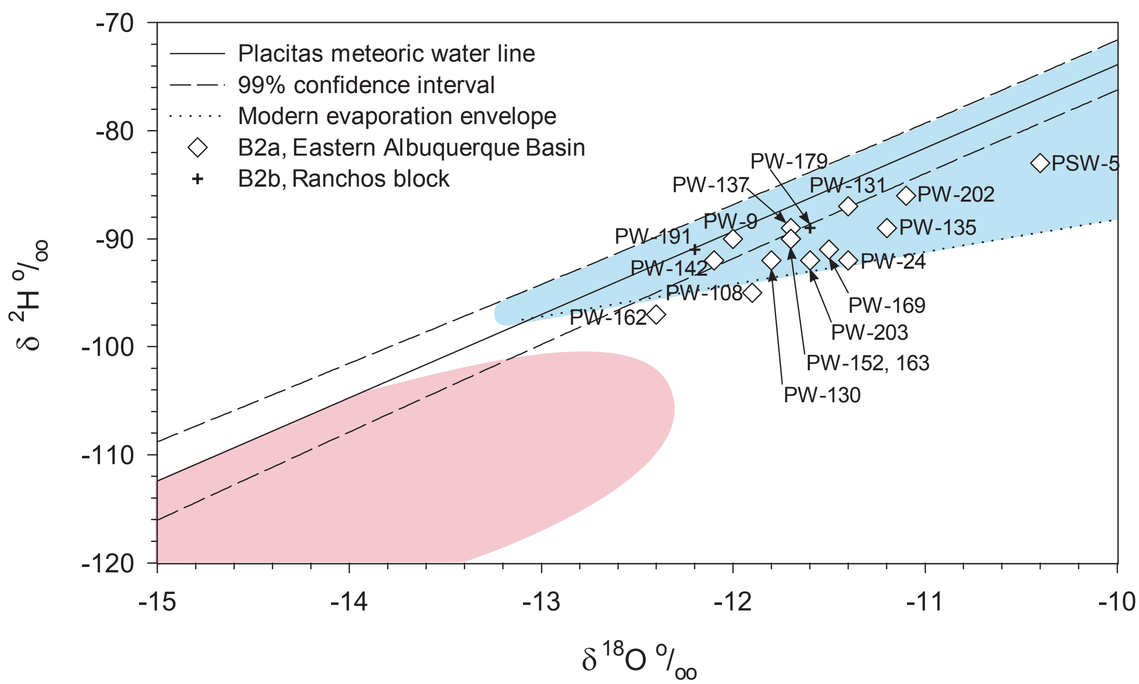


Figure 30. Major ion and stable isotope geochemistry of samples from basin hydrogeologic zones B2a and B2b.

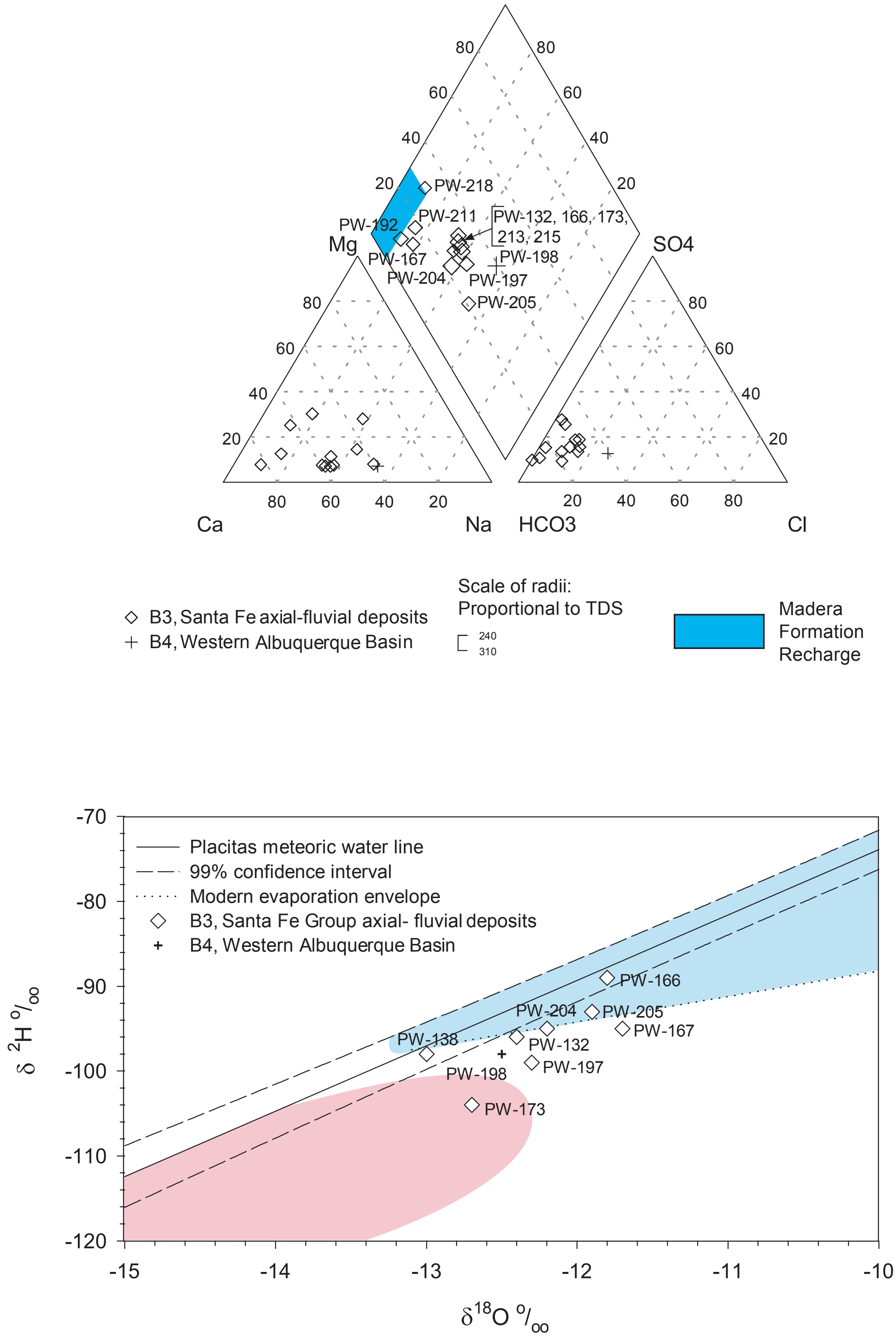


Figure 31. Major ion and stable isotope geochemistry of samples from basin hydrogeologic zones B3 and B4.

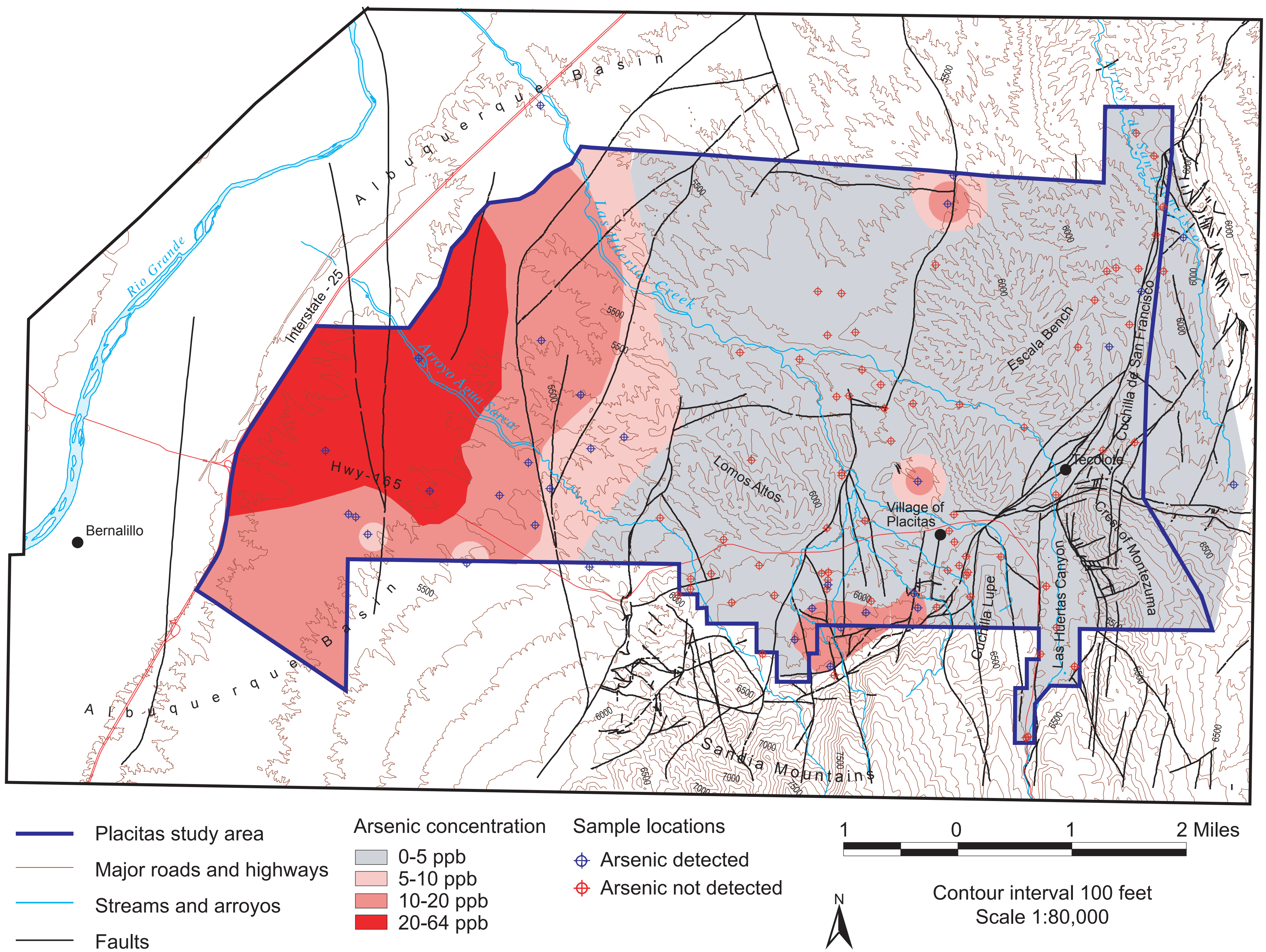


Figure 32. Distribution of arsenic in ground water.

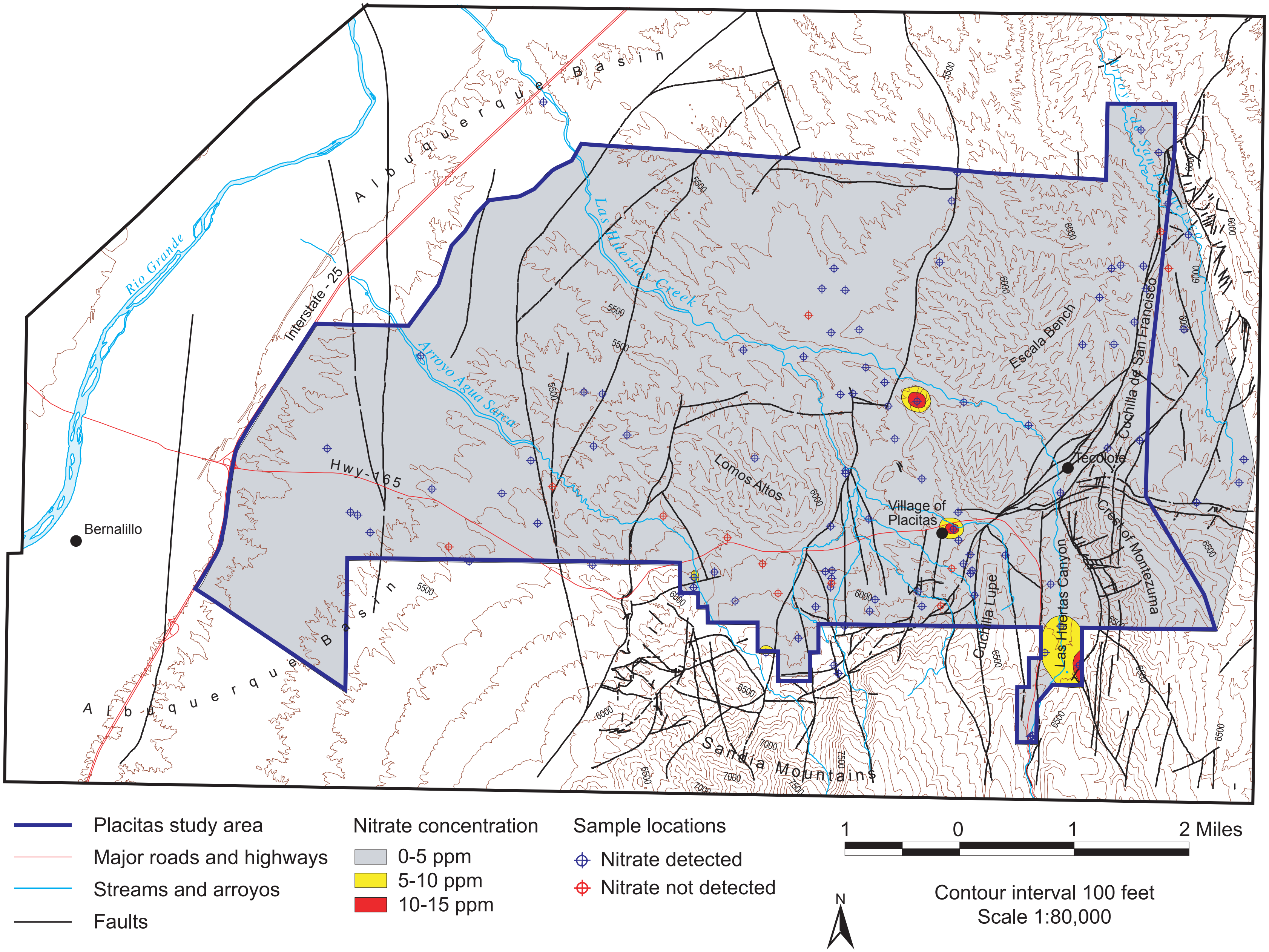


Figure 33. Distribution of nitrate in ground water.

TABLES

Table 1. Precipitaton stations in the Placitas area, periods of record, and annual and seasonal precipitation.

NOAA Station ID or Data Source	Station Name (Figure 10)	Begin Record	End Record	UTM Easting (NAD83)	UTM Northing (NAD83)	Elevation (NAVD88)	Mean Annual Precipitation (in)	Mean Winter Precipitation (in)	% Winter	% Summer
299342	Van Huss Ranch	7/1/47	6/30/51	377359	3914580	5404	9.1	2.1*	--	--
298011	Sandia Crest	11/1/53	4/30/79	368031	3898071	10686	22.9	8.1*	35*	41**
298015	Sandia Park	7/1/46	Present	375963	3892301	7019	18.8	5.0*	29*	44**
296911	Placitas 4W	12/1/91	Present	363619	3907344	5515	11.5	2.6*	22*	50**
---	Placitas nr	10/1/10	3/31/13	371060	3899802	8000	23.8	6.7*	28*	51**
293781	Hagan	4/1/53	5/31/56	380258	3907108	5653	10.6	1.3*	--	--
290903	Bernalillo 3SW	9/1/1889	11/10/53	357497	3905553	5043	8.3	1.9*	22*	49**
290903	Bernalillo 1NNE	11/10/53	7/13/65	360675	3911051	5062	7.9	1.9*	24*	47**
290903	Bernalillo	7/13/65	8/31/82	359102	3909300	5052	9.6	1.9*	20*	51**
	Bernalillo combined	9/1/1889	8/31/82			5052	8.7	1.9*	22*	48**
NMBMMR	PPT-1	4/10/97	8/4/98	367941	3897987	10572	38.3^	8.9^^	--	--
NMBMMR	PPT-2	4/10/97	8/4/98	371063	3899166	8098	46.2^	7.9^^	--	--
NMBMMR	PPT-3	3/3/97	8/4/98	372263	3909156	5960	19.7^	1.1^^	--	--
NMBMMR	PPT-4	4/4/97	8/4/98	371129	3907404	6395	23.2^	1.4^^	--	--
NMBMMR	PPT-5	4/11/97	8/4/98	368461	3906181	6356	21.3^	1.5^^	--	--
NMBMMR	PPT-6	4/4/97	8/4/98	365822	3905098	6197	27.9^	1.2^^	--	--
NMBMMR	PPT-7	4/4/97	8/4/98	358458	3906632	4993	19.7^	1.0^^	--	--
J.Fish (unpubl. 1999)	PPT-8	5/1/91	Present	369512	3908450	5774	14.7	3.6*	25*	35**

* For months of December, January, February, and March.
** For months of June, July, August, and September.
^ For period of May 26, 1997 through May 10, 1998.
^^ For period December 4, 1997 through February 12, 1998.
"--" Length of record inadequate for data evaluation.

Table 2. Inventory of springs and stream discharge by drainage (see also Figures 9, 14, 15, 16; Appendix D) (page 1 of 2).

Drainage Basin	Spring or Stream Gage	Name	Discharge (gpm)	Date Measured	Method	Water Quality (App F-H)	Data Source for Discharge
	PS-01	Ciruela Spring	133	Avg 1999①	flume③/flow meter	X	L.Gonzales (unpubl. 1999)
	PS-02	Placitas Spring #3	32	Avg 1999①	flume③	X	L.Gonzales (1999)
	PS-03	Placitas Spring #5	13	Avg	flume③	X	L.Gonzales (1999)
	PS-04	El Oso Spring	156	Avg 1999①	flume④	X	L.Gonzales (1999)
	PS-05	Tunnel Spring	---			X	
	PS-06	Escarcida Spring	1	5/29/96	bucket/stopwatch	X	NMBMMR
	PS-07	Tecolote Spring	---			X	
	PS-08	Rosa de la Castilla Spring	100	1/27/98	estimated	X	NMBMMR
	PS-09	Pomecerro Fault Spring	---			X	
	PS-19	Harris Spring	---			X	
	PS-20	Placitas Spring #7	2.8	Avg	bucket/stopwatch		L.Gonzales (1999)
	PS-24	unnamed	---				
Las Huertas Creek	PGS-1	Las Huertas Creek below Tecolote	101	1/27/98	bucket/stopwatch	PSW-7	NMBMMR
	PGS-2	Las Huertas Creek at Tres Amigos	215	1/27/98	bucket/stopwatch	PSW-7	NMBMMR
	PGS-3	Las Huertas Creek @ Camino de las Huertas	38.6	1/27/98	bucket/stopwatch	PSW-5	NMBMMR
	PGS-4	Arroyo del Ojo del Orno at Cedar Crk Rd	3.5	1/27/98	bucket/stopwatch	PSW-5	NMBMMR
	LH-1	Las Huertas Crk above springs at Sandia Conference Grounds	0.0	6/18/91	observation		J.Brekhus et al. (unpubl. report for UNM, 1991)
	LH-2	Below highest spring at Sandia Conference Grounds	11.7	6/18/91	V-notch flume		J.Brekhus et al. (1991)
	LH-3	Culvert at Sandia Conference Grounds	40.4	6/18/91	bucket/stopwatch		J.Brekhus et al. (1991)
	LH-4	Las Huertas picnic area	319	6/18/91	current meter		J.Brekhus et al. (1991)
	LH-5	Las Huertas-La Jara ditch diversion	166	6/18/91	V-notch flume		J.Brekhus et al. (1991)
	LH-6	Las Huertas-La Jara ditch split	40.4	6/18/91	V-notch flume		J.Brekhus et al. (1991)
	WW-1	Las Huertas Creek at NM 165 mile 12	1250	Avg②	unknown		D.Shaw (unpubl. 1999)
Arroyo de San Francisco	PS-10	Lobo Spring	6.4	7/17/97	bucket/stopwatch	X	NMBMMR
			7.3	9/27/97	bucket/stopwatch		R.Cohen (unpubl. 1998)
	PS-11	Lady Spring	1.4	7/17/97	bucket/stopwatch	X	NMBMMR
			1.7	9/27/97	bucket/stopwatch		R.Cohen (1998)
	PS-12	Belle Spring	3.0	9/27/97	bucket/stopwatch		R.Cohen (1998)
	PS-13	Rambi Spring	---				

Table 2. Inventory of springs and stream discharge by drainage (see Figures 9, 14, 15, 16; Appendix D) (page 2 of 2).

Drainage Basin	Spring or Stream Gage	Name	Discharge (gpm)	Date Measured	Method	Water Quality (App. F-H)	Data Source
Arroyo de San Francisco	PS-14	Kas Spring	seep				
	PS-15	Bundes Spring	seep				
	PS-16	BD Sprng	seep				
	PS-17	Galves Spring	---			X	
	PS-18	Johnsonbaugh Spring	---				
	PS-21	Old San Francisco Spring	---				
	PS-22	Upper San Francisco Creek Spring	---				
	PGS-5	San Francisco Creek south of Wessely	200	1/28/98	bucket/stopwatch	PSW-6	NMBMMR
			30	8/11/98	bucket/stopwatch		NMBMMR
	PGS-6	San Francisco Creek at Wessely	146	1/28/98	bucket/stopwatch	PSW-6	NMBMMR
			60	8/11/98	bucket/stopwatch		NMBMMR
	PGS-7	San Francisco Creek at San Felipe Pueblo	142	1/28/98	bucket/stopwatch	PSW-6	NMBMMR
			45	8/11/98	bucket/stopwatch		NMBMMR
Arroyo Agua Sarca	PS-23	Ranchos Fault Spring	seep				

① Average instantaneous discharge for water year 1999 (April 1998 through March 1999) (see Figure 14 and Appendix D).
② Average instantaneous discharge, September 26, 1995 through April 9, 1999 (see Figure 13 and Appendix D).
③ 0.45 cfs (202 gpm) ramp flume
④ 2 cfs (898 gpm) ramp flume

Table 3. Discharge estimates for Placitas Village springs for water years 1998, 1999, and 2000 derived from spring hydrograph separation (see Figure 16) (Johnson, 1999).

		Quick flow discharge			Base flow discharge			Total discharge	
Spring	Water Year ①	10^3 m^3	ac-ft	% of total	10^3 m^3	ac-ft	% of total	10^3 m^3	ac-ft
El Oso	1998	215	174	70	91	74	30	306	248
	1999	159	129	54	135	109	46	294	238
	2000	46	37	28	118	96	72	164	133
#3	1998	13	10	29	32	26	71	45	36
	1999	20	16	33	41	33	67	61	49
	2000	6	5	14	38	31	86	44	36
Ciruela	1998	68	55	33	136	110	67	204	165
	1999	91	74	35	172	139	65	263	213
	2000	16	13	9	171	139	91	187	152

① From March 1 of previous year.
② Partial year record from 4/10/97 through 3/1/98.

Table 4. Amount (inches) and stable isotope composition ($^{o}/_{oo}$) of precipitation from the Placitas area.

Site ID	Installation Date	Precipitation Collection Date																	
		5/26/97			9/2/97			12/4/97			2/12/98			5/10/98			8/4/98		
		Amt	$\delta^{18}O$	$\delta^{2}H$	Amt	$\delta^{18}O$	$\delta^{2}H$	Amt	$\delta^{18}O$	$\delta^{2}H$	Amt	$\delta^{18}O$	$\delta^{2}H$	Amt	$\delta^{18}O$	$\delta^{2}H$	Amt	$\delta^{18}O$	$\delta^{2}H$
PPT-1	4/10/97	5.7	-13.7	-102	41.2	-7.8	-57	9.7	-7.6	-49	22.6*	-16	-115	1.7	-12.2	-82	12.5	-10.8	-77
PPT-2	4/10/97	19	-11.8	-88	41.2	-4.8	-34	17.9	-9.3	-61	20*	-16.3	-117	19.9	-10	-82	6.8	-8.5	-64
PPT-3	3/3/97	9.1	-13.2	-99	15.3	-3.7	-27	9.8	-11.9	-91	3.1	-15.6	-110	15.7	-11.6	-88	10.7	-7.2	-51
PPT-4	4/4/97	16.4	-10.9	-96	13.2	-31	-4.2	11.4	-11.9	-89	3.5	-11.9	-81	13.0	-11.5	-77	10.5	-7.5	-47
PPT-5	4/11/97	7.4	-11.3	-90	11.3	-3.8	-26	11.4	na	na	3.7	-15.9	-120	19.3	-11.4	-79	8.5	-8.1	-58
PPT-6	4/4/97	7.2	-12.2	-89	29.9	-4.2	-25	12.7	-10.3	-77	3.1	-15.9	-122	16.6	-11	-82	7.4	-8.4	-66
PPT-7	4/4/97	14.5	-15	-123	12.7	-3.7	-28	8.9	-11.3	-83	2.6	-17.6	-139	10.5	-11.5	-92	4.7	-7.3	-61

Table 5. Qualitative ground-water residence time based on tritium (Clark and Fritz, 1997) and deuterium (LeFevre, 1999) content, relative to 1995.

Qualitative ground-water residence time	^{3}H [TU]	$\delta^{2}H$ ($^{o}/_{oo}$)
Fossil water recharged prior to ~10,000 years B.P.	0	< -100
Mixture of fossil water and modern, submodern, or Holocene water	< 0.8	-100 to -95①
Submodern to Holocene water recharged between 10,000 and 43 yrs B.P.	< 0.8	≥ -95②
Mixture of modern water and submodern or Holocene water	0.8 to ~ 4	≥ -95②
Modern water recharged from <5 to 10 yr	5 to 15	≥ -95②
Modern water with minor component of recharge from 1960's to 1970's	15 to 30	≥ -95②
Modern water with considerable component of recharge from 1960’s to 1970’s	>30	≥ -95②
Modern water with predominantly 1960’s recharge (30 to 40 yr)	>50	≥ -95②

① $\delta^{2}H$ = -100 to -95 **AND** composition outside of MWL's modern envelope (Figure 23).
② $\delta^{2}H \geq$ -95 **AND** composition within MWL's modern envelope (Figure 23).

Table 6. Ground-water residence times based on ^{14}C, ^{3}H and $^{2}H/H$ analyses (see Table 5 and Figure 24).

Site ID	Uncorrected ^{14}C activity [PMC ± 1σ]	$\delta^{13}C$ (‰)	Corrected ^{14}C age [Years] ①	^{3}H [TU] ②	$\delta^{2}H$ (‰) ②	Ground-Water Residence Time
PS-10	34.08 ± 0.87	-7.9	4340 ± 230	0 ± 3	-90	Holocene
PW-05	57.36 ± 0.85	-10.2	2020 ± 130	2 ± 3	-89	Modern (<10 yrs) / Holocene mix
PW-39	31.68 ± 0.93	-9.1	6300 ± 270	2 ± 2	-100	Modern / fossil mix
PW-41	5.05 ± 0.81	-7.7	23280 ± 1340	0 ± 2	-96	Submodern or Holocene / fossil mix
PW-71	12.32 ± 0.68	-6.5	12500 ± 590	0 ± 2	-97	Submodern or Holocene / fossil mix
PW-73	66.12 ± 1.08	-10	630 ± 140	6 ± 2	-90	Modern (≤10 yrs)
PW-89	21.34 ± 0.79	-7.8	8610 ± 300	1 ± 2	-91	Modern / Holocene mix
PW-103	4.60 ± 0.63	-11.3	27400 ± 1090	0 ± 2	-104	Fossil
PW-109	71.26 ± 0.77	-10	-10 ± 90	1 ± 2	-91	Modern to young submodern (≤100 yrs)
PW-143	<0.8	-5.2	>35250	0 ± 3	-117	Fossil
PW-149	2.68 ± 0.80	-11	31710 ± 2190	0 ± 2	-113	Fossil
PW-163	75.60 ± 1.14	-7.7	-2710 ± 130	9 ± 3	-90	Modern (<5 to 10 yrs)

① ^{14}C ages corrected using a $\delta^{13}C$ mixing model (LeFevre, 1999).
② Tritium analyses and $^{2}H/H$ ratios from LeFevre (1999).

Table 7. Ground-water availability and water quality characteristics by hydrogeologic zone; see Plate 5 (page 1 of 2).

Zone (Plate 5)	Description	Hydrostratigraphic Units (Figure 6, Plate 2)	Aquifer Potential (Figure 6)	Ground-water Age/Mean Residence Time* (VI.A.2 Table 6)	Recharge Sources	Water Quality** (Figs. 17, 18; App. F, G, H)	Representative Wells and Springs
M1	Sandia north slope, Upper Las Huertas Canyon, Cuchilla Lupe	Madera Fm.	*Moderate*: fractured aquifer; high transmissivity, low storage; fault and bedding controlled	Modern/ 1 to 10 years	Infiltration from Las Huertas Creek, snowmelt, precipitation	*Excellent*: TDI 270-310 ppm; Ca-HCO_3	PW-37, 66, 70, 83, 100, 101, 208, 209; PS-1, 4
M2	Cuchilla de San Francisco	Upper Madera Fm.	*Moderate*: fractured aquifer; high transmissivity, low storage; fault and bedding controlled	Submodern-Holocene and Fossil mix/ 100s to 1000s of years	Interaquifer flow; minor infiltration of local precipitation	*Good*: TDI 320-490 ppm; Ca/Na- to Ca/Na/Mg-HCO_3 to HCO_3/SO_4	PW-71, 89, 91, 96, 98, 102, 111, 114, 116, 139; PS-16, 17, 18, 21
	Crest of Montezuma	Madera Fm.		Submodern(?)/ 10s to 100s of years	Interaquifer flow; infiltration of local precipitation	*Unknown:* probably excellent to good Ca-HCO_3	none
	San Francisco fault zone	Abo through Upper Mesozoic Fms.	*Poor to none*: isolated fault blocks with low permeability, locally enhanced by fracturing	Submodern-Holocene and Fossil mix/ 100s to 1000s of years; ground water extremely localized	Interaquifer flow localized at Tecolote and San Francisco Springs	*Excellent to good:* TDI 285-340 ppm; Ca/Na- to Ca/Na/Mg-HCO_3	PW-76, 87, 115, 157, 207; PS-7
M3	Las Huertas Canyon	Abo Fm. (Pa)	*Moderate to poor*: variable permeability; fault and bedding controlled	Modern-Submodern/ 1 to 10s of years	Infiltration from Las Huertas Creek, snowmelt, precipitation	*Excellent*: TDI 250-320 ppm; Ca-HCO_3	PW-3, 50, 51, 88, 92, 93, 94, 154, 155, 156, 164
M4	Highlands east of Cuchilla de San Francisco	Abo, Yeso, Glorieta, San Andres, Moenkopi, Agua Zarca, Petrified Forest Fms.	*Moderate to none*: north-south strip aquifers isolated by aquitards; fault and bedding controlled	Submodern-Fossil/ 100s of years to >10,000 years	Interaquifer flow with long residence time	*Moderate*: TDI 400-1000 ppm; Na/Mg/Ca-HCO_3 /SO_4	PW-95, 118, 119, 120, 161
R1	Placitas fault zone; western base of Cuchilla Lupe	Abo, Yeso, Glorieta, San Andres, Moenkopi, and Agua Zarca Fms.	*Moderate*: fractured sandstone aquifers; high transmissivity, low storage; fault controlled	Modern-Submodern and Holocene mix/ 10s to 100s of years; highly variable; localized along fault zones	Infiltration of snow melt, precipitation, arroyo and acequia channel flow; interaquifer flow	*Excellent to Good*: TDI 260-340 ppm; Ca-HCO_3 to Ca/Mg-HCO_3/SO_4	PW-4, 5, 61; PS-2, 3, 5, 20
R2	Southern Mesozoic ramp	Upper and Lower Petrified Forest Fm. (Trcpu, Trcpl)	*None*: primarily shale aquitard	Modern to Holocene and Fossil mix/ 10s to 1000s of years; localized along faults and arroyos	Interaquifer flow along fault zones; infiltration from Arroyo Agua Sarca	*Moderate to very poor:* TDI 560-5950 ppm; Ca-SO_4 Na-SO_4 and Na-HCO_3	PW-6, 10, 40, 44, 46, 107, 113, 140, 141, 171; PS-6, 9
		Middle Petrified Forest Fm. (Trcpm)	*Poor:* thin sandstone strip aquifer bounded by siltstone/shale aquitards		Interaquifer flow along fault zones; infiltration from Arroyo Agua Sarca	*Good to very poor:* TDI 390-3230 ppm; Na-HCO_3 Na-SO_4 Ca-HCO_3	PW-7, 30, 45, 73, 112, 122
R3	Mid Mesozoic Ramp	Upper Mancos Fm. (Km_2)	*Poor to none*: primarily fine grained siltstone and shale aquitard	Submodern to Holocene/ 100s to 1000s of years or more; localized	Interaquifer flow; Caballo-Pomecerro fault; arroyo channel infiltration	*Poor to very poor:* TDI 2250 ppm; Na-SO_4	PW-13, 14, 26, 158
		Lower Mancos Fm. (Km_1)	*Poor to none*: primarily fine grained siltstone and shale aquitard	Modern-Holocene and Fossil mix/ <10 to 1000s of years or more; very localized		*Excellent to very poor:* TDI 300 - >3000; Na-SO_4 Ca-HCO_3 Ca-SO_4	PW-1, 8, 12, 16, 31, 43, 47, 48, 56, 57, 58, 75, 126
		Dakota Fm. (Kd)	*Poor to none:* isolated sand aquifers separated by Mancos shale	Modern-Holocene and Fossil mix/ <10 to 1000s of years; localized		*Good:* TDI 300-400 ppm; Ca-HCO_3	PW-2, 38, 129
		Morrison Fm.(Jm) [Brushy Basin and Recapture Sh]	*Moderate to none:* isolated strip aquitards and aquifers	Modern-Holocene and Fossil mix/ <10 to 1000s of years; localized		*Excellent to moderate:* TDI 230-700 ppm; Ca-HCO_3 and Na-SO_4	PW-39, 53, 55, 85, 86, 99, 124, 128, 145
		Todilto Fm. (Jt)	*Poor:* isolated limestone/gypsum aquifer	Submodern to Holocene/ 10s to 1000s of years; localized		*Unknown:* probably poor to very poor Ca-SO_4/HCO_3	PW-160
		Point Lookout Fm. (Kpl)	*Moderate to poor:* isolated fine sand aquifer	Submodern-Holocene and Fossil mix/10s to 1000s of years; localized	Interaquifer flow; Caballo-Pomecerro fault; arroyo channel infiltration	*Poor to very poor:* TDI 1490-3140 ppm; Ca/Na-SO_4	PW-63, 127, 200, 212
		Hosta-Dalton (Khd)	*Moderate:* isolated sand aquifer	Submodern-Holocene/ 10s to 1000s of years; localized		*Unknown:* probably moderate to poor Ca-HCO_3/SO_4	PW-25, 27, 159
		Morrison Fm(Jm) [Jackpile and Westwater Canyon]	*Moderate to poor:* isolated sand aquifers	Modern-Holocene and Fossil mix/ 10s to 1000s of years; localized		*Moderate to poor:* TDI 810-1540 ppm; Ca-SO_4/HCO_3	PW-41, 42, 79, 109, 148, 183
		Entrada/U. Petrified Forest (Je)	*Moderate to poor:* isolated sand aquifers	Submodern to Holocene/ 10s to 1000s of years; localized		*Unknown:* probably moderate to poor Ca/Na-HCO_3/SO_4	PW-11, 17, 18, 28, 60
R4	Northern Mesozoic Ramp	Menefee Fm. (Kmf)	*Moderate to none*: primarily shale aquitard; isolated Harmon sandstone	Holocene to Fossil/ 1000s to >10,000 years	Infiltration from Arroyo del Ojo del Orno or small ephemeral arroyos	*Moderate to very poor:* TDI 850-3820 ppm; Na/Ca-SO_4	PW-21, 23, 33, 59, 78, 80, 103, 123, 147, 149, 174; PS-19

Table 7. Ground-water availability and water quality characteristics by hydrogeologic zone; see Plate 5 (page 2 of 2).

Zone (Plate 5)	Description	Hydrostratigraphic Units (Figure 6)	Aquifer Potential (Figure 6)	Ground-water Age/Mean Residence Time* (VI.A.2 Table 6)	Recharge Sources	Water Quality** (Figs. 17, 18; App. F, G, H)	Representative Wells and Springs
B1a	Escala bench	Lower Santa Fe Group piedmont deposits	*Good*: thick sequence of moderate to high transmissivity gravels and sands	Modern to Fossil/ <10 to >10,000 years; modern at Tecolote and Las Huertas Creek	Infiltration from Las Huertas Creek, San Francisco Creek; subsurface flow at Tecolote and Cuchilla de San Francisco	*Excellent to good:* TDI 280-500 ppm; Ca/Na-HCO_3/SO_4	PW-77, 82, 84, 90, 97, 110, 143, 150, 186
B1b	Lomos Altos (Overlook)	Lower Santa Fe Group piedmont deposits	*Good*: thin sequence of moderate transmissivity gravels and sands, with some mudstone	Modern-Holocene/ annual to 100s of years or more; localized along arroyos	Infiltration from Arroyo del Ojo del Orno	*Good*: TDI ~530 ppm; Ca/Mg- SO_4/HCO_3	PW-184
B2a	Eastern basin adjacent to Rincon and Escala faults	Upper Santa Fe Group piedmont deposits	*Good*: thick sequence of moderate transmissivity gravels and sands	Modern-Holocene and Fossil mix/ annual to 1000s of years; localized along arroyos	Infiltration from Las Huertas Ck, Arroyo del Ojo del Orno, Arroyo Agua Sarca	*Excellent to good*: TDI 240-420 ppm; Ca-HCO_3	PW-9, 22, 24, 29, 105, 108, 130, 135, 137, 142, 151, 152, 162, 163, 169, 202, 203, 214, 217, 219
B2b	Eastern basin between Ranchos and Valley View faults	Upper Santa Fe Group piedmont deposits	*Good*: thin sequence of moderate transmissivity gravels and sands	Modern-Holocene/ 10s to 1000s years; localized along arroyos	Infiltration from Arroyo Agua Sarca and	*Excellent:* TDI 220-270 ppm, Ca-HCO_3	PW-165, 179, 191
B3	Central basin	Upper Santa Fe Group axial river and transitional axial/piedmont deposits	*Excellent*: thick sequence of high transmissivity sands and gravels with some mudstone	Submodern-Fossil and Fossil mix/ 10s to 1000s of years; localized along arroyos	Infiltration along distal reaches of arroyos; interaquifer flow with long residence time	*Excellent to good:* TDI 240-640 ppm (degrades with depth); Ca/Na/Mg-HCO_3	PW-132, 138, 166, 167, 168, 173, 197, 204, 205, 211, 213, 215, 218
B4	Western basin	Loma Barbon member of Upper Santa Fe Group	*Good to moderate*: thick sequence of fine sand, silt, and minor gravel	Submodern?-Holocene and Fossil mix/ 10s to 1000s of years	Infiltration along distal reaches of arroyos, and limited reaches of Rio Grande; interaquifer flow with long residence time	*Excellent*: TDI ≤ 300 ppm; Na/Ca-HCO_3/Cl	PW-198, 210

* **Ground-water age/mean residence time**
Modern: ground-water residence time is ≤ 50 years
Submodern: ground-water residence time is approximately 50 to 1000 years
Holocene: ground-water residence time is approximately 1000 to 10,000 years
Fossil: ground-water residence time > 10,000 years

** **Water Quality**
Excellent: water has less than 300 ppm total dissolved solids (TDI)
Good: water has 300 to 500 ppm TDI
Moderate: water has 500 to 1000 ppm TDI
Poor: water has 1000 to 2000 ppm TDI
Very poor: water has greater than 2000 ppm TDI

Table 8. Aquifer parameters for various hydrostratigraphic units in the Placitas area.

Well I.D.	NMOSE File	Location	Subdivision	Geologic Formation	Specific Capacity (gal/day ft)	Transmissivity T (ft^2/d)	Storage Coefficient	Hydraulic Conductivity K (ft/d)	Data Source
PW-89	RG-64529	13.5.22.4413		325MDERU/fractured	-	76	-	4	Turner Environmental Consultants (1996)
	RG-69572	9.6.6.144		325MDER/fractured	-	20-460	0.0003 - 0.0014	0.09-2	Clay Kilmer & Assoc., Ltd. (1998)
PW-208	RG-66702-ex	12.5.4.1424	San Antonio de las H.	325MDER/fractured	-	1840-2160	*	60-108	Johnson (1999)
PW-96	RG-60484	13.5.23.3342	Diamond Tail	318ABOL/325MDERU	173	126-566	-	36200	John Shomaker & Assoc., Inc. (1995)
PW-95	RG-60484	13.5.23.1124	Diamond Tail	318ABO	720	38-55	-	0.7-1	John Shomaker & Assoc., Inc. (1995)
PW-118	RG-60485	13.5.35.1434	Diamond Tail	318ABO	14	4.4-44	-	0.1-1	John Shomaker & Assoc., Inc. (1995)
PW-119	RG-60066	13.5.35.2144	Diamond Tail	318ABOU	115	30-60	-	0.5-1	John Shomaker & Assoc., Inc. (1995)
PW-120	RG-60067	13.5.35.2122	Diamond Tail	318ABOU	418	176-705	-	36231	John Shomaker & Assoc., Inc. (1995)
	RG-57988CLW	13.5.32.224	Los Pastores	211PNLK	-	23	-	1.1	Turner Environmental Consultants (1998)
PW-212	RG-57988	13.5.32.2244	Los Pastores	211MENF[HARN]	0.2	21	-	0.52	Turner Env.Con. (1998); Newcomer (1994)
PW-157	RG-64551-ex2	13.5.22.4211	Colinas dela Aurora	Fault Material	-	3.6-13.2	-	0.042	Turner Environmental Consultants (1998)
PW-185	RG-64551-ex	13.5.22.4211	Colinas dela Aurora	122SNTFPC		4.4-9.9	0.019	0.11	Turner Environmental Consultants (1998)
PW-206	RG-40708	13.5.22.2323	San Francisco Hills	122SNTFPC	-	140	-	3.5	Turner Environmental Consultants (1996)
	RG-42802	13.5.22.344	Linda Placitas	122SNTFPC	-	178	-	4.4	Turner Environmental Consultants (1996)
	RG-59635	13.5.22.344	Linda Placitas	122SNTFPC	-	2068	0.11	3.4	Turner Environmental Consultants (1996)
PW-191	RG-12871-CD	13.4.25.3413	N Ranchos de Placitas	112SNTFPCS	690	72	-	-	Geohydrology Assoc. Inc. (1995)
PW-214	RG-65081	13.5.19.442	Brenner	112SNTFPCS	317	62	-	-	John Shomaker & Assoc., Inc. (1997)
PW-219	RG-64470	13.5.19.443		112SNTFPCS	-	280	-	7	Glorieta Geoscience, Inc. (1996)
PW-192	RG-12871-CDS	13.4.25.3112	N Ranchos de Placitas	112SNTFT	2376	226	-	-	Geohydrology Assoc. Inc. (1995)
PW-194	RG-10032-S	13.4.26.4433	Ranchos de Placitas	112SNTFT	1008	93	-	-	John Shomaker & Assoc., Inc. (1987)
PW-197	RG-42562	13.4.34.2314	Placitas Trails	112SNTFT	-	4095	-	204	Turner Environmental Consultants (1997)
PW-198	RG-42562-S2	13.4.33.2121	Placitas Trails	112SNTFT[A]	-	13,690	-	456	Turner Environmental Consultants (1997)
PW-205	RG-49516	13.4.27.1244		112SNTFA	44,640	-	-	-	John Shomaker & Assoc., Inc. (1993)

* $(S_f + S_m)$ = 0.20 to 0.26
S_f = 0.003 to 0.012
S_m = 0.197 to 0.228, where S_f is storativity of fractures, and S_m is storativity of matrix

APPENDIX A

Placitas Data Inventory

Appendix A. Placitas Data Inventory

Site ID	Site Type	Latitude (NAD83)	Longitude (NAD83)	UTM Easting (NAD83)	UTM Northing (NAD83)	Latitude (NAD27)	Longitude (NAD27)	ELEV (HAE)	Elevation* (NAVD88)	Elevation* (NGVD29)	REC ORD	LEV EL	SAM PLE
Base	GPS Base	35.310756	106.435378	369512	3908450	35.310716	106.434798	5707.6	5773.8	5770.8			
PGS-01	StreamGage	35.325563	106.418856	371038	3910071	35.325523	106.418276	5710	5776	5773			
PGS-02	StreamGage	35.325950	106.421576	370791	3910118	35.325910	106.420996	5700	5766	5764			
PGS-03	StreamGage	35.332110	106.442257	368921	3910828	35.332071	106.441677	5524	5590	5587			
PGS-04	StreamGage	35.331366	106.448992	368308	3910754	35.331327	106.448412	5439	5506	5503			
PGS-05	StreamGage	35.356542	106.394161	373331	3913475	35.356503	106.393581	5647	5713	5710			
PGS-06	StreamGage	35.357234	106.394881	373266	3913553	35.357195	106.394301	5614	5680	5677			
PGS-07	StreamGage	35.363549	106.397230	373063	3914256	35.363511	106.396650	5565	5631	5628			
PPT-1	Precipitation	35.216229	106.450973	367941	3897987	35.216186	106.450394	10506	10572	10569			
PPT-2	Precipitation	35.227264	106.416866	371063	3899166	35.227221	106.416287	8033	8098	8095			
PPT-3	Precipitation	35.317472	106.405239	372263	3909156	35.317432	106.404659	5894	5960	5957			
PPT-4	Precipitation	35.301535	106.417426	371129	3907404	35.301495	106.416846	6329	6395	6392			
PPT-5	Precipitation	35.290158	106.446572	368461	3906181	35.290117	106.445992	6290	6356	6353			
PPT-6	Precipitation	35.280047	106.475408	365822	3905098	35.280006	106.474828	6131	6197	6194			
PPT-7	Precipitation	35.292864	106.556622	358458	3906632	35.292824	106.556041	4925	4993	4990			
PS-01	Spring	35.301330	106.418983	370988	3907384	35.301290	106.418403	6108	**6188**	**6185**		x	x
PS-02	Spring	35.304431	106.419429	370952	3907728	35.304391	106.418849	5988	**6138**	**6135**		x	x
PS-03	Spring	35.306419	106.419767	370924	3907949	35.306379	106.419187	5929	**6088**	**6085**		x	xD
PS-04	Spring	35.306372	106.413764	371470	3907936	35.306332	106.413184	5942	**6143**	**6140**		x	x
PS-05	Spring	35.291129	106.439886	369070	3906280	35.291088	106.439306	6310	**6388**	**6385**			x
PS-06	Spring	35.299876	106.424174	370513	3907229	35.299836	106.423594	5896	**6113**	**6110**		x	x
PS-07	Spring	35.320182	106.398761	372856	3909448	35.320142	106.398181	5962	6028	6025			x
PS-08	Spring	35.325733	106.421061	370837	3910093	35.325693	106.420481	5553	**5781**	**5778**			x
PS-09	Spring	35.292180	106.440568	369010	3906397	35.292139	106.439988	6247	6313	6310			x
PS-10	Spring	35.357750	106.393321	373409	3913608	35.357711	106.392741	5744	**5788**	**5785**		x	x
PS-11	Spring	35.357673	106.391506	373574	3913597	35.357634	106.390926	5757	5823	5820		x	x
PS-12	Spring	35.357377	106.394156	373332	3913568	35.357338	106.393576	5690	**5746**	**5743**		x	
PS-13	Spring	35.357127	106.394046	373342	3913540	35.357088	106.393466		**5733**	**5730**			
PS-14	Spring	35.356890	106.391424	373580	3913510	35.356851	106.390844	5711	**5800**	**5797**			
PS-15	Spring	35.356404	106.391300	373590	3913456	35.356365	106.390720	5734	5800	5797			
PS-16	Spring	35.353364	106.390467	373661	3913118	35.353325	106.389887	5746	5812	5809			
PS-17	Spring	35.340378	106.393140	373398	3911681	35.340339	106.392560	5960	6027	6024			x
PS-18	Spring	35.350515	106.390078	373692	3912802	35.350476	106.389498	5772	**5808**	**5805**			
PS-19	Spring	35.316853	106.439171	369177	3909132	35.316813	106.438591	5640	5707	5704			x
PS-20	Spring	35.306780	106.419158	370980	3907988	35.306740	106.418578	6054	6120	6117		x	
PS-21	Spring	35.344770	106.391158	373585	3912166	35.344731	106.390578	5869	**5948**	**5945**			
PS-22	Spring	35.347048	106.392410	373475	3912420	35.347009	106.391830		**5878**	**5875**			
PS-23	Spring	35.309674	106.472513	366134	3908380	35.309634	106.471933		**5623**	**5620**			
PS-24	Spring	35.290180	106.448200	368313	3906185	35.290137	106.447619		**6240**	**6237**			
PSW-01	Surface Water	35.318851	106.440471	369062	3909355	35.318811	106.439891		**5663**	**5660**			x
PSW-02	Surface Water	35.304737	106.462414	367044	3907819	35.304697	106.461834	5686	5753	5750			x
PSW-03	Surface Water	35.249150	106.411652	371572	3901587	35.249108	106.411072	7033	7098	7095			x
PSW-04	Surface Water	35.319978	106.408233	371994	3909438	35.319938	106.407653	5830	5896	5893			x
PSW-05	Surface Water	35.333297	106.455192	367747	3910977	35.333258	106.454611	5409	5476	5473			x
PSW-06	Surface Water	35.362462	106.396573	373121	3914135	35.362424	106.395993	5552	5619	5616			x
PSW-07	Surface Water	35.323783	106.413554	371517	3909867	35.323743	106.412974	5805	5871	5868			x
PW-001	Well	35.310792	106.435524	369499	3908455	35.310752	106.434944	5708	5774	5771	x		x
PW-002	Well	35.304636	106.422538	370670	3907755	35.304596	106.421958	5962	6028	6025	TD		x
PW-003	Well	35.302821	106.407262	372056	3907534	35.302781	106.406682	6077	**6161**	**6158**	x		x
PW-004	Well	35.304070	106.419653	370931	3907688	35.304030	106.419073	6076	6142	6139	TD		x
PW-005	Well	35.297145	106.439016	369159	3906946	35.297105	106.438436	5919	5985	5982	x		x

Appendix A. Placitas Data Inventory

Site ID	Site Type	Latitude (NAD83)	Longitude (NAD83)	UTM Easting (NAD83)	UTM Northing (NAD83)	Latitude (NAD27)	Longitude (NAD27)	ELEV (HAE)	Elevation* (NAVD88)	Elevation* (NGVD29)	REC ORD	LEV EL	SAM PLE
PW-006	Well	35.299100	106.435177	369511	3907157	35.299060	106.434597	5784	**5998**	**5995**	x	a	x
PW-007	Well	35.300559	106.434337	369590	3907318	35.300519	106.433757	5751	5817	5814	x		x
PW-008	Well	35.303033	106.462360	367046	3907630	35.302993	106.461780	5628	5695	5692	x		x
PW-009	Well	35.306425	106.500202	363611	3908057	35.306385	106.499622	5425	5492	5489	x		x
PW-010	Well	35.298238	106.446427	368487	3907077	35.298198	106.445847	5942.2	6008.3	6005.4	x	n	
PW-011	Well	35.298651	106.447055	368431	3907123	35.298611	106.446475	5957	6023	6020	x	x	
PW-012	Well	35.309647	106.422468	370684	3908311	35.309607	106.421888	5875.7	5941.7	5938.8	x	n	xD
PW-013	Well	35.317800	106.433321	369710	3909229	35.317760	106.432741	5689.2	5755.5	5752.6	x	n	
PW-014	Well	35.304904	106.451773	368012	3907823	35.304864	106.451193	5849	5915	5912	x		x
PW-015	Well	35.304941	106.451003	368082	3907826	35.304901	106.450423	5852	5919	5916	x		
PW-016	Well	35.311752	106.421714	370756	3908543	35.311712	106.421134	5917	**5971**	**5968**	x		x
PW-017	Well	35.307511	106.439279	369152	3908096	35.307471	106.438699	5758.2	5824.4	5821.5	TD	n	
PW-018	Well	35.306371	106.437817	369283	3907967	35.306331	106.437237	5768.2	5834.3	5831.4	TD	n	
PW-019	Well	35.306295	106.452930	367909	3907979	35.306255	106.452350	5823	5889	5886	x		
PW-020	Well	35.305714	106.452672	367931	3907914	35.305674	106.452092	5838	5904	5901	TD		
PW-021	Well	35.306049	106.452208	367974	3907951	35.306009	106.451628	5801.3	5867.6	5864.7	x	n	
PW-022	Well	35.330244	106.441929	368948	3910621	35.330205	106.441349	5587	**5640**	**5637**	TD	x	
PW-023	Well	35.326598	106.438250	369276	3910211	35.326559	106.437670	5578.7	5645.3	5642.4	x	n	*
PW-024	Well	35.329954	106.436253	369463	3910581	35.329915	106.435673	5635.7	5702.3	5699.4	x	n	x
PW-025	Well	35.318543	106.436771	369398	3909316	35.318503	106.436191	5675.1	5741.5	5738.6	x	n	
PW-026	Well	35.318797	106.436389	369433	3909344	35.318757	106.435809	5668.7	5735.1	5732.2	TD	n	
PW-027	Well	35.317693	106.434150	369635	3909218	35.317653	106.433570	5679.2	5745.5	5742.6	x	n	
PW-028	Well	35.305491	106.441325	368963	3907874	35.305451	106.440745	5793.0	5859.2	5856.2	TD	n	
PW-029	Well	35.327970	106.438960	369214	3910364	35.327931	106.438380	5600.7	5667.3	5664.3	x	n	
PW-030	Well	35.295537	106.446102	368512	3906777	35.295497	106.445522	6032.4	6098.5	6095.6	x	n	xD
PW-031	Well	35.301624	106.453967	367807	3907462	35.301584	106.453387	5900.1	5966.4	5963.5	x	n	
PW-032	Well	35.324125	106.433338	369719	3909931	35.324085	106.432758	5652	5719	5716	x		
PW-033	Well	35.325954	106.433790	369681	3910134	35.325915	106.433210	5644.7	5711.2	5708.2	x	n	
PW-034	Well	35.325317	106.433523	369704	3910063	35.325277	106.432943	5665	5732	5729	TD		
PW-035	Well	35.310077	106.415587	371310	3908349	35.310037	106.415007	5998	6064	6061	TD		
PW-036	Well	35.310419	106.415643	371306	3908387	35.310379	106.415063	5997	**6047**	**6044**	x		
PW-037	Well	35.304177	106.412057	371622	3907690	35.304137	106.411477	6122.4	6188.2	6185.3	TD	n	
PW-038	Well	35.307040	106.420832	370828	3908019	35.307000	106.420252	5968	6034	6031	x		
PW-039	Well	35.305263	106.420803	370828	3907822	35.305223	106.420223	6029	**6068**	**6065**	x		x
PW-040	Well	35.302962	106.440406	369042	3907593	35.302922	106.439826	5849.8	5915.9	5913.0	x	n	
PW-041	Well	35.300120	106.455988	367621	3907298	35.300080	106.455408	5922	5988	5985	x		x
PW-042	Well	35.300194	106.458032	367435	3907309	35.300154	106.457452	5915	**5993**	**5990**	x		
PW-043	Well	35.303780	106.459204	367334	3907708	35.303740	106.458624	5869	**5911**	**5908**	x	*	x
PW-044	Well	35.303114	106.440929	368979	3907618	35.303074	106.440349	5849.1	5915.3	5912.3	TD	n	x
PW-045	Well	35.302576	106.441059	368982	3907551	35.302536	106.440479	5883	5950	5947	x		x
PW-046	Well	35.304165	106.441070	368984	3907727	35.304125	106.440490	5823	**5904**	**5901**	x		x
PW-047	Well	35.308262	106.421581	370762	3908156	35.308222	106.421001	5931	**5982**	**5979**	x		x
PW-048	Well	35.308350	106.421532	370767	3908165	35.308310	106.420952	5950	**5982**	**5979**	x		
PW-049	Well	35.303923	106.407486	372037	3907656	35.303883	106.406906	6092	6157	6155	x		
PW-050	Well	35.303147	106.403893	372362	3907566	35.303107	106.403313	6055.0	6120.7	6117.8	x	n	
PW-051	Well	35.294189	106.407989	371976	3906577	35.294148	106.407409	6194	6260	6257	TD		x
PW-052	Well	35.296547	106.404843	372266	3906835	35.296507	106.404263	6126	6192	6189	x	*	
PW-053	Well	35.299513	106.461275	367139	3907238	35.299473	106.460695	5822	5889	5886	x		
PW-054	Well	35.299933	106.462036	367071	3907285	35.299893	106.461456	5800	5866	5863			
PW-055	Well	35.301657	106.460877	367179	3907475	35.301617	106.460297	5779.3	5845.7	5842.8	TD	n	
PW-056	Well	35.304611	106.462589	367028	3907805	35.304571	106.462009	5709.8	5776.2	5773.4	x	n	

Appendix A. Placitas Data Inventory

Site ID	Site Type	Latitude (NAD83)	Longitude (NAD83)	UTM Easting (NAD83)	UTM Northing (NAD83)	Latitude (NAD27)	Longitude (NAD27)	ELEV (HAE)	Elevation* (NAVD88)	Elevation* (NGVD29)	REC ORD	LEV EL	SAM PLE
PW-057	Well	35.302334	106.454148	367792	3907541	35.302294	106.453568	5892	5958	5955	x		
PW-058	Well	35.302292	106.454168	367790	3907537	35.302252	106.453588	5889	**5968**	**5965**	x		
PW-059	Well	35.326615	106.435761	369503	3910210	35.326576	106.435181	5659	5725	5722	x		
PW-060	Well	35.306885	106.439193	369159	3908026	35.306845	106.438613	5763	5829	5826	TD		
PW-061	Well	35.303779	106.419797	370917	3907656	35.303739	106.419217	6064	6130	6127	x	x	
PW-062	Well	35.310777	106.407094	372083	3908416	35.310737	106.406514	5948	**6032**	**6029**	TD	n	
PW-063	Well	35.308100	106.457331	367512	3908185	35.308060	106.456751	5779	**5833**	**5830**	x		x
PW-064	Well	35.292078	106.406685	372091	3906341	35.292037	106.406105	6176	**6262**	**6259**	x		
PW-065	Well	35.336273	106.400723	372703	3911236	35.336234	106.400143	5963	6029	6026	x		
PW-066	Well	35.300111	106.413579	371477	3907241	35.300071	106.412999	6215.9	6281.6	6278.7	x	n	
PW-067	Well	35.305051	106.412774	371558	3907788	35.305011	106.412194	6120	**6198**	**6195**	x	a	
PW-068	Well	35.288060	106.410878	371704	3905901	35.288019	106.410298	6322	**6378**	**6375**	x	*	
PW-069	Well	35.284216	106.409376	371834	3905473	35.284175	106.408796	6300	6365	6363	x		
PW-070	Well	35.284236	106.409455	371827	3905475	35.284195	106.408875	6282.8	6348.3	6345.2	TD	n	
PW-071	Well	35.343024	106.389747	373711	3911970	35.342985	106.389167	5908.7	5974.9	5972.0	x	n	x
PW-072	Well	35.328051	106.436409	369446	3910370	35.328012	106.435829	5630	**5685**	**5682**	x		
PW-073	Well	35.293659	106.451089	368056	3906575	35.293618	106.450509	6146	6212	6209	x		x
PW-074	Well	35.300344	106.448945	368262	3907314	35.300304	106.448365	5951	6017	6014	x		
PW-075	Well	35.300948	106.448112	368338	3907379	35.300908	106.447532	5902.4	5968.6	5965.7	TD	n	
PW-076	Well	35.318407	106.403316	372439	3909257	35.318367	106.402736	5929.7	5995.7	5992.7	x	n	
PW-077	Well	35.360496	106.394346	373320	3913914	35.360457	106.393766	5675	5742	5739	TD		x
PW-078	Well	35.325123	106.432765	369773	3910041	35.325083	106.432185	5661	5727	5724	TD		x
PW-079	Well	35.302285	106.458833	367366	3907542	35.302245	106.458253	5888	**5945**	**5942**	x		
PW-080	Well	35.325122	106.432953	369755	3910041	35.325082	106.432373	5638.8	5705.3	5702.4	TD	n	
PW-081	Well	35.335682	106.401868	372598	3911171	35.335643	106.401288	6048	6115	6112	x		
PW-082	Well	35.343266	106.393606	373360	3912002	35.343227	106.393026	5871	5937	5934	x		x
PW-083	Well	35.288681	106.411347	371662	3905971	35.288640	106.410767	6336.0	6401.6	6398.6	x	n	
PW-084	Well	35.333196	106.402838	372506	3910897	35.333157	106.402258	6108	**6163**	**6160**	x		x
PW-085	Well	35.300983	106.464299	366867	3907405	35.300943	106.463719	5916.9	5983.3	5980.4	x	n	x
PW-086	Well	35.301301	106.462320	367047	3907438	35.301261	106.461740	5772.8	5839.2	5836.3	x	n	
PW-087	Well	35.347627	106.391036	373601	3912482	35.347588	106.390456	5796	**5875**	**5872**	x	a	x
PW-088	Well	35.320123	106.408168	372000	3909454	35.320083	106.407588	5835.0	5901.1	5898.2	x	n	
PW-089	Well	35.336181	106.394902	373231	3911218	35.336142	106.394322	5957.5	6023.7	6020.8	x	n	x
PW-090	Well	35.342890	106.398542	372911	3911967	35.342851	106.397962	5960.7	6027.0	6024.1	x	n	x
PW-091	Well	35.351223	106.390000	373700	3912880	35.351184	106.389420	5779.2	5845.6	5842.7	TD	n	x
PW-092	Well	35.319225	106.407204	372087	3909353	35.319185	106.406624	5849.4	5915.5	5912.5	x	n	
PW-093	Well	35.314435	106.406012	372188	3908820	35.314395	106.405432	5905.7	5971.7	5968.7	TD	n	
PW-094	Well	35.314392	106.405998	372189	3908815	35.314352	106.405418	5925	5991	5989	TD		x
PW-095	Well	35.347296	106.386768	373988	3912440	35.347257	106.386188	5783.3	5849.6	5846.7	x	x	x
PW-096	Well	35.335338	106.387205	373930	3911115	35.335299	106.386625	5927.7	5993.8	5990.9	x	x	*
PW-097	Well	35.322925	106.411004	371747	3909768	35.322885	106.410424	5802	**5881**	**5878**	x		x
PW-098	Well	35.341084	106.389962	373688	3911755	35.341045	106.389382	5936	**6041**	**6038**	x	x	
PW-099	Well	35.301775	106.462414	367039	3907490	35.301735	106.461834	5774	5840	5838	TD	n	x
PW-100	Well	35.283646	106.409784	371796	3905410	35.283605	106.409204	6287.5	6353.0	6350.0	TD	n	x
PW-101	Well	35.283691	106.409600	371813	3905415	35.283650	106.409018	6308	6374	6371	x		x
PW-102	Well	35.346074	106.390073	373686	3912309	35.346035	106.389493	5843	5910	5907	x		
PW-103	Well	35.320968	106.431665	369866	3909578	35.320928	106.431085	5677	5744	5741	x		x
PW-104	Well	35.329379	106.444521	368711	3910528	35.329340	106.443941	5566	5633	5630	x		
PW-105	Well	35.325892	106.439184	369190	3910134	35.325853	106.438604	5573	5639	5637	TD		
PW-106	Well	35.325618	106.439344	369175	3910104	35.325579	106.438764	5593	5660	5657	x		
PW-107	Well	35.304045	106.442084	368891	3907715	35.304005	106.441504	5824	**5905**	**5902**	x		x

Appendix A. Placitas Data Inventory

Site ID	Site Type	Latitude (NAD83)	Longitude (NAD83)	UTM Easting (NAD83)	UTM Northing (NAD83)	Latitude (NAD27)	Longitude (NAD27)	ELEV (HAE)	Elevation* (NAVD88)	Elevation* (NGVD29)	REC ORD	LEV EL	SAM PLE
PW-108	Well	35.328064	106.433344	369725	3910367	35.328025	106.432764	5663	5730	5727	TD		x
PW-109	Well	35.309793	106.441385	368964	3908352	35.309753	106.440805	5746	5812	5810	x		x
PW-110	Well	35.339238	106.400330	372743	3911564	35.339199	106.399750	5906	5972	5969	x		x
PW-111	Well	35.345956	106.390801	373619	3912297	35.345917	106.390221	5834	5900	5897	x		
PW-112	Well	35.299823	106.427137	370244	3907227	35.299783	106.426557	5977.3	6043.2	6040.2	x	n	x
PW-113	Well	35.301616	106.427759	370190	3907427	35.301576	106.427179	5899.2	5965.1	5962.2	TD	n	x
PW-114	Well	35.345432	106.389536	373734	3912237	35.345393	106.388956	5875	5941	5938	TD		
PW-115	Well	35.346905	106.391432	373564	3912403	35.346866	106.390852	5832	5899	5896	x	a	
PW-116	Well	35.348349	106.390314	373667	3912562	35.348310	106.389734	5799	5865	5862	x		*
PW-117	Well	35.302226	106.443427	368766	3907515	35.302186	106.442847	5862	5928	5925	x		
PW-118	Well	35.313417	106.384939	374102	3908680	35.313377	106.384359	6198.8	6264.5	6261.6	x	x	*
PW-119	Well	35.315998	106.378383	374702	3908958	35.315958	106.377803	6158	6224	6221	x	*	xD
PW-120	Well	35.318966	106.377683	374770	3909287	35.318926	106.377103	6117	6183	6180	x	*	*
PW-121	Well	35.298168	106.445287	368591	3907067	35.298128	106.444707	5969	6035	6032	x		
PW-122	Well	35.302050	106.441251	368964	3907493	35.302010	106.440671	5877	**5956**	**5953**	x	x	x
PW-123	Well	35.304049	106.447730	368378	3907723	35.304009	106.447150	5855	**5933**	**5933**	x	*	
PW-124	Well	35.302689	106.443032	368803	3907566	35.302649	106.442452	5851.9	5918.1	5915.2	x	n	
PW-125	Well	35.302794	106.443566	368755	3907578	35.302754	106.442986	5860	5927	5924	x		
PW-126	Well	35.301159	106.449311	368230	3907404	35.301119	106.448731	5910	5976	5973	x	*	x
PW-127	Well	35.303697	106.450268	368147	3907687	35.303657	106.449688	5855	**5938**	**5935**	x	*	
PW-128	Well	35.299238	106.455754	367641	3907200	35.299198	106.455174	5951	6017	6014	x	*	
PW-129	Well	35.300191	106.453434	367853	3907303	35.300151	106.452854	5936.1	6002.4	5999.4	x	n	
PW-130	Well	35.331910	106.455283	367737	3910823	35.331871	106.454702	5459	5526	5523	x		x
PW-131	Well	35.326500	106.440199	369099	3910203	35.326461	106.439619	5555	5621	5619	x		x
PW-132	Well	35.313302	106.492184	364352	3908809	35.313262	106.491604	5417	5484	5481	x		x
PW-133	Well	35.302587	106.437198	369333	3907547	35.302547	106.436618	5874	5940	5937	TD	a	*
PW-134	Well	35.320969	106.432068	369829	3909579	35.320929	106.431488	5678	5744	5741	TD		
PW-135	Well	35.309622	106.486634	364850	3908393	35.309582	106.486054	5481	5548	5545	x		x
PW-136	Well	35.307987	106.488828	364648	3908215	35.307947	106.488248	5470	5537	5534	x		
PW-137	Well	35.314284	106.484379	365063	3908907	35.314244	106.483799	5476	5543	5540	x		x
PW-138	Well	35.333073	106.486103	364937	3910994	35.333034	106.485522	5337	5404	5402	x		
PW-139	Well	35.343302	106.391952	373511	3912004	35.343263	106.391372	5891	5957	5954	x	a	
PW-140	Well	35.300195	106.438970	369168	3907284	35.300155	106.438390	5960	6026	6023	TD	*	
PW-141	Well	35.300147	106.438030	369254	3907277	35.300107	106.437450	5975.6	6041.7	6038.8	TD	n	
PW-142	Well	35.351195	106.423397	370666	3912920	35.351156	106.422816	5624	5691	5688	TD		x
PW-143	Well	35.343391	106.425079	370500	3912057	35.343352	106.424499	5817	5884	5881	x		x
PW-144	Well	35.300340	106.454824	367727	3907321	35.300300	106.454244	5940	6007	6004	x		
PW-145	Well	35.299537	106.443465	368759	3907217	35.299497	106.442885	6029	6095	6092	x		x
PW-146	Well	35.342122	106.425276	370480	3911916	35.342083	106.424696	5794	5860	5858			
PW-147	Well	35.316490	106.439171	369176	3909091	35.316450	106.438591	5654	5721	5718	x		x
PW-148	Well	35.300171	106.453450	367852	3907300	35.300131	106.452870	5945	6011	6008	x		
PW-149	Well	35.310772	106.467243	366615	3908495	35.310732	106.466663	5605	5672	5669	x		x
PW-150	Well	35.354764	106.422575	370746	3913315	35.354725	106.421994	5600	5667	5664	TD		x
PW-151	Well	35.349214	106.423912	370616	3912701	35.349175	106.423331	5628.7	5695.4	5692.5	x	n	
PW-152	Well	35.334718	106.437410	369366	3911111	35.334679	106.436830	5637	5703	5700	x		x
PW-153	Well	35.323093	106.436850	369398	3909821	35.323053	106.436270	5617	5683	5681	TD		*
PW-154	Well	35.297574	106.405634	372195	3906950	35.297534	106.405054	6123	6188	6185			x
PW-155	Well	35.298482	106.404395	372309	3907049	35.298442	106.403815	6084.9	6150.6	6147.6		x	
PW-156	Well	35.298399	106.404404	372309	3907040	35.298359	106.403824	6085.6	6151.3	6148.4		x	
PW-157	Well	35.340968	106.394618	373265	3911748	35.340929	106.394038	5935	**6023**	**6020**	x		
PW-158	Well	35.315868	106.430381	369974	3909011	35.315828	106.429801	5743.6	5809.8	5806.9	TD	n	

Appendix A. Placitas Data Inventory

Site ID	Site Type	Latitude (NAD83)	Longitude (NAD83)	UTM Easting (NAD83)	UTM Northing (NAD83)	Latitude (NAD27)	Longitude (NAD27)	ELEV (HAE)	Elevation* (NAVD88)	Elevation* (NGVD29)	RECORD	LEVEL	SAMPLE
PW-159	Well	35.315837	106.430339	369978	3909007	35.315797	106.429759	5744	5810	5807	x		
PW-160	Well	35.306798	106.437071	369352	3908014	35.306758	106.436491	5757	5823	5820	x	*	
PW-161	Well	35.321221	106.393886	373300	3909557	35.321181	106.393306	6077	**6161**	**6158**	x		x
PW-162	Well	35.304645	106.497117	363889	3907856	35.304605	106.496537	5451	**5508**	**5505**	x		x
PW-163	Well	35.339817	106.443282	368840	3911684	35.339778	106.442701	5613	5680	5677	x		x
PW-164	Well	35.292614	106.402678	372456	3906396	35.292573	106.402098	6171	6236	6233	TD		x
PW-165	Well	35.313944	106.484004	365096	3908869	35.313904	106.483424	5473	5540	5537	x		
PW-166	Well	35.319448	106.478163	365637	3909472	35.319408	106.477583	5501	**5528**	**5525**	x		x
PW-167	Well	35.326271	106.479803	365499	3910231	35.326232	106.479222	5477	**5523**	**5520**	x		xD
PW-168	Well	35.333591	106.493349	364280	3911061	35.333552	106.492768	5274	**5327**	**5324**	x	*	
PW-169	Well	35.334257	106.441745	368971	3911065	35.334218	106.441165	5653	**5695**	**5692**	x		x
PW-170	Well	35.314078	106.483823	365113	3908884	35.314038	106.483243	5470	5537	5534	x		
PW-171	Well	35.293752	106.451102	368055	3906585	35.293711	106.450522	6104.8	6171.0	6168.0	x	n	
PW-172	Well	35.302233	106.443456	368764	3907516	35.302193	106.442876	5855.6	5921.7	5918.8	x	n	
PW-173	Well	35.308141	106.512487	362497	3908265	35.308101	106.511906	5297	5365	5362	x		x
PW-174	Well	35.320461	106.435103	369553	3909527	35.320421	106.434523	5643	5709	5706	x		
PW-175	Well	35.336059	106.396885	373051	3911207	35.336020	106.396305	6020	**6060**	**6057**	x		
PW-176	Well	35.311325	106.517033	362089	3908624	35.311285	106.516452	5250	5318	5315	x		
PW-177	Well	35.309937	106.474402	365963	3908412	35.309897	106.473822	5524	5591	5588	x		
PW-178	Well	35.304010	106.483570	365119	3907767	35.303970	106.482990	5526	5593	5590	x		
PW-179	Well	35.304391	106.478078	365619	3907802	35.304351	106.477498	5655	5722	5719	x		x
PW-180	Well	35.304430	106.478255	365603	3907806	35.304390	106.477675	5666	**5707**	**5704**	x		
PW-181	Well	35.308934	106.443419	368778	3908259	35.308894	106.442839	5796	5862	5859	x		
PW-182	Well	35.309689	106.447311	368425	3908348	35.309649	106.446731	6024	6090	6087	x		
PW-183	Well	35.308536	106.442901	368824	3908214	35.308496	106.442321	5802	5869	5866	x		
PW-184	Well	35.318249	106.453200	367904	3909305	35.318209	106.452620	5790	5856	5853	x		x
PW-185	Well	35.340917	106.394780	373250	3911743	35.340878	106.394200	5935	**6023**	**6020**	x	*	
PW-186	Well	35.325740	106.428327	370177	3910103	35.325700	106.427747	5808	**5893**	**5890**	x		x
PW-187	Well	35.326752	106.428969	370120	3910216	35.326713	106.428389	5781	5847	5844	x		
PW-188	Well	35.327593	106.458119	367472	3910348	35.327554	106.457539	5617	5684	5681	x		
PW-189	Well	35.326584	106.455793	367682	3910233	35.326545	106.455213	5585	**5663**	**5660**	x		
PW-190	Well	35.329018	106.455201	367739	3910502	35.328979	106.454621	5502	5568	5566	x		
PW-191	Well	35.320965	106.473053	366104	3909633	35.320925	106.472473	5508	5575	5572	x	*	x
PW-192	Well	35.326065	106.476943	365758	3910204	35.326026	106.476362	5407	5474	5471	x		*
PW-193	Well	35.316689	106.477530	365689	3909165	35.316649	106.476950	5473	5540	5537	x		
PW-194	Well	35.319491	106.481751	365310	3909481	35.319451	106.481171	5434	5501	5498	x		
PW-195	Well	35.318414	106.477943	365655	3909357	35.318374	106.477363	5469	5536	5533	x		
PW-196	Well	35.336846	106.449915	368233	3911363	35.336807	106.449334	5597	**5655**	**5652**	x		
PW-197	Well	35.313726	106.502994	363370	3908871	35.313686	106.502413	5339	5406	5403	x		x
PW-198	Well	35.318686	106.519300	361896	3909444	35.318647	106.518719	5235	5303	5300	x	*	x
PW-199	Well	35.316756	106.490911	364473	3909191	35.316716	106.490331	5420	5487	5484	x		
PW-200	Well	35.306396	106.453351	367871	3907991	35.306356	106.452771	5815	5881	5878	x		
PW-201	Well	35.316649	106.515779	362212	3909213	35.316609	106.515198	5243	5311	5308	x		
PW-202	Well	35.331189	106.445962	368583	3910731	35.331150	106.445382	5526	5592	5589	x		x
PW-203	Well	35.339649	106.439643	369171	3911661	35.339610	106.439062	5598	5665	5662	TD		x
PW-204	Well	35.310670	106.515541	362224	3908549	35.310630	106.514960	5262	5330	5327	x		x
PW-205	Well	35.330553	106.505074	363209	3910740	35.330514	106.504493	5192	5259	5256	x		x
PW-206	Well	35.343326	106.397111	373042	3912013	35.343287	106.396531	5990	6056	6053	x		*
PW-207	Well	35.319283	106.406635	372139	3909359	35.319243	106.406055	5869	5935	5932	TD		
PW-208	Well	35.299356	106.418002	371074	3907163	35.299316	106.417422	6271.6	6337.4	6334.5	x	x	
PW-209	Well	35.299361	106.418101	371065	3907164	35.299321	106.417521	6269.6	6335.4	6332.5	x	x	

Appendix A. Placitas Data Inventory

Site ID	Site Type	Latitude (NAD83)	Longitude (NAD83)	UTM Easting (NAD83)	UTM Northing (NAD83)	Latitude (NAD27)	Longitude (NAD27)	ELEV (HAE)	Elevation* (NAVD88)	Elevation* (NGVD29)	REC ORD	LEV EL	SAM PLE
PW-210	Well	35.317524	106.529890	360931	3909330	35.317485	106.529309	5120	5188	5185		x	
PW-211	Well	35.317500	106.487778	364759	3909269	35.317461	106.487194		**5462**	**5459**			*
PW-212	Well	35.315904	106.427416	370244	3909011	35.315861	106.426833		**5840**	**5837**			*
PW-213	Well	35.362964	106.486732	364930	3914310	35.362925	106.486150		**5180**	**5177**			*
PW-214	Well	35.336428	106.445167	368663	3911311	35.336383	106.444583		**5670**	**5667**	x	*	
PW-215	Well	35.310278	106.514444	362323	3908504	35.310239	106.513861		**5340**	**5337**			*
PW-216	Well	35.333333	106.398056	372940	3910906	35.333294	106.397472		**6060**	**6057**			*
PW-217	Well	35.342419	106.441436	369012	3911970	35.342378	106.440861		**5640**	**5637**			*
PW-218	Well	35.363333	106.459167	367435	3914313	35.363306	106.491917		**5520**	**5517**			*
PW-219	Well	35.334222	106.446000	368584	3911066	35.334183	106.445417		**5632**	**5629**		*	
PW-301	Well	35.327261	106.530859	360859.5	3910411	35.327222	106.530278		*5097*	*5094*		*	
PW-302	Well	35.331428	106.531970	360765.7	3910874.8	35.331389	106.531389		*5074*	*5071*		*	
PW-303	Well	35.323650	106.532803	360676.6	3910013.3	35.323611	106.532222		*5090*	*5087*		*	
PW-304	Well	35.342539	106.522803	361617.8	3912094.3	35.342500	106.522222		*5085*	*5082*		*	
PW-305	Well	35.338928	106.524192	361485.4	3911695.8	35.338889	106.523611		*5090*	*5087*		*	
PW-306	Well	35.331983	106.530859	360867.6	3910934.8	35.331944	106.530278		*5091*	*5088*		*	
PW-307	Well	35.331428	106.525859	361321.1	3910866.2	35.331389	106.525278		*5110*	*5107*		*	
PW-308	Well	35.331706	106.525303	361372.1	3910896.3	35.331667	106.524722		*5110*	*5107*		*	
PW-309	Well	35.331983	106.525025	361397.9	3910926.6	35.331944	106.524444		*5110*	*5107*		*	
PW-310	Well	35.330039	106.530303	360914.8	3910718.4	35.330000	106.529722		*5094*	*5091*		*	
PW-311	Well	35.325872	106.515581	362245.9	3910235.6	35.325833	106.515000		*5210*	*5207*		*	
PW-312	Well	35.326149	106.515581	362246.4	3910266.4	35.326110	106.515000		*5211*	*5208*		*	
PW-313	Well	35.324761	106.532803	360678.5	3910136.5	35.324722	106.532222		*5300*	*5297*		*	
PW-314	Well	35.318096	106.518081	362005.4	3909376.6	35.318056	106.517500		*5310*	*5307*		*	
PW-315	Well	35.316429	106.511137	362633.9	3909182.1	35.316389	106.510556		*5350*	*5347*		*	
PW-316	Well	35.333928	106.394810	373236	3910968.2	35.333889	106.394226		*6100*	*6097*		*	
PW-317	Well	35.317818	106.407247	372080.6	3909197.1	35.317778	106.406667		*5941*	*5938*		*	

* Elevations indicated by standard type are obtained from GPS (accuracy +/- 0.1 ft); elevations in bold type are from a 10-m digit elevation model (accuracy +/- 10 ft); elevations in italics are from USGS GWSI Database (accuracy unknown).

"x" = data available for well record ("RECORD"), spring or stream discharge or water level ("LEVEL"), or water sample ("SAMPLI

"xD" = water sample duplicate taken

"TD" = total depth of well known; well record not available

"n" = well included in monitoring network; repeat water levels measured

"*" = water quality or water level data generated from source other than this study

"a" = artesian water level

APPENDIX B

Well and Spring Data

Appendix B. Placitas Well and Spring Data

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PS-01	12N.5E.4.1243	351805106250601	35.301330	106.418983	6188	na	na	na	na	na	D	325MDER Suela Flt	NMBMMR
PS-02	12N.5E.4.1221	351816106250801	35.304431	106.419429	6138	na	na	na	na	na	I	318ABO Suela Flt	NMBMMR
PS-03	13N.5E.33.3441	351823106250901	35.306419	106.419767	6088	na	na	na	na	na	I	318ABO Suela Flt	NMBMMR
PS-04	13N.5E.33.4324	351823106244901	35.306450	106.414314	6143	na	na	na	na	na	I	325MDER	NMBMMR
PS-05	12N.5E.5.3342	351728106262201	35.291129	106.439886	6376	na	na	na	na	na	I,D,R	325MDER Pomecerro Flt	NMBMMR
PS-06	12N.5E.4.1323	351759106252501	35.299876	106.424174	6113	na	na	na	na	na	U	231PFDF	NMBMMR
PS-07	13N.5E.27.4331	351912106235301	35.320182	106.398761	6028	na	na	na	na	na	I	318ABO Tecolote Flt	NMBMMR
PS-08	13N.5E.28.3211	351932106251401	35.325733	106.421061	5781	na	na	na	na	na	I,D	122SNTFP Las Huertas Crk	NMBMMR
PS-09	12N.5E.5.3323	351732106262401	35.292180	106.440568	6313	na	na	na	na	na	I,R	231PFDF Pomecerro Flt	NMBMMR
PS-10	13N.5E.15.2414	352128106233401	35.357750	106.393321	5788	na	na	na	na	na	D,I,S,C	122SNTFP	NMBMMR
PS-11	13N.5E.15.2424	352127106232701	35.357673	106.391506	5823	na	na	na	na	na	D,I	122SNTFP	NMBMMR
PS-12	13N.5E.15.2431	352126106233701	35.357377	106.394156	5746	na	na	na	na	na	I,S	122SNTFP	NMBMMR
PS-13	13N.5E.15.2430	352126106233601	35.357127	106.394046	5733	na	na	na	na	na	R	122SNTFP	NMBMMR
PS-14	13N.5E.15.2442	352125106232701	35.356890	106.391424	5800	na	na	na	na	na	R	122SNTFP	NMBMMR
PS-15	13N.5E.15.2440	352123106232701	35.356404	106.391300	5800	na	na	na	na	na	R	122SNTFP	NMBMMR
PS-16	13N.5E.14.3131	352112106232401	35.353364	106.390467	5812	na	na	na	na	na	R,C	325MDER SanFrancisco Flt	NMBMMR
PS-17	13N.5E.22.4212	352025106233301	35.340378	106.393140	6027	na	na	na	na	na	R	325MDER SanFrancisco Flt	NMBMMR
PS-18	13N.5E.14.3313	352102106232201	35.350515	106.390078	5808	na	na	na	na	na	R	325MDER SanFrancisco Flt	NMBMMR
PS-19	13N.5E.32.1231	351901106261901	35.316853	106.439171	5707	na	na	na	na	na	R	211MENF Caballo Flt	NMBMMR
PS-20	13N.5E.33.3423	351824106250701	35.306780	106.419158	6120	na	na	na	na	na	I	318ABO Suela Flt	NMBMMR
PS-21	13N.5E.22.2244	352041106232601	35.344770	106.391158	5948	na	na	na	na	na	I,C,R	325MDER SanFrancisco Flt	NMBMMR
PS-22	13N.5E.22.2223	352049106233101	35.347048	106.392410	5878	na	na	na	na	na	R	122SNTFP SanFrancisco Flt	NMBMMR
PS-23	13N.4E.36.3232	351835106281901	35.309674	106.472513	5623	na	na	na	na	na	U	122SNTFP Ranchos Flt	NMBMMR
PS-24	12N.5E.6.4344	351724106265401				na	na	na	na	na	I	310YESO	NMBMMR
PW-001	13N.5E.32.3220	351839106260601	35.310792	106.435524	5774	125	125	103	5649	5671	D,I	210MNCSL	RG-51025
PW-002	13N.5E.33.3344	351817106251901	35.304636	106.422538	6028	125	125	105	5903	5923	D	211DKOT	Owner
PW-003	12N.5E.3.1114	351810106242401	35.302821	106.407262	6161	100	90 30	80 20	6071 6131	6081 6141	D	318ABO	RG37179
PW-004	12N.5E.4.1221	351815106250901	35.304070	106.419653	6142	65	65	55	6077	6087	D	318ABO	Owner
PW-005	12N.5E.5.1433	351750106261801	35.297145	106.439016	5985	322	317	302	5668	5683	D	231AGZC	RG23679X3
PW-006	12N.5E.5.1424	351757106260501	35.299100	106.435177	5998	162	162	157	5836	5841	I,S	231PFDFL	RG23679X2
PW-007	12N.5E.5.2311	351802106260201	35.300559	106.434337	5817	115	115	95	5702	5722	A	231PFDFM	RG23679X
PW-008	12N.4E.1.2223	351811106274201	35.303033	106.462360	5695	92	92	69	5603	5626	D	210MCDK	RG9375
PW-009	13N.4E.34.4324	351823106300101	35.306425	106.500202	5492	594	591 551	571 521	4901 4941	4921 4971	P	112SNTFP	RG11802S
PW-010	12N.5E.6.2431	351753106264501	35.298238	106.446427	6008.3	475	475	425	5533	5583	D	231PFDFU	RG44507

Appendix B. Placitas Well and Spring Data

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PW-011	12N.5E.6.2431	351755106264701	35.298651	106.447055	6023	165	165	145	5858	5878	D	231PFDFU	RG49454
PW-012	13N.5E.33.3142	351835106251901	35.309647	106.422468	5941.7	60	60	50	5882	5892	D	210MNCSL	RG63893
PW-013	13N.5E.32.2114	351904106255801	35.317800	106.433321	5755.5	200	200	160	5556	5596	D	210MNCSU	RG55395X
PW-014	13N.5E.31.3444	351818106270401	35.304904	106.451773	5915	425	425	385	5490	5530	I,S	210MNCSU	RG26878
PW-015	13N.5E.31.4333	351818106270201	35.304941	106.451003	5919	220	220	200	5699	5719	Y,A	211MENFL	RG26878
PW-016	13N.5E.33.1433	351842106251601	35.311752	106.421714	5971	360	360	320	5611	5651	D	210MNCSL	RG67118
PW-017	13N.5E.32.3411	351827106261901	35.307511	106.439279	5824.4	90	90	80	5734	5744	U	220ENRD Pomecerro Flt	Owner
PW-018	13N.5E.32.3414	351823106261401	35.306371	106.437817	5834.3	90	90	80	5744	5754	U	220ENRD	Owner
PW-019	13N.5E.31.3441	351823106270801	35.306295	106.452930	5889	205	205	195	5684	5694	Y	211MENFL	RG25304
PW-020	13N.5E.31.3440	351820106270801	35.305714	106.452672	5904	460	460	360	5444	5544	Y,A	211PNLK	Driller
PW-021	13N.5E.31.3442	351822106270601	35.306049	106.452208	5867.6	190	190	160	5678	5708	D	211MENFL	RG25304
PW-022	13N.5E.29.1134	351949106262901	35.330244	106.441929	5640	430	430	410	5210	5230	A	112SNTFP	Driller
							230	220	5410	5420			
PW-023	13N.5E.29.1434	351936106261601	35.326598	106.438250	5645.3	525	525	505	5120	5140	D	211MENFU Lomos Flt	RG43080
PW-024	13N.5E.29.1243	351948106260801	35.329954	106.436253	5702.3	295	295	275	5407	5427	D	112SNTFP	RG49263
PW-025	13N.5E.32.1221	351907106261001	35.318543	106.436771	5741.5	430	412	397	5329	5344	D	210HOSTD	RG64481
PW-026	13N.5E.32.1221	351907106260901	35.318797	106.436389	5735.1	140	140	130	5595	5605	D	210MNCSU	Driller
PW-027	13N.5E.32.2113	351903106260101	35.317693	106.434150	5745.5	420	420	400	5326	5346	D	210HOSTD	RG62652
PW-028	13N.5E.32.3341	351819106262701	35.305491	106.441325	5859.2	100	100	80	5759	5779	D	231PFDFU	Owner
PW-029	13N.5E.29.1434	351940106261801	35.327970	106.438960	5667.3	345	345	300	5322	5367	D	112SNTFP Caballo Flt	RG38654
PW-030	12N.5E.6.4213	351744106264401	35.295537	106.446102	6098.5	390	390	370	5709	5729	D	231PFDFM	RG59293
PW-031	12N.5E.6.1234	351806106271201	35.301624	106.453967	5966.4	315	305	295	5661	5671	D	210MNCSL	RG43244
PW-032	13N.5E.29.4132	351927106255801	35.324125	106.433338	5719	400	400	360	5319	5359	D	211MENFU	RG41477
PW-033	13N.5E.29.4112	351933106260001	35.325954	106.433790	5711.2	580	560	545	5151	5166	U	211MENFU Lomos Flt	RG56368
PW-034	13N.5E.29.4114	351931106255901	35.325317	106.433523	5732	320	320	300	5412	5432	D	211MENFU Lomos Flt	Driller
PW-035	13N.5E.33.4114	351836106245401	35.310077	106.415587	6064	170	170	160	5894	5904	U	318ABO	Owner
PW-036	13N.5E.33.4114	351838106245401	35.310419	106.415643	6047	320	320	310	5727	5737	D	318ABO	RG65069X
PW-037	12N.5E.4.2211	351815106244101	35.304177	106.412057	6188.2	100	100	90	6088	6098	U	325MDER Flt	Owner
PW-038	13N.5E.33.3410	351825106251301	35.307040	106.420832	6034	420	420	380	5614	5654	I	211DKOT	RG64598
PW-039	13N.5E.33.3430	351819106251301	35.305263	106.420803	6068	490	490	450	5578	5618	D	318ABO/325MDER Suela Flt	RG65764
PW-040	12N.5E.5.1123	351810106262301	35.302962	106.440406	5915.9	220	220	200	5696	5716	U	231PFDFU	RG65805
PW-041	12N.5E.6.1141	351800106272001	35.300120	106.455988	5988	330	320	300	5668	5688	D	221MRSN[JCKP]	RG55409
PW-042	12N.5E.6.1321	351801106272701	35.300194	106.458032	5993	420	420	360	5573	5633	D	221MRSN[WWCN]	RG64614
PW-043	12N.5E.6.1112	351813106273101	35.303780	106.459204	5911	535	535	515	5376	5396	D	210MNCSL	RG52896
PW-044	12N.5E.5.1123	351811106262501	35.303182	106.441103	5915.3	120	120	100	5795	5815	D	231PFDFU	Driller
PW-045	12N.5E.5.1141	351809106262601	35.302576	106.441059	5950	350	349	342	5601	5608	D	231PFDFM	RG30634

Appendix B. Placitas Well and Spring Data

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PW-046	12N.5E.5.1121	351815106262601	35.304165	106.441070	5904	90	90	70	5814	5834	D	231PFDFU	RG64527
PW-047	13N.5E.33.3233	351830106251601	35.308262	106.421581	5982	165	165	155	5817	5827	I	210MNCSL	RG58960
PW-048	13N.5E.33.3233	351830106251501	35.308350	106.421532	5982	185	180	40	5802	5942	I	210MNCSL	RG58960
PW-049	12N.5E.3.1112	351814106242501	35.303923	106.407486	6157	100	100	80	6057	6077	D	318ABO	RG36163
PW-050	12N.5E.3.1213	351811106241201	35.303147	106.403893	6120.7	200	200	180	5921	5941	U	318ABO	RG36218
PW-051	12N.5E.3.3133	351739106242701	35.294189	106.407989	6260	95	95	85	6165	6175	D	318ABO	Owner
PW-052	12N.5E.3.3122	351747106241701	35.296547	106.404843	6192	140	140	120	6052	6072	D	318ABO	RG43979
PW-053	12N.4E.1.2424	351758106273901	35.299513	106.461275	5889	100	100	80	5789	5809	D	221MRSN[RCAP]	RG1916
PW-054	12N.4E.1.2423	351800106274101	35.299933	106.462036	5866	-	-	-	-	-	U	221MRSN	-
PW-055	12N.4E.1.2244	351806106273701	35.301657	106.460877	5845.7	95	95	85	5751	5761	U	221MRSN	Owner
PW-056	13N.4E.36.4434	351817106274301	35.304611	106.462589	5776.2	70	70	58	5706	5718	D	210MNCSL	RG19481X
PW-057	12N.5E.6.1232	351808106271301	35.302334	106.454148	5958	300	300	280	5658	5678	Y,A	210MNCSL	RG60175
PW-058	12N.5E.6.1232	351808106271301	35.302292	106.454168	5968	410	410	370	5558	5598	D	210MNCSL	RG60175
PW-059	13N.5E.29.1444	351936106260701	35.326615	106.435761	5725	505	505	480	5220	5245	D	211MENFU	RG41562
							260	240	5465	5485			
PW-060	13N.5E.32.3413	351825106261901	35.306885	106.439193	5829	80	80	70	5749	5759	D	220ENRD Pomecerro Flt	Owner
PW-061	12N.5E.4.1212	351813106250901	35.303779	106.419797	6130	95	95	55	6035	6075	D	318ABO	RG65295
PW-062	13N.5E.34.3114	351839106242301	35.310777	106.407094	6032	31	31	-	6001	-	U	318ABO	NMBMMR
PW-063	13N.5E.31.3321	351829106272401	35.308100	106.457331	5833	220	220	200	5613	5633	D	211PNLK	RG55346
PW-064	12N.5E.3.3323	351731106242201	35.292078	106.406685	6262	140	140	80	6122	6182	D	318ABO	RG41013
PW-065	13N.5E.22.3420	352010106240101	35.336273	106.400723	6029	285	285	275	5744	5754	D	122SNTFP	RG57957
PW-066	12N.5E.4.2322	351800106244701	35.300111	106.413579	6281.6	230	222	202	6060	6080	D	325MDERL	RG51716
PW-067	13N.5E.33.4433	351818106244401	35.305051	106.412774	6198	85	85	75	6113	6123	D	318ABO Flt	RG61239X
PW-068	12N.5E.9.2241	351717106243601	35.288060	106.410878	6378	340	340	330	6038	6048	D	325MDER	RG51620
PW-069	12N.5E.9.2442	351703106243201	35.284216	106.409376	6365	320	280	240	6085	6125	D	325MDER	RG65441
PW-070	12N.5E.9.2442	351703106243201	35.284236	106.409455	6348.3	300	300	280	6048	6068	U	325MDER	Owner
PW-071	13N.5E.23.1314	352035106232101	35.343024	106.389747	5974.9	240	240	220	5735	5755	D	325MDERU	RG64808
PW-072	13N.5E.29.1441	351941106260901	35.328051	106.436409	5685	375	365	355	5320	5330	D	112 SNTFP	RG44418
PW-073	12N.5E.6.4133	351737106270201	35.293659	106.451089	6212	295	295	275	5917	5937	P	231PFDFM	RG18058
PW-074	12N.5E.6.2321	351801106265401	35.300344	106.448945	6017	176	174	154	5843	5863	P	210MNCSL Caballo Flt	RG18058S
PW-075	12N.5E.6.2144	351803106265101	35.300948	106.448112	5968.6	165	165	155	5804	5814	U	210MNCSL Caballo Flt	RG28291
PW-076	13N.5E.34.1210	351906106241001	35.318407	106.403316	5995.7	105	105	95	5891	5901	D	SanFrancisco Flt	RG50261
PW-077	13N.5E.15.2231	352138106233801	35.360496	106.394346	5742	100	100	80	5642	5662	D	122SNTFP	Owner
PW-078	13N.5E.29.4114	351930106255601	35.325123	106.432765	5727	320	320	300	5407	5427	D	211MENF	Owner
PW-079	12N.5E.6.1132	351808106273201	35.302285	106.458833	5945	600	580	560	5365	5385	D	221MRSN[JCKP]	RG33613
PW-080	13N.5E.29.4114	351930106255701	35.325122	106.432953	5705.3	300	300	280	5405	5425	U	211MENF	Owner

Appendix B. Placitas Well and Spring Data

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PW-081	13N.5E.22.3423	352008106240501	35.335682	106.401868	6115	272	272	250	5843	5865	D	122SNTFP	RG19358
PW-082	13N.5E.22.2414	352036106233501	35.343266	106.393606	5937	125	125	85	5812	5852	D	122SNTFP SanFrancisco Flt	RG35856
PW-083	12N.5E.9.2214	351719106243901	35.288681	106.411347	6401.6	420	420	330	5982	6072	D	325MDERL	RG52874
PW-084	13N.5E.27.1212	351959106240801	35.333196	106.402838	6163	440	440	400	5723	5763	D	122SNTFP	RG39416
PW-085	12N.4E.1.2233	351803106274901	35.300983	106.464299	5983.3	320	320	280	5663	5703	U	221MRSN[RCAP]	RG60465
PW-086	12N.4E.1.2243	351804106274201	35.301301	106.462320	5839.2	100	88	76	5751	5763	U	221MRSN[BBSN]	RG24443
PW-087	13N.5E.22.2222	352051106232601	35.347627	106.391036	5875	365	361	325	5514	5550	D	325MDERU SanFrancisco Flt	RG24059
PW-088	13N.5E.27.3331	351912106242701	35.320123	106.408168	5901.1	100	100	40	5801	5861	U	210CRCS SanFrancisco Flt	RG56378X
PW-089	13N.5E.22.4413	352010106234001	35.336181	106.394902	6023.7	200	200	180	5824	5844	D	325MDERU SanFrancisco Flt	RG64529
PW-090	13N.5E.22.2313	352034106235301	35.342890	106.398542	6027.0	300	300	280	5727	5747	D	122SNTFP	RG66261
PW-091	13N.5E.14.3311	352104106232201	35.351223	106.390000	5845.6	106	105	95	5741	5751	U	325MDERU	Owner
PW-092	13N.5E.27.3334	351909106242401	35.319225	106.407204	5915.5	120	120	100	5795	5815	D	210CRCS SanFrancisco Flt	RG63974
PW-093	13N.5E.34.1323	351852106242001	35.314435	106.406012	5971.7	210	210	190	5762	5782	U	230TRSC	Owner
PW-094	13N.5E.34.1323	351852106242001	35.314392	106.405998	5991	220	220	200	5771	5791	D	230TRSC	Owner
PW-095	13N.5E.23.1124	352050106231001	35.347296	106.386768	5849.6	114	110	55	5740	5795	U	318ABO	RG60484
PW-096	13N.5E.23.3342	352007106231201	35.335338	106.387205	5993.8	380	380	320	5614	5674	U	325MDERU	RG60484
PW-097	13N.5E.28.3211	351922106243801	35.322925	106.411004	5881	120	112	105	5769	5776	D	122SNTFP	RG56378
PW-098	13N.5E.23.1333	352028106232201	35.341084	106.389962	6041	300	300	280	5741	5761	D	325MDERU	RG67542
PW-099	12N.4E.1.2240	351806106274301	35.301775	106.462414	5840	250	250	-	5590	-	D	221MRSN	Owner
PW-100	12N.5E.9.2440	351701106243301	35.283646	106.409784	6353.0	100	100	-	6253	-	U	325MDER West Las Huertas Fl	Owner
PW-101	12N.5E.9.2443	351701106243401	35.283522	106.410061	6374	200	190	170	6184	6204	D	325MDER West Las Huertas Fl	RG61116
PW-102	13N.5E.23.1131	352046106232201	35.346074	106.390073	5910	150	150	120	5760	5790	D	325MDERU	RG60857
PW-103	13N.5E.29.4324	351915106255201	35.320968	106.431665	5744	380	380	340	5364	5404	D	211MENFU	RG59143
PW-104	13N.5E.30.2421	351946106263801	35.329379	106.444521	5633	360	360	320	5273	5313	D	112SNTFP	RG62363
PW-105	13N.5E.29.3211	351933106261901	35.325892	106.439184	5639	390	390	360	5249	5279	A	112SNTFP Caballo Flt	Driller
PW-106	13N.5E.29.3211	351932106262001	35.325618	106.439344	5660	365	365	335	5295	5325	D	112SNTFP Caballo Flt	RG63161
PW-107	12N.5E.5.1112	351814106262901	35.304045	106.442084	5905	120	120	110	5785	5795	D	231PFDFU	RG52784
PW-108	13N.5E.29.2314	261941106255801	35.328064	106.433344	5730	360	360	340	5370	5390	D	112SNTFP	Owner
PW-109	13N.5E.32.3141	351835106262701	35.309793	106.441385	5812	180	180	160	5632	5652	D	221MRSN[JCKP] Caballo Flt	RG58618
PW-110	13N.5E.22.3224	352021106235901	35.339238	106.400330	5972	177	177	137	5795	5835	D	122SNTFP	RG27740
PW-111	13N.5E.22.2242	352045106232501	35.345956	106.390801	5900	180	180	140	5720	5760	D	325MDERU SanFrancisco Flt	RG48625
PW-112	12N.5E.5.2420	351759106253601	35.299823	106.427137	6043.2	425	425	415	5618	5628	U	231PFDFM	RG65067
PW-113	12N.5E.5.2240	351806106253801	35.301616	106.427759	5965.1	400	400	360	5565	5605	U	231PFDFU	Owner
PW-114	13N.5E.23.1134	352043106232001	35.345432	106.389536	5941	300	300	280	5641	5661	D	325MDERU	Owner
PW-115	13N.5E.22.2224	352049106232701	35.346905	106.391432	5899	180	180	173	5719	5726	D	325MDER/318ABO	RG57913
							163	143	5736	5756		@ SanFrancisco Flt	

Appendix B. Placitas Well and Spring Data

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PW-116	13N.5E.14.3333	352054106232301	35.348349	106.390314	5865	105	105	65	5760	5800	D	325MDERU SanFrancisco Flt	RG32494
PW-117	12N.5E.6.2242	351808106263401	35.302226	106.443427	5928	200	200	160	5728	5768	D	221MRSN[BBSN]	RG32612
PW-118	13N.5E.35.1434	351848106230401	35.313417	106.384939	6264.5	660	660	620	5605	5645	U	318ABO	RG60485
PW-119	13N.5E.35.2144	351857106224001	35.315998	106.378383	6224	500	496	436	5728	5788	U	318ABOU	RG60066
PW-120	13N.5E.35.2122	351908106223801	35.318966	106.377683	6183	420	420	360	5763	5823	U	318ABOU	RG60067
PW-121	12N.5E.6.2434	351753106264101	35.298168	106.445287	6035	221	218	207	5817	5828	D	231PFDFU	RG30686
PW-122	12N.5E.5.1130	351807106262601	35.302050	106.441251	5956	140	140	120	5816	5836	D	231PFDFM	RG67522
PW-123	12N.5E.6.2122	351814106265001	35.304049	106.447730	5933	265	265	220	5668	5713	D	211MENFL	RG58788
							200	180	5733	5753			
PW-124	12N.5E.6.2242	351810106263301	35.302689	106.443032	5918.1	236	234	184	5684	5734	U	221MRSN[BBSN]	RG24952
PW-125	12N.5E.6.2242	351810106263501	35.302794	106.443566	5927	200	200	140	5727	5787	D	221MRSN[JCKP]	RG24952
PW-126	12N.5E.6.2413	351804106265501	35.301159	106.449311	5976	155	155	120	5821	5856	D	210MNCSL	RG43384
PW-127	12N.5E.6.2112	351813106265901	35.303697	106.450268	5938	100	90	70	5848	5868	D	211PNLK	RB30170
PW-128	12N.5E.6.1413	351757106271901	35.299238	106.455754	6017	250	250	210	5767	5807	D	221MRSN[BBSN]	RG26806
PW-129	12N.5E.6.1412	351801106271201	35.300191	106.453434	6002.4	198	198	158	5804	5844	U	211DKOT	RG29295
PW-130	13N.5E.30.1232	351955106271701	35.331910	106.455283	5526	400	400	320	5126	5206	D	112SNTFP	RG62833
PW-131	13N.5E.29.1344	351935106262301	35.326500	106.440199	5621	200	200	180	5421	5441	D	112SNTFP	RG64459
							120	100	5501	5521			
PW-132	13N.4E.35.1342	351848106293001	35.313302	106.492184	5484	620	620	580	4864	4904	D	112SNTFT	RG62805
PW-133	12N.5E.5.1232	351809106261201	35.302587	106.437198	5940	<100	-	-	-	-	D	231PFDFM	Owner
PW-134	13N.5E.29.4323	351915106255301	35.320969	106.432068	5744	500	500	-	5244	-	U	211MENFU	Owner
PW-135	13N.4E.35.4131	351835106291001	35.309622	106.486634	5548	650	650	610	4898	4938	D	112SNTFP	RG63457
PW-136	13N.4E.35.3421	351829106291801	35.307987	106.488828	5537	660	660	640	4877	4897	D	112SNTFP	RG58639
PW-137	13N.4E.35.2323	351851106290201	35.314284	106.484379	5543	560	560	540	4983	5003	D	112SNTFP ValleyView Flt	RG64580
PW-138	13N.4E.26.2111	351959106290801	35.333073	106.486103	5404	590	590	550	4814	4854	D,I	112SNTFA	RG63688
PW-139	13N.5E.22.2423	352036106232901	35.343302	106.391952	5957	220	220	190	5737	5767	D	325MDERU SanFrancisco Flt	RG61394
PW-140	12N.5E.5.1411	351801106261801	35.300195	106.438970	6026	190	190	180	5836	5846	D	231PFDFL	Owner
PW-141	12N.5E.5.1411	351800106261501	35.300147	106.438030	6041.7	100	100	90	5942	5952	U	231PFDFL	Owner
PW-142	13N.5E.16.3320	352104106252201	35.351195	106.423397	5691	520	520	500	5171	5191	D	112SNTFP Escala Flt	Owner
PW-143	13N.5E.21.1313	352036106253001	35.343391	106.425079	5884	725	685	645	5199	5239	D	122SNTFP Escala Flt	RG63468
PW-144	12N.5E.6.1412	351801106271501	35.300340	106.454824	6007	150	150	110	5857	5897	D	210MNCSL	RG28943
PW-145	12N.5E.6.2420	351758106263601	35.299537	106.443465	6095	180	180	130	5915	5965	D	221MRSN	RG36306
PW-146	13N.5E.21.1331	352032106252901	35.342122	106.425276	5860	-	-	-	-	-	P	122SNTFP Escala Flt	
PW-147	13N.5E.32.1231	351859106262101	35.316490	106.439171	5721	32	none	none	5689		U	211MENF Caballo Flt	RG28790
PW-148	12N.5E.6.1412	351801106271201	35.300171	106.453450	6011	340	340	320	5671	5691	D	221MRSN[JCKP]	RG29295
PW-149	13N.4E.36.4114	351839106280201	35.310772	106.467243	5672	440	420	400	5252	5272	D	211MENFU	RG59899

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PW-150	13N.5E.16.3120	352117106252101	35.354764	106.422575	5667	370	370	340	5297	5327	D	122SNTFP Escala Flt	Owner
PW-151	13N.5E.16.3330	352057106252601	35.349214	106.423912	5695.4	515	515	495	5180	5200	U	112SNTFP Escala Flt	RG9986
PW-152	13N.5E.20.3432	352005106261501	35.334718	106.437410	5703	340	340	300	5363	5403	D	112SNTFP	RG59532
PW-153	13N.5E.29.3243	351923106261101	35.323093	106.436850	5683	880	880	-	4803	-	S	211MENFL	Owner
PW-154	12N.5E.3.1343	351751106242001	35.297574	106.405634	6188	-	-	-	-	-	D	318ABO	
PW-155	12N.5E.3.1431	351754106241401	35.298482	106.404395	6150.6	-	-	-	-	-	U	318ABO	
PW-156	12N.5E.3.1431	351754106241601	35.298399	106.404404	6151.3	-	-	-	-	-	U	318ABO	
PW-157	13N.5E.22.4211	352028106234101	35.340968	106.394618	6023	560	320	80	5703	5943	U	122SNTFP SanFrancisco Flt	RG64551EX2
PW-158	13N.5E.32.2233	351857106254701	35.315868	106.430381	5809.8	115	115	105	5695	5705	U	210MNCSU	Owner
PW-159	13N.5E.32.2233	351857106254701	35.315837	106.430339	5810	210	205	185	5605	5625	D	210HOSTD	RG56015
PW-160	13N.5E.32.3423	351824106261301	35.306798	106.437071	5823	175	175	155	5648	5668	D	221TDLT	RG65605
PW-161	13N.5E.27.4414	351916106233801	35.321221	106.393886	6161	370	370	350	5791	5811	N	318ABO	RG57098
PW-162	13N.4E.34.4443	351817106295001	35.304645	106.497117	5508	603	603	555	4905	4953	D	112SNTFP	RG44347
PW-163	13N.5E.20.3113	352023106263401	35.339817	106.443282	5680	280	270	230	5410	5450	D	112SNTFP	RG49597
PW-164	12N.5E.3.3412	351733106241001	35.292614	106.402678	6236	80	80	-	6156	-	D	318ABO/325MDER Flt	Owner
PW-165	13N.4E.35.2323	351850106290201	35.313944	106.484004	5540	590	570	565	4970	4975	U	112SNTFP ValleyView Flt	RG50111
PW-166	13N.4E.26.4444	351910106284101	35.319448	106.478163	5528	690	690	380	4838	5148	P	112SNTFT	RG49802
PW-167	13N.4E.26.2443	351935106284701	35.326271	106.479803	5523	720	708	386	4815	5137	P	112SNTFT	RG49802S
PW-168	13N.4E.23.3343	352001106293601	35.333591	106.493349	5327	700	520	500	4807	4827	P	112SNTFA	RG49802S2
PW-169	13N.5E.20.3334	352003106262801	35.334257	106.441745	5695	320	320	300	5375	5395	D	112SNTFP	RG58873
PW-170	13N.4E.35.2323	351851106290201	35.314078	106.483823	5537	595	595	575	4942	4962	D	112SNTFP ValleyView Flt	RG65361
PW-171	12N.5E.6.4133	351738106270401	35.293752	106.451102	6171.0	225	215	205	5956	5966	U	231PFDFU	RG19204
							165	155	6006	6016			
							130	120	6041	6051			
PW-172	12N.5E.6.2242	351808106263401	35.302233	106.443456	5921.7	50	50	30	5872	5892	U	110AVMB/210MNCSL	RG32612
PW-173	13N.4E.34.3133	351829106304501	35.308141	106.512487	5365	396	396	-	4969	-	D	112SNTFT	RG29164
PW-174	13N.5E.29.3442	351914106260601	35.320461	106.435103	5709	220	210	200	5499	5509	D	211MENFL	RG56782
PW-175	13N.5E.22.4323	352010106234701	35.336059	106.396885	6060	350	350	320	5710	5740	D	122SNTFP	RG68220
							300	280	5760	5780			
PW-176	13N.4E.33.4211	351841106310101	35.311325	106.517033	5318	420	420	400	4898	4918	D	112SNTFT	RG61931
PW-177	13N.4E.36.3142	351836106282601	35.309937	106.474402	5591	370	370	290	5221	5301	D	112SNTFP	RG67635
PW-178	12N.4E.2.2210	351814106290101	35.304010	106.483570	5593	684	674	664	4919	4929	Y,A	112SNTFP	RG54556
							505	500	5088	5093			
PW-179	12N.4E.1.1110	351816106283901	35.304391	106.478078	5722	830	820	800	4902	4922	P	112SNTFP	RG54556X
PW-180	12N.4E.1.1110	351816106284001	35.304430	106.478255	5707	800	798	758	4909	4949	P	112SNTFP	RG54556S2
PW-181	13N.5E.32.3133	351832106263601	35.308934	106.443419	5862	103	103	73	5759	5789	P	211MENFU	RG49957

Appendix B. Placitas Well and Spring Data

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PW-182	13N.5E.31.4231	351835106265001	35.309689	106.447311	6090	700	none	none	5390	5324	Y,A	211MENF[HARN]	RG49940
PW-183	13N.5E.32.3133	351831106263401	35.308536	106.442901	5869	196	196	186	5673	5683	U	221MRSN[WWCN]	RG49957X2
PW-184	13N.5E.31.1221	351906106271201	35.318249	106.453200	5856	500	500	440	5356	5416	P	122SNTFP	RG52013
PW-185	13N.5E.22.4211	352027106234101	35.340917	106.394780	6023	230	230	200	5793	5823	U	122SNTFP SanFrancisco Flt	RG64551EX
PW-186	13N.5E.29.4221	351933106254201	35.325740	106.428327	5893	500	500	460	5393	5433	P	122SNTFP	RG61622
PW-187	13N.5E.29.2434	351936106254401	35.326752	106.428969	5847	530	530	470	5317	5377	P	122SNTFP	RG61624
PW-188	13N.5E.30.1341	351939106272701	35.327593	106.458119	5684	620	623	580	5061	5104	P	112SNTFP	RG62867
PW-189	13N.5E.30.1433	351936106271901	35.326584	106.455793	5663	540	540	500	5123	5163	P	112SNTFP	RG62868
PW-190	13N.5E.30.1414	351944106271701	35.329018	106.455201	5568	420	420	380	5148	5188	P	112SNTFP	RG62869
PW-191	13N.4E.25.3413	351915106282101	35.320965	106.473053	5575	490	472	272	5103	5303	P	112SNTFP	RG18159
PW-192	13N.4E.25.3112	351934106283501	35.326065	106.476943	5474	560	520	500	4954	4974	P	112SNTFT ValleyView Flt	RG12871CDS
							340	320	5134	5154			
							280	260	5194	5214			
PW-193	13N.4E.36.1131	351900106283701	35.316689	106.477530	5540	501	500	350	5040	5190	P	112SNTFP	RG10032
PW-194	13N.4E.26.4433	351910106285401	35.319491	106.481751	5501	670	665	420	4836	5081	P	112SNTFT ValleyView Flt	RG10032S
PW-195	13N.4E.36.1111	351906106283901	35.318414	106.477943	5536	596	596	586	4940	4950	D	112SNTFP	RG59333
							466	416	5070	5120			
PW-196	13N.5E.19.4321	352013106265801	35.336846	106.449915	5655	340	340	320	5315	5335	P	112SNTFP	RG68743
PW-197	13N.4E.34.2314	351849106301101	35.313726	106.502994	5406	612	612	-	4794	-	P	112SNTFT	RG42562
PW-198	13N.4E.33.2121	351907106310901	35.318686	106.519300	5303	580	575	545	4728	4758	P	112SNTFOB	RG42562S2
PW-199	13N.4E.35.1231	351900106292701	35.316756	106.490911	5487	660	655	635	4832	4852	P	112SNTFT	RG53424
PW-200	13N.5E.31.3441	351823106271201	35.306396	106.453351	5881	345	345	245	5536	5636	P	211PNLK	RG52191S
PW-201	13N.4E.33.2232	351900106305701	35.316649	106.515779	5311	475	470	460	4841	4851	D	112SNTFA	RG58464
PW-202	13N.5E.30.2232	351952106264301	35.331189	106.445962	5592	446	446	436	5146	5156	P	112SNTFP	RG48788
PW-203	13N.5E.20.3124	352023106262301	35.339649	106.439643	5665	405	405	385	5260	5280	D	112SNTFP	Owner
PW-204	13N.4E.33.4200	351838106305601	35.310670	106.515541	5330	440	440	420	4890	4910	P	112SNTFT	RG59519
PW-205	13N.4E.27.1244	351950106301801	35.330553	106.505074	5259	521	420	280	4839	4979	N	112SNTFA	RG49516
PW-206	13N.5E.22.2323	352036106235001	35.343326	106.397111	6056	195	195	155	5861	5901	D	122SNTFP	RG40708
PW-207	13N.5E.27.3334	351909106242401	35.319283	106.406635	5935	300	300	280	5635	5655	Y,A	210CRCS SanFrancisco Flt	Owner
PW-208	12N.5E.4.1424	351758106250501	35.299356	106.418002	6337.4	270	270	250	6067	6087	U	325MDERL	RG66702EX1
PW-209	12N.5E.4.1424	351758106250501	35.299361	106.418101	6335.4	273	270	240	6065	6095	U	325MDERL	RG66702EX1
PW-210	13N.4E.33.1114	351903106314801	35.317524	106.529890	5188	-	-	-	-	-	U	112SNTFOB	
PW-211	13N.4E.35.1224	351903106291601	35.317500	106.487778	5462	-	-	-	-	-	D	112SNTFT	
PW-212	13N.5E.32.2244	351857106253901	35.315904	106.427416	5840	310	310	270	5530	5570	P	211MENF/HARN	RG57988
PW-213	13N.4E.11.4333	352147106291201	35.362964	106.486732	5180	-	-	-	-	-	N	112SNTFA	
PW-214	13N.5E.19.442	352011106264301	35.336428	106.445167	5670	610	600	540	5070	5130	P	112SNTFP	RG65081

Appendix B. Placitas Well and Spring Data

Point ID	Local Identifier	Site ID	Latitude NAD83	Longitude NAD83	Elev NAVD 88	Well Depth	Bottom Screen	Top Screen	Bottom Screen Elev	Top Screen Elev	Water Use *	Aquifer Code **	NMOSE Well File or Data Source
PW-215	13N.4E.33.4223	351837106305201	35.310278	106.514444	5340	-	-	-	-	-	D	112SNTFA	
PW-216	13N.5E.27.2112	352000106235301	35.333333	106.398056	6060	-	-	-	-	-	D	122SNTFP	
PW-217	13N.5E.20.1332	352033106262901	35.342419	106.441436	5640	310	310	260	5330	5380	P	112SNTFP	RG31586
PW-218	13N.5E.18.1111	352148106293301	35.363333	106.459167	5520	-	-	-	-	-	S	112SNTFA	
PW-219	13N.5E.19.4444	352003106264601	35.334222	106.446000	5632	460	455	415	5177	5217	D	112SNTFP	RG64470
PW-301	13N.4E.28.133	351938106314901	35.327261	106.530859	5097	80	-	-	-	-	-	110PTOD	USGS
PW-302	13N.4E.29.222	351953106315301	35.331428	106.531970	5074	55	-	-	-	-	-	110PTOD	USGS
PW-303	13N.4E.29.424	351925106315601	35.323650	106.532803	5090	40	-	-	-	-	-	110PTOD	USGS
PW-304	13N.4E.21.142	352033106312001	35.342539	106.522803	5085	212	-	-	-	-	-	112SNTFOB	USGS
PW-305	13N.4E.21.324	352020106312501	35.338928	106.524192	5090	450	-	-	-	-	-	112SNTFOB	USGS
PW-306	13N.4E.28.111	351955106314901	35.331983	106.530859	5091	86	-	-	-	-	-	110PTOD	USGS
PW-307	13N.4E.28.123	351953106313101	35.331428	106.525859	5110	490	-	-	-	-	-	112SNTFOB	USGS
PW-308	13N.4E.28.123	351954106312901	35.331706	106.525303	5110	91	-	-	-	-	-	110PTOD	USGS
PW-309	13N.4E.28.123	351955106312801	35.331983	106.525025	5110	65	-	-	-	-	-	110PTOD	USGS
PW-310	13N.4E.28.131	351948106314701	35.330039	106.530303	5094	80	75	65	5019	5029	-	110PTOD/112SNTFOB	USGS
PW-311	13N.4E.28.421	351933106305401	35.325872	106.515581	5210	150	-	-	-	-	-	112SNTFOB	USGS
PW-312	13N.4E.28.421	351934106305401	35.326149	106.515581	5211	160	-	-	-	-	-	112SNTFOB	USGS
PW-313	13N.4E.33.212	351908106310801	35.324761	106.532803	5300	451	-	-	-	-	-	112SNTFOB	USGS
PW-314	13N.4E.33.214	351905106310301	35.318096	106.518081	5310	464	-	-	-	-	-	112SNTFA	USGS
PW-315	13N.4E.34.113	351859106303801	35.316429	106.511137	5350	480	-	-	-	-	-	112SNTFA	USGS
PW-316	13N.5E.27.2212	352002106234001	35.333928	106.395024	6100	220	220	215	5880	5885	D	325MDER	USGS
PW-317	13N.5E.34.1114	351904106242401	35.317818	106.407247	5941	56	56	26	5885	5915	-	110PTOD	USGS

* Water Use Codes: D=domestic; I=irrigation; P=public; C=recreation; R=riparian; S=stock; N=industrial; U=unused; Y=dry; A=abandoned.

** Aquifer Codes: see attached.

AQUIFER CODES:

110AVMB	Quaternary fill
112SNTFOB	Upper Santa Fe Group, Loma Barbon member of Arroyo Ojito Formation
112SNTFA	Upper Santa Fe Group, axial facies
112SNTFT	Upper Santa Fe Group, transitional axial/piedmont facies
112SNTFP	Upper Santa Fe Group, piedmont facies
122SNTFP	Lower Santa Fe Group, piedmont facies
210CRCS	Cretaceous undivided
211MENF	K Menefee
211MENFU	K Upper Menefee (above Harmon Sandstone)
/HARN	Harmon Sandstone Member of Menefee
211PNLK	K Point Lookout
210MNCS	K Mancos undivided
210MNCSU	K Upper Mancos
210HOSTD	K Hosta Dalton
210MNCSL	K Lower Mancos
210MCDK	K Mancos/Dakota undivided
211DKOT	K Dakota
221MRSN	J Morrison
/JCKP	Jackpile Sandstone Member of Morrison
/WWCN	Westwater Canyon Member of Morrison
/BBSN	Brushy Basin Member of Morrison
/RCAP	Recapture Shale Member of Morrison
221TDLT	J Todilto
220ENRD	J Entrada
231PFDF	Tr Petrified Forest
231PFDFU	Tr Upper Petrified Forest (above middle sandstone)
231PFDFM	Tr Middle Petrified Forest sandstone
231PFDFL	Tr Lower Petrified Forest (below middle sandstone)
231AGZC	Tr Agua Zarca
231AGZCU	Tr Upper Agua Zarca
310YESO	P Yeso
318ABO	P Abo
325MDER	Penn Madera undivided
325MDERU	Penn Upper Madera
325MDERL	Penn Lower Madera

APPENDIX C

Precipitation Data

Appendix C. Monthly precipitation data.

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bernalillo*	1890	0.13	2.54	3.30	2.54	---	---	2.79	3.05	3.81	1.27	1.52	5.08	---
Bernalillo*	1891	2.54	1.78	4.06	0.00	5.08	0.00	0.05	0.25	7.11	0.00	0.00	1.27	22.61
Bernalillo*	1892	2.54	---	---	---	---	---	---	---	---	---	---	---	---
Bernalillo*	1895	---	---	---	---	---	0.56	6.48	3.91	0.05	2.67	3.05	0.53	---
Bernalillo*	1896	0.03	0.00	0.00	0.00	0.00	1.57	2.03	2.97	3.48	9.42	0.00	0.53	20.04
Bernalillo*	1897	0.71	0.00	1.73	1.40	5.66	1.60	1.75	1.19	10.21	4.50	0.25	0.18	29.18
Bernalillo*	1898	1.32	1.22	0.94	1.45	0.05	1.04	2.29	3.51	0.00	0.30	0.76	1.91	14.78
Bernalillo*	1899	0.38	0.00	0.51	0.25	0.00	1.07	8.15	1.63	4.32	0.00	1.14	0.05	17.50
Bernalillo*	1900	1.40	0.38	0.41	1.14	0.94	0.36	0.00	0.86	4.27	1.47	0.99	0.18	---
Bernalillo*	1901	2.36	0.91	1.02	0.43	1.68	---	---	---	---	---	---	---	---
Bernalillo*	1923	---	---	---	---	1.32	0.05	2.31	5.26	0.91	2.67	3.20	1.04	---
Bernalillo*	1924	0.00	0.56	1.07	3.58	0.33	---	---	---	---	---	---	---	
Bernalillo*	1938	0.38	3.78	0.84	---	---	---	---	---	7.26	2.41	0.00	0.66	---
Bernalillo*	1939	2.77	0.56	3.10	0.69	0.81	0.00	2.11	2.21	3.56	2.03	2.72	0.91	21.46
Bernalillo*	1940	0.64	3.35	1.57	0.41	3.35	2.59	4.80	5.56	3.76	0.74	4.39	4.29	35.46
Bernalillo*	1941	3.51	0.81	3.63	2.90	8.66	0.61	1.88	4.75	7.24	6.83	0.48	1.17	42.47
Bernalillo*	1942	0.08	0.66	0.05	8.03	0.00	0.41	2.79	2.36	4.55	3.28	0.00	2.92	25.12
Bernalillo*	1943	1.17	0.56	0.56	0.00	2.69	1.19	1.42	0.54	1.73	1.04	1.27	2.41	21.59
Bernalillo*	1944	1.47	0.61	2.13	2.64	0.81	0.69	4.37	4.62	5.56	1.91	1.83	1.47	28.12
Bernalillo*	1945	1.37	0.43	1.17	2.79	0.00	0.00	3.12	1.09	1.37	0.76	0.00	0.56	12.67
Bernalillo 3SW	1946	0.66	0.84	0.66	0.64	0.71	0.00	3.89	1.75	0.91	2.13	2.95	0.30	15.44
Bernalillo 3SW	1947	0.38	0.64	0.64	0.00	1.19	0.41	0.25	6.45	1.12	1.14	1.32	4.04	17.58
Bernalillo 3SW	1948	0.69	4.37	0.66	0.81	1.27	---	---	---	---	---	---	---	---
Bernalillo 3SW	1948	---	---	---	---	---	1.45	0.58	1.32	1.52	1.45	0.64	0.36	---
Bernalillo 3SW	1949	1.96	1.30	1.52	3.02	2.72	1.07	4.06	0.53	5.23	0.13	0.00	0.28	21.82
Bernalillo 3SW	1950	0.00	0.64	0.13	0.86	0.00	1.68	7.70	0.94	3.40	0.13	0.00	0.00	15.49
Bernalillo 3SW	1951	1.32	0.66	0.38	0.71	0.51	0.13	1.83	9.73	0.00	0.94	0.25	0.53	16.99
Bernalillo 3SW	1952	0.64	0.18	1.55	2.54	1.27	4.55	3.48	3.58	0.81	0.00	1.52	1.96	22.07
Bernalillo 3SW	1953	0.00	1.32	2.13	0.46	---	3.68	3.63	1.12	0.10	---	---	---	---
Median		0.70	0.66	1.02	0.84	0.94	0.69	2.55	2.67	3.48	1.36	0.88	0.79	21.53
		1.09	1.12	1.35	1.55	1.70	1.07	2.99	2.88	3.29	1.97	1.18	1.36	22.24
		0.05	0.05	0.06	0.07	0.08	0.05	0.13	0.13	0.15	0.09	0.05	0.06	0.31

Locations in Table 1 and Fig. 10. Precipitation depths in centimeters. "---" indicates one or more days per month of missing data. Data for Bernalillo between January 1, 1890 and July 1, 1946 has been attributed to Bernalillo 3SW. Data for Bernalillo, Bernalillo 3SW, Bernalillo 1NNE, Hagan, Sandia Crest, Sandia Park, Placitas 4W, Placitas nr., and Van Huss Ranch sites from National Climatic Data Center (NCDC) at http://www.ncdc.noaa.gov/ol/climate/online/coop-precip/new-mexico.html. Data for PPT-8 from J. Fish (personal commun. 1999).

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bernalillo 1NNE	1953	---	---	---	---	---	---	---	---	---	---	---	0.76	---
Bernalillo 1NNE	1954	1.60	0.15	1.42	0.03	2.74	1.75	5.18	1.22	1.45	1.02	0.30	0.81	17.70
Bernalillo 1NNE	1955	0.84	0.53	0.00	0.36	1.98	0.61	5.03	4.67	0.51	0.03	0.18	0.64	15.37
Bernalillo 1NNE	1956	1.50	1.02	0.00	0.00	0.23	0.25	3.10	3.91	0.00	1.14	0.00	0.00	11.15
Bernalillo 1NNE	1957	1.47	1.75	1.75	1.37	1.37	0.41	3.18	7.52	0.18	6.53	2.79	0.64	28.96
Bernalillo 1NNE	1958	1.07	0.43	4.39	1.42	1.57	0.84	0.33	1.60	3.07	2.62	1.22	2.69	21.26
Bernalillo 1NNE	1959	0.03	0.03	1.85	2.39	0.76	1.65	0.89	8.84	0.10	5.23	0.08	3.86	25.70
Bernalillo 1NNE	1960	1.17	1.12	1.57	0.03	1.70	2.59	3.48	2.29	1.55	8.13	0.43	1.65	25.70
Bernalillo 1NNE	1961	1.40	0.36	1.47	1.55	0.13	0.30	1.73	4.75	0.64	1.75	1.37	2.11	17.55
Bernalillo 1NNE	1962	1.42	0.33	0.23	0.25	0.13	0.71	4.17	0.76	2.46	2.29	3.02	0.94	16.71
Bernalillo 1NNE	1963	0.61	2.57	1.17	0.51	0.13	1.04	2.24	9.27	1.24	1.68	0.81	0.03	21.29

Appendix C. Monthly precipitation data.

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bernalillo 1NNE	1964	0.05	3.10	0.33	0.76	1.55	0.08	7.21	1.60	0.04	0.20	0.51	1.45	20.57
Bernalillo 1NNE	1965	1.35	2.36	1.85	1.50	1.12	---	---	---	---	---	---	---	---
Median		1.26	0.77	1.45	0.64	1.24	0.71	3.18	3.91	1.24	1.75	0.51	0.88	20.57
		1.04	1.15	1.34	0.85	1.12	0.93	3.32	4.22	1.02	2.78	0.97	1.30	20.18
		0.05	0.06	0.07	0.04	0.06	0.05	0.16	0.21	0.05	0.14	0.05	0.06	0.42
Bernalillo	1965	---	---	---	---	---	---	---	2.92	3.07	2.95	1.07	---	---
Bernalillo	1966	---	0.71	0.00	0.00	0.66	5.11	1.57	3.02	1.52	0.00	0.05	0.76	---
Bernalillo	1967	0.15	0.69	0.56	0.00	0.05	3.25	4.83	8.46	2.69	0.36	1.19	1.22	23.44
Bernalillo	1968	0.00	2.87	3.68	1.88	2.72	0.18	4.75	5.03	0.15	1.14	1.63	1.52	25.55
Bernalillo	1969	0.13	0.51	1.63	3.00	5.56	0.89	2.36	3.53	3.10	6.96	0.64	1.68	29.97
Bernalillo	1970	0.03	0.71	1.88	0.20	1.63	2.64	8.36	4.47	1.78	1.35	1.24	0.00	24.28
Bernalillo	1971	1.30	1.09	0.28	3.15	1.12	0.13	8.08	3.48	2.77	5.69	1.32	3.28	31.67
Bernalillo	1972	0.86	0.18	0.23	0.00	---	2.51	1.40	5.26	5.16	11.63	2.29	1.88	---
Bernalillo	1973	1.98	1.91	5.84	---	1.73	0.84	5.66	3.76	4.50	0.66	0.25	0.00	---
Bernalillo	1974	3.05	1.22	1.96	0.10	0.99	0.33	6.40	3.28	2.79	7.70	1.04	1.04	29.90
Bernalillo	1975	---	---	3.07	0.48	0.13	0.28	7.67	3.30	6.93	0.00	---	-0.66	---
Bernalillo	1976	0.00	0.56	0.25	2.64	1.70	0.61	4.24	3.68	1.24	0.15	1.27	0.03	16.38
Bernalillo	1977	1.55	0.18	0.89	2.82	0.53	0.46	2.06	5.94	1.85	0.00	2.11	0.46	18.85
Bernalillo	1978	---	---	2.67	0.74	3.15	2.11	2.03	3.05	1.47	3.28	---	2.90	---
Bernalillo	1979	---	1.63	0.91	0.99	6.68	4.47	3.99	6.05	1.32	1.17	3.48	1.75	---
Bernalillo	1980	3.84	2.26	0.84	0.00	1.80	0.00	2.11	0.38	6.17	0.00	0.74	0.94	19.08
Bernalillo	1981	0.15	0.94	1.75	1.14	2.31	1.40	2.24	3.15	1.17	4.65	---	0.03	---
Bernalillo	1982	0.48	---	---	0.00	---	0.00	2.26	3.05	---	---	---	---	---
Median		0.48	0.83	1.27	0.61	1.70	0.84	3.99	3.51	2.69	1.17	1.22	0.99	24.28
		1.04	1.10	1.65	1.07	2.05	1.48	4.12	3.99	2.80	2.81	1.31	1.05	24.35
		0.04	0.05	0.07	0.04	0.08	0.06	0.17	0.16	0.12	0.12	0.05	0.04	0.39
TOTALS		1.07	1.12	1.44	1.24	1.66	1.18	3.43	3.54	2.66	2.41	1.17	1.25	22.14
Hagan	1953	---	---	---	0.76	1.78	1.80	4.90	1.47	0.15	1.57	1.98	1.78	---
Hagan	1954	1.07	0.00	2.39	0.00	3.05	1.88	8.56	4.85	2.79	1.50	0.38	0.33	26.80
Hagan	1955	0.64	0.53	0.00	0.64	1.75	0.41	12.75	7.90	0.71	---	---	---	---
Median		0.85	0.27	1.19	0.64	1.78	1.80	8.56	4.85	0.71	1.54	1.18	1.05	26.80
		0.86	0.27	1.20	0.47	2.19	1.36	8.74	4.74	1.22	1.54	1.18	1.06	26.80
		0.03	0.01	0.04	0.02	0.08	0.05	0.33	0.18	0.05	0.06	0.04	0.04	0.55
Sandia Crest	1953	---	---	---	---	---	---	---	---	---	---	---	7.04	---
Sandia Crest	1954	5.08	0.91	6.02	0.13	5.56	3.68	7.75	3.76	3.48	2.64	1.45	2.16	42.62
Sandia Crest	1955	4.01	4.09	1.09	0.69	3.35	1.14	15.82	10.74	2.67	0.38	0.30	6.65	50.98
Sandia Crest	1956	6.07	4.57	0.00	0.89	0.46	1.19	11.35	4.98	0.18	3.56	0.33	1.19	34.77
Sandia Crest	1957	5.49	5.79	9.55	7.11	6.38	0.81	7.85	8.89	1.14	11.86	9.25	2.54	76.66
Sandia Crest	1958	5.41	3.00	16.64	8.15	0.97	0.05	1.24	6.78	11.58	7.70	6.81	6.68	75.01
Sandia Crest	1959	2.11	0.76	6.17	5.49	2.03	2.34	4.70	15.70	0.25	7.29	0.64	13.67	61.14
Sandia Crest	1960	8.00	6.17	5.54	1.27	3.10	4.06	2.69	3.71	2.39	12.17	0.89	4.65	54.64
Sandia Crest	1961	5.44	3.71	7.72	3.63	0.99	0.41	5.33	8.71	2.69	1.65	3.51	6.10	49.89
Sandia Crest	1962	4.04	4.78	4.04	0.76	0.13	0.86	9.78	3.61	6.60	3.58	4.83	4.37	47.37
Sandia Crest	1963	3.25	7.26	4.27	1.98	0.30	0.99	3.05	19.41	3.78	2.79	4.01	0.89	51.99
Sandia Crest	1964	1.57	6.71	2.90	3.25	6.40	0.00	13.64	5.46	4.83	0.84	3.81	4.95	54.36
Sandia Crest	1965	2.92	---	6.65	2.67	0.46	8.36	3.73	5.38	9.55	4.62	2.26	13.28	---

Appendix C. Monthly precipitation data.

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Sandia Crest	1966	2.24	3.53	0.64	---	---	9.86	8.56	6.73	3.00	0.13	1.40	1.96	---
Sandia Crest	1967	0.71	4.32	1.40	0.89	0.13	5.13	12.17	16.79	5.64	0.76	3.07	4.85	55.85
Sandia Crest	1968	1.65	7.19	10.77	6.93	3.18	0.61	11.94	14.48	1.80	0.58	6.38	9.25	74.75
Sandia Crest	1969	6.25	6.22	4.17	2.92	5.89	3.15	7.62	---	3.61	10.80	1.91	---	---
Sandia Crest	1970	0.43	3.02	8.81	3.51	0.61	2.79	9.96	9.47	4.80	2.90	1.75	2.95	51.00
Sandia Crest	1971	4.62	3.68	2.24	7.14	0.15	0.00	10.24	8.74	2.84	6.02	7.62	9.17	62.46
Sandia Crest	1972	---	1.02	1.42	0.15	3.02	2.77	4.85	8.53	7.92	14.71	---	6.63	---
Sandia Crest	1973	9.45	4.98	16.18	7.52	3.51	2.84	9.93	4.29	7.06	1.91	6.20	1.73	75.59
Sandia Crest	1974	10.41	3.86	4.09	0.43	0.84	0.15	7.95	9.40	6.48	12.93	1.93	4.52	62.99
Sandia Crest	1975	6.40	12.52	8.43	2.29	1.07	0.00	13.89	4.70	11.73	0.00	5.05	2.13	68.22
Sandia Crest	1976	0.94	3.78	5.82	3.15	---	1.55	8.59	9.35	2.31	---	1.17	0.86	---
Sandia Crest	1977	9.40	4.55	1.96	8.10	0.33	2.18	5.72	11.81	3.91	1.45	3.53	1.93	54.86
Sandia Crest	1978	---	9.98	12.17	1.96	4.88	5.08	4.39	8.97	5.26	---	6.60	5.49	---
Sandia Crest	1979	---	6.22	5.99	3.99	---	---	---	---	---	---	---	---	---
Median		4.62	4.55	5.68	2.92	1.07	1.55	7.95	8.72	3.78	2.90	4.65	4.59	54.86
		4.60	4.90	5.95	3.40	2.34	2.40	8.11	8.77	4.62	4.84	3.53	5.03	58.17
		0.08	0.08	0.10	0.06	0.04	0.04	0.14	0.15	0.08	0.08	0.06	0.09	0.33
Sandia Park	1939	6.60	2.01	5.87	3.23	0.25	0.61	7.65	7.75	6.25	4.29	3.73	1.24	49.48
Sandia Park	1940	3.28	6.60	5.23	1.85	4.29	1.45	1.22	6.91	4.22	1.83	7.77	6.50	51.16
Sandia Park	1941	6.38	2.72	---	6.35	10.06	2.36	---	3.84	8.36	---	5.54	3.38	83.21
Sandia Park	1942	0.89	---	---	---	0.64	1.37	0.66	---	5.82	7.21	0.00	---	---
Sandia Park	1943	2.06	---	---	---	---	---	---	9.80	1.09	---	---	---	---
Sandia Park	1944	---	---	4.37	3.23	0.76	1.09	8.99	7.80	3.63	3.00	4.11	5.03	---
Sandia Park	1945	4.24	---	---	4.88	0.00	0.76	6.45	8.23	2.67	3.23	0.00	5.61	---
Sandia Park	1946	3.10	0.25	2.08	2.26	1.60	0.84	6.99	---	1.83	6.40	8.56	2.31	52.78
Sandia Park	1947	1.04	0.99	0.94	1.07	2.64	1.14	3.30	9.88	1.52	1.78	3.86	3.78	31.95
Sandia Park	1948	---	---	---	---	---	3.18	3.23	---	---	---	2.79	1.88	---
Sandia Park	1948	2.95	6.81	5.08	1.88	2.08	---	---	---	---	---	---	---	---
Sandia Park	1949	5.33	0.00	4.72	4.62	5.44	2.34	7.77	---	---	0.91	0.38	2.41	---
Sandia Park	1950	4.22	2.46	0.61	0.61	0.46	1.02	---	2.95	7.32	0.10	0.00	0.05	36.12
Sandia Park	1951	3.96	1.12	2.44	1.12	1.22	0.08	7.87	9.32	0.13	1.85	2.01	4.55	35.66
Sandia Park	1952	2.51	2.21	4.14	2.54	4.98	3.35	4.32	---	3.99	0.00	4.98	2.18	46.36
Sandia Park	1953	1.07	2.87	4.32	3.38	2.21	7.72	3.63	4.60	0.00	---	5.44	2.11	---
Sandia Park	1954	3.00	0.18	4.34	0.05	2.59	2.67	---	6.86	3.25	1.78	0.69	1.57	38.35
Sandia Park	1955	1.73	2.59	0.18	0.94	2.95	1.17	9.60	---	6.02	0.36	0.61	4.70	42.16
Sandia Park	1956	2.62	2.29	0.00	0.43	0.99	1.40	7.37	4.62	0.00	4.29	0.69	0.61	25.30
Sandia Park	1957	3.68	4.34	5.64	2.41	4.09	0.28	---	---	0.43	7.14	8.46	0.64	59.41
Sandia Park	1958	2.44	2.82	8.74	7.67	---	0.61	0.51	7.87	---	5.18	4.62	3.51	---
Sandia Park	1959	0.89	---	---	4.17	---	---	5.38	---	---	---	---	---	---
Sandia Park	1960	---	---	---	---	2.92	---	3.20	5.59	1.02	---	1.14	---	---
Sandia Park	1961	---	---	---	---	1.30	1.45	6.40	9.04	3.20	1.02	3.73	3.48	---
Sandia Park	1962	1.98	3.66	1.93	0.28	0.61	2.46	---	2.41	4.83	2.82	4.78	2.90	44.35
Sandia Park	1963	1.60	6.17	5.26	1.40	0.66	2.01	2.67	---	2.87	3.28	1.83	0.76	41.78
Sandia Park	1964	1.75	6.65	1.17	4.09	5.77	0.00	9.25	5.99	4.24	0.79	2.49	3.12	45.31
Sandia Park	1965	3.51	4.37	4.27	2.67	2.06	6.83	9.45	8.08	7.59	3.78	5.44	---	---
Sandia Park	1966	---	0.91	0.13	0.28	2.01	4.72	---	4.47	2.95	1.07	0.53	3.38	---
Sandia Park	1967	---	3.23	2.84	0.86	0.71	5.26	6.68	---	3.76	1.12	1.75	---	---
Sandia Park	1968	0.20	6.10	---	3.53	2.64	0.28	8.64	---	0.33	0.99	---	3.89	---

Appendix C. Monthly precipitation data.

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Sandia Park	1969	3.02	---	3.28	4.85	8.81	2.54	2.92	9.78	8.69	---	---	5.69	---
Sandia Park	1970	---	0.99	---	---	0.13	2.16	9.98	6.02	3.40	5.26	1.57	---	---
Sandia Park	1971	3.84	---	3.05	2.59	0.15	0.41	---	2.54	4.85	5.49	3.78	7.92	---
Sandia Park	1972	0.81	1.04	0.13	0.00	7.21	1.47	3.73	---	7.19	---	4.34	5.28	56.21
Sandia Park	1973	---	4.57	6.83	3.58	5.36	1.80	9.75	5.21	4.57	1.12	2.44	0.13	---
Sandia Park	1974	6.99	---	2.95	0.76	0.30	0.10	8.08	7.85	4.39	---	2.03	3.48	---
Sandia Park	1975	3.45	5.64	5.13	2.59	2.95	0.00	7.09	6.22	9.73	0.00	---	1.27	---
Sandia Park	1976	0.05	1.78	1.63	0.89	2.29	2.13	8.10	5.11	3.02	0.91	---	0.53	---
Sandia Park	1977	---	1.93	1.27	2.39	1.42	1.09	8.89	8.28	3.68	0.71	3.25	0.41	---
Sandia Park	1978	5.44	4.06	7.14	0.53	7.57	3.84	3.63	6.60	4.47	3.56	---	4.06	---
Sandia Park	1979	5.84	2.90	1.32	---	4.04	4.45	6.25	7.52	1.96	2.21	0.61	2.90	---
Sandia Park	1980	5.54	4.88	---	1.50	1.78	0.28	1.37	3.94	8.28	3.51	2.77	---	---
Sandia Park	1981	---	0.79	---	2.34	4.37	3.48	5.28	---	2.16	3.05	1.63	0.00	---
Sandia Park	1982	---	---	5.49	---	2.49	0.66	4.19	9.47	---	4.17	2.51	3.86	---
Sandia Park	1983	2.74	4.24	---	3.45	0.43	4.88	6.68	5.87	---	---	---	1.09	---
Sandia Park	1984	1.27	0.00	2.62	---	0.00	2.79	0.48	8.81	5.72	---	---	---	---
Sandia Park	1985	---	---	9.17	7.44	4.06	2.39	5.44	3.40	7.70	7.47	2.03	1.60	---
Sandia Park	1986	0.46	---	2.82	3.28	5.72	8.15	---	4.06	6.71	7.42	---	4.90	---
Sandia Park	1987	---	---	1.57	3.91	5.49	4.62	4.17	6.83	0.97	2.13	4.83	6.99	---
Sandia Park	1988	3.58	0.99	2.87	8.26	4.34	6.60	7.21	9.14	9.27	1.63	3.78	2.21	59.89
Sandia Park	1989	4.06	---	3.53	0.30	0.25	0.33	---	3.84	2.54	3.66	0.03	1.70	---
Sandia Park	1990	4.75	6.27	3.66	4.01	1.80	1.35	---	8.86	8.05	1.37	5.61	7.39	65.30
Sandia Park	1991	2.97	3.30	4.37	0.00	3.81	4.72	---	---	6.73	2.18	---	7.21	---
Sandia Park	1992	3.07	2.24	---	0.18	7.44	2.49	8.74	7.04	4.04	4.14	4.52	---	---
Sandia Park	1993	---	---	3.48	0.15	3.10	0.66	7.95	8.69	1.50	5.56	6.17	---	---
Sandia Park	1994	---	---	9.55	3.23	8.00	3.18	7.82	---	3.45	7.62	6.71	2.97	---
Sandia Park	1995	---	2.82	---	3.40	2.18	2.34	4.27	9.30	3.45	0.00	1.37	1.45	---
Sandia Park	1996	---	2.51	1.35	0.00	0.13	---	9.14	8.94	6.78	---	4.83	0.00	---
Sandia Park	1997	---	---	---	---	---	---	---	---	---	---	4.88	7.09	---
Median		3.07	2.98	3.58	2.51	2.94	2.32	5.92	6.73	4.24	2.99	3.24	3.12	48.04
Placitas 4W	1992	1.73	1.65	2.59	0.64	5.36	1.12	1.75	5.74	2.97	1.40	4.19	---	27.41
Placitas 4W	1993	3.71	2.97	1.85	0.00	0.61	0.66	4.32	7.80	1.27	1.32	2.39	0.00	26.90
Placitas 4W	1994	---	0.25	2.87	---	---	3.25	2.29	4.93	3.45	4.47	5.89	2.49	29.89
Placitas 4W	1995	---	1.96	1.80	1.98	1.91	0.00	1.73	3.40	4.95	0.00	0.00	0.20	17.93
Placitas 4W	1996	0.08	0.61	0.00	0.00	0.00	5.26	4.14	9.04	4.52	3.61	2.08	0.00	29.34
Placitas 4W	1997	4.24	0.53	0.10	5.44	2.57	2.59	6.07	7.16	3.28	0.99	5.05	2.87	40.89
Median		2.72	1.13	1.83	0.64	1.91	1.85	3.21	6.45	3.37	1.36	3.29	0.20	29.34
		2.44	1.33	1.54	1.61	2.09	2.15	3.38	6.35	3.41	1.97	3.27	1.11	28.73
		0.08	0.05	0.05	0.06	0.07	0.07	0.12	0.22	0.12	0.07	0.11	0.04	0.41
Placitas nr.	1910	---	---	---	---	---	---	---	---	---	5.44	2.29	1.73	---
Placitas nr.	1911	3.63	10.95	2.57	5.38	2.31	3.68	16.10	2.95	5.54	9.27	1.91	3.84	68.12
Placitas nr.	1912	0.23	4.80	5.44	2.21	1.91	8.08	12.78	11.66	0.30	2.97	0.20	2.36	52.93
Placitas nr.	1913	7.24	5.59	2.39	---	---	---	---	---	---	---	---	---	---
Median		3.63	5.59	2.57	3.80	2.11	5.88	14.44	7.30	2.92	5.44	1.91	2.36	60.53
		3.70	7.11	3.47	3.80	2.11	5.88	14.44	7.31	2.92	5.89	1.47	2.64	60.53
		0.06	0.12	0.06	0.06	0.03	0.10	0.24	0.12	0.05	0.10	0.02	0.04	0.46

Appendix C. Monthly precipitation data.

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Van Huss Ranch	1944	---	---	---	---	---	---	8.56	7.42	2.74	5.03	1.65	4.42	---
Van Huss Ranch	1945	1.98	0.51	5.51	2.13	0.00	0.18	2.34	8.97	1.30	2.34	0.00	1.85	27.10
Van Huss Ranch	1946	0.00	0.51	1.14	2.18	0.97	0.00	2.18	5.08	1.73	1.91	6.22	0.41	22.33
Van Huss Ranch	1947	0.00	0.89	0.51	0.00	2.79	0.28	1.17	5.26	3.58	0.81	2.24	2.54	20.07
Van Huss Ranch	1948	1.02	---	---	---	---	---	---	---	---	---	---	---	---
Van Huss Ranch	1950	---	---	---	---	0.00	3.18	8.20	3.61	4.09	0.48	0.00	0.00	---
Van Huss Ranch	1951	0.81	1.02	0.58	---	---	---	---	---	---	---	---	---	---
Median		0.81	0.70	0.86	2.13	0.48	0.23	2.34	5.26	2.74	1.91	1.65	1.85	24.71
		0.76	0.73	1.94	1.44	0.94	0.91	4.49	6.07	2.69	2.11	2.02	1.84	23.17
		0.03	0.03	0.08	0.06	0.04	0.04	0.19	0.26	0.12	0.09	0.09	0.08	0.49
PPT-8	1991					1.65	1.46	3.50	1.67	2.70	0.00	2.16	1.63	14.77
PPT-8	1992	0.00	0.00	0.31	0.00	2.74	0.33	1.48	2.25	1.50	0.51	1.56	1.21	11.89
PPT-8	1993	1.72	2.37	1.02	0.00	0.27	0.48	2.16	3.92	0.55	0.49	1.14	0.60	14.72
PPT-8	1994	0.30	0.34	1.73	0.34	2.74	0.37	0.92	2.92	2.08	3.17	2.28	0.86	18.05
PPT-8	1995	0.98	1.51	0.71	1.20	0.82	0.20	0.77	0.80	1.90	0.00	0.30	0.30	9.49
PPT-8	1996	0.30	0.40	0.17	0.00	0.00	3.22	2.10	2.37	2.75	2.90	0.95	0.00	15.16
PPT-8	1997	1.30	0.90	0.15	3.34	0.97	1.30	2.57	1.20	1.55	0.80	2.15	1.42	17.65
PPT-8	1998	0.25	0.65	5.10	1.30	0.00	0.30	2.65	0.97	0.52	1.95	1.45	0.25	15.39
PPT-8	1999	0.30	0.20	2.20	3.15	0.87	1.17	1.70	4.28					13.87
Median		0.64	0.80	1.42	1.17	1.12	0.98	1.98	2.26	1.69	1.23	1.50	0.78	14.55

APPENDIX D

Spring and Stream Discharge Data

Appendix D. Spring and Stream Discharge Data

Stream Gage ID	Discharge Date	Discharge (cfs)	Discharge (gpm)
WW-1*	9/26/95	0.8	359
	10/27/95	0.6	269
	11/10/95	1	449
	12/14/95	0.5	224
	1/12/96	1.1	494
	2/9/96	0.5	224
	3/8/96	0.3	135
	4/5/96	0.2	90
	5/3/96	0.2	90
	6/9/96	0.1	45
	7/15/96	0.6	269
	8/16/96	0.2	90
	9/16/96	1.3	583
	10/9/96	0.7	314
	11/6/96	1	449
	12/3/96	2.1	943
	1/22/97	0.7	314
	2/11/97	1.9	853
	3/3/97	0.9	404
	4/2/97	1.5	673
	5/7/97	19.8	8887
	6/16/97	12.1	5431
	7/10/97	4.6	2065
	8/19/97	2.6	1167
	9/17/97	0.9	404
	10/15/97	0.6	269
	11/10/97	3.5	1571
	12/15/97	3.2	1436
	1/12/98	nd	nd
	2/11/98	1	449
	3/2/98	4.3	1930
	4/8/98	1.9	853
	5/6/98	30.1	13510
	6/9/98	9.8	4399
	7/20/98	2.8	1257
	8/13/98	2.5	1122
	9/14/98	1.4	628
	10/14/98	1	449
	11/12/98	0.8	359
	12/4/98	1	449
	1/1/99	0.7	314
	2/10/99	0.4	180
	3/4/99	0.9	404
	4/9/99	1.9	853

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-01	4/10/97	107.9
	5/5/97	122.6
	6/30/97	155.6
	7/22/97	146.9
	8/2/97	142.7
	9/4/97	138.5
	10/9/97	107.9
	1/11/98	81.7
	1/26/98	81.7
	02/24/98	81.7
	03/12/98	81.7
	03/25/98	81.7
	04/16/98	115.1
	04/29/98	138.5
	05/14/98	180
	05/19/98	200
	5/23/98	203.6
	5/24/98	203.2
	5/25/98	202.5
	5/26/98	203.6
	5/27/98	201.4
	5/28/98	201.8
	5/29/98	203.8
	5/30/98	203.5
	5/31/98	203.4
	6/1/98	203.4
	6/2/98	204.8
	6/3/98	202.4
	6/4/98	203.7
	6/5/98	204.9
	6/6/98	204.8
	6/7/98	206.2
	6/8/98	204.1
	6/9/98	202.1
	6/10/98	204.4
	6/11/98	205.8
	6/12/98	207.9
	6/13/98	208.7
	6/14/98	206.9
	6/15/98	204.7
	6/16/98	204.0
	6/17/98	205.9
	6/18/98	206.0
	6/19/98	209.4
	6/20/98	208.1
	6/21/98	206.5
	6/22/98	203.7
	6/23/98	203.9
	6/24/98	203.5
	6/25/98	200.9

Spring ID	Discharge Date	Discharge (gpm)
PS-01	6/26/98	200.2
	6/27/98	201.7
	6/28/98	199.6
	6/29/98	201.0
	6/30/98	196.8
	7/1/98	198.4
	7/2/98	199.7
	7/3/98	199.0
	7/4/98	198.9
	7/5/98	196.9
	7/6/98	196.9
	7/7/98	197.0
	7/8/98	198.3
	7/10/98	194.1
	7/12/98	195.3
	7/14/98	193.5
	7/16/98	190.5
	7/18/98	191.0
	7/20/98	187.5
	7/22/98	181.2
	7/24/98	181.9
	7/26/98	176.9
	7/28/98	176.4
	7/30/98	176.5
	8/1/98	173.5
	8/3/98	171.6
	8/5/98	167.9
	8/7/98	167.7
	8/9/98	165.3
	8/11/98	161.7
	8/13/98	150.3
	8/15/98	152.2
	8/17/98	158.4
	8/19/98	157.3
	8/21/98	147.9
	8/23/98	157.6
	8/25/98	158.2
	8/27/98	154.3
	8/29/98	150.0
	8/31/98	147.2
	9/2/98	145.7
	9/4/98	145.0
	9/6/98	143.8
	9/8/98	141.7
	9/10/98	139.5
	9/18/98	120.5
	9/20/98	124.4
	9/22/98	122.9
	9/24/98	122.2
	9/26/98	121.1

Spring ID	Discharge Date	Discharge (gpm)
PS-01	9/28/98	119.1
	9/29/98	102.7
	9/30/98	90.5
	10/1/98	84.9
	10/2/98	97.4
	10/3/98	106.8
	10/4/98	113.4
	10/5/98	114.6
	10/6/98	116.8
	10/7/98	116.8
	10/8/98	116.0
	10/9/98	113.8
	10/10/98	112.5
	10/11/98	110.7
	10/12/98	110.3
	10/13/98	118.3
	10/15/98	120.1
	10/16/98	119.9
	10/17/98	118.1
	10/18/98	118.1
	10/19/98	119.1
	10/22/98	116.9
	10/23/98	116.1
	10/25/98	117.8
	10/27/98	113.9
	10/28/98	113.1
	11/01/98	110.5
	11/05/98	108.1
	11/07/98	106.1
	11/13/98	105.5
	11/16/98	105.1
	11/17/98	104.4
	11/21/98	105.5
	11/24/98	106.3
	11/28/98	107.4
	12/01/98	108.1
	12/06/98	109.3
	12/09/98	108.7
	12/16/98	108.7
	12/19/98	110.0
	2/13/99	91.5
	2/17/99	91.5
	2/21/99	92.5
	2/23/99	93.5
	2/24/99	92.5
	2/25/99	96.5
	2/27/99	91.5
	3/01/99	94.5
	3/04/99	92.5
	3/06/99	92.5

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-01	3/08/99	92.5
	3/10/99	92.5
	3/13/99	96.5
	3/16/99	98.5
	3/22/99	96.5
	3/24/99	92.5
	3/26/99	91.5
	3/29/99	92.5
	4/04/99	94.0
	4/07/99	93.0
	4/09/99	95.0
	4/11/99	94.0
	4/14/99	96.0
	4/18/99	95.0
	4/21/99	96.0
	4/24/99	96.0
	4/26/99	97.0
	4/28/99	104.0
	4/29/99	105.0
	5/02/99	105.0
	5/05/99	108.0
	5/14/99	103.0
	5/19/99	109.0
	5/21/99	109.0
	6/08/99	112.0
	6/09/99	112.0
	6/14/99	110.0
	6/17/99	118.0
	6/21/99	109.0
	6/22/99	114.0
	6/24/99	113.0
	6/27/99	114.0
	7/1/99	113.0
	7/5/99	110.0
	7/8/99	109.0
	7/11/99	107.0
	7/15/99	105.0
	7/17/99	105.0
	7/22/99	99.0
	7/25/99	97.0
	7/28/99	97.0
	8/1/99	97.0
	8/6/99	97.0
	8/9/99	97.0
	8/12/99	95.0
	8/16/99	90.0
	8/19/99	99.7
	8/22/99	101.7
	8/26/99	102.1
	8/28/99	103.4

Spring ID	Discharge Date	Discharge (gpm)
PS-01	9/1/99	103.8
	9/2/99	103.1
	9/15/99	101.2
	9/19/99	101.8
	9/22/99	100.0
	9/25/99	100.5
	9/29/99	100.4
	10/2/99	100.7
	10/7/99	100.3
	10/13/99	97.9
	10/16/99	98.0
	10/19/99	98.1
	10/23/99	97.8
	10/27/99	95.0
	10/29/99	91.4
	11/7/99	90.3
	11/13/99	90.3
	11/19/99	89.5
	11/27/99	88.7
	11/30/99	88.2
	12/8/99	87.4
	12/10/99	84.8
	12/15/99	83.8
	12/22/99	82.4
	12/24/99	79.5
	12/30/99	81.2
	12/31/99	79.5
	1/7/00	78.1
	1/20/00	76.5
	1/27/00	67.7
	2/2/00	65.7
	2/13/00	65.7
	2/28/00	64.1
	3/3/00	63.9
	3/13/00	63.8
	3/19/00	63.2
	3/24/00	63.2
	4/3/00	62.7
	4/8/00	62.4
	4/16/00	72.6
PS-02	3/19/96	13.6
	3/20/96	18.8
	3/22/96	12.5
	3/25/96	15.0
	3/27/96	11.5
	3/29/96	12.5
	4/1/96	11.5
	4/2/96	15.0
	4/4/96	15.0

Spring ID	Discharge Date	Discharge (gpm)
PS-02	4/9/96	16.7
	4/12/96	12.5
	4/15/96	7.9
	4/16/96	11.5
	4/17/96	9.4
	4/18/96	10.0
	4/19/96	10.0
	4/23/96	10.7
	4/24/96	11.5
	4/25/96	9.4
	4/26/96	10.7
	4/29/96	7.5
	4/30/96	10.0
	5/5/96	10.0
	5/6/96	9.4
	5/7/96	11.5
	5/8/96	9.4
	5/9/96	8.3
	5/10/96	10.0
	5/14/96	8.8
	5/15/96	8.8
	5/16/96	10.0
	5/17/96	10.0
	5/20/96	8.3
	5/21/96	8.3
	5/23/96	9.4
	5/28/96	9.4
	5/29/96	9.4
	5/30/96	10.0
	5/31/96	10.0
	6/3/96	5.6
	6/4/96	11.5
	6/5/96	9.4
	6/6/96	8.8
	6/7/96	7.9
	6/10/96	8.8
	6/12/96	8.3
	6/13/96	7.5
	6/17/96	6.8
	6/18/96	7.9
	6/20/96	7.5
	6/21/96	7.5
	6/24/96	7.5
	6/25/96	7.1
	6/26/96	6.8
	7/2/96	7.1
	7/3/96	7.5
	7/5/96	7.1
	7/8/96	6.0
	7/9/96	7.9

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-02	7/10/96	6.8
	7/11/96	6.8
	7/12/96	6.8
	7/15/96	6.5
	7/16/96	6.0
	7/17/96	5.8
	7/18/96	6.0
	7/19/96	5.8
	7/22/96	5.8
	7/23/96	6.0
	7/24/96	6.8
	7/25/96	5.0
	7/26/96	5.8
	7/29/96	5.4
	7/30/96	5.4
	7/31/96	5.8
	8/1/96	6.3
	8/2/96	6.0
	8/6/96	6.5
	8/7/96	6.3
	8/8/96	6.0
	8/9/96	6.5
	8/10/96	6.3
	8/13/96	6.5
	8/14/96	6.3
	8/15/96	6.3
	8/17/96	6.5
	8/19/96	7.9
	8/21/96	7.1
	8/22/96	6.8
	8/23/96	6.8
	8/26/96	7.1
	8/27/96	6.8
	8/28/96	7.1
	8/29/96	7.1
	9/3/96	7.5
	9/5/96	7.5
	9/6/96	7.5
	9/10/96	7.9
	9/11/96	7.9
	9/13/96	8.1
	9/16/96	7.9
	9/17/96	8.1
	9/18/96	8.1
	9/19/96	8.3
	9/21/96	8.3
	9/23/96	8.6
	9/25/96	8.6
	9/27/96	8.6
	9/29/96	8.6

Spring ID	Discharge Date	Discharge (gpm)
PS-02	10/8/96	9.1
	10/9/96	8.8
	10/18/96	9.1
	10/24/96	9.1
	10/29/96	9.4
	10/30/96	9.1
	10/31/96	9.4
	11/4/96	9.4
	11/14/96	10.0
	11/25/96	10.5
	12/17/96	11.5
	1/31/97	13.6
	2/17/97	14.6
	2/27/97	14.5
	3/2/97	15.9
	3/21/97	15.9
	3/31/97	19.7
	4/1/97	19.7
	4/7/97	23.0
	4/10/97	21.9
	4/17/97	24.1
	5/5/97	29.0
	5/30/97	34.5
	6/24/97	19.7
	6/30/97	29.0
	7/22/97	31.7
	8/2/97	29.0
	9/4/97	24.1
	10/2/97	21.9
	1/11/98	15.9
	1/26/98	17.8
	1/29/98	18.7
	2/11/98	17.8
	2/24/98	17.8
	3/12/98	18.7
	3/25/98	19.7
	4/16/98	24.1
	4/30/98	31.7
	5/14/98	39.0
	5/23/98	48.3
	5/24/98	48.2
	5/25/98	47.4
	5/26/98	47.3
	5/27/98	48.3
	5/28/98	47.8
	5/29/98	48.5
	5/30/98	48.0
	5/31/98	49.3
	6/1/98	48.7
	6/2/98	49.3

Spring ID	Discharge Date	Discharge (gpm)
PS-02	6/3/98	48.0
	6/4/98	47.7
	6/5/98	47.7
	6/6/98	46.7
	6/7/98	48.0
	6/8/98	48.3
	6/9/98	48.0
	6/10/98	47.7
	6/11/98	48.0
	6/12/98	48.3
	6/13/98	47.3
	6/14/98	48.7
	6/15/98	48.0
	6/16/98	48.7
	6/17/98	47.7
	6/18/98	48.7
	6/19/98	48.3
	6/20/98	49.3
	6/21/98	48.7
	6/22/98	48.7
	6/23/98	49.0
	6/24/98	49.3
	6/25/98	49.3
	6/26/98	48.7
	6/27/98	48.0
	6/28/98	47.3
	6/29/98	49.0
	6/30/98	46.3
	7/1/98	47.7
	7/2/98	46.7
	7/3/98	46.7
	7/4/98	46.0
	7/5/98	45.7
	7/6/98	45.0
	7/7/98	45.5
	7/8/98	46
	7/9/98	46.7
	7/10/98	45.5
	7/12/98	45.5
	7/14/98	44.7
	7/16/98	45.5
	7/18/98	46
	7/20/98	45
	7/22/98	44
	7/24/98	41
	7/26/98	43
	7/28/98	43
	7/30/98	41.5
	8/1/98	40
	8/3/98	40

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-02	8/5/98	40
	8/7/98	40
	8/9/98	40
	8/11/98	38.5
	8/13/98	38
	8/15/98	37
	8/17/98	36.5
	8/19/98	35
	8/21/98	35
	8/23/98	35
	8/25/98	33.5
	8/27/98	35
	8/29/98	33
	8/31/98	31
	9/2/98	30
	9/4/98	31
	9/6/98	30
	9/8/98	30
	9/10/98	31
	9/12/98	31
	9/14/98	30
	9/16/98	30
	9/18/98	30
	9/20/98	30
	9/22/98	30
	9/24/98	30
	9/26/98	29
	9/27/98	29
	9/28/98	29.6
	9/29/98	26.5
	9/30/98	25
	10/1/98	25.8
	10/2/98	24.8
	10/3/98	25.7
	10/4/98	28.2
	10/5/98	28.5
	10/6/98	27.5
	10/7/98	30
	10/8/98	28
	10/9/98	28
	10/10/98	28
	10/11/98	28
	10/12/98	28
	10/13/98	28
	10/15/98	28
	10/16/98	28
	10/17/98	27
	10/18/98	28
	10/19/98	27
	10/22/98	27.5

Spring ID	Discharge Date	Discharge (gpm)
PS-02	10/23/98	27
	10/25/98	27
	10/27/98	25
	10/29/98	25
	11/01/98	25
	11/05/98	24
	11/07/98	24
	11/13/98	22
	11/16/98	24
	11/17/98	25
	11/21/98	24
	11/24/98	25
	11/28/98	23
	12/01/98	25
	12/06/98	24
	12/09/98	24
	12/16/98	23
	12/19/98	25
	12/26/98	25
	12/31/98	25
	1/03/99	24
	1/06/99	24
	1/10/99	24
	1/14/99	23
	1/18/99	24
	1/21/99	23
	1/24/99	23
	1/27/99	24
	1/30/99	23
	2/04/99	22
	2/08/99	22
	2/10/99	22
	2/13/99	22
	2/17/99	22
	2/21/99	22
	2/25/99	22
	2/27/99	24
	3/01/99	22
	3/04/99	22
	3/06/99	22
	3/08/99	21
	3/10/99	22
	3/13/99	22
	3/16/99	22
	3/22/99	22
	3/24/99	21
	3/26/99	21
	3/29/99	21
	4/04/99	21
	4/07/99	21

Spring ID	Discharge Date	Discharge (gpm)
PS-02	4/09/99	21
	4/11/99	21
	4/14/99	21
	4/18/99	22
	4/21/99	22
	4/24/99	21
	4/26/99	21
	4/28/99	22
	4/29/99	22
	5/02/99	24
	5/05/99	25
	5/08/99	25
	5/14/99	24
	5/16/99	26
	5/19/99	27
	5/21/99	27
	5/24/99	26
	5/25/99	27
	5/31/99	30
	6/03/99	30
	6/05/99	30
	6/08/99	30
	6/09/99	31
	6/14/99	31
	6/17/99	31
	6/21/99	31
	6/24/99	30
	6/27/99	31
	7/1/99	30
	7/5/99	30
	7/8/99	28
	7/11/99	30
	7/15/99	26
	7/17/99	29
	7/22/99	25
	7/25/99	25
	7/28/99	22
	8/1/99	23
	8/6/99	22
	8/9/99	24
	8/12/99	21
	8/16/99	24
	8/19/99	22
	8/22/99	24
	8/26/99	25
	8/28/99	25
	9/2/99	25
	9/6/99	25
	9/11/99	24
	9/15/99	25

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-02	9/19/99	24
	9/22/99	24
	9/25/99	24
	9/29/99	22
	10/2/99	23
	10/7/99	21
	10/13/99	20
	10/16/99	21
	10/19/99	20
	10/23/99	22
	10/27/99	20
	10/29/99	21
	11/7/99	20
	11/13/99	19
	11/19/99	17
	11/27/99	18
	11/30/99	17
	12/8/99	17
	12/10/99	18
	12/15/99	16.5
	12/22/99	16
	12/24/99	17
	12/30/99	16
	12/31/99	18
	1/7/00	18
	1/20/00	16
	1/27/00	17
	2/2/00	16
	2/13/00	15
	2/28/00	15
	3/3/00	15
	3/13/00	16
	3/19/00	16
	3/24/00	15
	4/3/00	14
	4/8/00	16
	4/16/00	
PS-03	3/15/96	7.89
	3/16/96	7.89
	3/20/96	10.71
	3/22/96	10.71
	3/25/96	10.71
	3/27/96	12.5
	3/28/96	11.54
	3/29/96	11.54
	4/1/96	10.71
	4/2/96	9.38
	4/4/96	10.71
	4/9/96	7.89

Spring ID	Discharge Date	Discharge (gpm)
PS-03	4/12/96	7.89
	4/15/96	8.33
	4/16/96	9.38
	4/17/96	10
	4/18/96	9.38
	4/19/96	8.82
	4/23/96	10
	4/24/96	9.38
	4/25/96	8.33
	4/26/96	8.33
	4/27/96	8.82
	4/29/96	8.82
	4/30/96	8.82
	5/5/96	9.38
	5/6/96	7.89
	5/7/96	9.38
	5/8/96	6.82
	5/9/96	8.82
	5/10/96	8.82
	5/14/96	9.38
	5/15/96	8.33
	5/16/96	7.89
	5/17/96	8.33
	5/20/96	7.5
	5/21/96	8.33
	5/23/96	7.89
	5/28/96	10
	5/29/96	10
	5/30/96	8.82
	5/31/96	9.38
	6/3/96	8.82
	6/4/96	9.38
	6/5/96	8.82
	6/6/96	8.82
	6/7/96	7.14
	6/10/96	8.82
	6/12/96	8.33
	6/13/96	6.82
	6/17/96	9.38
	6/18/96	9.38
	6/20/96	8.82
	6/21/96	8.82
	6/24/96	7.5
	6/25/96	8.33
	6/26/96	8.82
	7/2/96	7.14
	7/3/96	7.14
	7/5/96	6.82
	7/8/96	6.52
	7/9/96	7.89

Spring ID	Discharge Date	Discharge (gpm)
PS-03	7/10/96	7.14
	7/11/96	6.82
	7/12/96	6.52
	7/15/96	6.52
	7/16/96	6.82
	7/17/96	7.5
	7/18/96	6.82
	7/19/96	6.82
	7/22/96	6.82
	7/23/96	8.33
	7/24/96	8.33
	7/25/96	8.33
	7/26/96	7.5
	7/29/96	6.82
	7/30/96	7.5
	7/31/96	8.82
	8/1/96	6.82
	8/2/96	7.14
	8/5/96	6.82
	8/6/96	6.82
	8/7/96	7.14
	8/8/96	7.89
	8/9/96	6.82
	8/10/96	8.33
	8/13/96	7.89
	8/14/96	7.5
	8/15/96	7.89
	8/17/96	7.5
	8/19/96	8.33
	8/21/96	8.82
	8/22/96	8.82
	8/23/96	8.82
	8/26/96	8.82
	8/27/96	8.82
	8/28/96	8.82
	8/29/96	8.82
	9/2/96	8.82
	9/3/96	8.82
	9/5/96	8.82
	9/6/96	9.09
	9/9/96	8.82
	9/10/96	8.82
	9/11/96	8.82
	9/13/96	9.09
	9/16/96	9.09
	9/17/96	9.09
	9/18/96	8.33
	9/19/96	9.09
	9/21/96	9.09
	9/23/96	9.09

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-03	9/25/96	9.38
	9/27/96	9.09
	9/30/96	9.09
	10/8/96	9.38
	10/9/96	9.38
	10/18/96	9.68
	10/24/96	9.38
	10/29/96	9.38
	10/30/96	9.38
	10/31/96	9.68
	11/4/96	9.38
	11/14/96	9.68
	11/25/96	9.52
	12/17/96	9.23
	1/31/97	9.38
	2/17/97	9.61
	2/27/97	9.09
	3/3/97	8.83
	3/8/97	8.69
	4/7/97	10.91
	4/10/97	10.85
	4/17/97	11.16
	5/5/97	11.32
	5/30/97	11.08
	6/24/97	10.92
	6/30/97	11.04
	7/22/97	10.81
	8/2/97	11.72
	9/4/97	11.55
	10/1/97	11.34
	1/11/98	12.09
	1/26/98	11.59
	1/29/98	11.71
	2/11/98	11.6
	2/24/98	11.44
	3/12/98	11.34
	3/25/98	12.2
	4/16/98	11.47
	4/30/98	11.64
	5/14/98	12.05
	5/23/98	16.4
	5/25/98	14.8
	5/27/98	15.8
	5/29/98	15.2
	5/31/98	15.7
	6/2/98	16
	6/4/98	16
	6/6/98	15.3
	6/8/98	15
	6/10/98	15

Spring ID	Discharge Date	Discharge (gpm)
PS-03	6/12/98	16.7
	6/14/98	15
	6/16/98	15.7
	6/18/98	15.7
	6/20/98	15
	6/22/98	15
	6/24/98	15
	6/26/98	15.5
	6/28/98	16
	6/30/98	15.7
	7/2/98	15.7
	7/4/98	15.7
	7/6/98	15.5
	7/8/98	17
	7/9/98	16
	7/10/98	16.5
	7/12/98	17
	7/14/98	16.7
	7/16/98	16.5
	7/18/98	17
	7/20/98	16
	7/22/98	16.5
	7/24/98	16
	7/26/98	16.5
	7/28/98	16.5
	7/30/98	16.5
	8/1/98	16.5
	8/3/98	16.5
	8/5/98	17
	8/7/98	16.5
	8/9/98	16.5
	8/11/98	16.5
	8/13/98	17
	8/15/98	16.5
	8/17/98	16
	8/19/98	17
	8/21/98	16.5
	8/23/98	16.5
	8/25/98	17.5
	8/27/98	18
	8/29/98	18
	8/31/98	18
	9/2/98	18
	9/4/98	18
	9/6/98	18
	9/8/98	18
	9/10/98	18
	9/12/98	18
	9/14/98	18
	9/16/98	18

Spring ID	Discharge Date	Discharge (gpm)
PS-03	9/18/98	18
	9/20/98	18
	9/22/98	18
	9/24/98	18
	9/26/98	18
	9/28/98	18.3
	9/30/98	18.3
	10/1/98	18.8
	10/2/98	18
	10/3/98	18
	10/5/98	18
	10/7/98	18
	10/9/98	18
	10/11/98	18
	10/13/98	18
	1/30/99	16
	2/04/99	15
	2/08/99	16
	2/10/99	15
	2/13/99	15
	2/17/99	15
	2/21/99	16
	2/25/99	15
	2/27/99	16
	3/01/99	15
	3/04/99	14
	3/06/99	16
	3/08/99	15
	3/10/99	15
	3/13/99	16
	3/16/99	15
	3/22/99	13
	4/29/99	14
	5/02/99	14
	5/05/99	15
	5/08/99	14
	5/14/99	16
	5/16/99	14
	5/19/99	16
	5/21/99	14
	5/24/99	13
	5/25/99	15
	5/31/99	13
	6/03/99	14
	6/05/99	15
	6/08/99	13
	6/09/99	15
	6/14/99	15
	6/17/99	15
	6/21/99	15

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-03	6/24/99	15
	6/27/99	16
	7/1/99	15
	7/5/99	15
	7/8/99	14
	7/11/99	15
	7/15/99	15
	7/17/99	15
	7/22/99	15
	7/25/99	16
	7/28/99	15
	8/1/99	15
	8/6/99	14
	8/9/99	15
	8/12/99	15
	8/16/99	15
	8/19/99	15
	8/22/99	15
	8/26/99	16
	8/28/99	15
	9/2/99	15
PS-04	2/21/97	41
	3/8/97	42
	3/31/97	70
	4/1/97	70
	4/2/97	184
	4/7/97	260
	5/30/97	339
	6/24/97	213
	6/30/97	213
	7/22/97	178
	9/4/97	185
	10/11/97	132
	1/12/98	55
	1/26/98	50
	2/27/98	50
	3/12/98	50
	3/25/98	60
	4/16/98	193
	4/30/98	284
	5/20/98	359
	5/23/98	359
	5/24/98	359
	5/25/98	359
	5/26/98	359
	5/27/98	359
	5/28/98	359
	5/29/98	356
	5/30/98	356.3

Spring ID	Discharge Date	Discharge (gpm)
PS-04	5/31/98	355
	6/1/98	356.3
	6/2/98	359
	6/3/98	357.7
	6/4/98	355
	6/5/98	356.3
	6/6/98	353.3
	6/7/98	352.5
	6/8/98	354.7
	6/9/98	354.7
	6/10/98	351.7
	6/11/98	353.3
	6/12/98	353.3
	6/13/98	353.3
	6/14/98	351.7
	6/15/98	348.7
	6/16/98	345.7
	6/17/98	348.7
	6/18/98	347.3
	6/19/98	344.3
	6/20/98	335.3
	6/21/98	328
	6/22/98	317
	6/23/98	317.3
	6/24/98	311.3
	6/25/98	312.7
	6/26/98	311.3
	6/27/98	311.3
	6/28/98	309.2
	6/29/98	305
	6/30/98	303.7
	7/1/98	304.7
	7/2/98	301.7
	7/3/98	304.3
	7/4/98	303
	7/5/98	299.3
	7/6/98	287.5
	7/7/98	285
	7/8/98	273.5
	7/10/98	262.5
	7/12/98	258
	7/14/98	233
	7/16/98	222
	7/18/98	222
	7/20/98	215
	7/22/98	202
	7/24/98	191
	7/26/98	186.5
	7/28/98	182
	7/30/98	180

Spring ID	Discharge Date	Discharge (gpm)
PS-04	8/1/98	171
	8/3/98	166.5
	8/5/98	166
	8/7/98	157
	8/9/98	148
	8/11/98	144
	8/13/98	139
	8/15/98	139
	8/17/98	135
	8/19/98	135
	8/21/98	130
	8/23/98	130
	8/25/98	126
	8/27/98	112
	8/29/98	98.5
	8/31/98	99
	9/2/98	94
	9/4/98	90
	9/6/98	85
	9/8/98	81
	9/10/98	81
	9/12/98	81
	9/14/98	76
	9/16/98	72
	9/18/98	85
	9/20/98	81
	9/22/98	81
	9/25/98	81
	9/26/98	81
	9/27/98	85
	9/28/98	81
	9/29/98	83
	9/30/98	81
	10/1/98	82
	10/2/98	78
	10/3/98	76
	12/6/98	76
	12/9/98	72
	1/11/99	76
	1/14/99	81
	2/25/99	85
	2/27/99	81
	3/01/99	81
	3/04/99	81
	3/06/99	67
	3/08/99	76
	3/10/99	67
	3/13/99	72
	3/22/99	76
	3/24/99	76

Appendix D. Spring and Stream Discharge Data

Spring ID	Discharge Date	Discharge (gpm)
PS-04	3/26/99	76
	3/29/99	76
	4/04/99	76
	4/07/99	76
	4/09/99	76
	4/11/99	81
	4/14/99	76
	4/18/99	81
	4/21/99	81
	4/24/99	85
	4/26/99	85
	4/28/99	85
	4/29/99	85
	5/02/99	90
	05/05/99	90
	05/08/99	96
	05/14/99	94
	05/16/99	112
	05/19/99	130
	05/21/99	180
	5/22/99	189
	5/23/99	193
	5/24/99	211
	5/25/99	215
	5/27/99	220
	5/31/99	224
	6/03/99	224
	6/05/99	224
	6/08/99	215
	6/09/99	215
	6/14/99	197
	6/17/99	180
	6/21/99	166
	6/24/99	144
	6/27/99	135
	6/30/99	123

Spring ID	Discharge Date	Discharge (gpm)
PS-04	7/1/99	123
	7/5/99	112
	7/7/99	101
	7/11/99	90
	7/14/99	90
	7/15/99	90
	7/19/99	81
	7/22/99	81
	7/25/99	72
	7/29/99	72
	8/1/99	67
	8/6/99	67
	8/9/99	67
	8/12/99	72
	8/16/99	85
	8/19/99	72
	8/22/99	108
	8/26/99	117
	8/28/99	112
	9/2/99	121
	9/6/99	121
	9/11/99	108
	9/15/99	99
	9/19/99	90
	9/23/99	85
	9/25/99	81
	9/30/99	76
	10/2/99	81
	10/7/99	72
	10/14/99	58
	10/19/99	58
	10/23/99	49
	10/27/99	54
	10/30/99	54
	11/7/99	49
	11/13/99	58

Spring ID	Discharge Date	Discharge (gpm)
PS-04	11/21/99	49
	11/28/99	49
	11/30/99	49
	12/8/19	49
	12/10/99	49
	12/15/99	45
	12/22/99	45
	12/24/99	43
	12/30/99	45
	12/31/99	43
	2/13/00	34
	3/24/00	36
PS-20	8/19/96	3.1
	9/9/96	3.0
	9/17/96	2.8
	10/9/96	3.2
	10/30/96	3.2
	11/14/96	3.2
	1/31/97	3.2
	2/17/97	2.9
	2/27/97	2.9
	3/31/97	2.9
	4/1/97	2.9
	8/2/97	2.5
	9/4/97	2.1
	10/2/97	2.4
	1/11/98	2.7
	1/26/98	2.7
	2/11/98	2.7
	2/24/98	2.6
	3/12/98	2.6
	3/25/98	2.6
	4/16/98	2.6
	4/30/98	2.6
	5/14/98	2.7

Data Sources:
WW-1: D.Shaw (personal commun. 1999); see Table 2, Figure 9.
PS-01, PS-02, PS-03, PS-04, PS-20: L. Gonzales (unpubl. 1998, 1999, 2000); Johnson (1999)

APPENDIX E

Water Level Elevation Data

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PS-01	35.30129	-106.41840	6185	na	0	na	6185	na	325MDER Suela Flt		B	
PS-02	35.30439	-106.41885	6135	na	0	na	6135	na	318ABO Suela Flt		B	
PS-03	35.30638	-106.41919	6085	na	0	na	6085	na	318ABO Suela Flt		B	
PS-04	35.30641	-106.41373	6140	na	0	na	6140	na	325MDER		B	
PS-05	35.29109	-106.43931	6385	na	0	na	6385	na	325MDER Pomecerro Flt		B	
PS-06	35.29984	-106.42359	6110	na	0	na	6110	na	231PFDF		B	
PS-07	35.32014	-106.39818	6025	na	0	na	6025	na	318ABO Tecolote Flt		B	
PS-08	35.32569	-106.42048	5778	na	0	na	5778	na	122SNTFP Las Huertas Crk		B	
PS-09	35.29214	-106.43999	6310	na	0	na	6310	na	231PFDF Pomecerro Flt		B	
PS-10	35.35771	-106.39274	5785	na	0	na	5785	na	122SNTFP		B	
PS-11	35.35763	-106.39093	5820	na	0	na	5820	na	122SNTFP		B	
PS-12	35.35734	-106.39358	5743	na	0	na	5743	na	122SNTFP		B	
PS-13	35.35709	-106.39347	5730	na	0	na	5730	na	122SNTFP		B	
PS-14	35.35685	-106.39084	5797	na	0	na	5797	na	122SNTFP		B	
PS-15	35.35637	-106.39072	5797	na	0	na	5797	na	122SNTFP		B	
PS-16	35.35333	-106.38989	5809	na	0	na	5809	na	325MDER SanFrancisco Flt		B	
PS-17	35.34034	-106.39256	6024	na	0	na	6024	na	325MDER SanFrancisco Flt		B	
PS-18	35.35048	-106.38950	5805	na	0	na	5805	na	325MDER SanFrancisco Flt		B	
PS-19	35.31681	-106.43859	5704	na	0	na	5704	na	211MENF Caballo Flt		B	
PS-20	35.30674	-106.41858	6117	na	0	na	6117	na	318ABO Suela Flt		B	
PS-21	35.34473	-106.39058	5945	na	0	na	5945	na	325MDER SanFrancisco Flt		B	
PS-22	35.34701	-106.39183	5875	na	0	na	5875	na	122SNTFP SanFrancisco Flt		B	
PS-23	35.30963	-106.47193	5620	na	0	na	5620	na	122SNTFP Ranchos Flt		B	
PS-24	35.28993	-106.44771	6237	na	0	na	6237	na			B	
PW-001	35.31075	-106.43494	5771	8/30/89	18	R	5753	5660	211MNCSL		D	
PW-003	35.30278	-106.40668	6158	11/9/81	10	R	6148	6076 6136	318ABO		D	
PW-006	35.29906	-106.43460	5995		0	E	5995	5838	231PFDFL	E, F	B	
PW-009	35.30638	-106.49962	5489	02/00/67	419	R	5070	4991 4956	112SNTFP		D	
PW-010	35.29820	-106.44585	6005.4	11/7/96	45	R	5960	5558	231PFDFU		D	
PW-010			6005.4	3/10/97	58.42	T	5946.97			R	B	Domestic well; pumped lightly
PW-010			6005.4	5/29/97	67.57	T	5937.82			R	B	
PW-010			6005.4	8/7/97	91.42	T	5913.97			R	B	
PW-010			6005.4	10/2/97	72.92	T	5932.47			R	B	
PW-010			6005.4	12/5/97	64.65	T	5940.74			R	B	
PW-010			6005.4	2/5/98	67.58	T	5937.81			R	B	
PW-010			6005.4	4/5/98	64.45	T	5940.94			R	B	
PW-010			6005.4	6/1/98	66.93	T	5938.46			R	B	
PW-010			6005.4	8/10/98	93.75	T	5911.64			R	B	Water level rising from 100'
PW-011	35.29861	-106.44647	6020	6/18/88	45	R	5975	5868	231PFDFU		D	
PW-011			6020	3/10/97	136.45	T	5884			R	B	Domestic well; pumped lightly
PW-012	35.30961	-106.42189	5938.8	4/20/96	30	R	5908.81	5887	210MNCSL		D	
PW-012			5938.8	3/10/97	37.40	T	5901.41			R	B	Domestic well; pumped lightly
PW-012			5938.8	5/29/97	36.06	T	5902.75			R	B	
PW-012			5938.8	8/7/97	36.50	T	5902.31			R	B	
PW-012			5938.8	10/2/97	37.80	T	5901.01			R	B	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-012			5938.8	12/4/97	36.69	T	5902.12			R	B	
PW-012			5938.8	2/5/98	35.49	T	5903.32			R	B	
PW-012			5938.8	4/4/98	33.54	T	5905.27			R	B	Water level dropping slowly
PW-012			5938.8	6/1/98	33.97	T	5904.84			R	B	
PW-012			5938.8	8/10/98	39.2	T	5899.61			R	B	Pump cycling; drawing down from 39.2
PW-013	35.31776	-106.43274	5752.6	9/17/92	70	R	5682.62	5576	210MNCSU		D	
PW-013			5752.6	3/10/97	71.00	T	5681.62			R	B	Domestic well; pumped lightly
PW-013			5752.6	5/29/97	72.00	T	5680.62			R	B	
PW-013			5752.6	8/7/97	74.22	T	5678.40			R	B	
PW-013			5752.6	10/2/97	73.52	T	5679.10			R	B	
PW-013			5752.6	12/4/97	73.55	T	5679.07			R	B	
PW-013			5752.6	2/5/98	72.45	T	5680.17			R	B	
PW-013			5752.6	4/7/98	69.83	T	5682.79			R	B	
PW-013			5752.6	6/1/98	76.87	T	5675.75			R	B	
PW-013			5752.6	8/11/98	82.28	T	5670.34			R	B	Water level rising
PW-016	35.31171	-106.42113	5968	4/14/97	170	R	5798	5631	210MNCSL		D	
PW-017	35.30747	-106.43870	5821.5	5/29/97	30.11	T	5791.39	5739	220ENRD		B	Non-pumping well
PW-017			5821.5	8/7/97	28.02	T	5793.48				B	
PW-017			5821.5	10/2/97	28.08	T	5793.42				B	
PW-017			5821.5	12/5/97	27.90	T	5793.60				B	
PW-017			5821.5	2/5/98	27.69	T	5793.81				B	
PW-017			5821.5	4/3/98	27.28	T	5794.22				B	
PW-017			5821.5	6/1/98	27.28	T	5794.22				B	
PW-017			5821.5	8/10/98	25.79	T	5795.71				B	
PW-018	35.30633	-106.43724	5831.4	3/12/97	33	T	5798.42	5749	220ENRD		B	Non-pumping well
PW-018			5831.4	5/29/97	35.51	T	5795.91				B	
PW-018			5831.4	8/7/97	33.56	T	5797.86				B	
PW-018			5831.4	10/2/97	32.74	T	5798.68				B	
PW-018			5831.4	12/5/97	31.05	T	5800.37				B	
PW-018			5831.4	2/5/98	31.15	T	5800.27				B	
PW-018			5831.4	4/4/98	26.32	T	5805.10				B	
PW-018			5831.4	6/1/98	29.35	T	5802.07				B	
PW-018			5831.4	8/10/98	27.82	T	5803.60				B	
PW-021	35.30601	-106.45163	5864.7	8/17/95	126	R	5738.72	5693	211MENFL		D	
PW-021			5864.7	3/12/97	147	T	5717.72				B	Domestic well; intermittently pumped
PW-021			5864.7	5/29/97	145.46	T	5719.26				B	
PW-021			5864.7	8/7/97	150.45	T	5714.27				B	
PW-021			5864.7	10/2/97	>160	E,T	5704.72			R	B	Recently pumped; dry @ 160 ft
PW-021			5864.7	12/5/97	>160	E,T	5704.72			R	B	Dry at 160 ft
PW-021			5864.7	2/5/98	>160	E,T	5704.72			R	B	Dry at 160 ft
PW-021			5864.7	4/4/98	154.92	T	5709.80			R	B	
PW-021			5864.7	6/1/98	150.67	T	5714.05			R	B	
PW-021			5864.7	8/10/98	147.70	T	5717.02			R	B	
PW-022	35.33020	-106.44135	5637	3/13/97	277	T	5360	5220 5415	112SNTFP	R	B	Domestic well; pumped lightly
PW-023	35.32656	-106.43767	5642.4	3/13/97	212	T	5430.35	5130	211MENFU Lomos Flt	R	B	Domestic well; pumped lightly

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-023			5642.4	6/16/97	152.50	T	5489.85			R	B	
PW-023			5642.4	8/8/97	164.00	T	5478.35			R	B	
PW-023			5642.4	10/2/97	185.00	T	5457.35			R	B	Level rising
PW-023			5642.4	12/4/97	150.80	T	5491.55				B	House empty
PW-023			5642.4	2/5/98	147.45	T	5494.90				B	House empty
PW-023			5642.4	4/6/98	145.57	T	5496.78				B	House empty
PW-023			5642.4	6/1/98	146.29	T	5496.06				B	House empty
PW-023			5642.4	8/11/98	144.05	T	5498.30				B	
PW-024	35.32991	-106.43567	5699.4	5/24/88	185.00	R	5514.41	5417	112SNTFP		D	
PW-024			5699.4	3/13/97	266.00	T	5433.41			R	B	Domestic well; pumped lightly
PW-024			5699.4	6/6/97	266.92	T	5432.49			R	B	
PW-024			5699.4	8/8/97	266.44	T	5432.97			R	B	
PW-024			5699.4	10/2/97	265.23	T	5434.18			R	B	
PW-024			5699.4	12/4/97	264.62	T	5434.79			R	B	
PW-024			5699.4	2/5/98	264.11	T	5435.30			R	B	
PW-024			5699.4	4/6/98	263.27	T	5436.14			R	B	
PW-024			5699.4	6/1/98	262.14	T	5437.27			R	B	
PW-024			5699.4	8/10/98	261.12	T	5438.29			R	B	
PW-025	35.31850	-106.43619	5738.6	5/13/96	51	R	5687.56	5336	210HOSTD		D	
PW-025			5738.6	3/13/97	49.55	T	5689.01			R	B	Domestic well; pumped lightly
PW-025			5738.6	5/29/97	49.92	T	5688.64			R	B	
PW-025			5738.6	8/7/97	50.48	T	5688.08			R	B	
PW-025			5738.6	10/2/97	50.30	T	5688.26			R	B	
PW-025			5738.6	2/5/98	51.51	T	5687.05			R	B	
PW-025			5738.6	4/7/98	51.10	T	5687.46				B	House empty
PW-025			5738.6	6/1/98	51.98	T	5686.58				B	House empty
PW-025			5738.6	8/11/98	52.25	T	5686.31				B	House empty
PW-026	35.31876	-106.43581	5732.2	3/13/97	43.75	T	5688.43	5600	210MNCSU	R	B	Domestic well; pumped lightly
PW-026			5732.2	5/29/97	44.79	T	5687.39			R	B	
PW-026			5732.2	8/7/97	42.92	T	5689.26				B	House empty
PW-026			5732.2	10/2/97	43.16	T	5689.02				B	
PW-026			5732.2	12/4/97	43.00	T	5689.18			R	B	House occupied
PW-026			5732.2	2/5/98	49.97	T	5682.21			R	B	
PW-026			5732.2	4/7/98	42.76	T	5689.42				B	House empty
PW-026			5732.2	6/1/98	42.33	T	5689.85				B	House empty
PW-026			5732.2	8/11/98	41.86	T	5690.32				B	House empty
PW-027	35.31765	-106.43357	5742.6	5/13/95	48.00	R	5694.58	5336	210HOSTD		D	
PW-027	35.31765	-106.43357	5742.6	3/13/97	53.70	T	5688.88			R	B	Domestic well; pumped lightly
PW-027			5742.6	5/29/97	54.13	T	5688.45				B	
PW-027			5742.6	8/7/97	54.60	T	5687.98				B	House empty
PW-027			5742.6	10/2/97	54.40	T	5688.18				B	House empty
PW-027			5742.6	12/4/97	54.55	T	5688.03				B	House empty
PW-027			5742.6	2/5/98	55.43	T	5687.15				B	House empty
PW-027			5742.6	4/7/98	55.20	T	5687.38				B	House empty
PW-027			5742.6	6/1/98	56.15	T	5686.43				B	House empty

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-027			5742.6	8/11/98	56.30	T	5686.28				B	House empty
PW-028	35.30545	-106.44074	5856.2	3/13/97	43.2	T	5813.04	5769	231PFDFU	R	B	Domestic well; pumped lightly
PW-028			5856.2	5/29/97	37.91	T	5818.33			R	B	
PW-028			5856.2	8/7/97	39.44	T	5816.80			R	B	
PW-028			5856.2	10/2/97	40.69	T	5815.55			R	B	
PW-028			5856.2	12/5/97	40.15	T	5816.09			R	B	
PW-028			5856.2	2/5/98	40.06	T	5816.18			R	B	
PW-028			5856.2	4/4/98	40.10	T	5816.14			R	B	
PW-028			5856.2	6/1/98	35.70	T	5820.54			R	B	
PW-028			5856.2	8/10/98	34.40	T	5821.84			R	B	
PW-029	35.32793	-106.43838	5664.3	11/18/82	250	R	5414.34	5344	112SNTFP Caballo Flt		D	
PW-029			5664.3	3/13/97	248.10	T	5416.24			R	B	Domestic well; pumped lightly
PW-029			5664.3	8/8/97	248.60	T	5415.74			R	B	
PW-029			5664.3	10/2/97	248.62	T	5415.72			R	B	
PW-029			5664.3	12/4/97	250.6	T	5413.74			R	B	Level rising
PW-029			5664.3	2/5/98	247.81	T	5416.53			R	B	
PW-029			5664.3	4/6/98	246.97	T	5417.37			R	B	Level rising
PW-029			5664.3	6/1/98	247.30	T	5417.04			R	B	
PW-029			5664.3	8/10/98	248.10	T	5416.24			R	B	
PW-030	35.29550	-106.44552	6095.6	6/2/94	208	R	5887.60	5719	231PFDFM		D	
PW-030			6095.6	3/14/97	247.70	T	5847.90			R	B	Domestic well; pumped lightly
PW-030			6095.6	5/29/97	258.68	T	5836.92			R	B	
PW-030			6095.6	8/7/97	270.38	T	5825.22			R	B	
PW-030			6095.6	10/2/97	273.07	T	5822.53			R	B	
PW-030			6095.6	12/5/97	268.50	T	5827.10			R	B	
PW-030			6095.6	2/5/98	266.83	T	5828.77			R	B	
PW-030			6095.6	4/5/98	265.30	T	5830.30			R	B	
PW-030			6095.6	6/1/98	268.78	T	5826.82			R	B	
PW-030			6095.6	8/10/98	271.15	T	5824.45			R	B	
PW-031	35.30158	-106.45339	5963.5	3/3/85	180.00	R	5783.50	5666	210MNCSL		D	
PW-031			5963.5	3/14/97	236.75	T	5726.75			R	B	Domestic well; pumped lightly
PW-031			5963.5	6/6/97	233.98	T	5729.52			R	B	
PW-031			5963.5	8/7/97	299.45	T	5664.05			R	B	
PW-031			5963.5	10/2/97	>307	E,T	5656.50			R	B	Dry at 307 ft
PW-031			5963.5	12/5/97	300.85	T	5662.65			R	B	
PW-031			5963.5	2/5/98	299.57	T	5663.93			R	B	
PW-031			5963.5	4/5/98	300.69	T	5662.81			R	B	
PW-031			5963.5	6/1/98	301.11	T	5662.39			R	B	
PW-031			5963.5	8/10/98	301.24	T	5662.26			R	B	
PW-033	35.32591	-106.43321	5708.2	11/22/93	175	R	5533.20	5158	211MENFU Lomos Flt		D	
PW-033			5708.2	5/29/97	166.31	T	5541.89				B	Non-pumping well
PW-033			5708.2	8/8/97	166.35	T	5541.85				B	
PW-033			5708.2	10/2/97	167.20	T	5541.00				B	
PW-033			5708.2	12/4/97	166.40	T	5541.80				B	
PW-033			5708.2	2/5/98	165.86	T	5542.34				B	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-033			5708.2	4/7/98	165.55	T	5542.65				B	
PW-033			5708.2	6/1/98	166.55	T	5541.65				B	
PW-033			5708.2	8/11/98	167.42	T	5540.78				B	
PW-036	35.31038	-106.41506	6044	5/9/96	121.00	R	5923	5732	318ABO		D	
PW-037	35.30414	-106.41148	6185.3	5/2/97	4.08	T	6181.22	6093	325MDERL Flt	G	B	Non-pumping well
PW-037			6185.3	5/29/97	2.70	T	6182.60			H	B	
PW-037			6185.3	8/7/97	3.40	T	6181.90				B	
PW-037			6185.3	10/2/97	3.76	T	6181.54				B	
PW-037			6185.3	12/4/97	4.13	T	6181.17				B	
PW-037			6185.3	2/5/98	4.40	T	6180.90				B	
PW-037			6185.3	4/4/98	4.59	T	6180.71				B	
PW-037			6185.3	6/1/98	3.29	T	6182.01				B	
PW-037			6185.3	8/10/98	6.10	T	6179.20				B	
PW-039	35.30522	-106.42022	6065	10/1/96	25	R	6040	5598	318ABO/325MDER Suela Flt		D	
PW-040	35.30292	-106.43983	5913.0	10/2/96	110	R	5803.00	5706	231PFDFU		D	
PW-040			5913.0	5/2/97	136	T	5777.00			R	B	Non-pumping well (previously pumped)
PW-040			5913.0	5/29/97	115.82	T	5797.18				B	Still recovering . . .
PW-040			5913.0	8/7/97	95.83	T	5817.17				B	
PW-040			5913.0	10/2/97	85.46	T	5827.54				B	
PW-040			5913.0	12/5/97	75.90	T	5837.10				B	
PW-040			5913.0	2/5/98	70.79	T	5842.21				B	
PW-040			5913.0	4/3/98	66.03	T	5846.97				B	
PW-040			5913.0	6/1/98	62.82	T	5850.18				B	
PW-040			5913.0	8/10/98	58.55	T	5854.45				B	
PW-041	35.30008	-106.45541	5985	5/21/92	150	R	5835	5678	221MRSN[JCKP]		D	
PW-042	35.30015	-106.45745	5990	9/27/96	170	R	5820	5603	221MRSN[WWCN]		D	
PW-043	35.30374	-106.45862	5908	10/15/90	210	R	5698	5386	210MNCSL		D	
PW-043			5908	11/00/96	190	R	5718				O	
PW-044	35.30307	-106.44035	5912.3	4/15/97	40	R	5872.30	5805	231PFDFU		D	
PW-044			5912.3	5/2/97	35.00	T	5877.30			R	B	Domestic well; pumped lightly
PW-044			5912.3	5/29/97	31.14	T	5881.16			R	B	
PW-044			5912.3	8/7/97	31.45	T	5880.85			R	B	
PW-044			5912.3	10/2/97	36.16	T	5876.14			R	B	
PW-044			5912.3	12/5/97	38.94	T	5873.36			R	B	
PW-044			5912.3	2/5/98	39.60	T	5872.70			R	B	
PW-044			5912.3	4/3/98	39.50	T	5872.80			R	B	
PW-044			5912.3	6/1/98	38.82	T	5873.48			R	B	
PW-044			5912.3	8/10/98	37.06	T	5875.24			R	B	
PW-046	35.30412	-106.44049	5901	7/24/95	32	R	5869	5824	231PFDFU		D	
PW-047	35.30822	-106.42100	5979	5/4/95	78	R	5901	5822	210MNCSL		D	
PW-049	35.30388	-106.40691	6155	5/13/81	10	R	6145	6067	318ABO		D	
PW-050	35.30311	-106.40331	6117.8	5/19/81	30	R	6087.80	5931	318ABO		D	
PW-050			6117.8	4/10/97	46.58	T	6071.22				B	Non-pumping well
PW-050			6117.8	5/29/97	31.88	T	6085.92			X	B	
PW-050			6117.8	8/7/97	33.52	T	6084.28				B	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-050			6117.8	10/2/97	38.32	T	6079.48				B	
PW-050			6117.8	12/4/97	48.75	T	6069.05				B	
PW-050			6117.8	2/5/98	50.17	T	6067.63				B	
PW-050			6117.8	4/4/98	50.14	T	6067.66				B	
PW-050			6117.8	6/1/98	30.25	T	6087.55				B	
PW-050			6117.8	8/10/98	31.17		6086.63				B	
PW-052	35.29651	-106.40426	6189	3/9/95	40.97	S	6148	6062	318ABO	R	S	USGS; Domestic well; pumped lightly
PW-053	35.29947	-106.46069	5886	5/2/58	50	R	5836	5799	221MRSN[RCAP]		D	
PW-055	35.30162	-106.46030	5842.8	10/2/97	46.06	T	5796.74	5756	221MRSN	T	B	Non-pumping well
PW-055			5842.8	12/4/97	51.90	T	5790.90			T	B	
PW-055			5842.8	2/5/98	55.10	T	5787.70			T	B	
PW-055			5842.8	4/3/98	56.72	T	5786.08			T	B	
PW-055			5842.8	6/10/98	38.53	T	5804.27			T, X	B	
PW-055			5842.8	8/10/98	41.77	T	5801.03			T	B	
PW-056	35.30457	-106.46201	5773.4	3/5/76	40.00	R	5733.40	5712	210MNCSL		D	
PW-056			5773.4	5/29/97	42.53	T	5730.87			R	B	Domestic well; intermittently pumped
PW-056			5773.4	7/28/97	35.91	T	5737.49				B	House empty
PW-056			5773.4	10/2/97	36.73	T	5736.67			R	B	
PW-056			5773.4	12/5/97	39.85	T	5733.55			R	B	
PW-056			5773.4	2/5/98	42.50	T	5730.90			R	B	
PW-056			5773.4	4/3/98	43.92	T	5729.48			R	B	
PW-056			5773.4	6/10/98	35.70	T	5737.70			R, X	B	
PW-056			5773.4	8/10/98	33.95	T	5739.45			R	B	
PW-058	35.30225	-106.45359	5965	09/31/95	182	R	5783	5578	210MNCSL		D	
PW-059	35.32658	-106.43518	5722	4/16/84	250	R	5472	5232 5475	211MENFU		D	
PW-061	35.30374	-106.41922	6127	7/28/97	40	R	6087	6055	318ABO		D	
PW-061			6127	7/24/97	25.40	T	6102				B	Domestic well; pre-pumping
PW-062	35.31074	-106.40651	6029	10/2/97	>31.00	T	5998	6001	318ABO	D	B	Non-pumping windmill well
PW-062			6029	6/1/98	23.05	T	6006				B	
PW-062			6029	8/10/98	25.32	T	6004				B	
PW-063	35.30806	-106.45675	5830	5/22/92	140	R	5690	5623	211PNLK		D	
PW-064	35.29204	-106.40611	6259	11/25/83	50	R	6209	6152	318ABO		D	
PW-065	35.33623	-106.40014	6026	9/8/93	214	R	5812	5749	122SNTFP		D	
PW-066	35.30007	-106.41300	6278.7	5/2/97	104	T	6174.70	6070	325MDERL	R	B	Domestic well; pumped lightly
PW-066			6278.7	5/29/97	102.49	T	6176.21			R	B	
PW-066			6278.7	8/7/97	104.52	T	6174.18			R	B	
PW-066			6278.7	10/2/97	105.21	T	6173.49			R	B	
PW-066			6278.7	12/4/97	106.40	T	6172.30			R	B	
PW-066			6278.7	2/5/98	106.48	T	6172.22			R	B	
PW-066			6278.7	4/4/98	105.53	T	6173.17			R	B	
PW-066			6278.7	6/1/98	101.14	T	6177.56			R	B	Water level dropping slowly
PW-066			6278.7	8/10/98	102.72	T	6175.98			R	B	
PW-066			6278.7	2/23/99	106.31	T	6172.39			R	B	
PW-066			6278.7	3/31/99	106.82	T	6171.88			R	B	
PW-066			6278.7	4/8/99	106.74	T	6171.96			R	B	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-066			6278.7	4/16/99	106.62	T	6172.08			R	B	
PW-066			6278.7	4/22/99	106.51	T	6172.19			R	B	
PW-066			6278.7	4/30/99	106.35	T	6172.35			R	B	
PW-066			6278.7	5/6/99	106.15	T	6172.55			R	B	
PW-066			6278.7	5/22/99	105.90	T	6172.80			R	B	
PW-066			6278.7	5/31/99	105.56	T	6173.14			R	B	
PW-066			6278.7	6/2/99	105.45	T	6173.25			R	B	
PW-066			6278.7	6/10/99	105.03	T	6173.67			R	B	
PW-067	35.30501	-106.41219	6195		0	E	6195	6118	318ABO Flt	F	B	Domestic well; pumped lightly
PW-068	35.28802	-106.41030	6375	11/13/89	200	R	6175	6043	325MDER		D	
PW-068			6375	2/2/95	196.24	S	6179				S	
PW-070	35.28420	-106.40888	6345.2	5/29/97	86.69	T	6258.51	6058	325MDER	T,X	B	Non-pumping well
PW-070			6345.2	8/7/97	94.03	T	6251.17			T	B	
PW-070			6345.2	10/2/97	99.13	T	6246.07			T	B	
PW-070			6345.2	12/4/97	99.42	T	6245.78			T	B	
PW-070			6345.2	2/5/98	92.24	T	6252.96			T	B	
PW-070			6345.2	4/4/98	96.32	T	6248.88			T	B	
PW-070			6345.2	6/1/98	84.47	T	6260.73			T	B	
PW-070			6345.2	8/10/98	96.10	T	6249.10			T	B	
PW-071	35.34298	-106.38917	5972.0	10/9/96	55	R	5917.00	5745	325MDERU		D	
PW-071			5972.0	5/2/97	74	T	5898.00				B	Domestic well; pre-pumping
PW-071			5972.0	5/29/97	74.18	T	5897.82				B	Domestic well; lightly pumped
PW-071			5972.0	7/16/97	76.01	T	5895.99			R	B	
PW-071			5972.0	8/8/97	76.20	T	5895.80			R	B	
PW-071			5972.0	10/2/97	78.84	T	5893.16			R	B	
PW-071			5972.0	12/5/97	77.05	T	5894.95			R	B	
PW-071			5972.0	2/6/98	76.19	T	5895.81			R	B	
PW-071			5972.0	4/6/98	75.75	T	5896.25			R	B	
PW-071			5972.0	6/1/98	77.14	T	5894.86			R	B	
PW-071			5972.0	8/11/98	78.60	T	5893.40			R	B	
PW-072	35.32801	-106.43583	5682	10/22/85	240	R	5442	5325	112 SNTFP		D	
PW-075	35.30091	-106.44753	5965.7	2/28/94	67	R	5898.70	5809	210MNCSL Caballo Flt		D	
PW-075			5965.7	6/6/97	87.26	T	5878.44				B	Non-pumping well
PW-075			5965.7	8/7/97	84.08	T	5881.62				B	
PW-075			5965.7	10/2/97	83.70	T	5882.00				B	
PW-075			5965.7	12/5/97	79.82	T	5885.88				B	
PW-075			5965.7	2/5/98	76.31	T	5889.39				B	
PW-075			5965.7	4/5/98	74.91	T	5890.79				B	
PW-075			5965.7	6/1/98	83.39	T	5882.31				B	
PW-075			5965.7	8/10/98	83.54	T	5882.16				B	
PW-076	35.31837	-106.40274	5992.7	1/4/89	60	R	5932.70	5896	210CRCS SanFrancisco Flt		D	
PW-076			5992.7	5/29/97	54.26	T	5938.44			R	B	Domestic well; lightly pumped
PW-076			5992.7	8/8/97	53.75	T	5938.95			R	B	
PW-076			5992.7	10/2/97	52.00	T	5940.70			R	B	
PW-076			5992.7	12/5/97	50.91	T	5941.79			R	B	

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-076			5992.7	2/6/98	50.64	T	5942.06			R	B	
PW-076			5992.7	4/5/98	50.81	T	5941.89			R	B	
PW-076			5992.7	6/1/98	51.85	T	5940.85			R	B	
PW-076			5992.7	8/10/98	51.59	T	5941.11			R	B	
PW-079	35.30224	-106.45825	5942	12/6/79	190	R	5752	5375	221MRSN[JCKP]		D	
PW-080	35.32508	-106.43237	5702.4	4/12/97	155.40	T	5547.00	5415	211MENF	T	B	
PW-080			5702.4	5/29/97	155.12	T	5547.28			T	B	Non-pumping well
PW-080			5702.4	8/7/97	155.75	T	5546.65			T	B	
PW-080			5702.4	10/2/97	155.59	T	5546.81			T	B	
PW-080			5702.4	12/4/97	155.52	T	5546.88			T	B	
PW-080			5702.4	2/5/98	155.65	T	5546.75			T	B	
PW-080			5702.4	4/7/98	155.88	T	5546.52			T	B	
PW-080			5702.4	6/1/98	156.80	T	5545.60			T	B	
PW-080			5702.4	8/11/98	157.04	T	5545.36			T	B	
PW-083	35.28864	-106.41077	6398.6	10/8/90	190	R	6208.60	6027	325MDERL		D	
PW-083			6398.6	5/2/97	236.80	T	6161.80			R	B	Domestic well; lightly pumped
PW-083			6398.6	5/29/97	221.36	T	6177.24			R	B	
PW-083			6398.6	8/7/97	223.80	T	6174.80			R	B	
PW-083			6398.6	10/2/97	230.66	T	6167.94			R	B	Level rising
PW-083			6398.6	12/4/97	225.99	T	6172.61			R	B	
PW-083			6398.6	2/5/98	226.28	T	6172.32			R	B	
PW-083			6398.6	4/4/98	224.83	T	6173.77			R	B	Level dropping
PW-083			6398.6	6/1/98	229.12	T	6169.48			R	B	
PW-083			6398.6	8/10/98	221.91	T	6176.69			R	B	
PW-083			6398.6	2/23/99	233.1	T	6165.50			R	B	
PW-083			6398.6	3/31/99	259.62	T	6138.98			R	B	Level fluctuating; pump on
PW-083			6398.6	4/8/99	226.38	T	6172.22			R	B	
PW-083			6398.6	4/16/99	226.56	T	6172.04			R	B	
PW-083			6398.6	4/22/99	226.05	T	6172.55			R	B	
PW-083			6398.6	4/30/99	257.04	T	6141.56			R	B	Well pumping
PW-083			6398.6	5/6/99	226.45	T	6172.15			R	B	
PW-084	35.33316	-106.40226	6160	3/11/83	370	R	5790	5743	122SNTFP		D	
PW-085	35.30094	-106.46372	5980.4	10/21/94	200	R	5780.40	5683	221MRSN[RCAP]		D	
PW-085			5980.4	5/29/97	132.55	T	5847.85				B	Non-pumping well
PW-085			5980.4	7/28/97	128.53	T	5851.87				B	
PW-085			5980.4	9/3/97	125.32	T	5855.08				B	
PW-085			5980.4	10/2/97	123.34	T	5857.06				B	
PW-085			5980.4	12/5/97	122.02	T	5858.38				B	
PW-085			5980.4	2/5/98	122.39	T	5858.01				B	
PW-085			5980.4	4/3/98	123.21	T	5857.19				B	
PW-085			5980.4	6/10/98	123.06	T	5857.34				B	
PW-085			5980.4	8/10/98	118.55	T	5861.85				B	
PW-086	35.30126	-106.46174	5836.3	2/5/74	62	R	5774.30	5757	221MRSN[BBSN]		D	
PW-086			5836.3	5/2/97	46.27	T	5790.03				B	Non-pumping well
PW-086			5836.3	5/29/97	46.44	T	5789.86				B	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-086			5836.3	7/28/97	47.52	T	5788.78				B	
PW-086			5836.3	10/2/97	47.44	T	5788.86				B	
PW-086			5836.3	12/5/97	46.20	T	5790.10				B	
PW-086			5836.3	2/5/98	45.22	T	5791.08				B	
PW-086			5836.3	4/3/98	45.00	T	5791.30				B	
PW-086			5836.3	6/10/98	44.93	T	5791.37				B	
PW-086			5836.3	8/10/98	45.54	T	5790.76				B	
PW-087	35.34759	-106.39046	5872		0	E	5872	5532	325MDERU SanFrancisco Flt	F,G,R	B	Domestic well; lightly pumped
PW-088	35.32008	-106.40759	5898.2	3/4/96	20	R	5878.20	5831	210CRCS SanFrancisco Flt		D	Non-pumping well
PW-088			5898.2	5/29/97	20.64	T	5877.56				B	
PW-088			5898.2	8/8/97	15.17	T	5883.03				B	
PW-088			5898.2	10/2/97	15.22	T	5882.98				B	
PW-088			5898.2	12/5/97	18.47	T	5879.73				B	
PW-088			5898.2	2/6/98	21.09	T	5877.11				B	
PW-088			5898.2	4/5/98	23.28	T	5874.92				B	
PW-088			5898.2	6/1/98	15.12	T	5883.08				B	
PW-088			5898.2	8/10/98	19.61	T	5878.59				B	
PW-089	35.33614	-106.39432	6020.8	7/25/96	20	R	6000.80	5834	325MDERU SanFrancisco Flt		D	
PW-089			6020.8	5/29/97	14.40	T	6006.40			R	B	Domestic well; lightly pumped
PW-089			6020.8	7/16/97	11.85	T	6008.95			R	B	
PW-089			6020.8	8/8/97	11.31	T	6009.49			R	B	
PW-089			6020.8	10/2/97	10.95	T	6009.85			R	B	
PW-089			6020.8	12/5/97	11.44	T	6009.36			R	B	
PW-089			6020.8	2/6/98	12.14	T	6008.66			R	B	
PW-089			6020.8	4/6/98	12.77	T	6008.03			R	B	
PW-089			6020.8	6/1/98	12.15	T	6008.65			R	B	
PW-089			6020.8	8/11/98	10.90	T	6009.90			R	B	
PW-090	35.34285	-106.39796	6024.1	9/25/96	206	R	5818.10	5737	122SNTFP		D	
PW-090			6024.1	5/29/97	205.45	T	5818.65			R	B	Domestic well; lightly pumped
PW-090			6024.1	8/8/97	205.34	T	5818.76			R	B	
PW-090			6024.1	10/2/97	205.16	T	5818.94			R	B	
PW-090			6024.1	12/5/97	205.15	T	5818.95			R	B	
PW-090			6024.1	2/6/98	204.86	T	5819.24			R	B	
PW-090			6024.1	4/6/98	204.52	T	5819.58			R	B	
PW-090			6024.1	6/1/98	204.68	T	5819.42			R	B	
PW-090			6024.1	8/11/98	204.80	T	5819.30			R	B	
PW-091	35.35118	-106.38942	5842.7	5/29/97	49.17	T	5793.53	5746	325MDERU		B	Non-pumping well
PW-091			5842.7	8/8/97	49.45	T	5793.25				B	
PW-091			5842.7	10/2/97	49.42	T	5793.28				B	
PW-091			5842.7	12/4/97	49.29	T	5793.41				B	
PW-091			5842.7	2/6/98	49.05	T	5793.65				B	
PW-091			5842.7	4/6/98	48.80	T	5793.90				B	
PW-091			5842.7	6/1/98	49.07	T	5793.63				B	
PW-091			5842.7	8/11/98	49.40	T	5793.30				B	
PW-092	35.31919	-106.40662	5912.5	7/1/96	60	R	5852.50	5805	210CRCS SanFrancisco Flt		D	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-092			5912.5	5/29/97	38.20	T	5874.30			R	B	Domestic well; lightly pumped
PW-092			5912.5	8/8/97	32.81	T	5879.69			R	B	
PW-092			5912.5	10/2/97	32.65	T	5879.85			R	B	
PW-092			5912.5	12/5/97	35.15	T	5877.35			R	B	
PW-092			5912.5	2/6/98	37.09	T	5875.41			R	B	
PW-092			5912.5	4/5/98	39.50	T	5873.00			R	B	Water level dropping slowly
PW-092			5912.5	6/1/98	35.63	T	5876.87			R	B	Water level dropping slowly
PW-092			5912.5	8/10/98	32.62	T	5879.88			R	B	Water level dropping slowly
PW-093	35.31440	-106.40543	5968.7	5/29/97	46.07	T	5922.63	5772	230TRSC	T	B	Non-pumping well
PW-093			5968.7	7/24/97	19.34	T	5949.36			T,X	B	
PW-093			5968.7	8/8/97	19.72	T	5948.98			T,X	B	
PW-093			5968.7	10/2/97	27.89	T	5940.81			T	B	
PW-093			5968.7	12/5/97	31.12	T	5937.58			T	B	
PW-093			5968.7	2/6/98	31.60	T	5937.10			T	B	
PW-093			5968.7	4/5/98	31.93	T	5936.77			T	B	
PW-093			5968.7	6/1/98	22.35	T	5946.35			T	B	
PW-093			5968.7	8/10/98	19.56	T	5949.14			T	B	
PW-095	35.34726	-106.38619	5846.7	12/12/94	10.35	T	5836.35	5768	318ABO		G	
PW-095			5846.7	7/23/97	9.10	T	5837.60				B	Non-pumping well
PW-095			5846.7	10/28/97	9.17	T	5837.53				B	
PW-095			5846.7	12/4/97	8.92	T	5837.78				B	
PW-095			5846.7	4/6/98	9.24	T	5837.46				B	
PW-095			5846.7	8/11/98	9.75	T	5836.95					
PW-096	35.33530	-106.38662	5990.9	12/29/94	198.71	T	5792.19	5644	318ABOL/325MDERU		G	
PW-096			5990.9	7/23/97	199.45	T	5791.45				B	Non-pumping well
PW-096			5990.9	12/5/97	199.33	T	5791.57				B	
PW-096			5990.9	4/6/98	198.82	T	5792.08				B	
PW-097	35.32289	-106.41042	5878	1/7/93	25	R	5853	5772	122SNTFP		D	
PW-098	35.34104	-106.38938	6038	8/9/97	100	R	5938	5751	325MDERU		D	
PW-098			6038	7/25/97	101.09	T	5937				B	Domestic well; pre-pumping
PW-099	35.30173	-106.46183	5838	10/2/97	18.47	T	5820	5590	221MRSN	R	B	Domestic well; lightly pumped
PW-099			5838	12/4/97	17.42	T	5821			R	B	
PW-099			5838	2/5/98	17.92	T	5820			R	B	
PW-099			5838	4/3/98	16.50	T	5822			R	B	
PW-099			5838	6/10/98	16.37	T	5822			R	B	
PW-099			5838	8/10/98	16.14	T	5822			R	B	
PW-100	35.28361	-106.40920	6350.0	8/7/97	95.03	T	6254.97	6253	325MDER W Las Huertas Flt		B	Non-pumping well
PW-100			6350.0	10/2/97	100.02	T	6249.98				B	
PW-100			6350.0	12/4/97	98.06	T	6251.94				B	
PW-100			6350.0	2/5/98	96.87	T	6253.13				B	
PW-100			6350.0	4/4/98	96.20	T	6253.80				B	
PW-100			6350.0	6/1/98	88.09	T	6261.91				B	
PW-100			6350.0	8/10/98	96.04	T	6253.96				B	
PW-103	35.32093	-106.43108	5741	6/23/94	106	R	5635	5384	211MENF		D	
PW-104	35.32934	-106.44394	5630	6/19/95	205	R	5425	5293	112SNTFP		D	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-106	35.32558	-106.43876	5657	2/19/96	260	R	5397	5310	112SNTFP Caballo Flt		D	
PW-107	35.30400	-106.44150	5902	8/20/90	50	R	5852	5790	231PFDFU		D	
PW-109	35.30975	-106.44080	5810	2/4/94	39	R	5771	5642	221MRSN[JCKP] Caballo Flt		D	
PW-112	35.29978	-106.42656	6040.2	9/5/97	45.42	T	5994.78	5623	231PFDFM		B	Non-pumping well (sampled 9/5)
PW-112			6040.2	10/2/97	69.38	T	5970.82			R	B	
PW-112			6040.2	12/5/97	58.87	T	5981.33				B	Still recovering . . .
PW-112			6040.2	2/5/98	54.25	T	5985.95				B	
PW-112			6040.2	4/3/98	51.30	T	5988.90				B	
PW-112			6040.2	6/1/98	49.18	T	5991.02				B	
PW-112			6040.2	8/10/98	47.51	T	5992.69				B	
PW-113	35.30158	-106.42718	5962.2	10/2/97	18.95	T	5943.25	5585	231PFDFU	R	B	Non-pumping well
PW-113			5962.2	12/5/97	16.56	T	5945.64				B	
PW-113			5962.2	2/5/98	16.63	T	5945.57				B	
PW-113			5962.2	4/3/98	16.33	T	5945.87				B	
PW-113			5962.2	6/1/98	16.25	T	5945.95				B	
PW-113			5962.2	8/10/98	16.42	T	5945.78				B	
PW-115	35.34687	-106.39085	5896		0	E	5896	5722 5746	325MDER/318ABO SanF Flt	E,F,R	B	Domestic well; lightly pumped
PW-118	35.31338	-106.38436	6261.6	11/2/94	361.26	T	5900.34	5625	318ABO		G	
PW-118			6261.6	12/5/97	362.19	T	5899.41				B	Non-pumping well
PW-119	35.31596	-106.37780	6221	11/28/94	280.90	T	5940	5758	318ABOU		G	
PW-120	35.31893	-106.37710	6180	1/19/95	246.44	T	5934	5793	318ABOU		G	
PW-121	35.29813	-106.44471	6032	6/15/78	30	R	6002	5822	231PFDFU		D	
PW-122	35.30201	-106.44067	5953	8/7/97	55	R	5898	5826	231PFDFM		D	
PW-122			5953	8/7/97	55.05	T	5898				B	Domestic well; pre-pumping
PW-123	35.30401	-106.44715	5930	3/24/94	60	R	5870	5690 5743	211MENFL		D	
PW-123			5930	7/1/97	29.0	S	5901			R	G	Domestic well; lightly pumped
PW-124	35.30265	-106.44245	5915.2	7/2/74	10	R	5905.20	5709	221MRSN[BBSN]		D	
PW-124			5915.2	7/1/97	36.8	S	5878.40				G	Non-pumping well
PW-124			5915.2	10/2/97	36.95	T	5878.25				B	
PW-124			5915.2	12/4/97	36.16	T	5879.04				B	
PW-124			5915.2	2/5/98	36.10	T	5879.10				B	
PW-124			5915.2	4/5/98	35.60	T	5879.60				B	
PW-124			5915.2	6/1/98	35.36	T	5879.84				B	
PW-124			5915.2	8/10/98	35.81	T	5879.39				B	
PW-126	35.30112	-106.44873	5973	6/17/97	88.5	S	5885	5838	210MNCSL	R	G	Domestic well; lightly pumped
PW-127	35.30366	-106.44969	5935	4/29/78	55	R	5880	5858	211PNLK		D	
PW-127			5935	6/15/97	42.8	S	5892			R	G	Domestic well; lightly pumped
PW-128	35.29920	-106.45517	6014	2/12/76	140	R	5874	5787	221MRSN[BBSN]		D	
PW-128			6014	6/15/97	177.4	S	5837				G	Non-pumping well
PW-129	35.30015	-106.45285	5999.4	9/7/77	130	R	5869.40	5824	211DKOT		D	
PW-129			5999.4	6/15/97	132.0	S	5867.40				G	Non-pumping well
PW-129			5999.4	10/2/97	128.72	T	5870.68				B	
PW-129			5999.4	12/4/97	129.80	T	5869.60				B	
PW-129			5999.4	2/5/98	129.92	T	5869.48				B	
PW-129			5999.4	4/7/98	129.82	T	5869.58				B	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-129			5999.4	6/1/98	130.62	T	5868.78				B	
PW-129			5999.4	8/10/98	132.20	T	5867.20				B	
PW-130	35.33187	-106.45470	5523	9/13/95	268.00	R	5255	5166	112SNTFP		D	
PW-132	35.31326	-106.49160	5481	9/19/95	410.00	R	5071	4884	112SNTFT		D	
PW-133	35.30255	-106.43662	5937		0	E	5937	-	231PFDFM	F,R	B	Domestic well; lightly pumped
PW-135	35.30958	-106.48605	5545	11/15/95	480	R	5065	4918	112SNTFP		D	
PW-137	35.31424	-106.48380	5540	8/4/96	318	R	5222	4993	112SNTFP ValleyView Flt		D	
PW-139	35.34326	-106.39137	5954		0	E	5954	5752	325MDERU SanFrancisco Flt	F,R	B	Domestic well; lightly pumped
PW-140	35.30015	-106.43839	6023	4/21/96	26.34	S	5997	5841	231PFDFL	R	O	Domestic well; lightly pumped
PW-140			6023	4/27/96	23.65	S	6000			R	O	
PW-140			6023	6/17/96	54.54	S	5969			R	O	
PW-140			6023	8/4/96	36.20	S	5987			R	O	
PW-140			6023	2/18/97	34.94	S	5988			R	O	
PW-140			6023	6/19/97	13.80	S	6009			R	O	
PW-141	35.30011	-106.43745	6038.8	1/9/96	81.60	S	5957.20	5947	231PFDFL		O	Non-pumping well
PW-141			6038.8	3/3/96	78.25	S	5960.55				O	
PW-141			6038.8	4/21/96	82.90	S	5955.90				O	
PW-141			6038.8	4/27/96	71.60	S	5967.20				O	
PW-141			6038.8	5/27/96	87.00	S	5951.80				O	
PW-141			6038.8	6/16/96	93.11	S	5945.69				O	
PW-141			6038.8	6/29/96	94.46	T	5944.34				O	
PW-141			6038.8	8/4/96	96.79	S	5942.01				O	
PW-141			6038.8	2/18/97	76.81	S	5961.99				O	
PW-141			6038.8	6/18/97	73.22	S	5965.58				O	
PW-141			6038.8	10/2/97	76.64	T	5962.16			T	B	
PW-141			6038.8	12/4/97	67.62	T	5971.18			T	B	
PW-141			6038.8	2/5/98	64.94	T	5973.86			T	B	
PW-141			6038.8	4/3/98	61.93	T	5976.87			T	B	
PW-141			6038.8	6/1/98	65.91	T	5972.89			T	B	
PW-141			6038.8	8/10/98	65.37	T	5973.43			T	B	
PW-145	35.29950	-106.44288	6092	6/4/81	110	R	5982	5940	221MRSN		D	
PW-148	35.30013	-106.45287	6008	10/29/91	130	R	5878	5681	211MRSN[JCKP]		D	
PW-149	35.31073	-106.46666	5669	7/6/94	39	R	5630	5262	211MENFU		D	
PW-151	35.34918	-106.42333	5692.5	10/00/63	400	R	5292.50	5190	112SNTFP Escala Flt		D	
PW-151			5692.5	10/2/97	396.02	T	5296.48				B	Non-pumping well
PW-151			5692.5	12/4/97	396.08	T	5296.42				B	
PW-151			5692.5	2/6/98	396.11	T	5296.39				B	
PW-151			5692.5	4/5/98	396.05	T	5296.45				B	
PW-151			5692.5	6/1/98	396.22	T	5296.28				B	
PW-151			5692.5	8/10/98	396.38	T	5296.12				B	
PW-155	35.29844	-106.40382	6147.6	12/4/97	44.49	T	6103.11	-	318ABO		B	Non-pumping well
PW-155			6147.6	2/5/98	42.86	T	6104.74				B	
PW-155			6147.6	4/4/98	42.28	T	6105.32				B	
PW-155			6147.6	6/1/98	14.86	T	6132.74				B	
PW-155			6147.6	8/10/98	19.92	T	6127.68				B	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-156	35.29836	-106.40382	6148.4	12/4/97	38.75	T	6109.65	-	318ABO		B	Non-pumping well
PW-156			6148.4	2/5/98	48.30	T	6100.10				B	
PW-156			6148.4	4/4/98	48.54	T	6099.86				B	
PW-156			6148.4	6/1/98	17.15	T	6131.25				B	
PW-156			6148.4	8/10/98	24.22	T	6124.18				B	
PW-158	35.31583	-106.42980	5806.9	12/4/97	30.64	T	5776.26	5700	210MNCSU		B	Non-pumping well
PW-158			5806.9	2/5/98	30.62	T	5776.28				B	
PW-158			5806.9	4/7/98	29.94	T	5776.96				B	
PW-160	35.30676	-106.43649	5820	08/00/98	8	T	5812	5658	221TDLT		D	
PW-161	35.32118	-106.39331	6158	4/17/92	204	R	5954	5801	318ABO		D	
PW-162	35.30460	-106.49654	5505	10/10/85	444	R	5061	4929	112SNTFP		D	
PW-166	35.31941	-106.47758	5525	2/24/89	305	R	5220	4993	112SNTFT		D	
PW-167	35.32623	-106.47922	5520	1/10/95	285	R	5235	4976	112SNTFT		D	
PW-168	35.33355	-106.49277	5324	4/12/98	245	T	5079	4817	112SNTFA		G	
PW-169	35.33422	-106.44116	5692	11/4/94	260	R	5432	5385	112SNTFP		D	
PW-170	35.31404	-106.48324	5534	7/8/96	317	R	5217	4952	112SNTFP Valley View Flt		D	
PW-171	35.29371	-106.45052	6168.0	9/7/71	62	R	6106.00	961 6011 604	231PFDFU		D	
PW-171			6168.0	2/5/98	68.28	T	6099.72				B	
PW-171			6168.0	4/5/98	66.00	T	6102.00				B	
PW-171			6168.0	6/1/98	63.21	T	6104.79				B	
PW-171			6168.0	8/10/98	61.88	T	6106.12				B	
PW-172	35.30219	-106.44288	5918.8	5/31/79	20	R	5898.80	5882	110AVMB, 210MNCSL		D	
PW-172			5918.8	1/28/98	29.86	T	5888.94			T	B	
PW-172			5918.8	2/5/98	30.01	T	5888.79			T	B	
PW-172			5918.8	4/5/98	31.03	T	5887.77			T	B	
PW-172			5918.8	6/1/98	31.85	T	5886.95			T	B	
PW-172			5918.8	8/10/98	32.56	T	5886.24			T	B	
PW-173	35.30810	-106.51191	5362	8/30/77	305	R	5057	4969	112SNTFT		D	
PW-174	35.32042	-106.43452	5706	6/23/93	43	R	5663	5504	211MENFL		D	
PW-175	35.33602	-106.39630	6057	11/7/97	200	R	5857	5725 5770	122SNTFP		D	
PW-176	35.31129	-106.51645	5315	4/21/95	255	R	5060	4908	112SNTFT		D	
PW-179	35.30435	-106.47750	5719	12/23/91	504	R	5215	4912	112SNTFP		D	
PW-180	35.30439	-106.47767	5704	7/1/93	504	R	5200	4929	112SNTFP		D	
PW-183	35.30850	-106.44232	5866	7/21/89	80	R	5786	5678	221MRSN[WWCN]		D	
PW-184	35.31821	-106.45262	5853	3/9/90	370	R	5483	5386	122SNTFP		D	
PW-185	35.34088	-106.39420	6020	11/15/97	162	R	5858	5808	122SNTFP SanF Flt		G	
PW-186	35.32570	-106.42775	5890	4/27/95	315	R	5575	5413	122SNTFP		D	
PW-187	35.32671	-106.42839	5844	5/17/95	330	R	5514	5347	122SNTFP		D	
PW-188	35.32755	-106.45754	5681	8/31/95	410	R	5271	5082	112SNTFP		D	
PW-189	35.32654	-106.45521	5660	9/9/95	380	R	5280	5143	112SNTFP		D	
PW-190	35.32898	-106.45462	5566	9/6/95	294	R	5272	5168	112SNTFP		D	
PW-191	35.32093	106.47247	5572	12/8/71	335	R	5237	5203	112SNTFP		D	
PW-191			5572	3/15/95	353.79	R	5218				G	Geohydrology Assoc., Inc. (1995)
PW-192	35.32603	-106.47636	5471	7/14/78	218	R	5253	964 5144 520	112SNTFT Valley View Flt		D	
PW-196	35.33681	-106.44933	5652	11/12/97	210	R	5442	5325	112SNTFP		D	

Appendix E. Placitas Water Level Elevation Data

Well ID	Latitude*	Longitude*	MPE(ft)**	DTW Date	Depth To Water (ft)	DTW Method	Water Level Elevation (ft)**	Mid-Screen Elevation (ft)	Aquifer Code	Water Level Status	Data Source	Comments
PW-197	35.31369	-106.50241	5403	9/14/84	360	R	5043	4794	112SNTFT		D	
PW-198	35.31865	-106.51872	5300	11/10/95	398	R	4902	4743	112SNTFT		D	
PW-198			5300	8/23/97	360.42	R	4940				G	Turner & Assoc (19??)
PW-200	35.30636	-106.45277	5878	5/24/96	158	R	5720	5586	211PNLK		D	
PW-201	35.31661	-106.51520	5308	4/10/94	260	R	5048	4846	112SNTFT		D	
PW-204	35.31063	-106.51496	5327	6/22/94	265	R	5062	4900	112SNTFT		D	
PW-205	35.33051	-106.50449	5256	8/11/89	172	R	5084	4909	112SNTFA		D	
PW-208	35.29932	-106.41742	6333.2	5/11/98	160	R	6173	6077	325MDERL		D	
PW-208			6334.5	10/15/98	161.87	T	6173				O	
PW-209	35.29932	106.41752	6332.5	4/29/98	160	R	6173	6080	325MDERL		O	
PW-210	35.31748	-106.52931	5185	5/13/98	129.37	T	5056	-	112SNTFA		B	
PW-214	35.33638	106.44458	5667	12/3/96	387.17	R	5280	5100	112SNTFP		G	John Shomaker & Assoc., Inc. (1997)
PW-219	35.33418	106.44542	5629	8/20/96	351	R	5278	5197	112SNTFP		G	Glorieta Geoscience, Inc. (1996)
PW-301	35.32722	106.53028	5097	2/2/88	42.06	R	5055	-	110PTOD		D	USGS Database
PW-302	35.33139	106.53139	5074	2/1/88	26	R	5048	-	110PTOD		D	USGS Database
PW-303	35.32361	106.53222	5090	2/2/88	28.89	R	5061	-	110PTOD		D	USGS Database
PW-304	35.34250	106.52222	5085	1/25/77	21.5	R	5064	-	112SNTFA		D	USGS Database
PW-305	35.33889	106.52361	5090	6/27/85	27.42	R	5063	-	112SNTFA		D	USGS Database
PW-306	35.33194	106.53028	5091	2/3/88	33.07	R	5058	-	110PTOD		D	USGS Database
PW-307	35.33139	106.52528	5110	5/31/88	50.45	R	5060	-	112SNTFA		D	USGS Database
PW-308	35.33167	106.52472	5110	5/31/88	52.02	R	5058	-	110PTOD		D	USGS Database
PW-309	35.33194	106.52444	5110	5/31/88	52.23	R	5058	-	110PTOD		D	USGS Database
PW-310	35.33000	106.52972	5094	3/3/95	35.06	S	5059	-	110PTOD/112SNTFA	R	S	USGS Database
PW-311	35.32583	106.51500	5210	2/3/88	147.98	R	5062	-	112SNTFA		D	USGS Database
PW-312	35.32611	106.51500	5211	10/16/56	146.56	S	5064	-	112SNTFA		S	USGS Database
PW-313	35.32472	106.53222	5300	3/20/85	238	R	5062	-	112SNTFA		D	USGS Database
PW-314	35.31806	106.51750	5310	5/1/00	260	R	5050	-	112SNTFA		D	USGS Database
PW-315	35.31639	106.51056	5350	6/16/83	297	R	5053	-	112SNTFA		D	USGS Database
PW-316	35.33389	106.39444	6100	5/24/93	39	R	6061	-	325MDER		D	USGS Database
PW-317	35.31778	106.40667	5941	12/20/93	20		5921	-	110PTOD			USGS Database

* = Latitude/Longitude coordinates in decimal degrees, NAD27; location accuracy for wells/springs shown in **bold** is +/- 0.1 ft, others +/-20 ft
** = Measuring Point Elevation in feet, NGVD29; elevation accuracy for wells/springs shown in bold is +/- 0.1 ft, others +/-20 ft
^ = Bottom well elevation
^^ = 60-ft total screen from 5666-5676, 5686-5696, 5706-5716, 5726-5746, 5756-5766

Depth to Water Method: E = estimated; R = reported; S = steel tape measurement; T = electric tape measurement

Water Level Status: D=dry; E=flowing recently or intermittently; F=flowing, head can't be measured; G=site nearby that taps the same aquifer was flowing; H=site nearby that taps the same aquifer had been flowing recently; P=pumping; R=recently pumped; S=site nearby that taps the same aquifer was being pumped; T=site nearby that taps the same aquifer had been pumped recently; W=destroyed; X=water level affected by stage in nearby surface water site; Z=other conditions affecting water level measurements explained in comments

Data Source: B=NMBMMR; S=USGS; G=Private consultant or university associate; D=Driller Log/Well Report; O=Owner

Figure E-1. Madera Formation, Dome Valley
T 12 N., R 5 E., sections 4 and 9

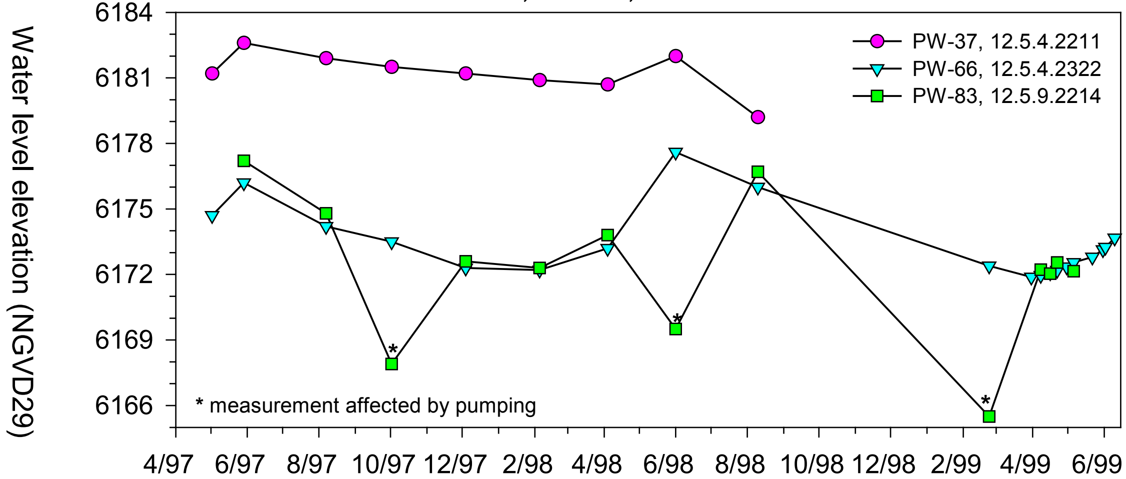


Figure E-2. Madera Formation, upper Las Huertas Canyon
T 12 N., R 5 E., section 9

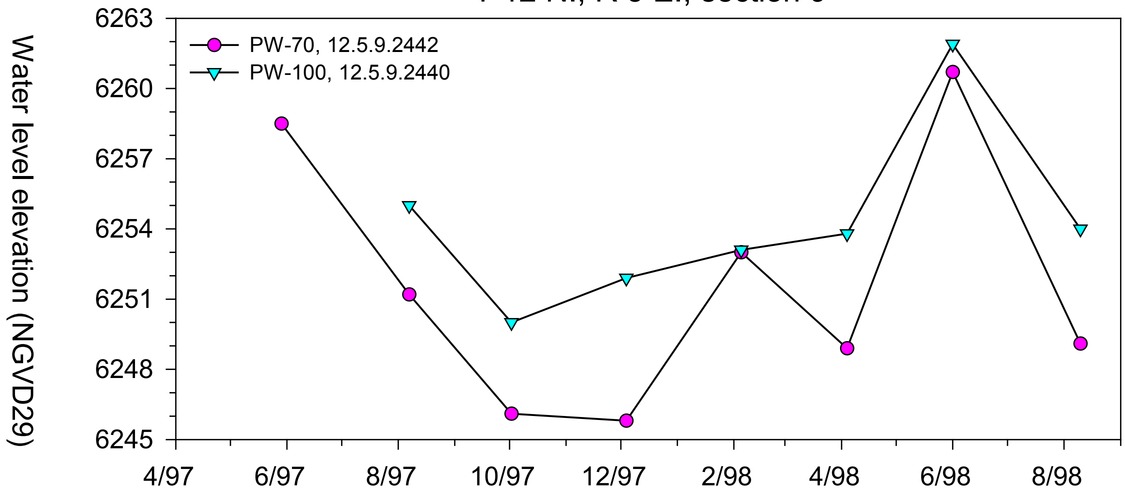


Figure E-3. Permian Abo Formation, mid Las Huertas Canyon
T 12 N., R 5 E., section 3

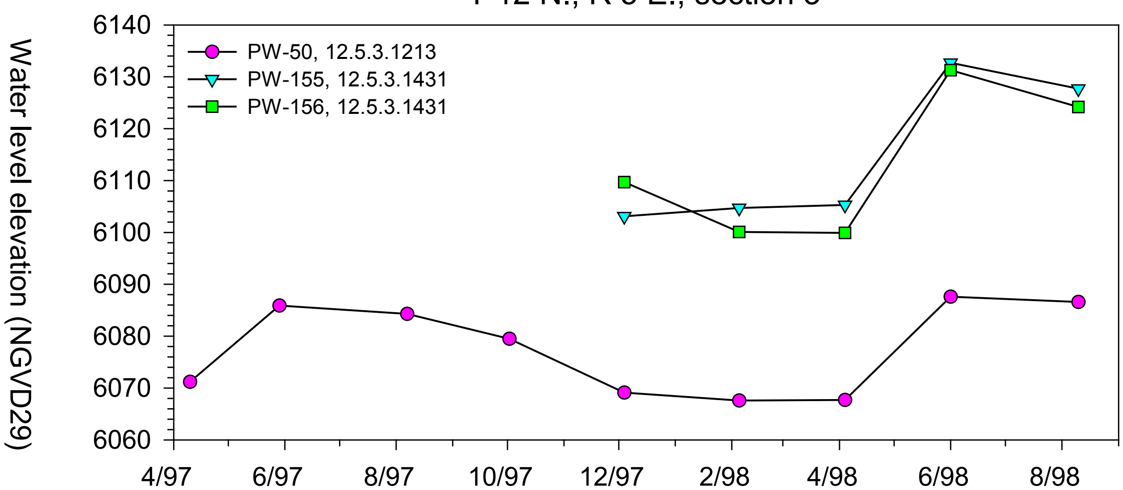


Figure E-4. San Francisco fault zone at Tecolote
T 13 N., R 5 E., section 34

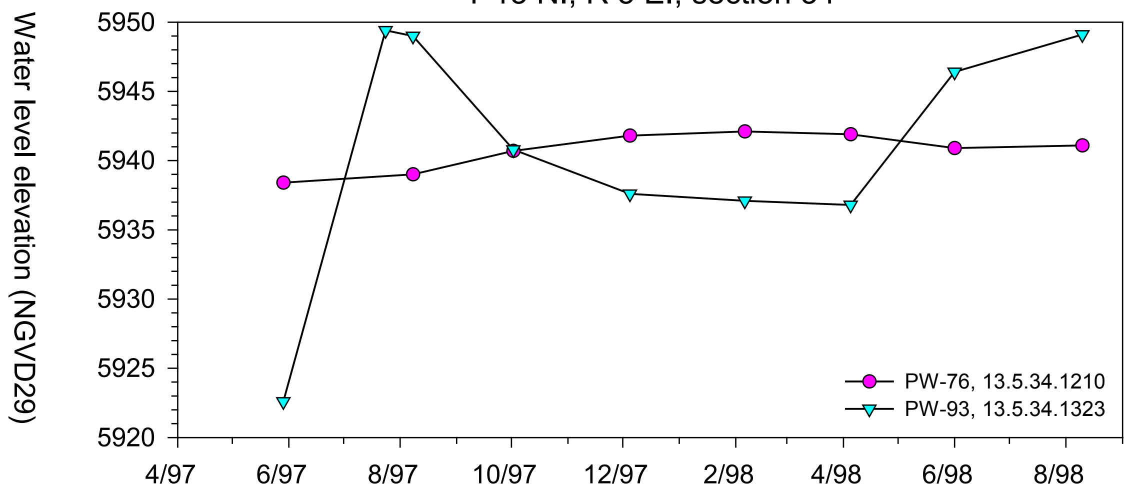


Figure E-5. San Francisco fault zone along Las Huertas Creek below Tecolote
T 13 N., R 5 E., section 27

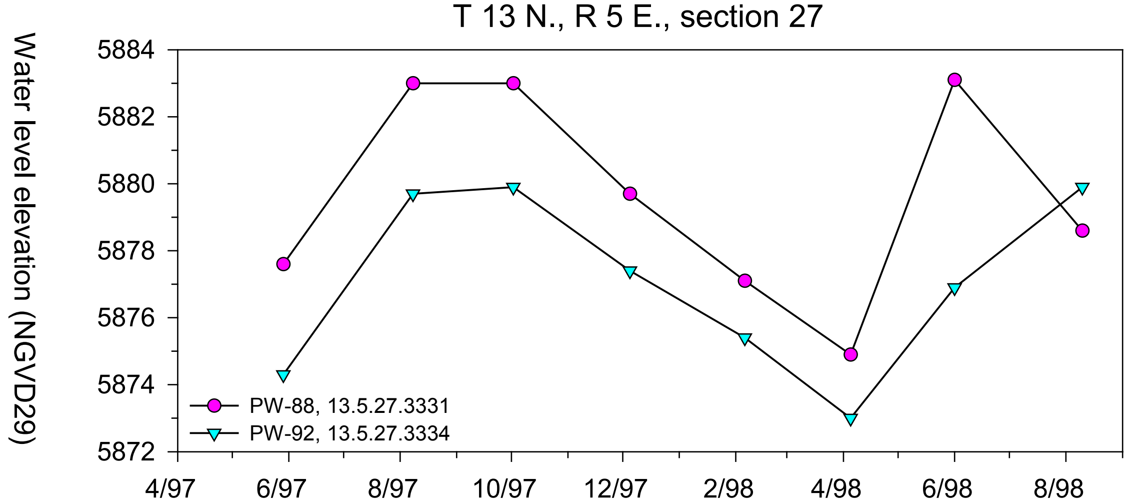


Figure E-6. Upper Santa Fe piedmont along lower Las Huertas Creek
T 13 N., R 5 E., section 29

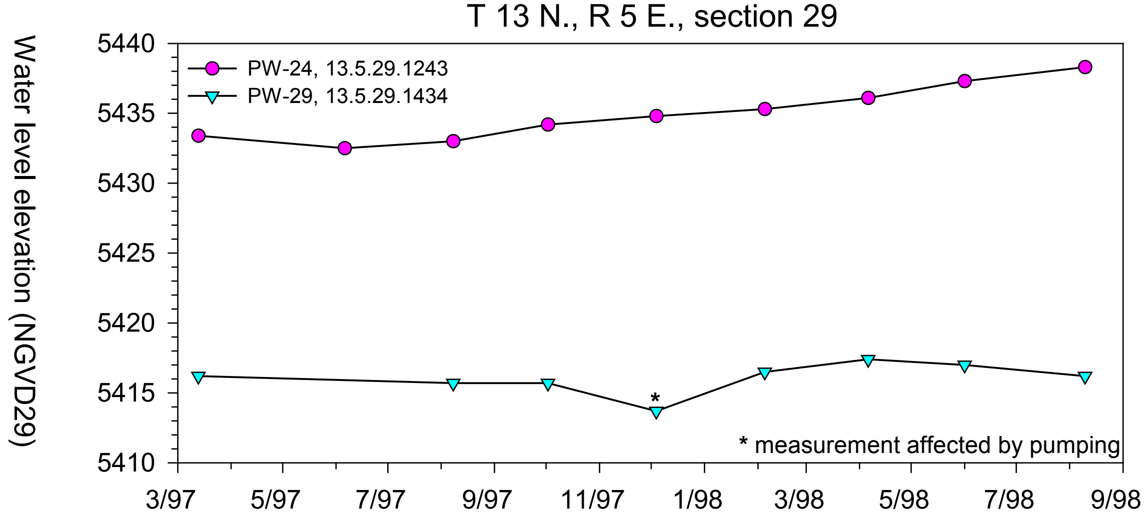


Figure E-7. Madera Formation near San Francisco Springs
T 13 N., R 5 E., sections 14 and 23

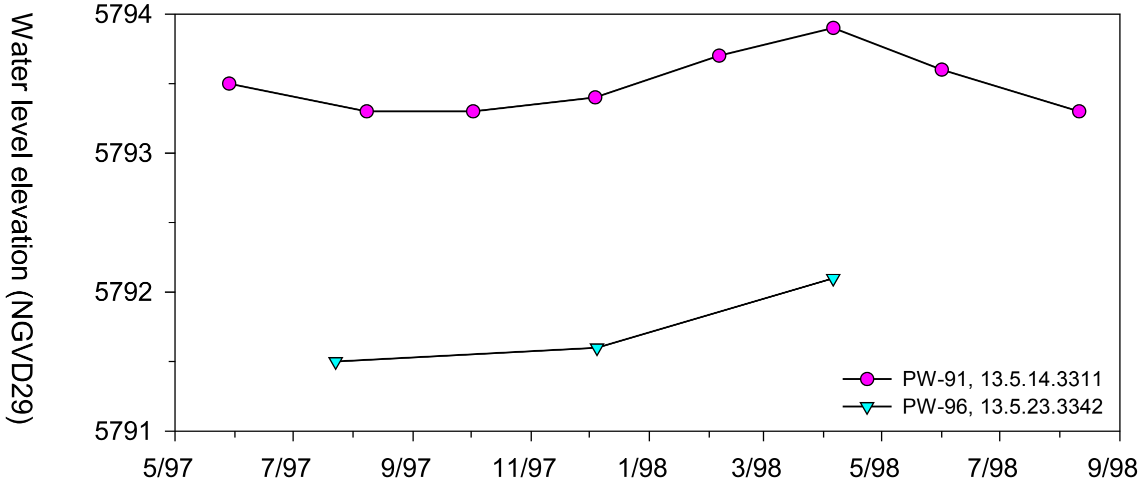


Figure E-8. Madera Formation, San Francisco fault zone, Cuchilla de San Francisco
T 13 N., R 5. E., section 22

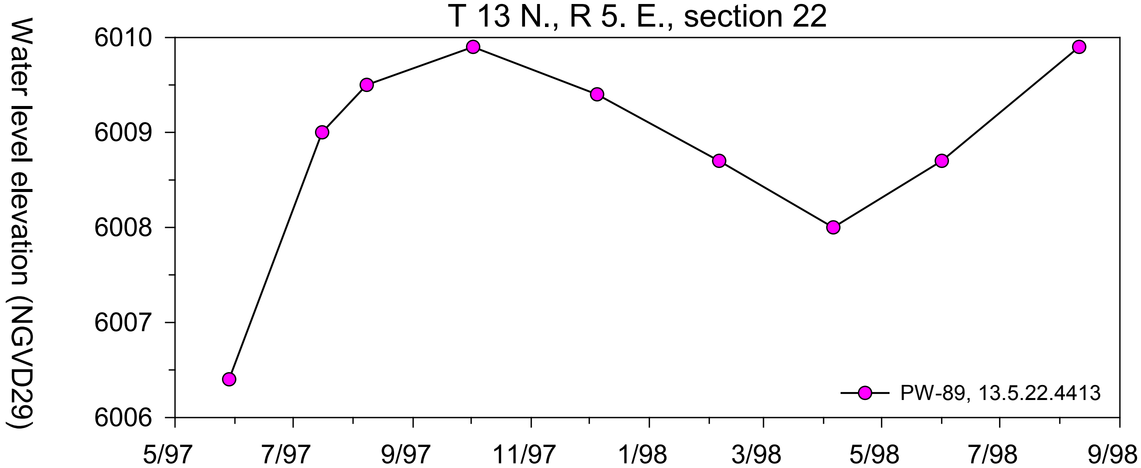


Figure E-9. Lower Santa Fe Fm near San Francisco Springs
T 13 N., R 5 E., section 22

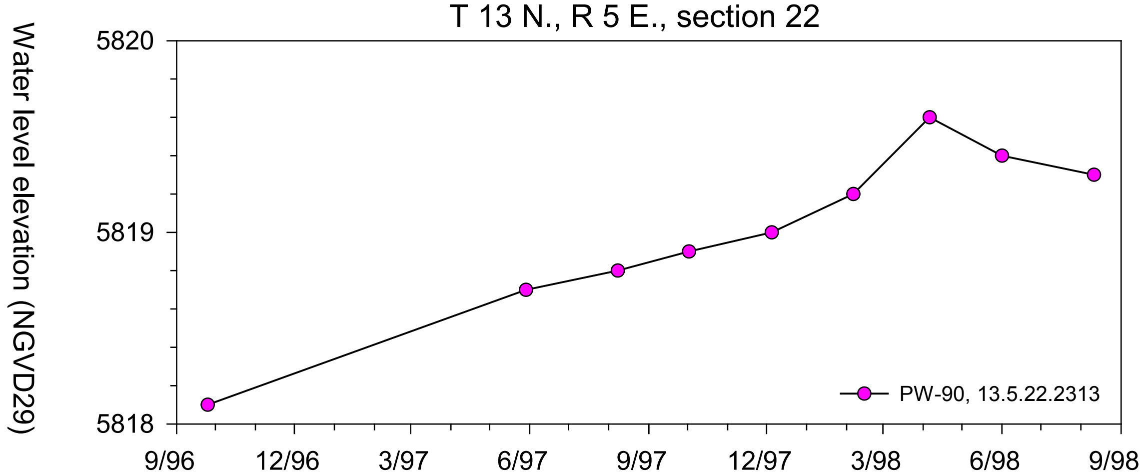


Figure E-10. Upper Madera Formation near San Francisco Springs
T 13 N., R 5 E., section 23

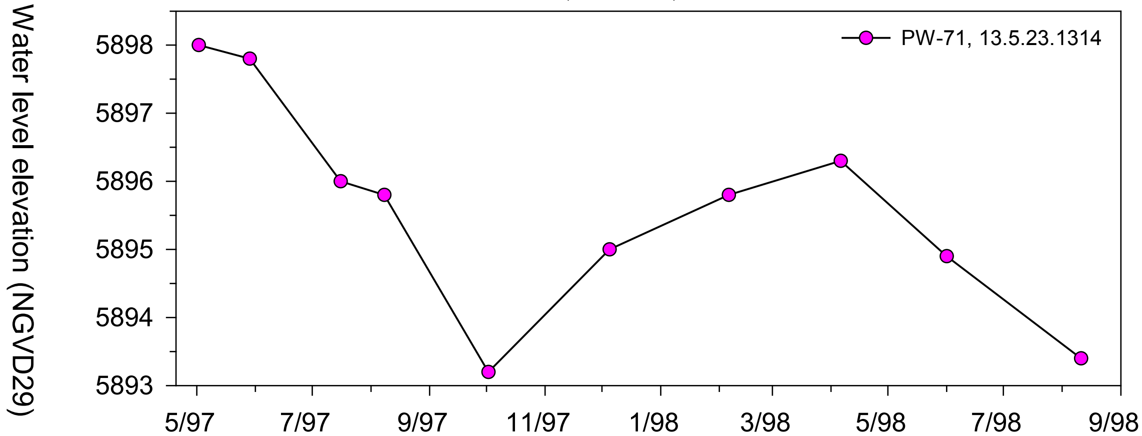


Figure E-11. Lower Abo Formation near San Francisco Springs
T 13 N., R 5 E., section 23

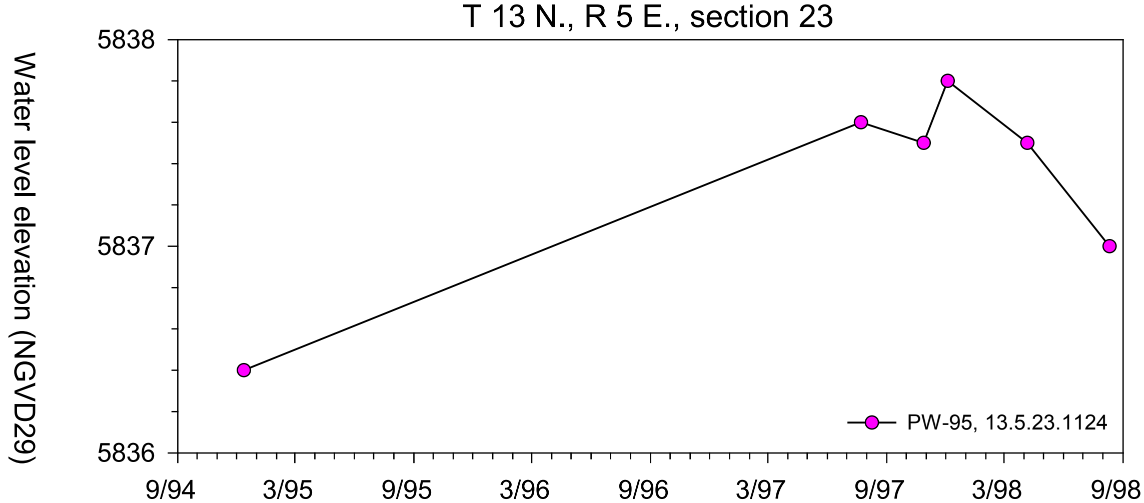


Figure E-12. Upper Santa Fe Piedmont, Indian Flats
T 13 N., R 5 E., section 16

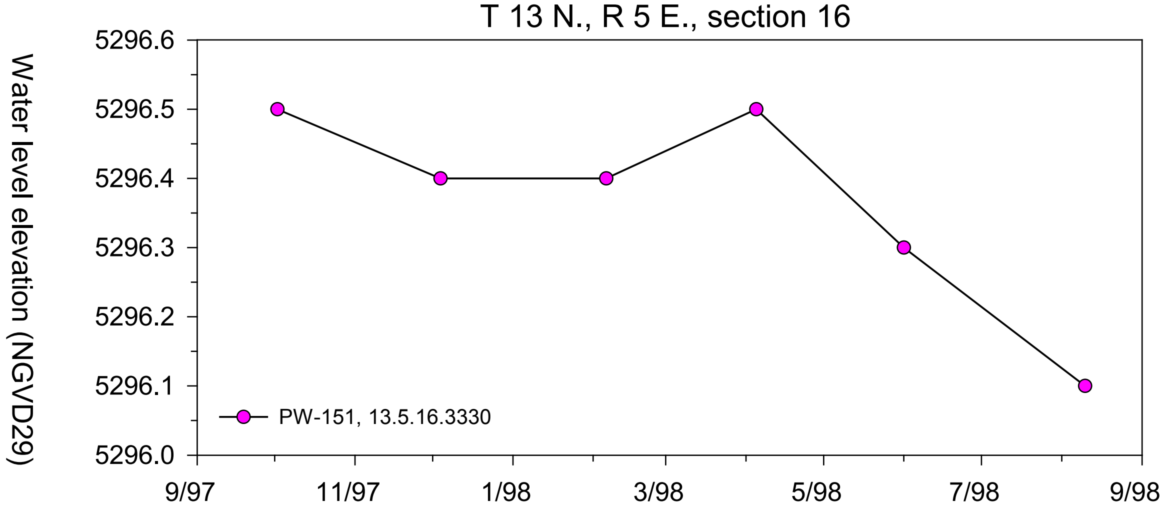


Figure E-13. Petrified Forest and Lower Mancos Formations, Tunnel Springs T 12 N., R 5 E., section 6

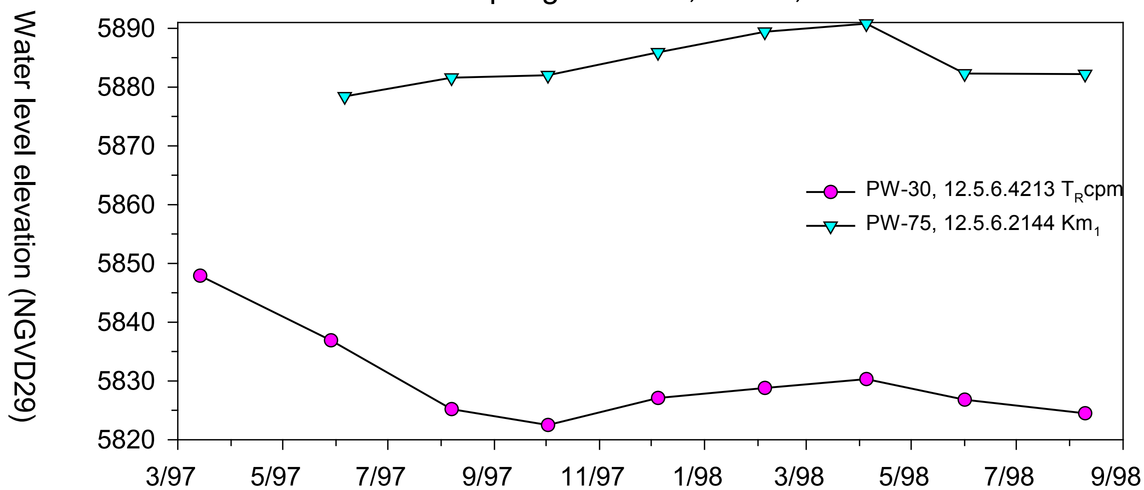


Figure E-14. Petrified Forest Formation near Tunnel Springs T 12 N., R 5 E., section 6

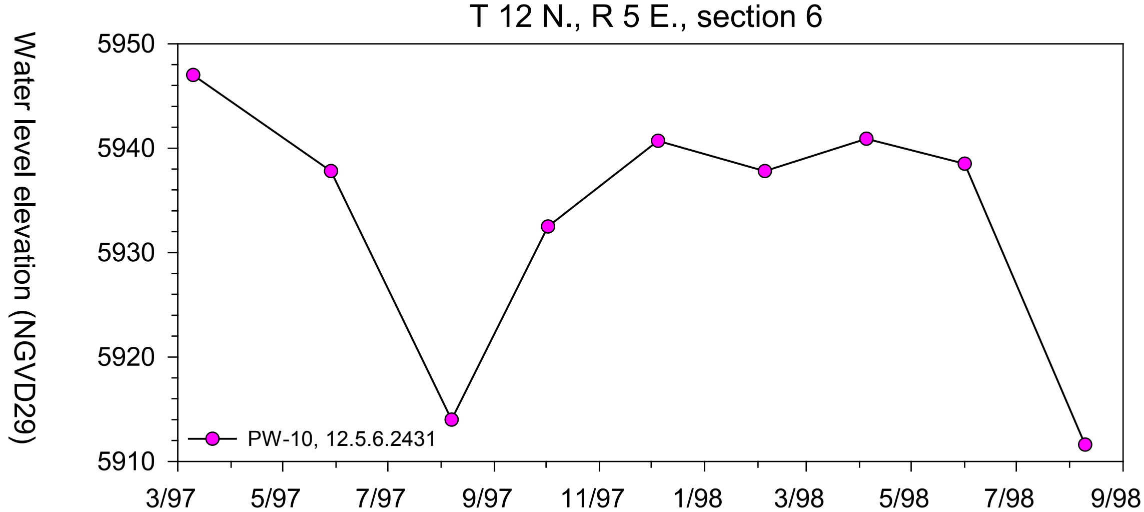


Figure E-15. Petrified Forest Formation at La Puerta T 12 N., R 5 E., section 6

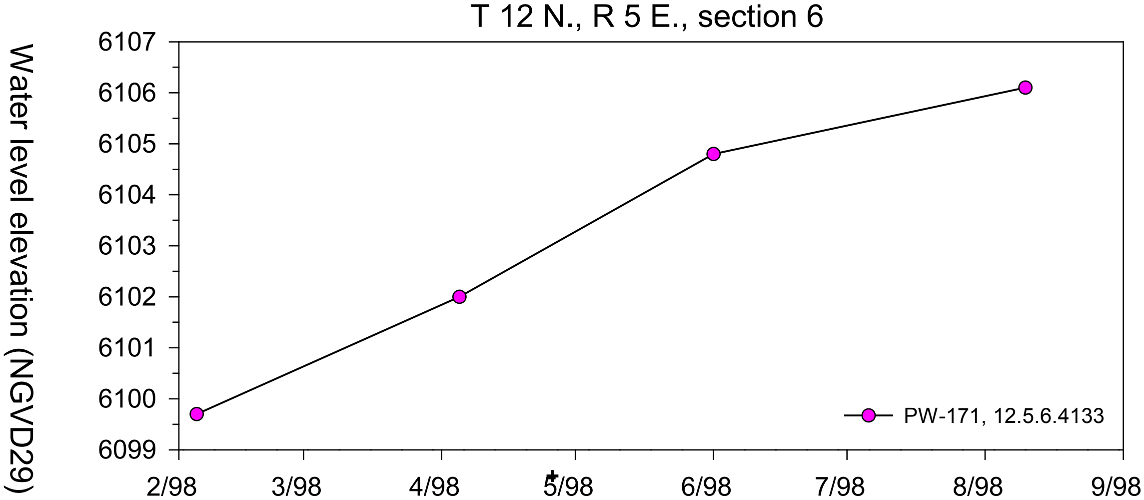


Figure E-16. Cretaceous Menefee and Lower Mancos Formations, Quail Meadows
T 13 N., R 5 E., section 31 and T 12 N., R 5 E., section 6

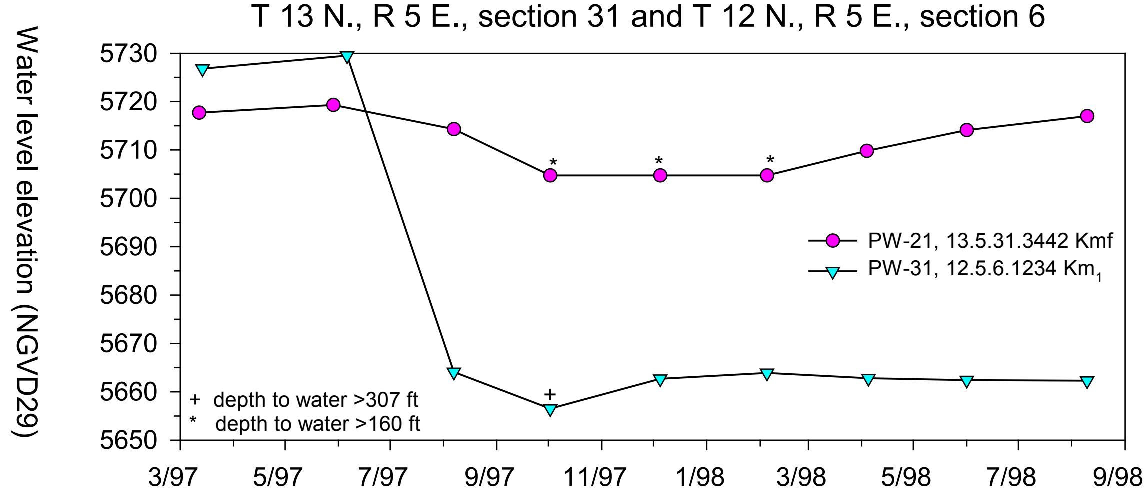


Figure E-17. Cretaceous Menefee Formation, Lomas de Placitas
T 13 N., R 5 E., section 29

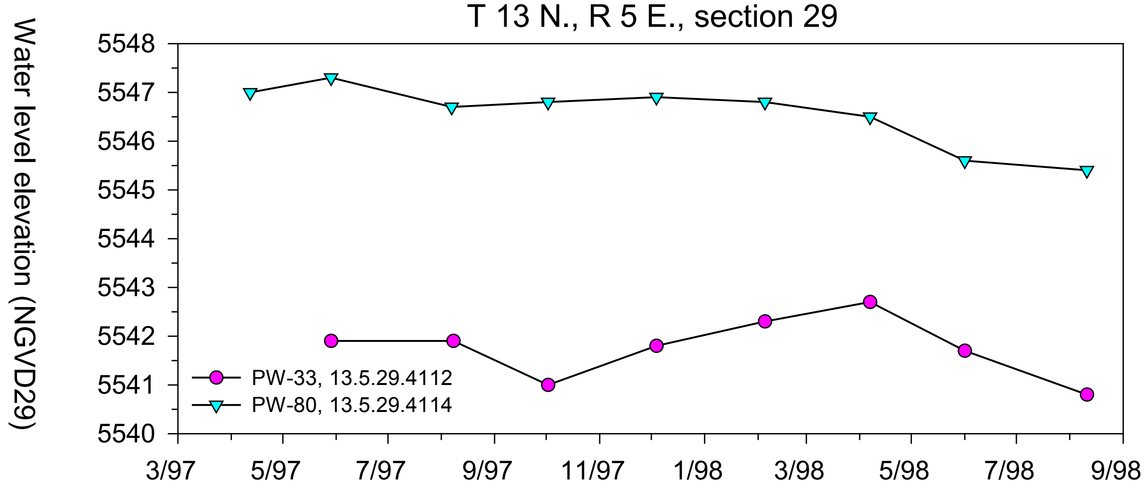


Figure E-18. Cretaceous Hosta Dalton and Upper Mancos Formations
T 13 N., R 5 E., section 32

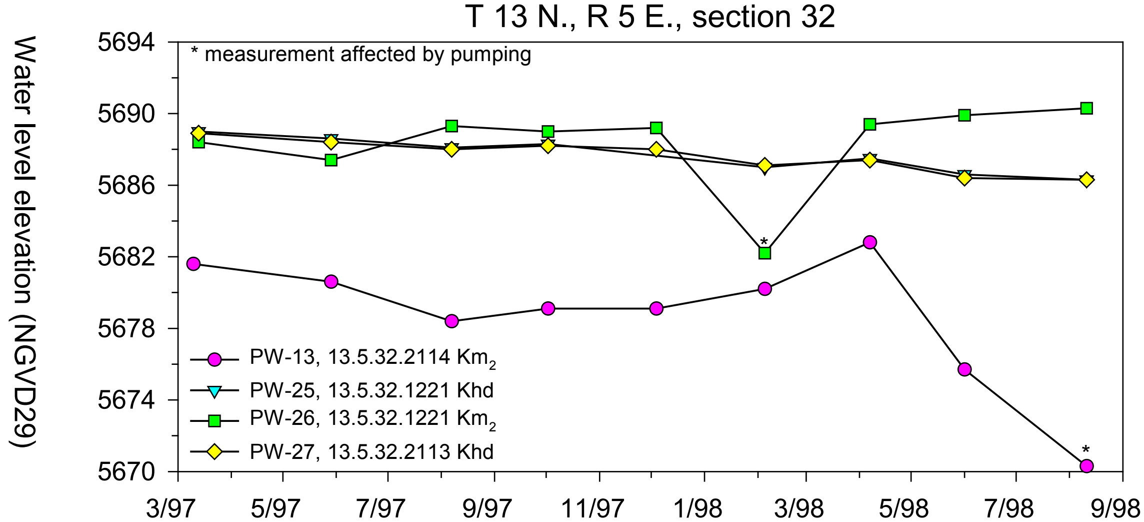


Figure E-19. Jurassic Morrison Formation in Rainbow Valley
T 12 N., R 4 E., section 1

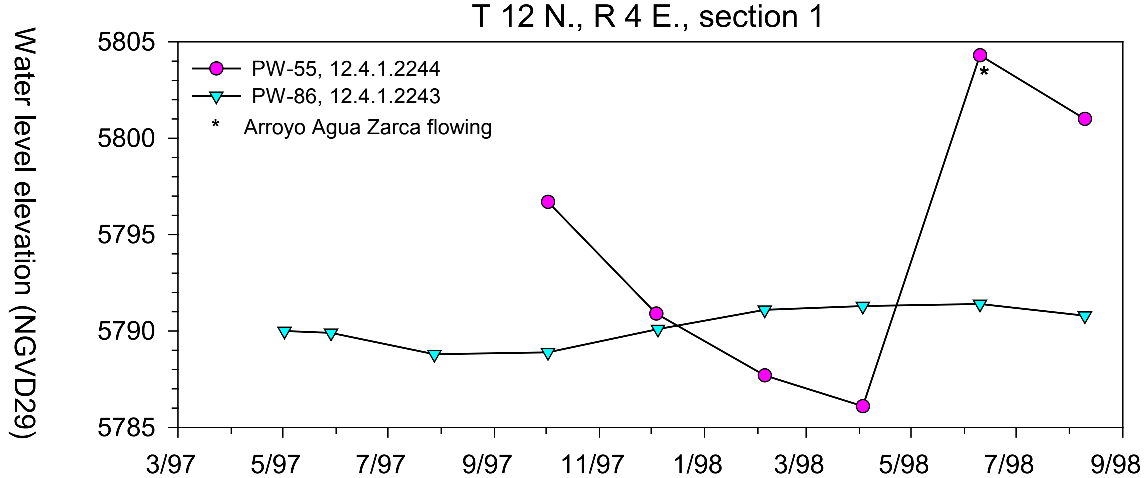


Figure E-20. Jurassic Morrison Formation in Rainbow Valley
T 12 N., R 4 E., section 1

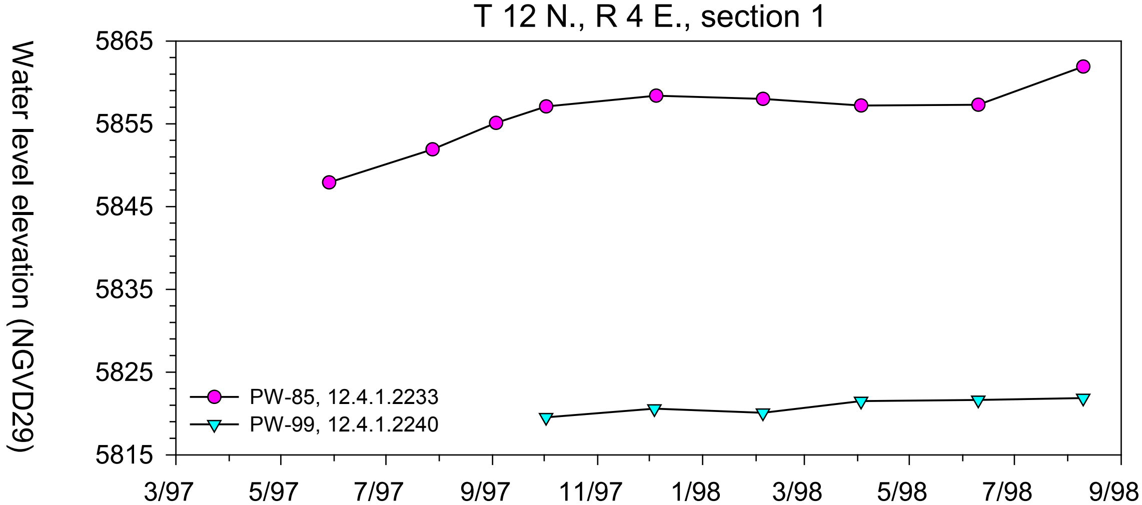


Figure E-21. Cretaceous Lower Mancos Formation in Rainbow Valley
T 13 N., R 4 E., section 36

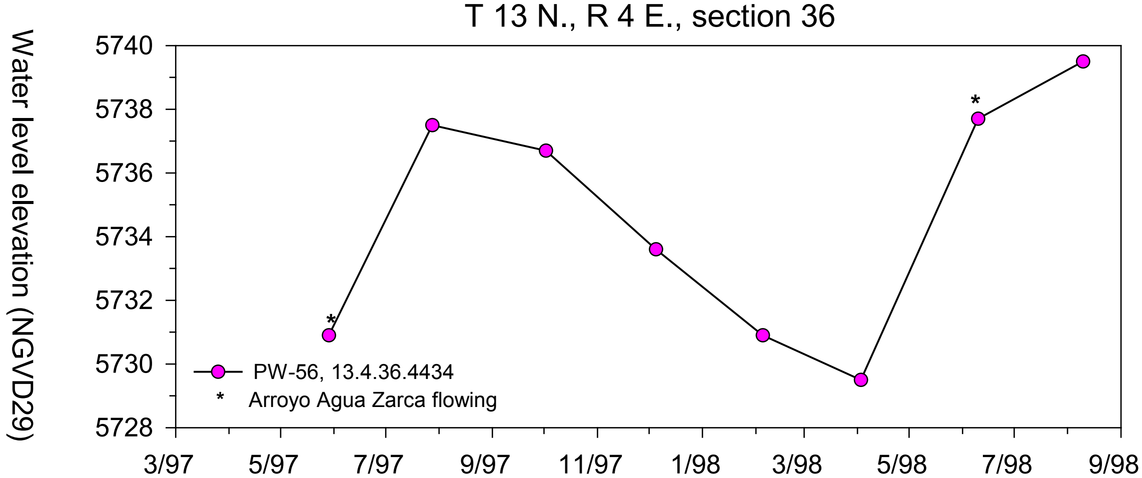


Figure E-22. Triassic Petrified Forest Formation, Placitas Heights
T 12 N., R 5 E., section 5

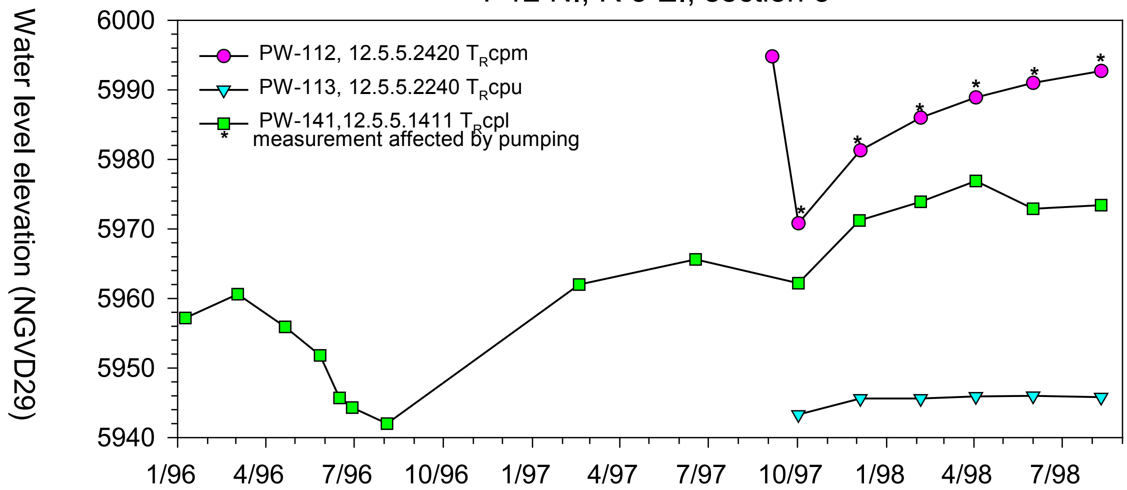


Figure E-23. Petrified Forest, Morrison, and Lower Mancos Formations
Vista de Placitas, T 12 N., R 5 E., sections 5 and 6

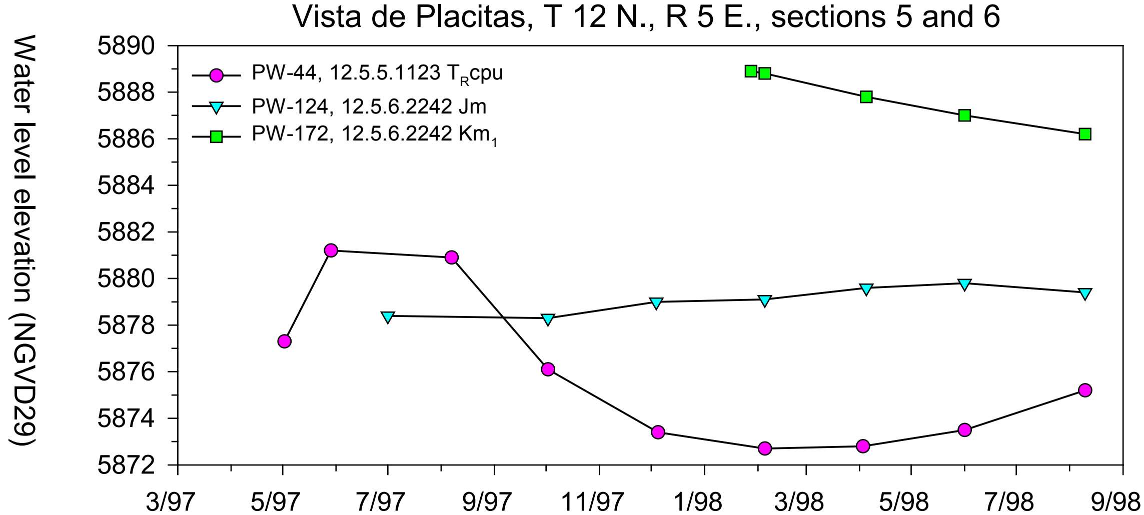
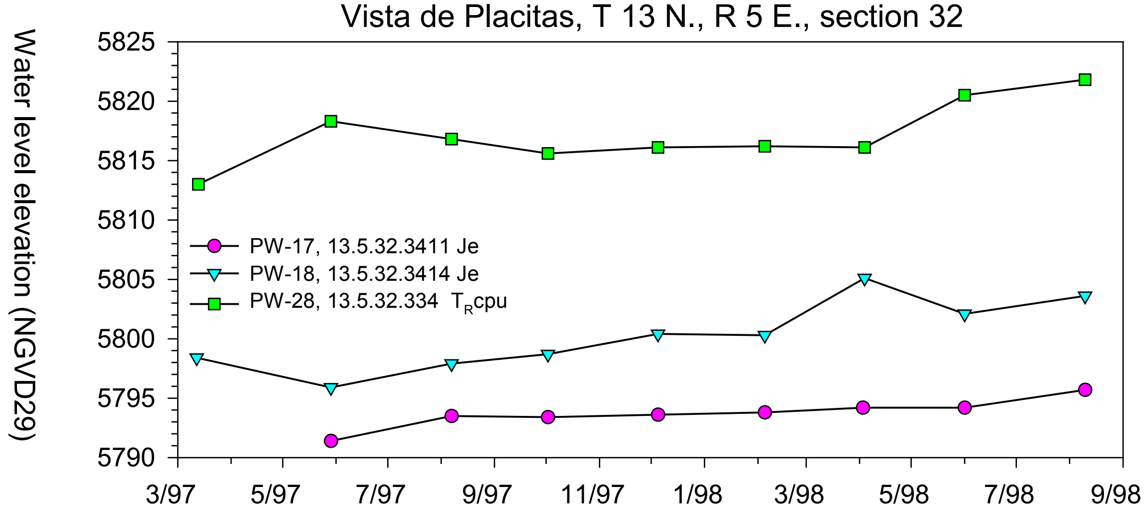


Figure E-24. Entrada and Upper Petrified Forest Formations,
Vista de Placitas, T 13 N., R 5 E., section 32



APPENDIX F

Major Ion Geochemistry

Appendix F. Major ion geochemistry of ground water and surface water.

Site ID	Sample Date	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	HCO_3^{-} ppm	CO_3^{2-} ppm	Cl^{-} ppm	SO_4^{2-} ppm	NO_3^{-} ppm
PS-01	4/26/96	88	6.1	5	1	270	nd	11	16	2
PS-02	4/26/96	83	5.5	4	0.85	260	nd	13	13	1.4
PS-03	4/26/96	88	5.9	5	0.9	260	nd	17	19	1.8
PS-03	4/26/96	87	5.9	5.1	0.85	260	nd	17	21	1.5
PS-04	4/26/96	96	7	7.5	0.75	270	nd	23	27	2
PS-05	5/28/96	96	5.6	3.3	0.77	280	nd	12	21	1.4
PS-06	5/29/96	76	8.4	8.6	1.3	242	nd	7	29	<0.2
PS-07	5/30/96	58	8.4	32	1.8	260	nd	7.6	32	1.1
PS-08	5/30/96	75	9	19	0.67	246	nd	16	38	2.8
PS-09	5/15/98	85	6.2	3.1	0.6	278	nd	2.4	18	1.1
PS-10	7/17/97	82	9.6	40	2.8	332	nd	14	41	1.2
PS-11	7/23/97	77	11	32	2.2	318	nd	12	34	0.9
PS-17	9/10/97	73	9	32	1.9	300	nd	7.6	32	0.96
PS-19	2/13/98	200	46	110	1.8	340	nd	55	585	1
PSW-01	3/11/97	121	28	45	5.1	237	nd	43	252	<0.2
PSW-02	5/6/97	53	5.4	4	0.7	175	nd	2	20	<0.2
PSW-03	9/ 1/97	70	5	7	0.72	228	nd	13	10	1.2
PSW-04	9/13/97	91	8.1	13	0.8	290	nd	21	27	<0.2
PSW-05	9/13/97	37	8.2	20	1	137	nd	22	30	0.2
PSW-06	1/ 1/98	70	17	50	2.4	335	nd	12	70	0.51
PSW-07	1/ 1/98	92	10	21	0.9	315	nd	18	38	0.72
PW-001	4/26/96	150	39	30	2	400	nd	25	220	0.8
PW-002	5/28/96	85	17	12	3.8	280	nd	15.5	46	<0.2
PW-003	5/28/96	75	6.8	6.8	0.93	220	nd	19	16	3.6
PW-004	7/24/97	95	8	5	1	310	nd	13	15	0.64
PW-005	5/30/96	81	23	6.2	1.4	290	nd	6.2	61	0.27
PW-006	10/29/97	415	41	45	6.2	255	nd	<4.0	1100	2.5
PW-007	5/30/96	340	130	470	5.8	270	nd	230	1900	0.73
PW-008	5/30/96	86	7.6	9.8	0.9	270	nd	5.4	29	8.5
PW-009	7/3/96	64	6.3	41	2.6	220	nd	21	59	0.58
PW-012	12/19/97	118	18	20	1.2	370	nd	37	53	15
PW-012	12/19/97	82	18	21	1.2	275	nd	32	51	15

Appendix F. Major ion geochemistry of ground water and surface water.

Site ID	Sample Date	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	HCO_3^- ppm	CO_3^{2-} ppm	Cl^- ppm	SO_4^{2-} ppm	NO_3^- ppm
PW-014	7/16/97	12.5	5.1	778	3.3	573	nd	15.5	1152	<0.2
PW-016	1/ 3/98	180	160	550	7.1	215	nd	25	1980	0.4
PW-023*	3/29/93	na	na	461	na	na	na	na	1490	0.49
PW-023*	4/ 6/93	740	280	na	na	na	na	na	1550	2.8
PW-023*	4/23/93	830	270	na	na	na	na	na	2125	1.7
PW-024	8/ 4/97	78	7.1	16	0.64	254	nd	17	33	0.65
PW-030	8/11/97	1.2	0.6	200	2.3	405	na	23	82	2.46
PW-030	8/11/97	1.3	0.62	198	2.3	405	na	23	82	2.6
PW-039	8/25/97	160	12	76	2.8	285	nd	5	380	1
PW-041	11/18/97	327	58	69	5.1	325	nd	6.5	910	2.0
PW-043	7/18/97	12	2.2	455	3	475	nd	8	635	0.2
PW-044	7/18/97	38	11	152	1.8	361	nd	16	160	0.4
PW-045	7/18/97	96	19	36	6.1	315	nd	12	108	<0.2
PW-046	8/24/97	105	22	50	1.3	260	nd	45	190	3
PW-047	11/18/97	123	34	262	4.2	360	nd	38	640	2.72
PW-051	7/18/97	82	6.5	8	1.1	246	nd	14	18	5.5
PW-063	11/18/97	225	96	110	3.5	400	nd	60	800	<0.2
PW-071	7/16/97	65	40	49	4.5	405	nd	8	105	<0.2
PW-073	1/15/98	4.6	0.8	155	0.41	250	16	29	63	6.8
PW-077	7/16/97	80	15.4	53.8	2	335	nd	18	82	1.5
PW-078	8/ 4/97	395	62	415	16	271	nd	48	1730	0.65
PW-082	7/16/97	74	9.1	35	1.7	308	nd	12	38	1.2
PW-084	7/18/97	60	12	30	1.5	265	nd	8	36	1.2
PW-085	9/ 3/97	56	10	14	1.5	158	nd	7	65	0.25
PW-087	7/23/97	66	19	37	3.2	330	nd	10	35	<0.2
PW-089	7/16/97	73	12	34	2	318	nd	8	42	0.8
PW-090	8/ 3/97	82	8.3	37	1.4	329	nd	7.8	43	2.55
PW-091	9/ 4/97	71	15	44	2.6	310	nd	9.4	70	1.32
PW-094	7/24/97	86	19	38	1.8	300	nd	27	98	0.56
PW-095	10/28/97	69	61	230	9.3	588	nd	30	410	<0.2
PW-095*	12/19/94	57.5	42.9	192	12.6	na	nd	30.1	248	0.16
PW-096*	12/30/94	98.6	45.8	80	7.15	na	nd	39.6	300	0.31

Appendix F. Major ion geochemistry of ground water and surface water.

Site ID	Sample Date	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	HCO_3^{-} ppm	CO_3^{2-} ppm	Cl^{-} ppm	SO_4^{2-} ppm	NO_3^{-} ppm
PW-154	12/ 4/97	88	12	13	2.3	310	nd	20	20	7.5
PW-161	12/ 3/97	60	24	54	4.6	330	nd	11	90	1.26
PW-162	1/ 8/98	63	7.8	64	4.1	255	nd	37	74	1.5
PW-163	1/10/98	68	3.8	12	0.8	175	nd	15	44	3.5
PW-164	1/17/98	75	11	7.2	1.4	270	nd	6	15	12
PW-166	1/24/98	36	18	46	4.8	225	nd	4	70	2.3
PW-166*	4/30/96	34	16	78	4.2	242	<2.0	37.7	70.1	<0.2
PW-167	1/19/98	45	16	18	3.2	255	nd	4.2	25	0.65
PW-167	1/19/98	44	16	17	3.2	240	nd	3.8	20	3.8
PW-167*	5/1/89	26	17	39.5	4.8	216.5	<2.0	9.6	55.5	0.08
PW-169	1/19/98	96	14	26	1	230	nd	23	129	2.7
PW-173	1/24/98	61	4.6	45	3.4	225	nd	28	40	1
PW-179	1/24/98	49	11	19	1.6	210	nd	6	25	1.9
PW-184	1/23/98	111	27	26.5	1.5	210	nd	17	245	3.0
PW-186	2/ 4/98	40	12	112	5.3	215	nd	18	190	11
PW-186*	8/15/95	na	na	137	na	na	na	na	182	1.8
PW-191	2/17/98	38	18	26	3.1	250	nd	<3.0	30	1.2
PW-191*	2/ 5/97	43	19	21	3.4	250	nd	<10	37	<0.1
PW-192*	2/ 5/97	53	13	12	2.1	243	nd	<10	21	0.1
PW-197	1/23/98	38	7.8	43	13	200	nd	25	30	4.2
PW-198	1/23/98	41	4.5	65	13	198	nd	51	33	1.6
PW-202	1/23/98	94	17	21	1.5	235	nd	12	127	1.9
PW-203	2/12/98	70	6.2	16	0.7	235	nd	10	35	2
PW-204	2/12/98	58	4.9	45	3.7	260	nd	18	36	1.7
PW-205	2/13/98	33	4	49	11	215	nd	18	20	2.9
PW-205*	12/23/96	50.5	3.8	55.9	10	163	nd	28	33.9	0.5
PW-206*	8/ 5/96	61	7.41	41.7	1.18	na	nd	7.27	38.7	0.62
PW-211#	8/23/96	61.1	6.5	14.7	1.8	na	nd	3.5	31.3	0.27
PW-212*	8/-/93	427	103	311	na	334	nd	23	2180	0.03
PW-213*	12/23/96	82.8	6.4	52.7	5.8	220	<2.0	24.6	48.4	.3
PW-214*	12/5/96	88	12	23	na	na	nd	19	74	0.5
PW-215^	8/23/96	65.2	4.79	44.1	4.5	na	nd	22.8	42.6	0.35

Appendix F. Major ion geochemistry of ground water and surface water.

Site ID	Sample Date	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	HCO_3^- ppm	CO_3^{2-} ppm	Cl^- ppm	SO_4^{2-} ppm	NO_3^- ppm
PW-097	7/25/97	74	10	22	1	285	nd	10	32	1.4
PW-099	7/25/97	74	16	146	4.1	258	nd	11	321	0.83
PW-100	9/ 4/97	81	5.7	9	1	270	nd	12	10	2.3
PW-101	9/ 1/97	86	5.1	7	0.82	275	nd	14	12	1
PW-103	8/22/97	21	8.5	1273	6.1	741	nd	138	1990	4
PW-107	8/12/97	111	30	102	2	353	nd	110	182	1.4
PW-108	8/12/97	76	6.4	19	0.64	250	nd	14	39	1.1
PW-109	8/12/97	146	35	73	2.3	331	nd	24.3	359	1.1
PW-110	8/12/97	65	9	36	1.5	294	nd	3	40	2.44
PW-112	9/ 5/97	57	13	665	8.9	380	nd	13	1310	1.5
PW-113	9/ 5/97	386	46	1445	6.3	71	nd	118	3910	0.96
PW-116*	5/13/83	125	11.7	39	3.48	386	<1.0	13.5	61	na
PW-118*	11/14/94	35.9	48.9	65	8.33	na	nd	51.8	55	0.99
PW-119	10/28/97	50	41	94	5.2	410	nd	24	135	3.2
PW-119	10/28/97	49	42	91	5.2	414	nd	23	130	3.8
PW-119*	11/28/94	42.5	36.1	47.7	6.9	na	nd	22.5	121	0.59
PW-119*	10/16/96	55	41	85	6	340	nd	23	140	0.9
PW-120*	1/25/95	56.8	35.5	37.5	5.83	na	nd	24.6	17.9	1.34
PW-122	8/30/97	21	5.2	230	6.2	412	nd	<4.0	255	0.4
PW-126	9/15/97	403	10	19	1.9	239	nd	12	865	<0.2
PW-130	8/23/97	86	22	24	1.7	340	nd	11	74	1.3
PW-131	7/21/97	94	21	31	1.6	230	nd	25	170	0.8
PW-132	8/21/97	55	7	40	2.6	225	nd	22	48	0.35
PW-135	8/31/97	56	11	23	3.2	230	nd	<4.0	53	0.75
PW-137	9/10/97	36	19	30	3.7	255	nd	<4.0	29	<0.2
PW-142	8/26/97	46	7.5	26	1.8	210	nd	7	25	2
PW-143	8/25/97	24	14.4	105	3.4	185	nd	28	165	<0.2
PW-145	9/ 1/97	79	28	4.5	1.2	314	nd	<4.0	72	0.25
PW-147	1/ 8/98	178	43	122	1.8	345	nd	65	520	1.7
PW-149	9/13/97	39	17	221	3	260	nd	20	396	<0.2
PW-150	9/15/97	35	9.3	64	2.5	190	nd	12	89	2.6
PW-152	9/17/97	77	6.4	15	0.65	224	nd	19	38	0.88

Appendix F. Major ion geochemistry of ground water and surface water.

Site ID	Sample Date	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	HCO_3^{-} ppm	CO_3^{2-} ppm	Cl^{-} ppm	SO_4^{2-} ppm	NO_3^{-} ppm
PW-216^	8/17/96	60.7	13.4	31.6	2	na	nd	7.53	35.9	0.26
PW-217*	9/6/89	47.4	3.55	16.4	na	237	<1.0	12.1	24	0.49
PW-218^	6/19/97	74.3	4.31	10.4	1.31	na	nd	7.5	58.4	0.75

nd = CO_3^{-2} not determined (pH < 8.3)
na = cation/anion not analyzed
<## = analyte not detected; value reflects the detection limit for the instrument
* = results provided by well owner from independent laboratory
^ = results provided by U. S. Geological Survey (N.Plummer, unpubl. 1997)

APPENDIX G

Stable Isotope Geochemistry
And Field Parameters

Appendix G. Stable isotope geochemistry and field parameters for ground water and surface water.

Site ID	Sample Date	δ^2H $^O/oo$	$\delta^{18}O$ $^O/oo$	Temp ^oC (field)	DO ppm (field)	pH (field)	Sp. Cond µS/cm (field)	pH (lab)	Cond µmhos/cm^2 (lab)	TDS ppm	Hardness ppm
PS-01	4/26/96	-87	-11.9	15.5	na	7.3	383	7.3	420	276	245
PS-02	4/26/96	-89	-12.0	15.5	na	7.1	367	7.3	400	263	230
PS-03	4/26/96	-91	-12.1	15.5	na	7.1	386	7.3	430	279	244
PS-03	4/26/96	-93	na	15.5	na	7.1	386	7.3	420	280	242
PS-04	4/26/96	-90	-12.1	12.5	na	7.2	393	7.5	460	310	269
PS-05	5/28/96	-90	-12.1	12.9	na	7.1	412	7.41	430	291	263
PS-06	5/29/96	-80	-11.3	14.0	na	7.5	402	7.4	400	264	224
PS-07	5/30/96	-93	-11.9	19.9	na	8.1	468	8.3	450	285	179
PS-08	5/30/96	-95	-12.1	17.3	na	8.1	500	8.1	500	297	224
PS-09	5/15/98	-93	-12.2	16.7	5.2	7.8	417	na	na	260	238
PS-10	7/17/97	-90	-11.8	23.5	2.5	7.2	581	na	550	360	244
PS-10	5/ 1/98	na	na	23.4	2.4	7.2	582	na	na	na	na
PS-11	7/23/97	-90	-11.8	22.1	1.8	7.2	559	na	440	330	238
PS-17	9/10/97	-90	-11.5	na	2.8	7.2	559	na	na	320	219
PS-19	2/13/98	-83	-11.7	13.2	5.4	6.9	1740	6.9	1740	1170	689
PSW-01	3/11/97	-92	-11.5	na	na	na	na	8.0	800	630	417
PSW-02	5/6/97	-87	-11.8	na	na	na	na	7.9	270	170	155
PSW-03	9/ 1/97	-93	-11.7	13.9	6.1	8.4	419	na	350	230	195
PSW-04	9/13/97	-90	-12.0	20.9	4.7	7.9	560	na	na	310	261
PSW-05	9/13/97	-83	-10.4	28.8	5.6	8.6	352	na	na	190	126
PSW-06	1/ 1/98	-89	-11.7	2.6	8.6	8.3	696	7.7	620	410	245
PSW-07	1/ 1/98	-93	-12.1	10.2	5.4	7.3	607	7.3	550	340	271
PW-001	4/26/96	-90	-11.3	11.7	na	7.2	767	7.1	990	695	535
PW-002	5/28/96	-89	-11.9	16.5	na	7.3	529	7.2	550	334	282
PW-003	5/28/96	-93	-11.8	15.6	na	7.6	397	7.3	410	249	215
PW-004	7/24/97	-93	-11.6	16.1	7.2	7.3	520	na	420	290	270
PW-005	5/30/96	na	na	20.2	na	7.2	564	7.3	500	336	297
PW-005	4/27/98	-89	-12.2	14.1	2.4	7.4	574	na	na	na	na
PW-006	10/29/97	-82	-11.9	13.6	2.3	7.0	2180	7.4	1500	1740	1205
PW-007	5/30/96	-84	-11.8	16.4	na	7.3	3280	7.2	3250	3229	1384
PW-008	5/30/96	-90	-12.1	16.4	na	7.5	457	7.4	450	297	246
PW-009	7/3/96	-91	-12.4	23.8	na	8.1	789	7.5	500	300	186
PW-012	12/19/97	-85	-11.8	12.5	3.4	7.3	833	6.9	750	450	369
PW-012	12/19/97	-85	-11.7	12.5	3.4	7.3	833	7.1	690	360	279

Appendix G. Stable isotope geochemistry and field parameters for ground water and surface water.

Site ID	Sample Date	δ^2H $^O/oo$	$\delta^{18}O$ $^O/oo$	Temp °C (field)	DO ppm (field)	pH (field)	Sp. Cond µS/cm (field)	pH (lab)	Cond µmhos/cm^2 (lab)	TDS ppm	Hardness ppm
PW-014	7/16/97	-95	-12.6	18.1	0.7	8.1	3610	na	3000	2250	52
PW-016	1/ 3/98	-92	-12.7	17.0	1.0	7.3	4210	7.1	3700	3010	1108
PW-023*	4/ 6/93	na	na	na	na	na	na	9	na	1631	1020
PW-023*	4/23/93	na	na	na	na	na	na	8.2	na	1641	1100
PW-024	8/ 4/97	-92	-11.4	17.1	10.8	7.7	490	na	430	280	224
PW-030	8/11/97	-97	-12.5	17.9	1.5	8.9	857	na	780	510	5
PW-030	8/11/97	na	na	17.9	1.5	8.9	857	na	760	520	6
PW-039	8/25/97	-99	-12.5	14.9	1.0	7.5	1153	na	na	780	449
PW-039	5/ 5/98	na	na	14.5	0.6	7.4	1175	na	na	na	na
PW-041	11/18/97	-96	-12.0	17.0	2.1	6.9	2000	6.7	1850	1540	1055
PW-041	4/27/98	na	na	17.6	0.3	6.8	2010	na	na	na	na
PW-043	7/18/97	-97	-13.1	25.1	1.3	8.4	2150	na	2000	1350	39
PW-044	7/18/97	-88	-11.5	17.3	3.0	7.8	895	na	850	560	140
PW-045	7/18/97	-91	-12.0	20.1	3.2	7.3	705	na	650	440	318
PW-046	8/24/97	-97	-12.0	17.5	6.2	7.6	899	na	na	560	353
PW-047	11/18/97	-97	-11.9	13.3	2.6	7.2	2010	7.2	1800	1280	447
PW-051	7/18/97	-93	-12.5	14.9	6.5	7.5	484	na	440	260	232
PW-063	11/18/97	-95	-11.9	16.0	1.9	6.9	2070	6.8	1900	1490	957
PW-071	7/16/97	-96	-12.3	18.4	1.2	7.4	786	na	700	470	327
PW-071	4/28/98	na	na	17.5	0.6	7.3	801	na	na	na	na
PW-073	1/15/98	-90	-11.4	15.1	4.1	8.8	773	8.9	680	390	15
PW-073	4/27/98	na	na	16.1	5.3	8.9	774	na	na	na	na
PW-077	7/16/97	-87	-11.7	16.2	4.4	7.4	745	na	600	420	263
PW-078	8/ 4/97	-98	-12.2	19.0	4.4	7.2	3360	na	2900	2800	1242
PW-082	7/16/97	-89	-12.2	17.2	4.4	7.3	560	na	460	330	222
PW-084	7/18/97	-85	-11.1	18.7	6.4	7.4	492	na	460	280	199
PW-085	9/ 3/97	-90	-11.6	16.9	1.2	7.3	578	na	470	230	181
PW-087	7/23/97	-84	-11.3	20.3	2.1	7.5	573	na	470	340	243
PW-089	7/16/97	-91	-12.2	18.8	2.1	7.3	559	na	450	330	232
PW-089	4/30/98	na	na	18.6	1.5	7.2	558	na	na	na	na
PW-090	8/ 3/97	-92	-12.2	16.8	8.0	7.4	562	na	500	350	239
PW-091	9/ 4/97	-94	-11.2	18.1	3.2	7.4	664	na	na	370	239
PW-094	7/24/97	-91	-12.5	17.6	4.7	7.5	647	na	550	420	293
PW-095	10/28/97	-106	-12.7	15.7	1.8	7.4	1715	7.2	1980	1100	423

Appendix G. Stable isotope geochemistry and field parameters for ground water and surface water.

Site ID	Sample Date	δ^2H $^O/oo$	$\delta^{18}O$ $^O/oo$	Temp ^oC (field)	DO ppm (field)	pH (field)	Sp. Cond µS/cm (field)	pH (lab)	Cond µmhos/cm^2 (lab)	TDS ppm	Hardness ppm
PW-095*	12/20/94	na	na	na	na	7.2	2500	7.2	2500	na	na
PW-096*	12/30/94	na	na	na	na	6.8	1760	6.9	1760	na	na
PW-097	7/25/97	-92	-11.4	17.5	5.6	7.4	542	na	490	290	226
PW-099	7/25/97	-91	-12.0	17.1	1.1	8.0	1106	na	900	700	251
PW-100	9/ 4/97	-95	-11.6	13.6	6.9	7.5	486	na	na	260	226
PW-101	9/ 1/97	-93	-11.7	13.9	5.7	7.4	481	na	400	270	236
PW-103	8/22/97	-104	-12.5	21.0	2.8	8.0	5710	na	na	3820	87
PW-103	5/14/98	na	na	16.8	1.7	8.0	5700	na	na	na	na
PW-107	8/12/97	-96	-12.3	16.0	5.8	7.6	1188	na	na	720	401
PW-108	8/12/97	-95	-11.9	17.6	7.0	7.5	524	na	na	280	216
PW-109	8/12/97	-91	-12.1	16.9	2.2	7.4	1197	na	na	810	509
PW-109	4/28/98	na	na	16.7	0.6	7.2	1229	na	na	na	na
PW-110	8/12/97	-86	-12.1	16.4	4.6	7.4	551	na	na	300	199
PW-112	9/ 5/97	-97	-12.4	18.0	1.6	7.9	3220	na	na	2260	196
PW-113	9/ 5/97	-98	-12.8	17.1	1.9	8.1	6860	na	na	5950	1153
PW-116*	5/13/83	na	na	na	na	na	na	7.3	730	488	360
PW-118*	11/11/94	na	na	na	na	7.3	1280	7.3	1280	na	na
PW-119	10/28/97	-96	-10.4	17.4	1.6	7.3	944	7.1	880	560	294
PW-119	10/28/97	-94	-10.5	17.4	1.6	7.3	944	7.1	890	550	295
PW-119*	11/28/94	na	na	na	na	6.9	1140	6.9	1140	na	na
PW-120*	1/30/95	na	na	na	na	7.2	1130	7.2	1130	na	na
PW-122	8/30/97	-91	-12.1	16.4	2.0	8.0	1186	na	1000	740	74
PW-126	9/15/97	-92	-11.9	17.1	1.6	7.0	1794	na	na	1430	1048
PW-130	8/23/97	-92	-11.8	19.2	5.4	7.3	689	na	652	420	305
PW-131	7/21/97	-87	-11.4	16.4	5.9	7.6	775	na	722	460	321
PW-132	8/21/97	-96	-12.4	21.9	4.0	7.5	507	na	472	290	166
PW-135	8/31/97	-89	-11.2	22.1	4.2	7.7	453	na	380	260	185
PW-137	9/10/97	-89	-11.7	21.3	5.2	7.7	466	na	na	270	168
PW-142	8/26/97	-92	-12.1	20.3	5.1	7.7	390	na	366	220	146
PW-143	8/25/97	-117	-13.6	18.5	0.5	8.1	747	na	679	460	119
PW-143	4/28/98	na	na	18.5	3.4	7.9	757	na	na	na	na
PW-145	9/ 1/97	-94	-12.6	18.6	1.4	7.3	607	na	550	350	313
PW-147	1/ 8/98	-89	-11.3	8.7	5.3	7.0	1740	7.2	1600	1100	622
PW-149	9/13/97	-113	-14.3	19.5	1.4	7.9	1355	na	na	850	167

Appendix G. Stable isotope geochemistry and field parameters for ground water and surface water.

Site ID	Sample Date	δ^2H $^O/oo$	$\delta^{18}O$ $^O/oo$	Temp ^oC (field)	DO ppm (field)	pH (field)	Sp. Cond µS/cm (field)	pH (lab)	Cond µmhos/cm^2 (lab)	TDS ppm	Hardness ppm
PW-149	4/29/98	na	na	19.9	0.7	7.6	1356	na	na	na	na
PW-150	9/15/97	-91	-12.0	18.3	4.3	7.9	565	na	na	310	126
PW-152	9/17/97	-90	-11.7	15.1	6.8	7.6	482	na	na	270	219
PW-154	12/ 4/97	-93	-12.1	13.1	4.3	7.3	565	7.3	565	320	269
PW-161	12/ 3/97	-88	-12.1	16.2	2.0	7.4	675	7.5	675	410	249
PW-162	1/ 8/98	-97	-12.4	23.1	1.9	7.2	709	7.1	700	380	189
PW-163	1/10/98	-90	-11.7	14.2	7.2	7.4	442	7.2	410	230	185
PW-163	5/ 3/98	na	na	15.9	7.8	7.6	441	na	na	na	na
PW-164	1/17/98	-96	-12.5	13.1	5.8	7.4	467	7.1	410	260	233
PW-166	1/24/98	-89	-11.8	18.8	3.8	7.5	542	7.5	542	290	164
PW-167	1/19/98	-94	-11.7	18.5	5.0	7.5	431	7.3	390	240	178
PW-167	1/19/98	-96	na	18.5	5.0	7.5	431	7.3	400	230	176
PW-169	1/19/98	-91	-11.5	15.6	8.5	7.4	722	7.1	650	410	297
PW-173	1/24/98	-104	-12.7	21.4	2.2	7.2	570	7.3	570	290	171
PW-179	1/24/98	-89	-11.6	20.2	2.7	7.3	421	7.3	421	220	168
PW-184	1/23/98	-91	-11.2	16.8	5.5	7.3	911	7.3	911	530	388
PW-186	2/ 4/98	-91	-10.5	14.6	6.0	7.8	874	7.8	874	500	149
PW-191	2/17/98	-91	-12.2	19.0	4.9	7.5	453	7.5	453	240	169
PW-191*	2/5/97	na	na	na	na	na	na	8	470	288	186
PW-192*	2/5/97	na	na	na	na	na	na	8	423	260	186
PW-197	1/23/98	-99	-12.3	24.7	1.6	7.5	516	7.5	516	260	127
PW-198	1/23/98	-98	-12.5	25.6	2.1	7.3	610	7.3	610	310	121
PW-202	1/23/98	-86	-11.1	16.2	6.0	7.3	703	7.3	703	390	305
PW-203	2/12/98	-92	-11.6	15.1	5.7	7.2	474	7.2	474	270	200
PW-204	2/12/98	-95	-12.2	25.5	3.0	7.4	554	7.4	554	300	165
PW-205	2/13/98	-93	-11.9	24.7	5.4	7.4	469	7.4	469	250	99
PW-205*	12/23/96	na	na	na	na	na	na	7.8	481	234	142
PW-206*	8/5/96	na	na	na	na	na	na	7.4	588	345	183
PW-211^	8/23/96	-82	-11.5	20.6	4.3	7.5	385	na	na	na	na
PW-212*	2/1/94	na	na	na	na	na	na	7	3800	3140	na
PW-213*	12/23/96	na	na	na	na	na	na	7.6	586	268	233
PW-214*	12/5/96	na	na	na	na	na	na	na	640	400	220
PW-215^	8/23/96	-90	-12.6	25.6	1.9	7.3	543	na	na	na	na
PW-216^	8/17/96	-84	-12.0	17.4	6.8	7.1	490	na	na	na	na

Appendix H. Trace element geochemistry of ground water and surface water.

Site ID	Sample Date	SiO_2 ppm	As ppb	Cu ppb	F ppm	Fe ppb	Mn ppb	Zn ppb	Al ppm	Ba ppb	Cd ppb	Cr ppb	Pb ppb	Mo ppb
PS-01	4/26/96	12	<10	<2	0.3	22	<2	<10	<0.1	<10	<20	<1.0	<1.0	<10
PS-02	4/26/96	12	<10	<2	0.3	15	<2	<10	<0.1	<10	<20	<1.0	<1.0	<10
PS-03	4/26/96	11	<10	<2	0.3	26	<2	<10	<0.1	<10	<20	<1.0	<1.0	<10
PS-03	4/26/96	11	<10	<2	0.3	20	<2	<10	<0.1	<10	<20	<1.0	<1.0	<10
PS-04	4/26/96	11	<10	<2	0.35	23	<2	<10	<0.1	<10	<20	<1.0	<1.0	<10
PS-05	5/28/96	10	<10	<0.5	0.45	<2	<1.0	<20	<0.1	na	<20	<2.5	<5	<10
PS-06	5/29/96	13	<10	<0.2	<0.2	4	<1.0	<20	<0.1	na	<20	<2.5	<5	<10
PS-07	5/30/96	13	<10	<0.2	0.82	19	<1.0	<20	<0.1	na	<20	<2.5	<5	<10
PS-08	5/30/96	13	<10	1	0.33	8	<1.0	<20	<0.1	na	<20	<2.5	<5	<10
PS-09	5/15/98	15	12	7	0.4	83	240	<10	na	na	na	na	na	na
PS-10	7/17/87	15	<3	1.6	1.0	<30	<2	<20	na	na	na	na	na	na
PS-11	7/23/97	14	<3	3	0.8	<30	7	90	na	na	na	na	na	na
PS-17	9/10/97	16	3.5	<3	0.65	102	3.3	<10	na	na	na	na	na	na
PS-19	2/13/98	21	<3	<2	0.36	49	9	<10	na	na	na	na	na	na
PSW-01	3/11/97	15	<10	<6	0.25	66	9.9	<10	na	na	na	na	na	na
PSW-02	5/6/97	12	<5	<6	0.32	<50	<30	<10	na	na	na	na	<3	na
PSW-03	9/ 1/97	11	<5	4.2	0.3	<30	9	<10	na	na	na	na	na	na
PSW-04	9/13/97	14	<4	<3	0.32	18	17	<10	na	na	na	na	na	na
PSW-05	9/13/97	16	<4	3.6	0.38	50	3.3	<10	na	na	na	na	na	na
PSW-06	1/ 1/98	15	<3	<1.0	0.9	57	62	<10	na	na	na	na	na	na
PSW-07	1/ 1/98	12	<3	<1.0	0.34	100	54	<10	na	na	na	na	na	na
PW-001	4/26/96	27	<10	<2	1.0	29	<2	120	<0.1	<10	<20	<1.0	<1.0	<10
PW-002	5/28/96	14	<10	<0.5	0.65	2800	68	200	<0.1	na	<20	<2.5	<5	<10
PW-003	5/28/96	10.7	<10	<0.5	0.39	3	<1.0	<20	<0.1	na	<20	<2.5	<5	<10
PW-004	7/24/97	14	<3	4	0.3	90	14	50	na	na	na	na	na	na
PW-005	5/30/96	12	17	<0.2	0.29	1700	22.5	70	<0.1	na	<20	<2.5	<5	<10
PW-006	10/29/97	11	12	<3	1.0	940	78	10	na	na	na	na	na	na
PW-007	5/30/96	17	<10	<1.0	0.58	104	5.2	60	<0.1	na	<20	<2.5	<5	<10
PW-008	5/30/96	14	<10	<0.2	0.44	7	<1	40	<0.1	na	<20	<2.5	<5	<10
PW-009	7/3/96	54	9.3	<5	0.22	15	<1.0	10	<0.1	na	<0.6	<2.5	<5	<10
PW-012	12/19/97	20	<3	1.5	0.35	200	14	30	na	na	na	na	na	na
PW-012	12/19/97	19	<3	1.3	0.42	150	10	30	na	na	na	na	na	na

APPENDIX H

Trace Element Geochemistry

Appendix H. Trace element geochemistry of ground water and surface water.

Site ID	Sample Date	SiO_2 ppm	As ppb	Cu ppb	F ppm	Fe ppb	Mn ppb	Zn ppb	Al ppm	Ba ppb	Cd ppb	Cr ppb	Pb ppb	Mo ppb
PW-014	7/16/97	9	<3	5	1.3	340	26	80	na	na	na	na	na	na
PW-016	1/ 3/98	13	<3	2.5	1.6	520	62	1300	na	na	na	na	na	na
PW-023*	3/29/93	na	<5	na	0.37	4.64	na	na	na	<500	7	33	<2	na
PW-023*	4/ 6/93	48	na	na	na	6.32	1.4	na	na	na	na	na	na	na
PW-024	8/ 4/97	12	<5	8	0.17	<30	<30	<10	na	na	na	na	na	na
PW-030	8/11/97	9	5.4	13	0.68	<30	<30	<10	na	na	na	na	na	na
PW-030	8/11/97	9	<5	13	0.68	<30	<30	<10	na	na	na	na	na	na
PW-039	8/25/97	12	<5	12.6	0.5	<30	18	<10	na	na	na	na	na	na
PW-041	11/18/97	22	<3	4	0.2	640	120	<10	na	na	na	na	na	na
PW-043	7/18/97	12	<3	<2	1.3	<30	7	<20	na	na	na	na	na	na
PW-044	7/18/97	16	<3	1	0.8	140	12	40	na	na	na	na	na	na
PW-045	7/18/97	11	14	1	1.2	900	43	60	na	na	na	na	na	na
PW-046	8/24/97	17	<5	<2	0.3	<30	<3	22	na	na	na	na	na	na
PW-047	11/18/97	19	<3	43	0.68	106	27	34	na	na	na	na	na	na
PW-051	7/18/97	11	<3	<1.0	0.3	160	<2	<20	na	na	na	na	na	na
PW-063	11/18/97	24	<3	21	0.2	920	140	26	na	na	na	na	na	na
PW-071	7/16/97	24	<3	<2	0.58	210	24	<10	na	na	na	na	na	na
PW-073	1/15/98	14	<3	<3	0.47	4	11	26	na	na	na	na	na	na
PW-077	7/16/97	21	<3	<2	0.79	30	6	<10	na	na	na	na	na	na
PW-078	8/ 4/97	20	<5	6	0.5	420	370	<10	na	na	na	na	na	na
PW-082	7/16/97	17	<3	<2	0.75	<30	<2	<10	na	na	na	na	na	na
PW-084	7/18/97	29	<3	<1.0	1.0	<30	3	<20	na	na	na	na	na	na
PW-085	9/ 3/97	22	<5	15.5	0.3	600	33	24	na	na	na	na	na	na
PW-087	7/23/97	13	<3	<1.0	1.2	320	17	<20	na	na	na	na	na	na
PW-089	7/16/97	15	<3	<2	0.68	140	18	30	na	na	na	na	na	na
PW-090	8/ 3/97	18	<5	4	0.61	<30	5	<10	na	na	na	na	na	na
PW-091	9/ 4/97	14	<4	3	0.7	55	3.8	<10	na	na	na	na	na	na
PW-094	7/24/97	12	<3	<1.0	0.6	<30	7	40	na	na	na	na	na	na
PW-095	10/28/97	21	4.2	<3	0.65	210	12	<10	na	na	na	na	na	na
PW-095*	12/12/94	28	na	na	1.37	<50	<20	na	na	na	na	na	na	na
PW-096*	12/29/94	1.4	na	na	0.7	<20	<20	na	na	na	na	na	na	na
PW-097	7/25/97	19	<3	5	0.6	<30	5	<20	na	na	na	na	na	na

Appendix H. Trace element geochemistry of ground water and surface water.

Site ID	Sample Date	SiO_2 ppm	As ppb	Cu ppb	F ppm	Fe ppb	Mn ppb	Zn ppb	Al ppm	Ba ppb	Cd ppb	Cr ppb	Pb ppb	Mo ppb
PW-099	7/25/97	12	<3	6	0.3	2000	130	30	na	na	na	na	na	na
PW-100	9/ 4/97	13	<4	3.3	0.22	220	60	<10	na	na	na	na	na	na
PW-101	9/ 1/97	11	<5	3.6	0.3	<30	3	20	na	na	na	na	na	na
PW-103	8/22/97	10	<5	270	na	<30	12	990	na	na	na	na	na	na
PW-107	8/12/97	18	<5	2	0.13	<30	<3	<10	na	na	na	na	na	na
PW-108	8/12/97	14	<5	4	0.2	<30	<3	340	na	na	na	na	na	na
PW-109	8/12/97	20	<5	1	0.31	210	55	<10	na	na	na	na	na	na
PW-110	8/12/97	20	<5	<2	0.49	<30	<3	<10	na	na	na	na	na	na
PW-112	9/ 5/97	12	21	9.4	1.5	135	50	14	na	na	na	na	na	na
PW-113	9/ 5/97	11	16	6.8	na	58	100	110	na	na	na	na	na	na
PW-116*	5/13/83	na	na	na	na	<100	na	na	na	na	na	na	na	na
PW-118*	11/2/94	0.96	na	na	1.07	<20	<20	na	na	na	na	na	na	na
PW-119	10/28/97	22	3.1	<3	0.29	50	38	1100	na	na	na	na	na	na
PW-119	10/28/97	22	3.0	<3	0.34	50	38	1100	na	na	na	na	na	na
PW-119*	11/28/94	31.1	na	na	0.52	830	<20	na	na	na	na	na	na	na
PW-119*	10/16/96	na	<5	<10	na	na	na	na	na	60	<1	<10	<25	na
PW-120*	1/30/95	23.8	na	na	0.39	<50	<20	na	na	na	na	na	na	na
PW-122	8/30/97	13	<5	4.9	0.84	<30	75	<10	na	na	na	na	na	na
PW-126	9/15/97	22	<4	5.5	0.29	200	23	<10	na	na	na	na	na	na
PW-130	8/23/97	26	<5	9	0.4	<30	<3	1100	na	na	na	na	na	na
PW-131	7/21/97	20	<2	<2	0.5	<30	<3	19	na	na	na	na	na	na
PW-132	8/21/97	45	9.8	3.4	0.3	<30	<3	550	na	na	na	na	na	na
PW-135	8/31/97	36	12.9	8	0.5	<30	<3	470	na	na	na	na	na	na
PW-137	9/10/97	25	5.1	75	0.41	36	3.2	460	na	na	na	na	na	na
PW-142	8/26/97	24	12.8	3.2	0.4	<30	<3	<30	na	na	na	na	na	na
PW-143	8/25/97	15	<5	2.6	0.4	<30	<3	230	na	na	na	na	<1	na
PW-145	9/ 1/97	11	5.6	2.8	0.32	<30	5	28	na	na	na	na	na	na
PW-147	1/ 8/98	23	<3	2	0.43	23	<2	170	na	na	na	na	na	na
PW-149	9/13/97	20	<4	3.2	0.1	210	11	<10	na	na	na	na	na	na
PW-150	9/15/97	19	10	4.2	0.63	<4	<3	<10	na	na	na	na	na	na
PW-152	9/17/97	13	<4	4.5	0.29	5.6	<3	<10	na	na	na	na	na	na
PW-154	12/ 4/97	11	<3	<2	0.25	3.5	<2	<10	na	na	na	na	na	na

Appendix H. Trace element geochemistry of ground water and surface water.

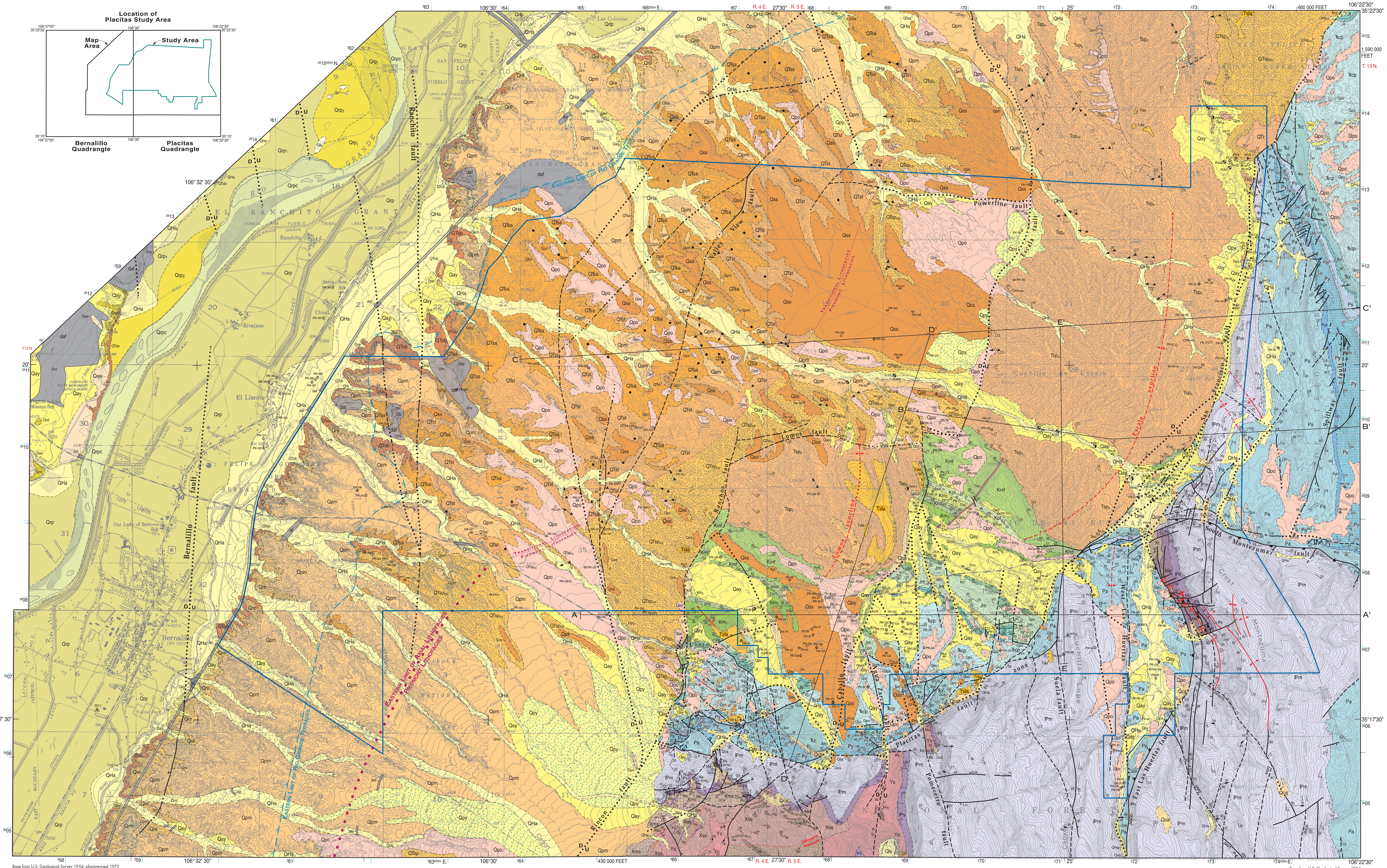
Site ID	Sample Date	SiO_2 ppm	As ppb	Cu ppb	F ppm	Fe ppb	Mn ppb	Zn ppb	Al ppm	Ba ppb	Cd ppb	Cr ppb	Pb ppb	Mo ppb
PW-161	12/ 3/97	18	<3	<2	0.49	22	<2	13	na	na	na	na	na	na
PW-162	1/ 8/98	54	9	2.5	0.22	6.2	<2	170	na	na	na	na	na	na
PW-163	1/10/98	12	<3	1.5	0.2	11	<2	30	na	na	na	na	na	na
PW-164	1/17/98	13	<3	<3	0.37	14	<3	14	na	na	na	na	na	na
PW-166	1/24/98	20	4	<3	0.3	15	<3	30	na	na	na	na	na	na
PW-166*	4/17/96	na	4	na	0.4	na	na	na	na	<100	<1	<2	na	na
PW-166*	4/30/96	na	<60	na	0.6	<300	<5	na	na	na	na	na	na	na
PW-167	1/19/98	27	4	<3	0.3	5100	63	230	na	na	na	na	na	na
PW-167	1/19/98	27	11	<3	0.33	1300	26	150	na	na	na	na	na	na
PW-167*	12/6/95	na	21	na	na	na	na	na	na	<100	<1	<2	na	na
PW-167*	5/15/89	na	na	na	0.41	120	<50	na	na	na	na	na	na	na
PW-169	1/19/98	15	<3	6	0.29	12	<3	<10	na	na	na	na	na	na
PW-173	1/24/98	49	3	<3	<0.2	35	<3	150	na	na	na	na	na	na
PW-179	1/24/98	20	3	<3	0.6	800	33	620	na	na	na	na	na	na
PW-184	1/23/98	21	<3	<3	0.4	52	<3	30	na	na	na	na	na	na
PW-186	2/ 4/98	17	<3	<2	1.1	7	<2	74	na	na	na	na	na	na
PW-186*	8/15/95	na	<5	na	na	na	na	na	na	20	<3	<20	<2	na
PW-191	2/17/98	26	10	<2	0.3	28	<2	140	na	na	na	na	na	na
PW-191*	2/ 5/97	na	na	na	na	<100	<50	na	na	na	na	na	na	na
PW-192*	2/ 5/97	na	na	na	na	<100	<50	na	na	na	na	na	na	na
PW-197	1/23/98	76	36	3.5	0.4	2200	48	60	na	na	na	na	na	na
PW-198	1/23/98	74	37	<3	0.6	34	14	50	na	na	na	na	na	na
PW-202	1/23/98	19	<3	<3	0.3	43	<3	10	na	na	na	na	na	na
PW-203	2/12/98	13	<3	<2	<0.2	30	<2	<10	na	na	na	na	na	na
PW-204	2/12/98	53	19	3	<0.2	80	4	10	na	na	na	na	na	na
PW-205	2/13/98	74	64	<2	0.46	10	<2	<10	na	na	na	na	na	na
PW-205*	12/23/96	na	40	70	0.5	<300	<5	300	na	80	<4	<20	<2	na
PW-206*	8/ 5/96	10.2	<5	20	0.9	<50	<20	<10	0.02	<500	<5	30	<2	<20
PW-211^	8/23/96	35.1	12	0.5	0.39	63	<1	165	0.003	88	na	<1	1.3	2.3
PW-212*	2/1/94	na	16	<20	1.2	6070	580	30	na	<250	<5	<50	<5	<10
PW-213*	12/23/96	na	9	10	<0.5	<300	<5	1100	na	50	<4	<20	<2	na
PW-214*	12/5/96	na	<5	<10	0.5	<0.02	<10	440	<0.06	40	<0.5	<10	<3	na

Appendix H. Trace element geochemistry of ground water and surface water.

Site ID	Sample Date	SiO_2 ppm	As ppb	Cu ppb	F ppm	Fe ppb	Mn ppb	Zn ppb	Al ppm	Ba ppb	Cd ppb	Cr ppb	Pb ppb	Mo ppb
PW-215^	8/23/96	56.5	18	0.3	0.3	68	<1	8	0.002	107	na	2	0.2	2.8
PW-216^	8/17/96	26.1	2.4	0.8	0.78	45	<1	6	0.003	64	na	<1	<0.1	3.1
PW-217*	9/29/89	na	na	na	0.34	<50	<20	na	na	na	na	na	na	na
PW-218^	6/19/97	27	1	0.6	0.25	43	<1	55	0.004	206	na	1	0.3	1

na = element not analyzed
<## = analyte not detected; value reflects the detection limit for the instrument
* = results provided by well owner from independent laboratory
^ = results provided by U. S. Geological Survey (N.Plummer, unpubl. 1997)

PLATES



Base from U.S. Geological Survey 1954, photorevised 1972
Polyconic projection, 1927 North American datum
10,000-foot grid based on New Mexico coordinate system,
cental zone1000-meter Universal Transverse Mercator grid ticks, zone 13, shown in blue
Dashed land lines indicate approximate locations
West boundaries of San Felipe Grant and Sandia Pueblo Grant
adjacient to Rio Grande omitted due to insufficient data

S. D. Connell: geologic mapping, compilation, Phanerozoic stratigraphy and regional structural interpretation refined from borehole data analyses, unit descriptions and correlations, and structural cross sections; geology depicted in areas of disturbance (af and daf) interpreted from aerial photography

D. J. McCraw M. M. Mansell, and G. E. Jones: digital cartographic production

Scale 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

BERNALILLO CONTOUR INTERVAL 10 FEET
PLACITAS CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Plate 1A. Geology of the Placitas area, Bernalillo and Placitas quadrangles, Sandoval County, New Mexico

BERNALILLO QUADRANGLE
by Sean D. Connell[1], 1999

PLACITAS QUADRANGLE
by Sean D. Connell[1], Steve M. Cather[2], Bradley Ilg[3], Karl E. Karlstrom[3], Barbara Menne[3], Mark Picha[3], Chris Andronicus[3], Adam S. Read[2], Paul W. Bauer[2], and Peggy S. Johnson[2], 1999

[1]New Mexico Bureau of Mines & Mineral Resources, Albuquerque, NM 87106
[2]New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801
[3]Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, NM 87131

Base from U.S. Geological Survey 1954
Polyconic projection, 1927 North American datum, 10,000-foot grid based on New Mexico coordinate system, cental zone
1000-meter Universal Transverse Mercator grid ticks, zone 13, shown in blue

Geologic mapping: S. D. Connell (Quaternary), S. M. Cather (Cenozoic), Bradley Ilg (S.E. section of quadrangle), C. Andronicus, A. S. Read, and K. E. Karlstrom (Proterozoic), B. Menne and M. Picha (M.S. Theses – Phanerozoic)

D. J. McCraw, M. M. Mansell, and Glen E. Jones: digital cartographic production

Unit Descriptions

Cenozoic Erathem

Quaternary System

Mass-movement, colluvial, eolian, and anthropogenic deposits

daf

Disturbed land and artificial fill , undivided (Historic) — Dumped fill and areas effected by human disturbances, including gravel quarry sites. Locally mapped where areally extensive.

Qe

Eolian sand (Holocene) — Unconsolidated, light yellowish-brown (10YR), fine-to medium-grained sand, primarily recognized in narrow, elongate zones along the western margin of the *Rio Grande* and major arroyos west of the *Rio Grande*. Surface is locally stabilized by vegetation. Soil development is very weak to nonexistent. 2 to 15 ft thick.

Qae

Eolian sand and stream alluvium, undivided (Holocene to uppermost Pleistocene) — Unconsolidated to poorly consolidated light reddish-brown to light-brown, fine- to medium-grained sand and silty sand with scattered pebbles that form a relatively thin and discontinuous mantle over upland areas and alluvial units west of the *Rio Grande*. 2 to 15 ft thick.

Qca

Colluvium and alluvium, undivided (Holocene to middle Pleistocene) — Poorly consolidated, poorly sorted and stratified, fine- to coarse-grained, clast- and matrix-supported deposits derived from a variety of mass-movement hill slope processes, including debris flow, shallow slump and creep. Clasts are typically angular and composition generally reflects local provenance. Locally present on eastern slope of Sandia Mountains where it includes small bedrock inliers. 2 to 15 ft thick.

Qls

Landslide deposits (upper to middle Pleistocene) — Poorly to well consolidated and very poorly sorted, sand, breccia, and minor mud deposits derived by mass movement, commonly along steep hill slopes. Arrows indicate direction of movement. 20 to 100 ft thick.

Alluvium of the Rio Grande

Qrpc

Modern channel facies of the Las Padillas Alloformation (Historic to late Holocene) — Unconsolidated sand and gravel within the active channel of the modern *Rio Grande*.

Qrp, Qrp_j, Qrp_2, Qrp_1

Las Padillas Alloformation (Historic to uppermost Pleistocene) — Floodplain deposits of unconsolidated to poorly consolidated coarse-grained sand and gravel with subordinate lensoidal interbeds of fine-grained sand, silt, and clay, derived either from the *Rio Grande* (*Qrp*, Qrp_2, and Qrp_1) or the *Rio Jemez* (Qrp_j). Locally divided into younger (Qrp_2) and older (Qrp_1) facies on the basis of inset relationships. 50 to 80 ft estimated thickness.

Qrd

Los Duranes Alloformation (upper to upper-middle Pleistocene) — Poorly to moderately consolidated deposits of pale-brown to yellowish-brown (10YR) conglomerate, sand, and minor sandy clay derived from the ancestral *Rio Grande*. Locally covered by discontinuous veneer of light-brown eolian sand with scattered small pebbles of *Qae*. 20 to 23 ft thick.

Qrm

Menaul Alloformation (upper to upper-middle Pleistocene) — Poorly consolidated deposits of yellowish-brown (10YR) pebble conglomerate and pebbly sand derived from the ancestral *Rio Grande*. Clasts are dominated by rounded quartzite that are generally smaller in size than those in *Qre*. Forms discontinuous exposures east of the inner valley escarpment of the *Rio Grande*. The base is approximately 85 to 120 ft above *Rio Grande* floodplain. Generally less than 10 ft.

Qre

Edith Alloformation (middle Pleistocene) — Poorly to moderately consolidated deposits of pale-brown to yellowish-brown (10YR) conglomerate, sand and sandy clay derived from the ancestral *Rio Grande*. Clasts of welded Bandelier Tuff are locally recognized. Unit unconformably overlies deposits of the upper Santa Fe Group. Forms extensive outcrops along the inner valley escarpment of the *Rio Grande*. The base is approximately 40 to 80 ft above the floodplain of the *Rio Grande*. 10 to 40 ft thick.

Stream Alluvium

Variable amounts of stream and fan alluvium, locally containing debris-flow and colluvial deposits derived from adjacent slopes and upland areas. Deposits commonly contain sediment recycled from older piedmont and valley-fill deposits. Terraces are associated with major arroyos and streams and are underlain by poorly to moderately stratified alluvium derived from local upland sources.

QHa

Stream alluvium, undivided (Historic to uppermost Pleistocene) — Unconsolidated deposits of brown, light gray-brown, and yellowish-brown (10YR) sand, sandy clay loam and gravel. Boulders are common along range front in southwest portion of map area. Unit grades westward to the *Rio Grande* floodplain. Thickness varies from less than 6 to 40 ft.

Qay

Younger stream alluvium, undivided (Holocene to uppermost Pleistocene) — Poorly consolidated deposits of very pale brown to light-brown (7.5-10YR) sand to sandy clay loam and gravel. Slightly dissected surface possesses well developed constructional bar-and-swale topography. Associated with broad valley fill units within modern stream valleys that grade to *Rio Grande* floodplain. 6 to 70 ft thick.

Piedmont alluvium

Complex juxtaposition of poorly sorted, poorly stratified, clast- and matrix-supported deposits consisting of subangular to subrounded, poorly to well sorted gravel and sand. Contains primarily granitic, metamorphic and minor limestone clasts derived from the Sandia Mountains and eastern basin margin.

Qpy

Younger piedmont alluvium (Holocene to uppermost Pleistocene) — Unconsolidated deposits of brown, light gray-brown, and yellowish-brown (10YR) sand, sandy clay loam and gravel. Boulders are common along mountain-front fans. Surface is moderately to weakly dissected and possesses bar-and-swale topography. Unit can be subdivided based on age, soil development, and inset relationships (see Connell, 1998; Connell *et al.*, 1995). Exposed thickness ranges from less than 10 ft to 120 ft.

Qpm

Middle piedmont alluvium (upper to middle Pleistocene) — Poorly to moderately consolidated deposits of very pale brown to light-brown (7.5-10YR) stratified sand to sandy clay loam and gravel. Slightly to moderately dissected surfaces possess bar-and-swale topography. Unit can be subdivided based on age, soil development, and inset relationships (see Connell, 1998; Connell *et al.*, 1995). Exposed thickness ranges from less than 10 ft to 50 ft.

Qpo

Older piedmont alluvium (middle to lower Pleistocene) — Poorly to moderately sorted and stratified, moderately consolidated gravel and sand with minor silty-clay mixtures. Unit can be subdivided based on age, soil development, and inset relationships (see Connell, 1998; Connell *et al.*, 1995). Exposed thickness ranges from less than 7 ft to 45 ft.

Quaternary and Tertiary Systems

Upper Santa Fe Group (lower Pleistocene to upper Miocene)

Qss

Suela alluvium (lower Pleistocene) — Moderately consolidated deposits of brown, very pale brown to white (7.5YR - 2.5Y) sandy loam, sand and subrounded to subangular cobble to pebble conglomerate overlying remnants of a northwest-sloping pediment surface that cuts across the Placitas fault. The deposit surface is moderately dissected and sits 110 to 165 ft above local base level. The basal contact becomes conformable with underlying *QTsa* northwest of the Escala and Lomos faults. Less than 15 ft thick.

QTt

Travertine (lower Pleistocene to Pliocene) — Light-gray nodular to massive limestone interlayered with mudstone. Prominent outcrop at the northern tip of the Cuchilla de San Francisco (Sections 14 and 15, T13N, R5E), where deposit overlies and interfingers with $QTsp_{cs}$. Spring deposits also occur along valleys associated with *Qay* (notably along the base of the Cuchilla de San Francisco) and locally at depositional contacts or along faults. Thickness is variable, but can be greater than 50 ft thick at the northern tip of the Cuchilla de San Francisco.

QTsa

Fluvial deposits of the ancestral Rio Grande (lower Pleistocene to Pliocene) — Variable proportions of sandstone, conglomerate and mudstone deposited by the ancestral *Rio Grande*. Sandstone is typically crossbedded. Clasts in conglomerate are quartzite, chert, granite, gneiss, sandstone, volcanic, siltstone, limestone, schist, phyllite and pumice. Mudstone ranges in color from light-brown to grayish-green. Paleoflow measurements are generally south to southwest. Black circles indicate selected exposures of axial sandstone and conglomerate used to delineate areal extent of axial river deposits (*QTsa*) and transitional axial-piedmont deposits (*QTst*).

QTst

Transitional fluvial-piedmont deposits (lower Pleistocene to Pliocene) — Interfingered axial river deposits (*QTsa*) and piedmont deposits (*QTsp*). Defined as the zone of overlap between the easternmost outcrops of axial river deposits and the westernmost outcrops of piedmont sandstone and conglomerate.

$QTsp_c$

Piedmont deposits, eastern margin (lower Pleistocene to Pliocene) — Conglomerate deposits with a conglomerate to sandstone ratio greater than 2. Clasts are pebbles, cobbles, and boulders of Paleozoic limestone, sandstone, siltstone, and chert, and Proterozoic granite, gneiss, phyllite, and schist. Proterozoic detritus becomes more abundant in the southern part of the map area. Sandstone is coarse to very coarse and typically crossbedded or horizontally laminated. Matrix-supported conglomerate (debris-flow) deposits are common. Mudstone is very rare.

$QTsp_{cs}$

Piedmont deposits, eastern margin (lower Pleistocene to Pliocene) — Subequal proportions of conglomerate and sandstone deposited in mountain-front alluvial fans. Conglomerate is typically poorly sorted and clast supported, consisting primarily of pebbles and cobbles of lithologies similar to clasts in $QTsp_c$. Sandstone is horizontally laminated or trough crossbedded, moderately to poorly sorted, and often pebbly. Mudstone is rare.

$QTsp_s$

Piedmont deposits, eastern margin (lower Pleistocene to Pliocene) — Sandstone deposits with a conglomerate to sandstone ratio less than 0.5, and with subordinate siltstone. Sandstone is horizontally laminated with subordinate trough and planar crossbedding. Conglomerate occurs in shallow, lenticular beds, is clast supported, and consists of pebbles of Paleozoic sedimentary rocks and Proterozoic rocks. Siltstone is massive to faintly laminated, and forms tabular to broadly lenticular beds.

$QTsp_{sm}$

Piedmont deposits, eastern margin (lower Pleistocene to Pliocene) — Fine-grained deposits with subequal proportions of siltstone and mudstone.

QTob

Loma Barbon Member of the Arroyo Ojito Formation (lower Pleistocene to upper Miocene) — Yellowish-brown to yellowish-red, fine-grained silty sand and clay, with well cemented and weakly cemented sandstone lenses and scattered cobbly to bouldery gravel lenses. Contains a thick sequence of reddish-brown sandstone with interbedded siltstone, claystone, and rare pebble to boulder conglomerate. Clasts are composed of subangular red granite, subrounded, light-gray tuff and basalt, and minor sandstone derived from the western margin of the Santo Domingo basin. Unit interfingers with and is overlain by *QTsa*. Unit is at least 1400 ft thick in borings.

Tsla

Gravel of Lomos Altos (Pliocene) — Well consolidated deposits of very pale brown to brown (10YR - 2.5Y), sandy clay loam, sandy loam and subrounded to subangular, limestone-dominated, cobble to pebble conglomerate overlying remnants of a formerly broad pediment preserved on Santa Fe Group deposits on Lomos Altos and surrounding hills. The deposit is poorly exposed, non-stratified, and sits about 260 to 330 ft above local base level. Thickness varies from 10 to 60 ft.

$Tspu_c$

Piedmont deposits, eastern margin (Pliocene) — Deposits of well consolidated, well cemented, limestone-dominated gravels that cap the top of Lomos Altos. Unit is recognized by an abrupt increase in limestone clasts above sandstone-clast dominated conglomerate of unit Tsp_c. Unit is about 40 ft thick.

Middle and Lower Santa Fe Group (Miocene)

Tsp_c

Piedmont deposits, eastern margin — Conglomerate deposits with a conglomerate to sandstone ratio greater than 2. Conglomerate is mostly clast supported, and clast content varies upsection. Tertiary volcanic clasts (Espinaso Formation, *Te*) occur near the base at the southern end of the Cuchilla de Escala, with Paleozoic and Proterozoic detritus dominating upsection. *Te* clasts are absent at Lomos Altos. Mudstone is absent.

Tsp_{cs}

Piedmont deposits, eastern margin — Subequal proportions of sandstone and conglomerate. Sandstone is medium to very coarse and is typically horizontally laminated or trough crossbedded. Conglomerate is mostly clast supported and consists largely of Paleozoic limestone, sandstone, siltstone, and chert with subordinate Proterozoic lithologies. Mudstone is rare.

Tsp_s

Piedmont deposits, eastern margin — Sandstone deposits with a conglomerate to sandstone ratio less than 0.5, and with subordinate siltstone. Sandstone is horizontally laminated with subordinate trough and planar crossbedding. Conglomerate occurs in shallow, lenticular beds, is clast supported, and consists of pebbles of Paleozoic sedimentary rocks and Proterozoic rocks. Siltstone is massive to faintly laminated and forms tabular to broadly lenticular beds.

Tsp_{sm}

Piedmont deposits, eastern margin — Fine-grained deposits with subequal proportions of siltstone and mudstone.

Other Tertiary Sedimentary Rocks

Te

Espinaso Formation (Oligocene) — Cross-section only. Unit comprises the remnants of widespread aprons of coarse-grained volcaniclastic debris accumulated adjacent to volcanic vent complexes south of Santa Fe. Consists primarily of upward-coarsening or crudely stratified tuffaceous sandstones, conglomerates, and debris flow deposits. Unit thickness varies locally and regionally, from 0 to 1300 ft.

Tg

Galisteo Formation (Eocene) — Cross-section only. Unit consists of red to white mudstone, sandstone, and conglomerate deposited in fluvial channels and broad floodplains in a continental basin between Albuquerque and Santa Fe. The Galisteo is most widely described in the Hagan basin, east of Placitas. Unit thickness varies regionally and locally from 0 to 2800 ft.

Td

Diamond Tail Formation (lowermost Eocene to upper Paleocene) — Cross-section only. Unit is dominantly coarse-grained subarkosic to arkosic sandstone and conglomeratic sandstone with lesser amounts of drab, green, gray, and maroon mudstone. It crops out in the Hagan basin where it unconformably overlies *Kmf*. Unit thickness varies up to 1450 ft.

Tertiary intrusive rocks

Tmi

Mafic or intermediate dike (late Oligocene) — A single, approximately 0.8 mi long, northeast-trending mafic to intermediate dike, about 0.6 mi north of the village of Placitas. Unit is unconformably overlain by Tsp_c and yields a $^{40}Ar/^{39}Ar$ date of 30.9 ± 0.5 Ma (W. C. McIntosh, 1995, *personal communication*).

Mesozoic Erathem

Upper Cretaceous

Kmf

Menefee Formation — Contains three informal members: a lower member (324 ft), the Harmon sandstone (140 ft), and an upper member (740 ft). Upper and lower members are similar and contain, in order of abundance: gray, tan to orange-tan, cross-bedded, and laminated to thick-bedded siltstone and sandstone; dark-gray to olive-gray and black shale; dull, dark-brown to shiny black lignitic coal; and maroon to dark-brown iron concretions. The upper Menefee has a greater abundance of shale, carbonaceous material, ironstone, thicker coal seams, and a lenticular calcareous sandstone. The light-gray to buff or gray-tan Harmon Sandstone is a medium grained, well-sorted, quartz sand with cross bedding and limonite staining. Thickness of the Harmon is variable and thins to at least 73 ft in the Hagan basin east of Placitas. The individual members are not differentiated in this study area, but are distinct hydrostratigraphic units. The Harmon hydrostratigraphic unit includes an underlying 41-foot gray-tan, fine- to medium-grained sandstone. The Menefee varies regionally in thickness from 680 ft to 1200 ft due in part to post-depositional erosion. The lower contact with the *Kpl* is interfingering and gradational.

Kpl

Point Lookout Sandstone — Gray-tan to light-tan and drab-yellow, very fine to fine-grained, massive, quartz sandstone, with limonitic sandstone lenses, and interbedded thin gray shale. The unit is weakly cemented and a prominent ridge- and ledge-former. Both upper and lower contacts are interfingering and gradational. The unit varies regionally in thickness from about 240 ft near Placitas, to 315 ft in the Hagan basin.

Km_2

Mancos Shale, upper Mancos Shale tongue — Medium- to dark-gray to olive-gray shale, and silty shale, with less abundant very fine to fine-grained sandstone that is locally gypsiferous. This unit is an upper tongue of Mancos shale and forms valleys and covered slopes between the more resistant *Kpl* and *Khd*. The unit produces poor quality, high sulfate ground water. Thickness is variable, and difficult to measure due to cover, but varies from about 240 ft west of Placitas, to 360 ft in the Hagan basin. Upper and lower contacts are gradational.

Khd

Hosta-Dalton Sandstone — Drab, yellow-gray to yellow-tan, very fine to medium-grained, weakly cemented sandstone with olive-brown sandstone lenses. The unit is a moderate ridge- and ledge-former. Unit thickness varies from 210 ft near Placitas, to 370 ft in the Hagan basin, where it contains a considerable amount of siltstone and fissile shale that does not occur in the Placitas area. Upper and lower contacts are gradational.

Km_1

Lower Mancos Shale — Lithology is similar to Km_2, with subequal proportions of olive-brown to gray to black shale, and laminated to interbedded olive-brown to gray, very fine grained sandstone, siltstone, and shale. Selenite and white to yellow gypsum are interbedded throughout the unit. Unit thickness is highly variable regionally and across the study area, ranging from 850 ft west of Placitas to 1850 ft in the Hagan basin. Thickness near the Village of Placitas is intermediate. Upper and lower contacts are gradational, with significant interfingering between the dark gray shale typical of the lower section and underlying *Kd* sandstone.

Kd

Dakota Formation — Medium-bedded, pervasively silica cemented, medium-grained, yellowish-gray to orange-yellow quartz arenite. Interbedded dark-gray Km_1 is commonly present. Sandstones are well cemented and weather to form angular and blocky ridges. Unit thickness varies from 75 ft west of Placitas, to less than 25 ft in the Hagan basin.

Upper Jurassic

Jm

Morrison Formation — Four members are commonly recognized in northern New Mexico, and discernable in subsurface geologic logs, but are not differentiated in this map area. The members are, in descending order, the Jackpile Sandstone, the Brushy Basin Shale, the Westwater Canyon Sandstone, and the Recapture Shale (correlative to the Summerville Formation). The uppermost Jackpile Sandstone is a distinctive gray-white, kaolinitic, fine- to medium-grained sandstone with a thickness of about 70 ft near Placitas. The Brushy Basin member is a gray, green, and maroon mudstone and shale, with interbedded and intercalated gray to tan sandstone. Thickness is about 240 ft near Placitas. The Westwater Canyon Sandstone is a gray to yellow-buff, medium-grained and weakly cemented sandstone, with a unit thickness of 216 ft near Placitas. The Recapture Shale is not well exposed in the Placitas area, but consists of purple-gray, red-brown, and green-gray mudstone interbedded with tan, gray, and greenish-gray, very fine grained, sandstone. Estimated thickness is 325 ft. The various members are discernable in the subsurface due to distinctive sequences of unique lithology and color. Total unit thickness is relatively uniform, varying regionally from about 850 ft near Placitas, to 780 ft in the Hagan basin.

Middle Jurassic

Jt

Todilto Formation — Lower limestone member is a medium-gray to olive-gray, laminated, fetid, micritic limestone. Dark-brown to black organic mud occurs between the limestone laminations near the base, and gypsum interlayers occur from the middle to the top of the limestone unit. An upper gypsum member is locally present. Total thickness and thickness of each member is highly variable. Thickness of the lower limestone member varies from 5 ft southwest of Placitas, to 20 ft at a location east of Cuchilla de San Francisco. Where present, the upper gypsum member has a maximum thickness of 45 ft. Total unit thickness is 50 to 65 ft. Upper and lower contacts are sharp.

Je

Entrada Formation — Variably colored, very fine to fine-grained, weakly cemented, crossbedded, eolian, quartz sandstone with coarser grained components. Near Placitas, the Entrada is described as three persistent units distinguished by color: a lower unit (75 ft) of pale reddish-brown to grayish-pink, a middle unit (15 ft) of gray-green, and an upper unit (29 ft) of grayish-yellow or light-tan. Due to the local dip of 20° to 30°, the Entrada forms round, unvegetated slopes rather than the cliffs and ledges typical of other localities. Total unit thickness varies from about 120 ft near Placitas, to 71 ft in the Hagan basin. Contact with underlying *TRcp* is disconformable.

Upper Triassic

TRcp, TRcpu, TRcpm, TRcpl

Petrified Forest Formation — Predominantly a reddish-brown mudstone, interbedded with thin, subordinate sandstone and limestone-pebble conglomerate. The formation is only partially exposed near Placitas due to faulting. Thickness and lithologic descriptions presented here are from the Hagan basin. Three informal subunits are recognized, and near Placitas are distinct hydrostratigraphic units, although are not differentiated at the surface. The upper unit is a thick reddish-brown mudstone, overlain by relatively thin intervals of reddish-orange siltstone and a reddish-brown to tan, coarse sandstone (Correo Sandstone equivalent according to Picha, 1982). The middle unit consists of medium-grained, moderately cemented sandstone, interbedded with minor mudstone. The lower unit is a reddish-brown to purple to greenish-gray mudstone interbedded with silty to fine-grained sandstone. Gypsum and distinctive limestone conglomerate lenses, characteristic of the Petrified Forest, are pervasive throughout the formation. The formation varies regionally in thickness from about 1300 ft to 1650 ft, and in the Hagan basin has been measured at 1590 ft. The lower contact with the underlying *TRz* is gradational and interfingering.

TRz

Agua Zarca Formation — Medium grained, tan to white and light grayish-pink, thin- to medium-bedded, quartz arenite and feldspathic arenite, with minor interbedded reddish-brown mudstone. Interbedded mudstone is of Petrified Forest (*TRcpl*) type. The dominant sandstones are very well cemented with silica, form major ridges, and typically are highly fractured. The lower contact with the underlying Moenkopi is disconformable. Total unit thickness near Placitas is 220 ft.

Middle and Lower Triassic

TRm

Moenkopi Formation — Laminated to thick-bedded, maroon-brown, micaceous, fine-grained sandstone and siltstone, intercalated with minor reddish-brown mudstone. Sandstones and mudstones are moderately to weakly cemented, sometimes friable, with generally low porosity. Both upper and lower contacts are erosional, and regional thickness varies significantly. The unit is poorly exposed in the Placitas area, and thickness varies from at least 45 ft near Placitas, to 100 ft in the Hagan basin.

Paleozoic Erathem

Upper Permian

Ps

San Andres Formation — Light-gray to tan, thin- to medium-bedded limestone, with interbedded grayish-white sandstone, similar to *Pg*, at the base. The limestones are well indurated, with high fracture porosity, and are locally cavernous. The lower contact with *Pg* is transitional. Unit thickness varies from about 80 ft near Placitas to 130 ft in the Hagan basin. The San Andres combines with the underlying *Pg* and uppermost *Py* to form a single hydrostratigraphic unit.

Pg

Glorieta Formation — White to grayish white, massively bedded, well-indurated, medium grained, quartz arenite. In some localities, a greenish-yellow silty mudstone, 2 to 3 ft thick, occurs near the top of the formation. The sandstone is extremely well cemented with silica, often well fractured, and forms prominent ridges and ledges. Unit thickness varies from about 50 ft near Placitas to 35 ft in the Hagan basin. The lower contact with *Py* is disconformable and sharp.

Lower Permian

Py

Yeso Formation — Two members of the Yeso Formation are recognized in the Sandia region: an upper, San Ysidro, member, and an underlying Meseta Blanca member. The San Ysidro is a friable, orange-brown, laminated to thickly bedded, silty to fine-grained sandstone and interbedded siltstone, with minor clay-rich and limestone layers. A moderately cemented, coarse sandstone occurs at the base. The Meseta Blanca member is lithologically distinct from the rest of the Yeso, and consists of a light-orange to gray-white, medium- to coarse-grained, moderately cemented sandstone. Picha (1982) mapped an additional Lower Yeso member as a separate unit in the Hagan basin. This lowest unit, similar to the San Ysidro, is an orange-brown, fine to very fine sandstone. Members are differentiated where possible. Unit thickness is 680 ft in the Hagan basin. The lower contact with *Pa* is conformable, but difficult to discern due to similar lithologies.

Pa

Abo Formation — Predominantly a reddish-brown mudstone, alternating with lenticular beds of grayish-white to light-orange, medium- to coarse-grained sandstone. The upper Abo is distinguishable from the lower Yeso based primarily on a slight color change from orange-brown to reddish-brown mudstone, and a higher incidence of coarser grained, orange or white sandstone. The sandstone is locally conglomeratic, and arkosic in the lower part. The lower contact with *IPm* is gradational and interfingering, with about 20% limestone units interbedded in reddish-brown mudstone over the lower 80 ft. Unit thickness on Cuchilla de San Francisco is 1070 ft.

Upper and Middle Pennsylvanian

IPm, IPmu, IPml

Madera Formation — Two members of the Madera Formation are recognized, but not differentiated in this study area. The upper Arkosic Limestone member is a gray, greenish-gray, olive-gray, tan and buff-brown fossiliferous limestone (57% of member) interbedded with intervals of subarkosic sandstone and mudstone. The limestone is thinly to thickly bedded and massive, with sparsely disseminated chert; sandstones and mudstones vary from reddish-brown to maroon to greenish-gray and gray, and are lenticular and laterally discontinuous; arkosic sandstones are typically coarse- to medium-grained, with granules and pebbles. The lower Gray Limestone member is a gray, ledge-forming, cherty limestone separated by thinner, less resistant intervals of light-brown, pale greenish-brown, tan, greenish-gray, and gray, argillaceous limestone. A unique 2.0-m thick interval of medium- to coarse-grained, green, subarkosic sandstone lies 160 ft below the top of the lower Gray member, and provides a marker for the lower unit. The top of the lower Gray member is placed at the top of the uppermost cliff-forming limestone exposed on the western rim of Montezuma Mountain, and is also approximately coincident with the top of Cuchilla Lupe. The unit measures 1260 ft thick on Montezuma Mountain.

IPs

Sandia Formation — The formation consists of a variety of lithologies including, in descending order: interbedded brown claystone and gray limestone, massive gray limestone, and a lower section of olive-brown to gray, subarkosic, fine- to coarse-grained sandstone. The contact with overlying *IPm* is chosen at the base of the lowest thick limestone ledge. The lower contact is an angular unconformity above *Ma*. Sandia Formation limestones are distinct from the *IPm* limestones, as they are typically thinner bedded, clast-supported, greenish, and contain abundant siliciclastic sand. Unit is 193 ft thick on Montezuma Mountain.

Mississippian

Ma

Arroyo Peñasco Formation — The Arroyo Peñasco group contains the oldest sedimentary rocks in the area and rests unconformably on a relatively flat surface of Precambrian quartzite, schist, and amphibolite. The unit consists of: an upper pinkish-gray, and gray limestone, with interbeds of red, greenish-gray, and light-gray siltstone and silty shale; a lower, very coarse-grained, green and purplish-brown Del Padre Sandstone; and a basal quartz-cobble conglomerate. Unit is about 90 ft thick on the west slope of Montezuma Mountain.

Proterozoic Erathem

Middle Proterozoic rocks

Yp

Pegmatite and aplite dikes — Dikes, pods, and lenses ranging from <1 in to >48 ft in thickness and up to 1 mi in length; 1.4 Ga.

Ys

Sandia granite — Mainly megacrystic biotite monzogranite to granodiorite. Abundant ellipsoidal enclaves of microdiorite, fine-grained granite, and gabbro, and xenoliths of quartzite and mafic metavolcanic rock; 1.4 Ga.

Early Proterozoic rocks

Xqs

Quartz-rich pelitic schist, quartz schist, and quartz-chlorite schist (metapelite) — Locally interlayered with amphibolites, mafic metavolcanic rocks, and calc-silicate rocks.

Xa

Amphibolite and amphibolite-biotite schist — Massive green amphibole-plagioclase metavolcanic rock.

Xms

Mica schist and phyllite — Quartz-muscovite schist and phyllite with local andalusite porphyroblasts.

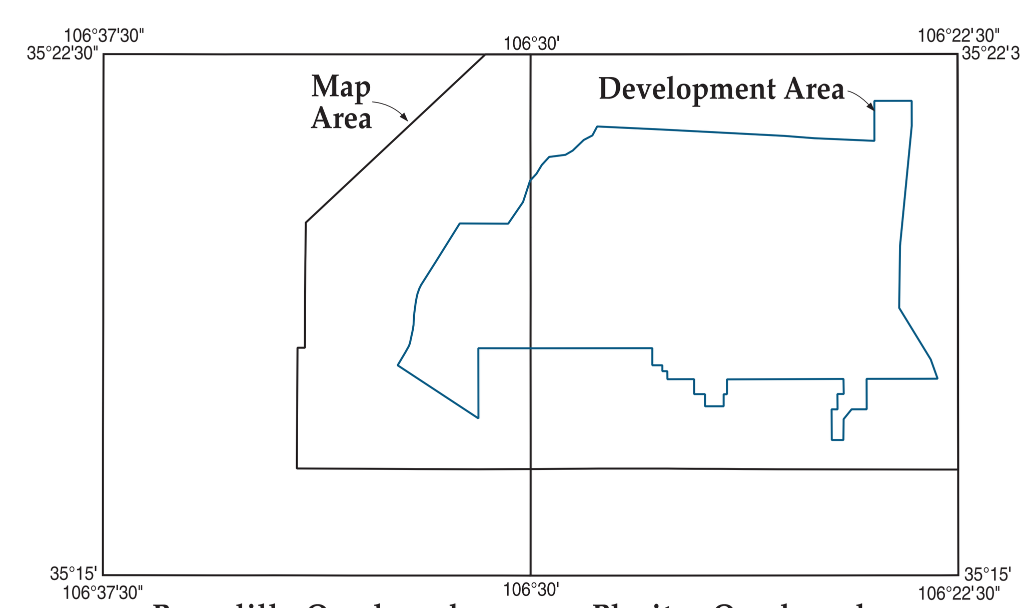
Explanation of Map Symbols

- Study area
- A—A' Location of cross sections
- Exposed contact
- Approximate or inferred contact
- Approximate location of contacts separating the axial, transitional, and piedmont facies of the Upper Santa Fe Group deposits; dotted where concealed
- Approximate location of the easternmost deposits (both surface and sub-surface) of Upper Santa Fe Group axial sands and gravels on the Bernalillo quadrangle
- 50 Fault–Movement unknown; tick shows dip if known
- 70 Normal fault–Solid where exposed, dashed where approximately located or inferred, dotted where concealed; bar and ball on downthrown side; tick shows dip
- 88 Reverse fault–Solid where exposed, dashed where approximately located or inferred, dotted where concealed; teeth on upthrown side; tick shows dip
- U D Mesoscopic fault showing separation
- 30 Slickenlines on fault
- Breccia or gouge zones
- Trace of axial plane of anticline, with fold plunge, dashed where approximate or inferred, dotted where concealed
- Trace of axial plane of syncline, with fold plunge, dashed where approximate or inferred, dotted where concealed
- Trace of axial plane of a monocline with an anticlinal bend; short arrow on steeper beds, dashed where approximate or inferred, dotted where concealed
- Trace of axial plane of a monocline with an synclinal bend; short arrow on steeper beds, dashed where approximate or inferred, dotted where concealed
- 30 Strike and dip of bedding, horizontal bedding
- 40 50 Strike and dip of bedding or overturned bedding where stratigraphic tops are known from primary features
- 60 Dominant tectonic foliation or gneissic foliation, if chronology of fabric elements is unknown
- 30 S2 foliation
- 80 Joints
- 60 Mineral lineation defined by aligned elongate minerals and stretched grains
- Adit
- Mine
- Shaft
- Paleoflow measurement locality
- Axial/Transitional sample locality

Explanation of Well Symbols

- PW-031 Well Identification Number
- Water well
- Water level station
- Water quality station
- Water level/quality station
- Spring
- Spring quality station
- Spring discharge station
- Spring quality/discharge station
- Surface water quality station
- Precipitation station
- Stream discharge station

Location of Placitas Development Area



Bernalillo Quadrangle – NMBMMR OF-DM-16 (Connell, 1998)

Placitas Quadrangle – NMBMMR OF-DM-2 (Connell, *et al.*, 1995)

Plate 1B. Explanation for Geology of the Placitas area, Bernalillo and Placitas quadrangles, Sandoval County, New Mexico

BERNALILLO QUADRANGLE
by Sean D. Connell[1], 1999

PLACITAS QUADRANGLE
by Sean D. Connell[1], Steve M. Cather[2], Bradley Ilg[3], Karl E. Karlstrom[3], Barbara Menne[3], Mark Picha[3], Chris Andronicus[3], Adam S. Read[2], Paul W. Bauer[2], and Peggy S. Johnson[2], 1999

[1]*New Mexico Bureau of Mines & Mineral Resources, Albuquerque, NM 87106*
[2]*New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801*
[3]*Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, NM 87131*

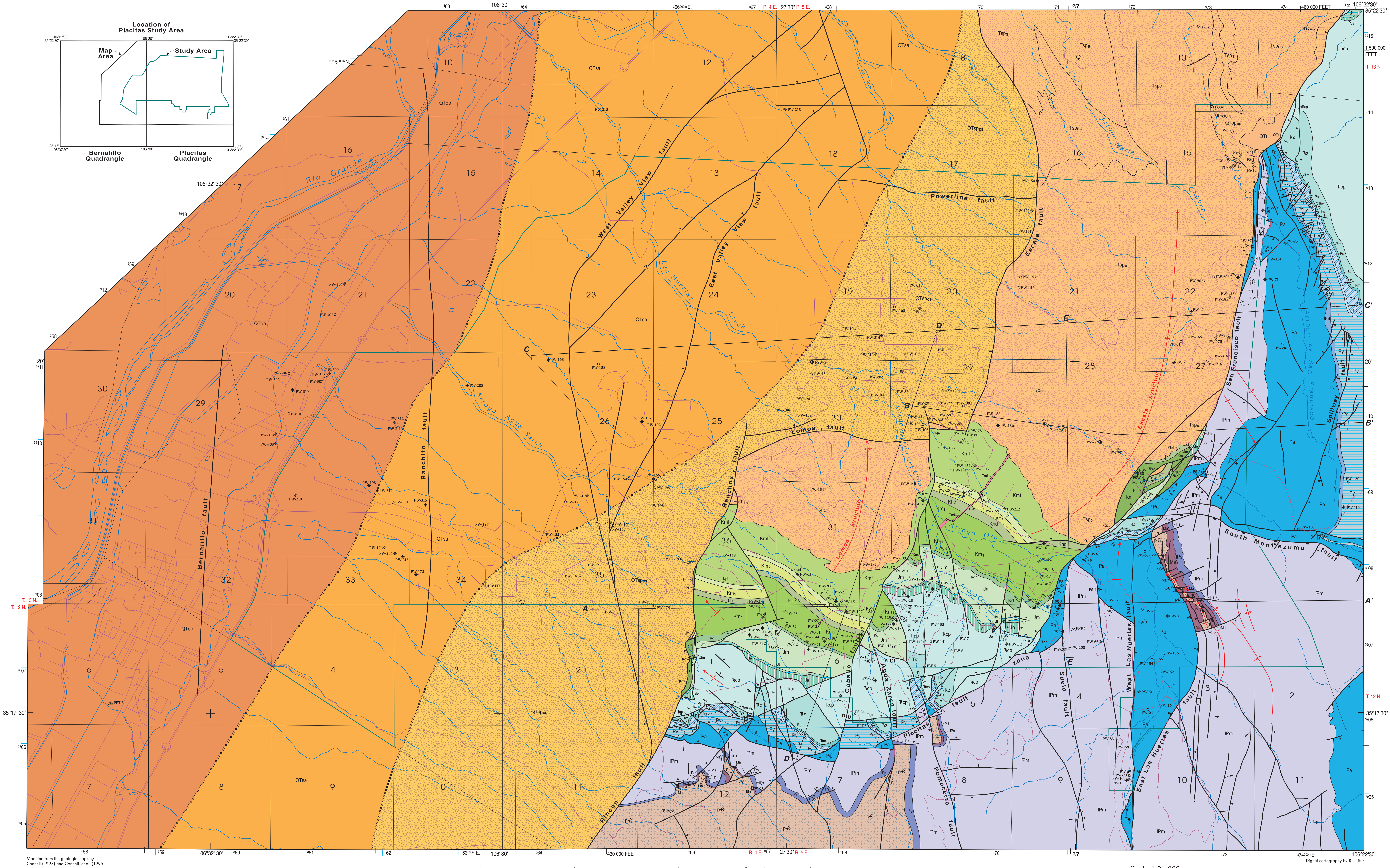
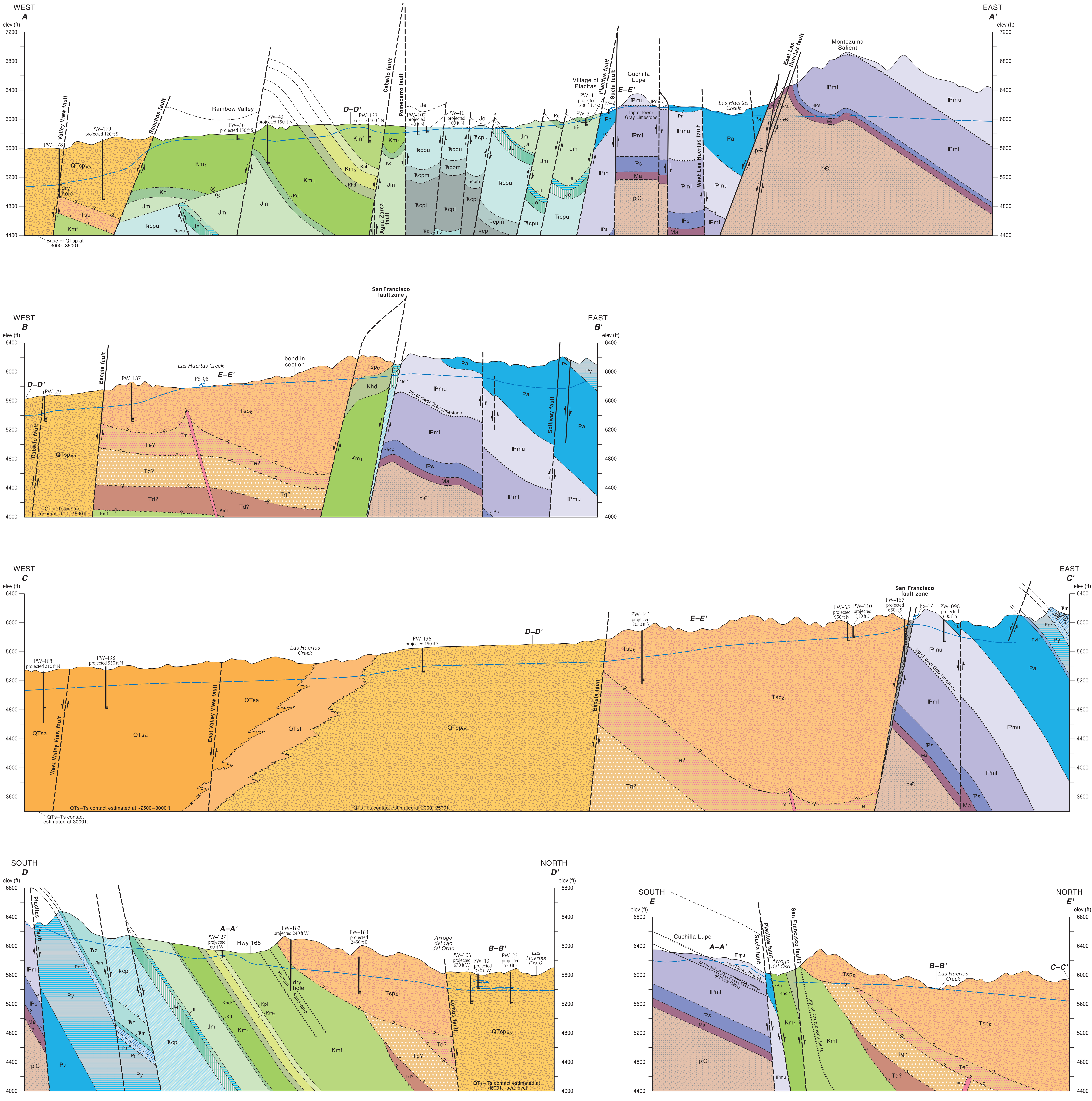


Plate 2. Subcrop geology of the Placitas area, Sandoval County, New Mexico

by Peggy S. Johnson, 2000

Scale 1:24,000



Scale 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

Plate 3. Geologic cross-sections A–A', B–B', C–C', D–D', and E–E' of the Placitas area, Sandoval County, New Mexico

by Peggy S. Johnson, 2000

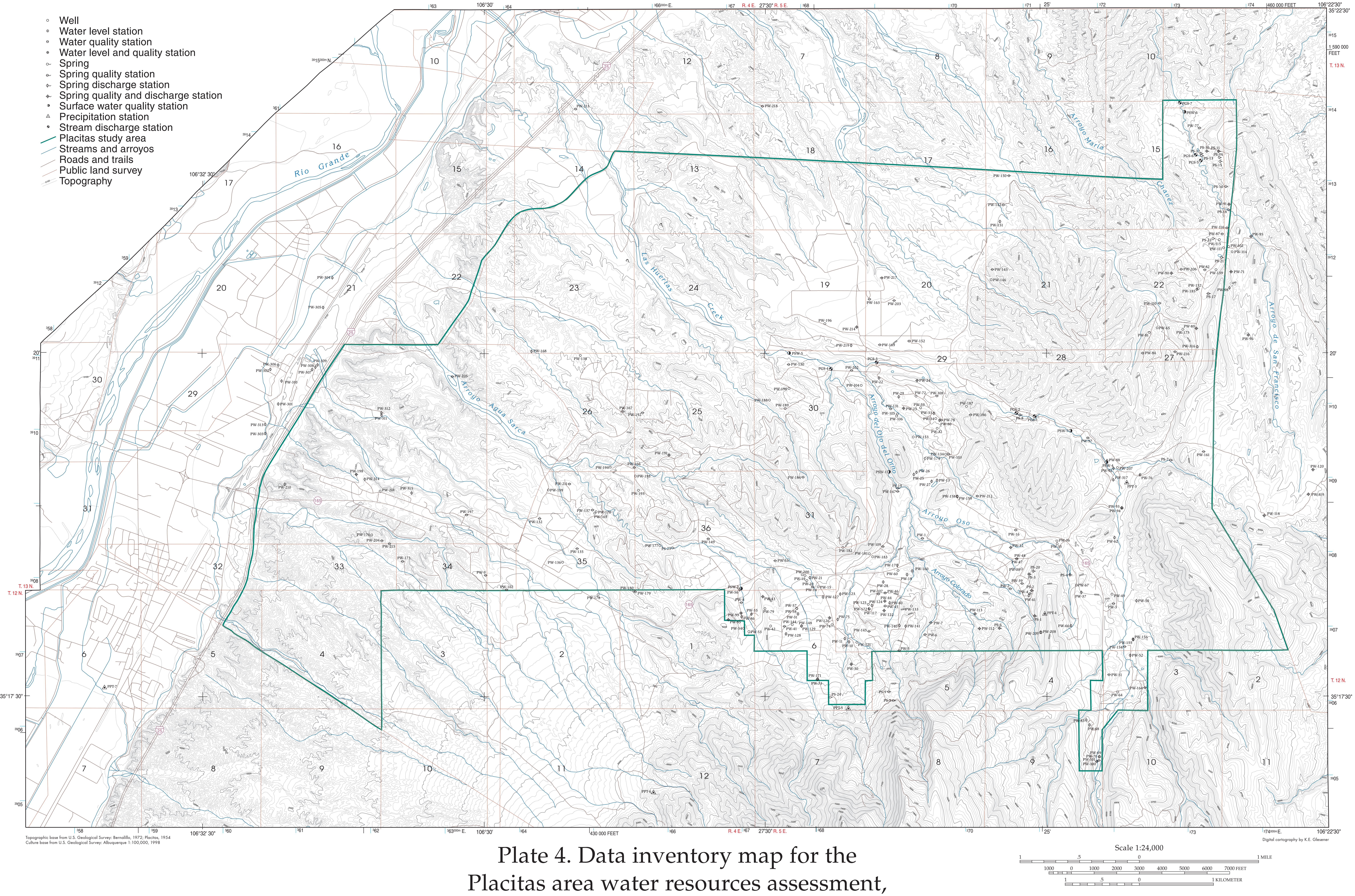


Plate 4. Data inventory map for the Placitas area water resources assessment, Sandoval County, New Mexico

by Peggy S. Johnson, 2000

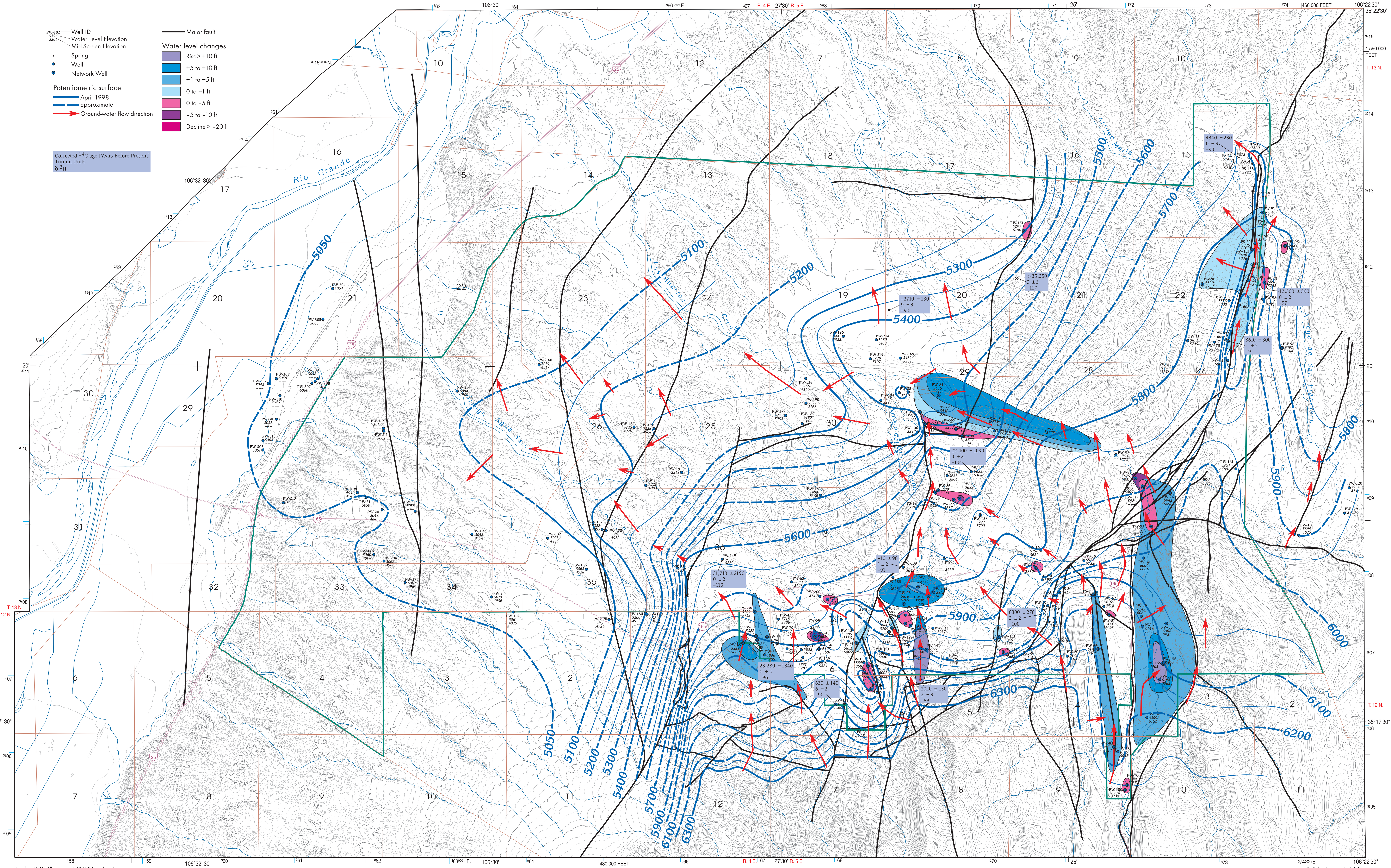


Plate 5. Potentiometric surface (April 1998) and water level changes August 1997–August 1998

by Peggy S. Johnson, 2000

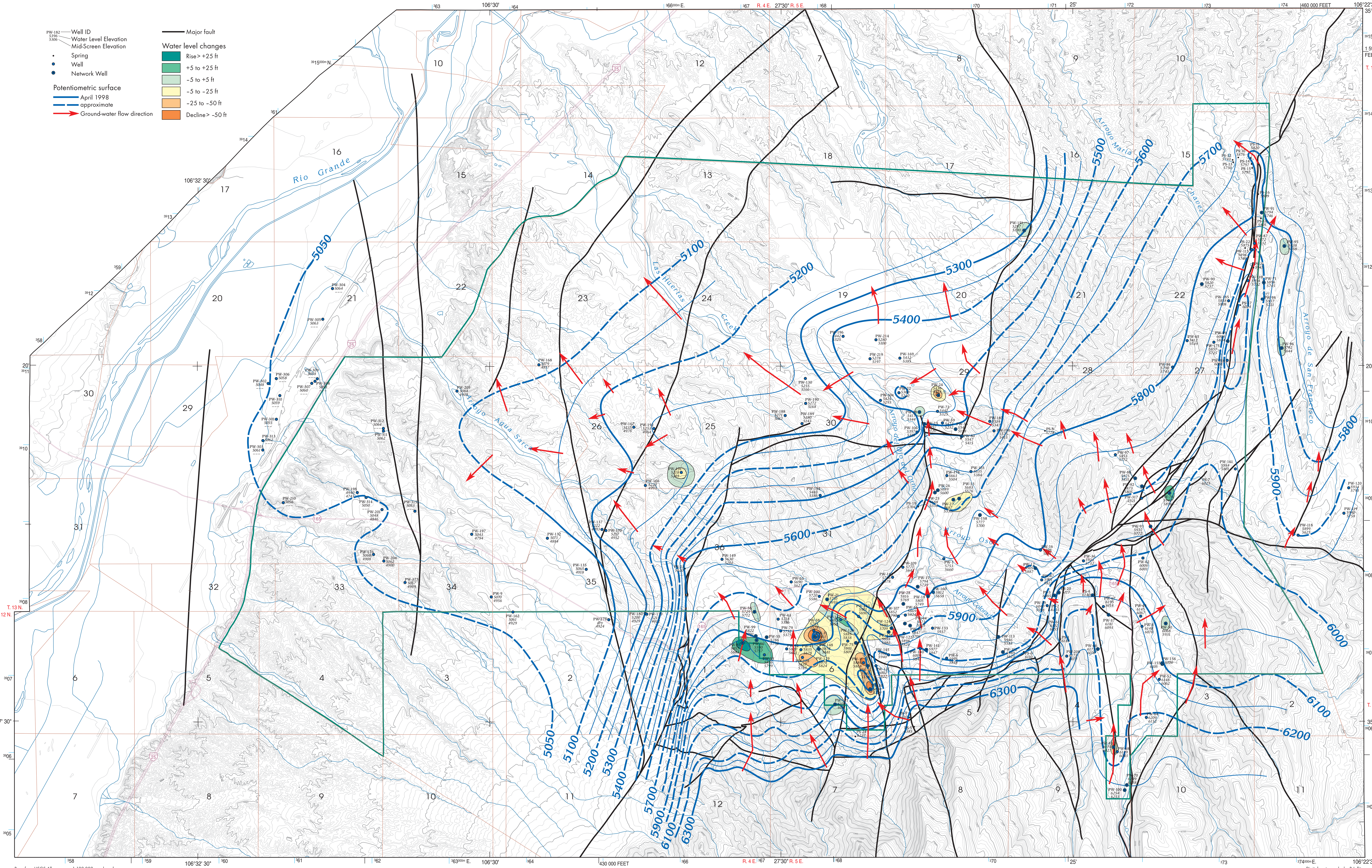
Scale 1:24,000

1 MILE

7000 FEET

1 KILOMETER

CONTOUR INTERVAL 20 FT



Scale 1:24,000

1 .5 0 1 MILE

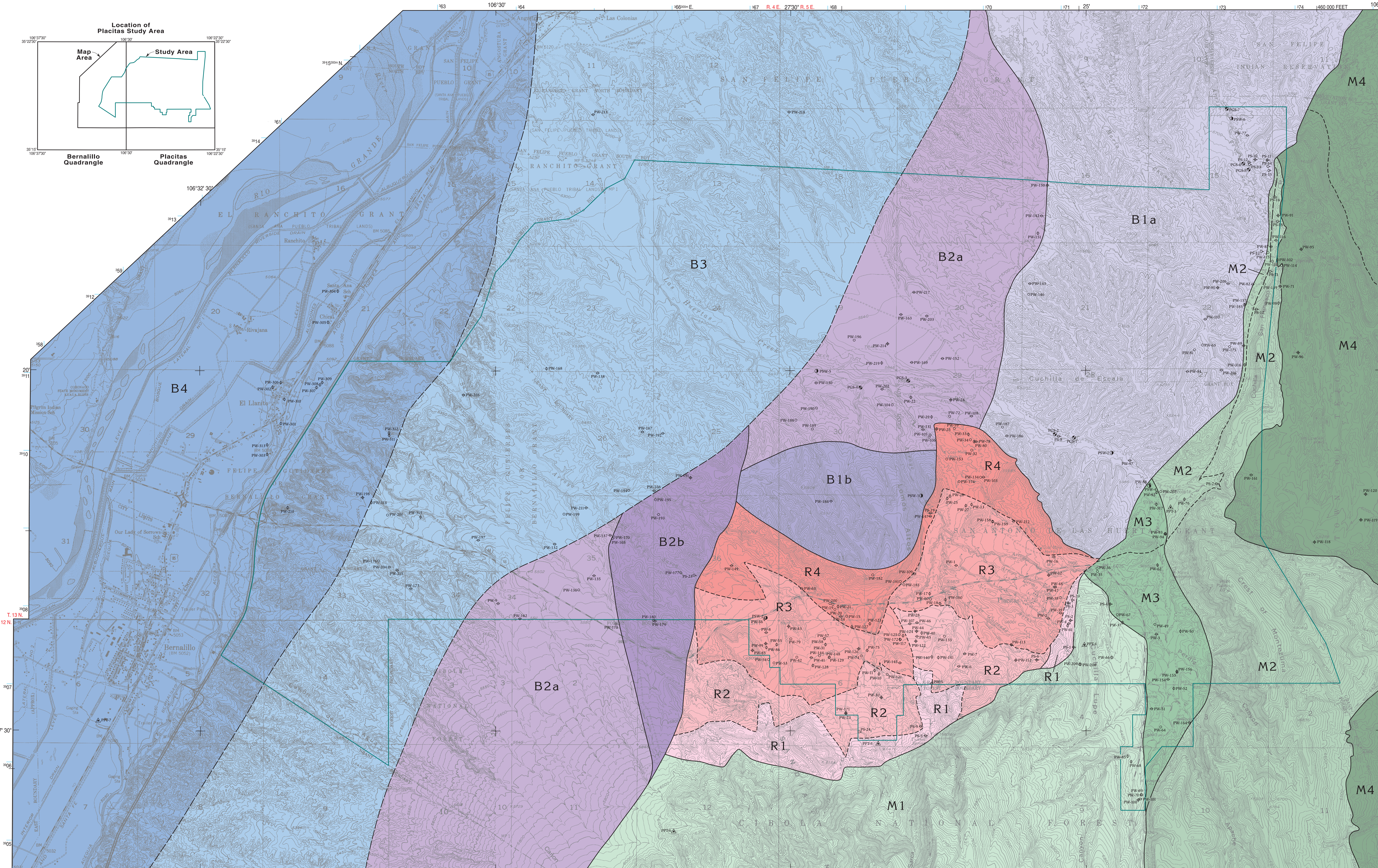
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FT

Plate 6. Potentiometric surface (April 1998) and long-term water level changes

by Peggy S. Johnson, 2000



Modified from the geologic maps by Connell (1998) and Connell, et al. (1995)

Digital cartography by R.J. Titus

See Table 7 for zone descriptions.

Plate 7. Hydrogeologic zones in the Placitas area, Sandoval County, New Mexico

by Peggy S. Johnson, 2000

Scale 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER