HYDROGEOLOGIC INVESTIGATION

Southeastern Madera County

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Prepared for:

Root Creek Water District

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EST. 1968
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I. EXECUTIVE SUMMARY

This report was prepared to evaluate groundwater impacts from development activities within the Root Creek Water District (RCWD). Specific issues discussed herein relate to the understanding and documentation of water supply capabilities. Root Creek Water District is located in southeastern Madera County along the San Joaquin River. Groundwater is the primary source of water supply to the area and groundwater levels have continued to decline since development occurred early this century. Owing to the fact that groundwater does not respect political boundaries, a large study area has been used in this evaluation to determine regional conditions. This larger area is then subdivided to review specific conditions related to RCWD. This report does not look at detailed Gateway Village groundwater conditions.

The primary purpose of the report is to determine the regional groundwater overdraft and to examine the feasibility of maintaining present groundwater levels. Certain studies and evaluations have been completed to accomplish this. These studies consist of quantifying the magnitude of overdraft, identifying potential means to stop declining water levels, and providing guidance on local strategies such that the present and planned land uses can be supported.

A. Regional Findings
   1. Groundwater

A number of factors influence the potential to develop groundwater in the study area. These factors include subsurface geologic conditions, depth to water, the direction of groundwater flow, water level trends, aquifer characteristics, pumpage, consumptive use, recharge, and groundwater quality. Subsurface geologic conditions below the water level are important in terms of well yields, and conditions above the water level are important when considering existing and potential groundwater recharge. The findings of the report with respect to groundwater may be summarized as follows:

- Groundwater overdraft in the larger study area approximates 22,000 af/yr. Included in this is about 3,400 af/yr in the Root Creek Water District.
- The direction of groundwater flow is toward the central part of the study area, where a pumping depression is present.
- Water supply is predominantly from groundwater sources.
- Maintenance of the water supply has been heavily reliant on groundwater inflow, primarily from the south and southeast
- Continued pumping without recharge could increase seepage losses from the San Joaquin River.
- Average long-term water-level declines have been five feet per year in the larger study area, and 3.3 feet per year in the Root Creek Water District (RCWD).
- The aquifer is thickest in the southwest portion of the study area and thins to the north and northeast.
- Approximately 10,000 acres in the northeast part of the study area overlie an area where the aquifer thins substantially, (bedrock becomes shallow) with a

resulting reduction in well production capacity.

- Surface and subsurface geologic conditions favorable for intentional recharge in the RCWD have been generally evaluated. The most favorable recharge areas generally appear to be in the south part of RCWD.
- Groundwater quality appears to be suitable for irrigation over most of the area.
- Water quality sampling for drinking water constituents has indicated that in certain parts of the study area, iron and manganese in well water exceed state standards. Also, high concentrations of chloride and arsenic have been encountered at depth in some areas and slime problems have resulted from production of water from blue-green strata in parts of the area.

These findings are based upon information that is presently available. In portions of the study area there are significant gaps in the available information. An improved water-level monitoring program would allow better definition of present and changing conditions and may allow the District to become alert to problems before they become serious. It is understood that the Department of Water Resources (DWR) has on-going investigative programs that can be undertaken cooperatively. It is recommended that the County and local water districts meet with the DWR to discuss future hydrogeologic studies and monitoring.

2. Surface Water

The County of Madera and the Madera Irrigation District have contracts with the United States Bureau of Reclamation (USBR) for water supplies from the Friant Division of the Central Valley Project. Additionally, private parties have entered into holding contracts with the USBR for water supplies to land adjacent to the San Joaquin River. Quantification of the amounts of surface water supplied to the larger study area is difficult because of the lack of records in some areas. It is estimated that surface water supplies have totaled as much as 7,500 acre-feet in a given year. The average surface water supply for the past eight years is approximately 3,500 acre-feet. Though this amount of surface supply is relatively small, the San Joaquin River contributes significant recharge to groundwater in the area through seepage from the river channel. Significant findings include:

- Use of surface water is critical to maintaining and augmenting groundwater supplies.
- Class I water supplies are available to Madera Irrigation District and Chowchilla Water District within Madera County every year.
- Class II water supplies and Section 215 water are generally available every other year to the same districts as for Class I supplies.

Local runoff is a resource that has contributed some recharge and may be utilized more effectively in the future. There are several creeks that meander throughout the area and have some ability to recharge the groundwater. Attempts should be made where possible to retain stormwater from new developments on-site. The *Field Review of Root Creek Watershed* (June, 1992) by the Soil Conservation Service states that there

is the potential to capture and recharge an annual average of approximately 1,500 acre feet of flood water from the Root Creek watershed itself.

3. Land Use

Based upon data collected and utilization of water consumption use factors, estimated water consumption was estimated for the years 1960, 1995, and a projected year 2020. 1995 was used because it is the most recent year for which the land use patterns are available in the Division of Planning and Local Assistance, Department of Water Resources Land Use Survey Data. Based upon the data and estimated consumptive use, the following has been determined:

- Additional water supplies are needed in the area to address groundwater overdraft.
- Consumptive use has increased over time due to development of both rural residential and irrigated lands.
- Changing irrigated lands from row crops to permanent agricultural plantings and rural residential development make reliability of water supplies critical.
- Water conservation activities are critical to the success of making best use of water supplies.

It is expected that in the future, the water demands of the area can be partially offset by retaining stormwater flows and wastewater effluent in the area.

Regional Study Area

The Regional Study Area encompasses approximately 55,485 acres in Madera County, including the land between Road 33 on the west, Highway 41 on the east, 145 on the north, and generally the San Joaquin River on the south. Land use varies from native vegetation (23,006 acres) to agricultural, with a large portion of the latter being in permanent crops (21,484). The remaining 10,815acres of the study area consists of field crops, row crops, truck crops, grain and hay (3,369), pasture (433), rural residential (6,757) and urban (256). The study area is estimated to have an overdraft of about 23,000 acre-feet per year.

Root Creek Water District

As stated previously, there is an estimated overdraft of approximately 3,400 acre- feet per year in the RCWD. The RCWD is in a location suitable for recharge activities and is pursuing studies to verify the results of this evaluation. Additionally, it may be beneficial for the District to contract with the USBR for Section 215 water. Discussions have taken place with the USBR and the Friant Water Users Authority on possibilities related to the timing and utilization of these potential supplies. A diversion capability of 23 cfs for direct use of surface water on irrigated lands (in-lieu recharge) or construction of approximately 150 acres of intentional recharge basins are estimated to be needed to enable the District to negate the estimated overdraft in the District. This assumes similar cropping patterns and resultant demands in the future as exist presently.

Proposed Village of Gateway

The proposed village is located in the northeast part of the RCWD. It is situated immediately west of Rolling Hills and to the east of the Madera Ranchos on Avenue 12. Total area of the planned community is about 2,378 acres, or about 25 percent of the RCWD. If the calculated overdraft is apportioned upon land area, the Village of Gateway would have an estimated overdraft of about 960 acre feet per year.

The Village of Gateway Draft Environmental Impact Report (released in February 2001) projects that water supply demands will approximate 6,400 acre-feet per year, based on land use demand factors for similar communities in the area.. Of this 6,400 acre-feet, the Draft EIR also notes (p. IV.K-11) that at project buildout, approximately 2,500 acre-feet of recycled water will be available for irrigation and groundwater recharge. Therefore, the consumptive use for Gateway Village is estimated to be 3,900 acre-feet per year This projected consumptive use is about two-thirds of the estimated present crop water consumption of 6,200 acre-feet or the 5,700 acre feet per year (1992 to 2000 average) indicated by historical pump records.

It is planned that the wastewater effluent produced by Gateway Village will be used on-site for irrigation of open space and will be used for irrigation of permanent crops in the area just to the west of the proposed Gateway Village. During the winter months, it is anticipated that a portion of this annual effluent production will be stored with some associated recharge. It is estimated that the net result of the direct reuse of the wastewater effluent will result in 2,000 acre feet of water returned to the groundwater. In addition to the activities related to the reuse and recharge of wastewater, it is also planned that the Village will be actively engaged with intentional recharge activities of the RCWD. To this end, it is estimated that intentional recharge activities will add an additional 1,000 acre-feet annually to the groundwater supply.

B. Conclusions

In conclusion, it is planned that in concert with the planned development the Root Creek Water District will strive to undertake studies, pursue acquisition of water supplies and balance the water supply needs within its boundaries. This will be accomplished through (1) reduction of pumped groundwater, (2) undertaking intentional recharge projects and (3) undertaking opportunities for in-lieu recharge where possible. If intentional recharge and other management projects are pursued to make use of flood water and the groundwater levels near the river are maintained, additional seepage losses from the San Joaquin River would not be expected.

II. INTRODUCTION

For some time, water supply concerns have been expressed about the portion of southeastern Madera County shown in Plate 1. Records indicate that groundwater pumping has caused groundwater levels to decline, particularly since about 1960.

The area has recently experienced new changes in water demands of irrigated and rural-residential development. Additionally, the State Center Community College District has established a campus on Avenue 12 east of State Highway 99 and the Valley Children's Hospital has completed its new facility near Highway 41. These new facilities are expected to spur residential and business activities on adjacent properties. Proposals related to changing the use of lands in southeastern Madera County have recently been discussed. Combined, they have the ability to negatively or positively impact the water resources of the area. A study area was defined that extends beyond the Root Creek Water District, to encompass other developing areas.

The study area is bounded by Highway 41 on the east, Highway 145 on the north, Road 33 on the west and the San Joaquin River on the south. Plate 2 shows a map of the study area boundary. Part of the western boundary coincides with the east edge of the Madera Irrigation District boundary, and further north follows Road 33. Boundaries of various existing residential developments and agencies are also shown on the map.

The Root Creek Water District (RCWD) includes a significant portion of the southeastern part of the study area. It extends from the San Joaquin River on the south to near Avenue 12 to the north and from Highway 41 on the east to Road 39 on the west. RCWD covers approximately 9,200 acres. Lands included in the Madera Irrigation District (MID) along Lateral 6.2 are scattered in the central part of the study area. Theses two districts are important in that they (or landowners within the districts) have access to surface water supplies. Additionally, they have the ability to contract with others for surface water supplies, as does the County of Madera.

In this document, the regional hydrogeologic conditions are first discussed. Specific issues in the Root Creek Water District are then discussed and related to the larger study area.

A. Data Collection

The first step undertaken for this study was a literature search to identify and review the existing body of knowledge. This included prior reports and studies that have been completed in the area. A list of the documents found and reviewed is contained in the bibliography. In addition to the historic reports, aerial photos and county assessor's data were utilized to identify development conditions and current parcelization. Aerial photos taken in 1960 and 1993, and 2000 (the latter by Air Photo USA) were collected to identify both surface features and existing land use. An important source of subsurface geologic information are the drillers logs and electric logs obtained from prior work in the area, and State Department of Resources (DWR) files were reviewed to supplement this data. Water level measurements were also obtained from DWR

database. Pumping and well water level records were collected from S&J Ranch in Root Creek Water District. Also, surface water diversion records were collected from Madera Irrigation District and S&J Ranch, as well as other landowners for surface water deliveries and pumped river water taken through holding contracts on the San Joaquin River. Crop Evapotranspiration data was gathered from the Irrigation, Training and Research Center (ITRC) website. In addition, Madera County supplied records on groundwater quality, pumping, and water measurements for some of the wells they operate. Also, several reports were available from specific projects in this area.

Another source of information is the knowledge and experience of residents and landowners. This pool of working knowledge is of great value. Contacts included farmers, water well drillers, and various agency officials. Several interviews resulted in valuable insight that helped in the evaluation.

B. Prior Studies and Documents

Information that is available consists of Madera County soil survey and field review of the Root Creek watershed. This study was prepared by the USDA Soil Conservation District in cooperation with the Madera County Flood Control District and was structured to identify flood related problems encountered in the area related to drainage and flooding. March and (1976) of the USGS mapped the geologic nature of surface materials in Open File Report 76-841. The area mapped covers most of the regional study area.

In addition, the Soil Conservation Service prepared a *Root Creek Watershed Field Review, a Part of California Special Studies Basin and Area Planning* in June 1992. The Department of Water Resources prepared an investigation in the Madera area in 1966. Unfortunately, this study was undertaken before substantial rural-residential developments and major changes in irrigated crops. This work is published in DWR Bulletin No. 135 and includes information on surface water, groundwater, and water levels.

A report prepared by the United States Geological Survey by Miller, Leblanc and Bertoldi titled "Geology, Hydrology and Quality of Water in the Madera Area" (1970) provides a general review of the regional groundwater conditions in the area. Groundwater in much of the area is present in the alluvial deposits and is recharged by seepage from the San Joaquin River and other sources. The boundary between where groundwater is found in bedrock versus in alluvium generally occurs along the northeastern edge of the regional study area. Areas generally indicated to be favorable for recharge were delineated and most were in the southern portion of the District. Additionally, the USGS prepared a proposed water resources study in cooperation with the Madera County Flood Control and Water Conservation Agency in 1972, due to the changing water levels experienced in the 1960's. Another USGS report includes "Profiles of a Reach of the San Joaquin River Below Friant Dam" that provides information on the stream channel along a length of the southern boundary of the study area. The USBR and others have undertaken studies and prepared reports on the conditions of flow and the amount of water lost or gained from the river during the past.

More recent information on groundwater includes work related to the Root Creek Water District Groundwater Management Plan, well development projects for the Madera Community College, Rolling Hills, and Madera Ranchos rural-residential developments, the new Valley Children's Hospital, and general investigations related to the proposed Rio Mesa planned community.

C. Aerial Photos

Aerial photos are useful for two purposes. The first purpose is to identify of surficial coarse-grained deposits, which may indicate conditions favorable for recharge. These deposits are formed by present-day or recent stream channels. Even in vegetated areas, these areas are often visible due to a lesser degree of vegetation. Plates 3, 4, and 5 display an August 2000 aerial photo overlaid with the boundaries of Gateway Village, RCWD, and the Regional Study Areas, respectively. Secondly, older photographs show the distinction and documentation of historic land use changes.

III. LAND USE

A. Historical Land Use

The study area encompasses approximately 87 square miles (55,485 acres) of urban, open, and agricultural land. Urban uses are considered to be commercial development inclusive of offices, restaurants, and retail outlets as would be encountered in a small city. Rural residential land is generally considered to be rural land established to develop a homesite, where individual parcels range in size from 1 to 5 acres. In addition to providing a homesite, developed rural residential property is used primarily for crop production and raising poultry, livestock, or domestic animals. In 1960, there was little residential development in the area. Agricultural lands are considered to be developed properties for the commercial production of grapes, cotton, alfalfa, pasture, deciduous fruits and nuts, citrus, grains, and truck crops. Idle land is considered to be land not used for agricultural, urban, or rural residential development. Much of the idle land is located in the northeastern portion of the study area, where only limited amounts of groundwater are present in hardrock.

Crops grown commercially in the area are categorized into the following four groups: pasture, row crop, vineyard, and deciduous orchard. The purpose for this classification is that it is fairy easy to delineate these crop types on the photographs and a different water unit demand can be utilized when estimating consumptive use for each category. Review of the photos indicates that by 1960 agricultural development had occurred from the San Joaquin River north to about Avenue 12. Significant open grassland areas are evident in the photos, suggesting that most of the agricultural production was pasture and field crops. Table 1 shows a breakdown of acreage in the study area in 1960.

To verify the information depicted in the aerial photographs, the county Agricultural Commissioner's office and the Department of Water Resources were contacted. The County had no information prior to 1990. However, the DWR had prepared crop surveys in 1958 and 1974 for the determination of water use organized by Detailed Analysis Unit(s) (DAU). The area in question is wholly in DAU 214, and the DWR information provided insight into the cropping of the land.

B. Current Land Use

Plate 6 shows the 1995 land use for the Regional Study Area. Urban areas that are within the study area include the communities of Madera Ranchos, the Bonadelle developments, Rolling Hills, and several other smaller projects. Rural residential lands within the study area for 1995 are estimated at approximately 6,757 acres. This represents about 86 percent buildout of the rural residential properties that are estimated to total 7,860 acres. Commercial, industrial, and urban-vacant accounted for another 256 acres in 1995. Of the rural residential land that is currently not developed, current use consists of agricultural production to vineyard, especially in the South Bonadelle tract. Native vegetation and idle land accounted for about 23,006 acres. The remainder (18,633 acres) was developed to agricultural uses. Historically, the urban acreage in the study area has been expanding.

Table 1 lists the estimated acreage within the Regional Study Area for 1993.

C. Change in Land Use

The study area is subject to several factors that have altered water use within the study area and the RCWD. The main agent for change is the rapid expansion of urban areas, which is converting both rural residential and agricultural lands to urban use. Cropping patterns also continually change in response to economic conditions. These have especially been evident over the past 30 years, with a significant conversion to permanent plantings (orchards and vineyards).

An attempt has been made to estimate how land use changes may impact water consumption. For purposes of this discussion, a planning horizon of the year 2020 is used. At this point in time, it is assumed that all of the rural residential property is developed and existing irrigated row-crop land is converted to vineyard and orchard. Urban development is expected to occur consisting of the Village of Gateway, and the area surrounding Valley Children's Hospital.

IV. ESTIMATED WATER DEMANDS

Water demand projections were developed based on the land use scenarios described previously. Plate 7 shows in graphical form the 1995 crop water use and pumping for the Regional Study Area. The focus is on urban, rural residential, and agricultural consumptive demands in the study area. Since existing intensive urban uses are limited, they have been included in the rural residential estimates for the years 1960 and 1995, rather than identifying them separately. For projecting future demands, the urban uses defined for the Village of Gateway have been utilized. None of the water demands can be viewed in isolation, as they are related. For example, as urban growth displaces irrigated farmland, the water demands will change. From a water resources perspective, this displacement raises the question of whether an acre of irrigated farmland uses more water than an acre of urban land use. The answer to this question is not straightforward, as it depends on the irrigated crop, source of water supply, density of urban land use, whether stormwaters are retained on site, and lastly, whether wastewater effluent is used or recharged in the local area or exported.

A. Rural Residential

The rural residential category has been used by the County in the unincorporated areas of the study area that allow for residential development. Most of these properties rely on individual wells and septic systems. However, there are two communities that provide public water supply to rural residential lands, namely Madera Ranchos and Rolling Hills. Pumping data was obtained from Madera County for these two communities, which represent about three percent of the acreage in the study area. The average demand for Madera Ranchos for 1986 to 2000 was about 900 af/yr, or 1.21 af/yr/connection. The average demand for Rolling Hills for the period of 1991 to 2000 was about 520 af/yr, or 1.61 af/yr/connection.

B. Agricultural

The agricultural category encompasses those lands that have been cultivated for the purpose of providing food and fiber. This designation includes large-scale enterprises as well as small hobby farms; these lands consist of both permanent and annual field crops. Irrigated grazing pasture-land is also included in this designation.

C. Urban

Different categories of water use are generally defined for analysis of use. Broadly based, these consist of two use types for housing, and separate categories for schools, parks, commercial, and offices. Typical types are as follows:

1. Single-family Residential, Low 2.1 to 4.0 Units Per Acre. The traditional subdivision type housing is represented by this category.
2. Single-family Residential, Medium 4.1 to 7.0 dwelling Units Per Acre. This category represents denser residential development.
3. Multi-family Residential, Medium-High 7 to 15 Units Per Acre. This area of multi-family housing is represented by duplexes, multi-family apartments, townhomes and small-lot, detached homes.

D. Commercial

All types of service-oriented businesses are included in this category. Commercial retail consists of shops, service stations and restaurants.

1. Office--this category includes professional offices, medical facilities, and corporate headquarters.
2. Public facility--Public facilities include government buildings, corporate and maintenance yards, churches, and meeting halls.
3. Schools--All schools included - generally with extensive lawn areas.
4. Parks and recreation facilities--Parks, irrigated open spaces and golf courses are included in this category.

The estimate of water consumption for the urban area is taken from the Draft EIR for the Village of Gateway that is presently under review. Gateway accounts for 2,500 acres of the 3,500 acres shown as urban development in the year 2020. For the remaining 1,000 acres that is in the Valley Children's Hospital area, it is assumed that the unit demand is essentially the same as the per-acre demand projected for Gateway Village.

E. Idle

This category includes the open space areas that consist of grasslands, natural drainages, and areas of sparse development.

V. WATER DEMAND BY LAND USE

A. Rural Residential

A review of Madera County service area records indicates an average water demand of about 1.5 acre-feet per acre (af/ac). In general, these areas control stormwater on-site and have septic-tank systems, which percolate water used within the home back into the ground. The consumptive use of rural residential developments is considered to be 60 percent of the demand because of recharge through septic systems. Therefore, the consumptive use in Madera County service areas is assumed to be 0.9 af/ac.

B. Agriculture

The agricultural water demand was estimated for 1960 and 1995, as shown in Table 1. These estimates use recent consumptive-use factors for four different categories of crops, namely pasture, row crops, vineyard, and deciduous orchard. The consumptive use values used for these categories are 3.8, 1. 8, 2.3, and 3.0 acre-feet per acre,

TABLE 1
Estimated Acreage and Associated Water Consumptive Use of Applied Water (Revised)

		1960		1995		2020	
Description	Unit Demand (af/ac)[1]	Area (acres)	Estimated Consumptive Use (af)	Area (acres)	Estimated Consumptive Use (af)	Area (acres)	Estimated Consumptive Use (af)
Pasture	3.75	6,000	22,500	433	1,624	0	0
Row Crop	1.78	3,000	5,333	3,369	5,989	0	0
Vineyard	2.31	2,500	5,775	6,653	15,368	6,440	14,876
Deciduous Orchard & Citrus	3.06	3,000	9,180	14,831	45,383	15,000	45,900
Rural Residential	0.90	0	0	6,757	6,082	7,860	7,074
Urban	2.75	0	0	256	703	3,500	9,625
Open	0.00	40,805	0	23,006	0	22,505	0
Totals		55,305	42,788	55,305	75,148	55,305	77,475

[1] Crop unit demands for 1960 and 2020 are based on those calculated for 1995.
[2] Estimated recharge of 4,107 AF of wastewater included in total.

respectively. These values were arrived at through a combination of (1) actual applied water use data, (2) values published from the University of California Extension Office, (3) Department of Water Resources information, and (4) the Cal Poly Irrigation Training & Research Center (ITRC). Included in Table 1 are the estimated consumptive uses for years shown.

A review of the land use over the past 35 years shows that about 18,000 acres of “open” land or native vegetation have been developed to other uses. About a third of this has been to rural residential development, the remainder to agriculture. The change in agricultural production from row crops to orchards has also had a profound impact on the water requirements of the area.

VI. GROUNDWATER CONDITIONS

Regional conditions influencing groundwater are discussed below, including subsurface geologic conditions, water levels, and groundwater quality. The regional direction of groundwater flow and the approximate saturated thickness of the alluvium are discussed. Sources of recharge and discharge are evaluated. Rates of water-level decline are reviewed, both in RCWD and the rest of the regional study area. The regional groundwater overdraft is then estimated.

A. Regional Conditions

The most recent regional hydrogeologic evaluation of groundwater in the Madera area was prepared by the U.S. Geological Survey in the 1960's, and reported by Miller, LeBlanc, and Bertoldi (1970). The boundaries of the area evaluated extended from the Merced County (Chowchilla River) boundary on the north, to the San Joaquin River on the south and west. At that time, few deep wells had been drilled in the area east of the Santa Fe Railroad tracks. Since the 1960's, thousands of water supply wells have been drilled in the area. Some irrigation wells have been drilled to depths ranging from 700 to more than 900 feet. Substantial development has occurred in many areas without a surface water supply. Recharge has not been able to keep up with the pumpage, and groundwater levels have fallen accordingly.

B. Subsurface Geologic Conditions

Miller, LeBlanc, and Bertoldi (1970) prepared a map showing the elevation of the top of the hardrock (basement complex). Few water wells in the area have encountered bedrock, except in the northeastern portion of the Regional Study Area. Several deep oil or gas exploration holes have been drilled in the area, and logs for these provide additional information. The top of the hardrock slopes steeply to the southwest and is estimated by the USGS to range from about 1,400 to more than 2,000 feet deep beneath the Root Creek Water District. Beneath the Santa Fe Railroad tracks, depth to the top of the hardrock is estimated to be more than 2,000 feet.

Plate 9 shows a number of geologic features of importance to groundwater in the study area. First, surface outcrops of the basement complex and the Ione Formation are shown. The Ione Formation is a cemented conglomerate lying above the basement complex, and forms the "table top" hills in the northeast part of the Study Area. Experience indicates that only small capacity (i.e. private domestic) wells can be developed in the hardrock and the Ione Formation. A northwest to southeast trending line is shown on Plate 4, representing the approximate boundary between where groundwater is developed from the alluvium (to the southwest) versus the hardrock (to the northeast).

Two subsurface geologic cross sections were developed as part of the evaluation (Plate 9). Cross Section A-A[1] (Plate 10) extends from near the San Joaquin River and Santa Fe Railroad tracks to the northeast to near the northeast corner of the Root Creek Water District. Cross Section B-B[1] (Plate 11), extends from near Cottonwood Creek and Road 32 on the northwest, to the southeast near Highway 41, south of the San

Joaquin River. Both coarse-grained water producing strata and fine-grained strata that may act as confining beds are shown for these sections. The entrenched San Joaquin River channel and its floodplain are shown on both sections, along with the water level as of Spring 2001. Another important feature is the approximate top of the blue-gray (reduced) deposits. As discussed later in the Groundwater Quality section, these deposits are important because of their relation to water quality problems for public supply wells in some areas. Along Section A-A[1], the reduced deposits haven't been encountered within the upper 700 feet, whereas near the northeast edge of the section, the deposits are present below a depth of about 400 feet. Along Section B-B[1], the top of the deposits becomes progressively shallower to the southeast. Near Cottonwood Creek and Road 32, the top of the reduced deposits is more than 700 feet deep, whereas near the San Joaquin River and Highway 41, the top of these deposits is less than 300 feet deep.

One of the most important trends of these cross sections is that coarse-grained deposits are predominant to the northwest, near the Fresno River, and to the south and southeast near the San Joaquin River. Along Section A-A[1], coarse-grained deposits are thinner and less predominant toward the northeast. Along Section B-B[1], coarse-grained deposits are the thinnest in the area between Road 33 and Road 36. Another trend shown on the cross sections is that below a depth of about 700 feet, fine-grained deposits are usually predominant. Exceptions are present, such as in the northwest part of the study area, where some coarse-grained deposits have been found below 900 feet and above 1,200 feet in depth. The water level shown on the cross section indicates a deepening away from the San Joaquin River, Fresno River, and the area served with canal water by the Madera Irrigation District.

C. Water Levels and Groundwater Flow Direction

Modified versions of maps prepared by DWR for the years 1936 and 1960 are included as Plates 12 and 13. Both of these plates indicate a predominant southwesterly direction of groundwater flow. Fall 1936 water level elevations ranged from about 270 feet above mean sea level (MSL) near the intersection of Highway 41 and Avenue 12 to about 235 feet near the corner of Road 36 and Avenue 9. Water level elevations in Spring of 1960 ranged from about 255 feet above mean sea level (MSL) near the intersection of Highway 41 and Avenue 12 to about 225 feet near the corner of Road 36 and Avenue 9. Spring 2001 water-level elevations were approximately 220 feet above MSL near the San Joaquin River between Road 38 and the Valley Children's Hospital. As of 1936, little if any groundwater recharge to the area came from San Joaquin River Seepage. As of 1960, recharge from river seepage was limited to a localized area near the river.

Plate 14 is a water-level elevation contour map for Spring 2001. Water levels were measured in a number of normally unmeasured wells in Spring 2001 in part of the Regional Study Area east of Highway 41. Some previous water-level maps in the area have combined water-level measurements for alluvial wells with those for hardrock wells, which is not meaningful from a technical standpoint.

The lowest water-level elevations in the RCWD in Spring 2001 were about 120 feet, in the area near Avenue 12 and between Road 38 and Road 40. A north to northwesterly direction of groundwater flow was indicated in the southern part of the study area. Groundwater flowed toward a large cone of depression in and to the east of the Madera Ranchos area and north of Avenue 12. Water-level elevations in this cone of depression were lower than 110 feet and the depression was north of the Rolling Hills area. West of the Santa Fe Railroad Tracks and north of the San Joaquin River, groundwater flowed northwest into the Madera Irrigation District. Most of the wells in which water levels are routinely measured are located in the Madera Irrigation District and the RCWD. One large area without water-level measurements is north of the Santa Fe Railroad tracks and north of Avenue 9, extending for several miles to the northeast. Another is the area north of Avenue 12 and east of Road 36, where few wells are routinely measured. Such measurements are necessary to more fully understand groundwater in portions of the study area outside of the two districts.

The cross sections show that the water levels in wells tapping the main water-producing strata were about 30 feet below the flood plain of the San Joaquin River. The San Joaquin River is a losing stream along most of the study area and is indicated to be one of the major sources of recharge by the contours and flow lines shown on Plate 14. Shallower wells (less than 50 feet deep) or excavating near the river have encountered groundwater in hydraulic connection with river water.

1. Water-Level Changes

Water-level hydrographs were available for 15 wells in the Root Creek Water District from the District groundwater management plan. Water-level hydrographs were also available for about 18 additional wells with long-term records outside of the Root Creek Water District. Rates of water-level decline during the past several decades have ranged from less than one foot per year near the San Joaquin and Fresno Rivers to almost ten feet per year in part of the interfan area at Madera Ranchos. Water-level declines in the Root Creek Water District increase with increasing distance from the San Joaquin River. For example, near Avenue 8 the average rate of decline has been about one foot per year, near Avenue 9 about two feet per year, near Avenue 10 about four feet per year, and near Avenue 11½ about five feet per year. The average rate of water-level decline in the Root Creek Water District during the past two decades has been about three and a half feet per year.

Average water-level declines in the portion of the Madera Irrigation District served with canal water, in the western part of the study area, have averaged about two feet per year since the 1950's. Water-level declines in the area east of the Santa Fe Railroad tracks and north of the Root Creek Water District have averaged about four feet per year, except in Madera Ranchos, where declines have reportedly ranged from five to ten feet per year. The average water-level decline outside of both the Madera Irrigation District and Root Creek Water District yet in the study area, is indicated to have averaged about five feet per year during the past two decades.

D. Sources of Recharge and Discharge

Recent water-level elevation maps for the north portion of the Fresno urban area indicate groundwater flow away from the San Joaquin River, to the south. There is presently little or no flow of groundwater from Fresno County into Madera County east of Highway 99. For the study area, major sources of recharge are seepage of San Joaquin River streamflow, and some groundwater inflow from the west, where canal water is used in the Madera Irrigation District. Additional recharge is from seepage from Cottonwood Creek, Little Dry Creek, and Root Creek. Groundwater outflow from the study area is not indicated, due to the pumping depression, and thus the main source of groundwater discharge is due to pumping wells. Seepage of San Joaquin River streamflow is indicated to be the predominant source of recharge to the Root Creek Water District. Deep percolation of irrigation return flow where river or canal water is used for irrigation is another source of recharge. Groundwater discharge from the Root Creek Water District is primarily by well pumpage and groundwater outflow to the northwest.

E. Groundwater Overdraft

To estimate overdraft, rates of water-level decline and the specific yield of the alluvium must be known. Once these factors are quantified, then the extent of groundwater overdraft can be estimated. The water-level declines in the Root Creek Water District and the rest of the study area have already been discussed. Miller, LeBlanc, and Bertoldi (1970) provided a graph relating the percentage of coarse-grained deposits versus the specific yield for an area south of Madera. Most specific yield values in the area ranged from 7 to 15 percent.

For this evaluation, the parts of the subsurface cross sections below the water level and above a depth of about 700 feet were categorized. Fine-grained deposits were assigned an average value of five percent and coarse-grained deposits an average value of twenty percent. Along Cross Section A-A[1], about 70 percent of the deposits were classified as fine-grained, and the average specific yield was estimated to be 10.5 percent. Along Cross Section B-B[1], about 60 percent of the deposits were classified as fine-grained, are the average specific yield was estimated to be 11 percent. For both the Root Creek Water District and rest of the study area (alluvial part only), an average specified value of 11 percent is utilized.

For the 9,200 acres in the Root Creek Water District, the average water-level decline has been about 3.3 feet per year. The amount of groundwater overdraft is then calculated at about 3,400 acre-feet per year. For the remaining 44,000 acres an estimated 10,000 acres of the study area are underlain by groundwater in hardrock. The long-term change in storage in the hardrock is assumed to be negligible. For the remaining 34,000 acres, water-level declines average about 5.0 feet per year. The annual overdraft for the remaining area can be calculated at about 19,000 acre-feet. The amount of groundwater overdraft is thus about 22,000 acre-feet per year for the entire study area. This can be compared to an estimated overdraft of almost 8,000 acre-feet in the 33,000 acre study area utilized in hydrogeologic studies for the City of Madera proposed sphere of influence, which extends to the south and immediately west

of the study area of this report (Kenneth D. Schmidt & Associates, 1997). The difference in overdraft is primarily associated with the lack of surface water or canal water in most of the study area, resulting in water-level declines about three times greater than in the Madera Irrigation District to the west.

F. Groundwater Quality

In general, much of the groundwater in the area has been of suitable quality for irrigation use. Relatively few wells have been drilled in the study area for community or public supply. Water for public supply has been developed at Rolling Hills, Madera Ranchos, at the Madera Community College, at the Sierra View School, and at the Valley Children's Hospital. Some groundwater quality problems have been encountered; they are discussed in the following section.

Connate (high salinity) water is indicated to be present beneath the southwest part of the study area (Miller, LeBlanc and Bertoldi, 1970). Depth to the top of the connate water has not been precisely determined, but is estimated to range from about 1,200 to 1,300 feet deep. This is beyond the depths of supply wells in the study area, and would probably only be of consequence if future wells are drilled below a depth of about 1,000 feet in the western part of the study area. For the Root Creek Water District, this factor does not appear to be important, because of its more easterly location.

A groundwater quality problem that has been found in and near the Root Creek Water District is of a biological nature, resulting in the production of slime in some wells. At Rolling Hills, this was found to be primarily associated with the blue-green or reduced deposits at a depth of about 350 to 550 feet. By sealing off these deposits and drilling deeper, good quality groundwater was found. At Madera Ranchos near Road 36, such deposits were indicated to be below a depth of about 600 feet, and two new public supply wells were successfully developed by tapping the over-lying deposits. The reduced deposits in the area frequently contain high manganese concentrations. At the Madera Community College, near the west boundary of the study area, reduced deposits were also found below a depth of about 600 feet and a new well tapping the over-lying deposits was successfully developed.

Another problem in the vicinity of Avenue 12 and Road 36 is high chloride concentrations. These concentrations range from lower than 100 to over 300 mg/l, and may reflect some connate water influence due to upward flow of deeper groundwater. This high chloride groundwater is indicated to primarily be below a depth of about 600 feet. Water-level measurements from a test well near Root Creek and Road 36 indicate an upward head gradient. This means that the deeper poor quality groundwater is now tending to move upward into the shallower water producing zones. A longer-term groundwater quality concern in the Madera Ranchos area is that the shallow good quality groundwater is gradually being removed by overdrafting. If water levels continue to fall, more groundwater quality problems can be expected. Lastly, high manganese concentrations have also been found in some shallow groundwater near the San Joaquin River, such as at the Valley Children's Hospital.

There are large data gaps in the Study Area groundwater quality database in terms of constituents on the Title 22 list for public drinking water supplies. That is, most private, domestic, and irrigation wells have not been tested for these constituents. However, available information indicates suitable quality groundwater in the part of the study area where data is available, with the exceptions previously noted.

VII. SURFACE WATER AVAILABILITY

A. Precipitation

Annual rainfall within the area typically varies from six inches in dry years to over 21 inches received in 1983. The average annual precipitation for the area is approximately ten inches. Some of this water is ponded locally and percolates to the groundwater. However, due to the topography, soils, and timing of precipitation events, some of the rainfall exceeds the transmission ability of the soils. Once saturation is reached, runoff collects and is concentrated to local streams, which drain towards the southwest.

B. Local Streams

Several foothill streams contribute to the area's water supply. Three streams with significant flows are Root Creek, Little Dry Creek, and Cottonwood Creek. The flows from these foothill watersheds vary considerably between wet and dry years. These flows contribute to winter irrigations and groundwater recharge, with some significant amounts captured outside the study area. Historical flow data is not available for the foothill streams, making accurate monthly flow estimates impossible. However, the SCS Root Creek Watershed Field Review (1992) estimates that the average annual runoff of Root Creek is 1,500 acre-feet. The SCS report mentions that this flood water flows overland and ponds (presumably at the Santa Fe Railroad grade) until evaporating. The lack of detailed data on these streams does not appreciably affect water management decisions, as the flows tend to come during the winter and occur over short time periods.

C. Friant Division - Central Valley Project

The Friant Division of the Central Valley Project extends from near Chowchilla in the north to Kern County in the south. Friant Dam, constructed on the San Joaquin River, controls the natural runoff of the San Joaquin River and redirects the water to the Madera and Friant-Kern canals for use in the areas previously described.

By the time construction began on Friant Dam in 1939, the watershed already was well developed. Located on the main stream on the San Joaquin River about 25 miles northeast of Fresno, Friant Dam (Millerton Reservoir) is the principal storage facility on the Friant Division of the CVP. The dam was completed to where it could regulate the river's flow in 1944, and was finished in 1947. Small diversions began into the Madera Canal in 1944 and the Friant-Kern Canal in 1949. However, full operation of Friant Dam did not occur until 1951, when the Delta-Mendota Canal was completed. Until this canal was built, water was released from Friant Dam for the exchange contractors downstream. The exchange contractors are the San Joaquin River water rights holders who exchanged their use of natural river runoff for a substitute supply from the Delta-Mendota Canal.

The plan of the United States for the San Joaquin River has been to acquire the water rights by purchase or providing a substitute water supply. Total water supplies were estimated to be 2,150,000 acre-feet; 800,000 acre-feet has been designated as Class I supply. Class I water is that supply which can be considered dependable in practically

every year, with deficiencies only in occasional critically dry years. Class I deficiencies have been experienced in nine of the last 21 years. The minimum Class I supply was 25 percent in 1977. The Class II allotment has averaged 45 percent since 1966, and has been 100 percent in eight of the last 31 years. Class II water is that water in excess of Class I, and accordingly, is much less dependable as to its quantity and time of occurrence. Class II supplies have been zero in ten of the last 31 years, including seven of the eight years between 1987 and 1994 (Table 2).

Contractors from the CVP in Madera County include the Madera Irrigation District, Chowchilla Water District, the County of Madera, and the Adobe Ranch. Collectively, the contractual water supply amounts to 140,500 acre-feet of Class I and 346,000 acre-feet of Class II water supplies.

In addition to these water service contractors the USBR entered into holding rights contracts with property owners along the San Joaquin River. In the study area there are approximately 15 different contracts that cover approximately 4,000 acres. Water is released to the river to meet the individual needs of each holding rights contractor.

A third source of Friant Division CVP water is Section 215 water, which is surplus flood flow on the San Joaquin River. The water is only useable when Millerton Reservoir is in flood release.

As shown in Table 2, when the water year is above about 110%, Section 215 water is expected to be available. On average, it has been available every two years for a period of approximately five months. It is assumed that recharge facilities can be constructed to utilize 20 cfs flow capacity. Using Section 215 flood water with the aforementioned availability, approximately 6,000 acre-feet can be recharged every other year. Therefore, 20 cfs capacity relates to an average supply of 3,000 acre-feet using San Joaquin River Section 215 water supply. It should be noted that the facilities would operate five months out of 24.

D. Water Transfers

It may be possible to contract with Madera County CVP contractors for surface water when it is available in excess of their needs. Additionally, there is also the possibility of water transfers with others in the system. For the purpose of this evaluation it is assumed that only Section 215 water is utilized in programs for intentional recharge. Purchase of other supplies may be available in the future, allowing both greater operational flexibility and additional supplies to the area.

Table 2

Friant Division - CVP Water Supplies

		CLASS I	CLASS II		
USBR Water Year	percent Year	Actual (%)	Actual (%)	Section 215 Available (months)	
1966	70.7	100	23	N	
1967	176.1	100	100	Y	(3)
1968	47.0	92	0	N	
1969	220.1	100	100	Y	(7)
1970	78.8	100	29	N	
1971	77.2	100	35	N	
1972	56.6	100	4	N	
1973	111.5	100	77	Y	(2)
1974	119.3	100	82	Y	(1)
1975	97.8	100	60	N	
1976	34.3	75	0	N	
1977	19.7	25	0	N	
1978	185.3	100	100	Y	(4)
1979	99.7	100	63	Y	(4)
1980	162.0	100	100	Y	(5)
1981	58.2	100	22	N	
1982	180.7	100	100	Y	(7)
1983	252.9	100	100	Y	(9)
1984	111.3	100	50	N	
1985	70	100	14	N	
1986	151	100	100	Y	(6)
1987	42	91	0	N	
1988	47.1	78	0	N	
1989	52.2	98	0	N	
1990	40.0	68	0	N	
1991	66.0	100	0	N	
1992	46.0	83	0	N	
1993	150	100	90	Y	(5)
1994	50	80	0	N	
1995	218	100	100	Y	(6)
1996	124	100	58	Y	(5)
1997	158	100	55	Y	(2)
1998	178	100	50	Y	(5)
1999	150	100	55	Y	(5)
2000	103	100	60	Y	(4)
2001	60	100	5	N	
AVERAGE		94%	44%	\1	(5)

Notes: \1 available every 2 years

VIII. POTENTIAL FOR AUGMENTING WATER SUPPLIES BY IN-LIEU RECHARGE

An in-lieu recharge program could be accomplished by supplying surface water for irrigation to the orchards in the vicinity of the Gateway Village area or in the RCWD. Surface water supplies from the San Joaquin River riparian or holding contracts could be more fully utilized. There is also a possibility of entering into long-term agreements with Madera and/or Chowchilla Irrigation Districts for excess supplies during wetter conditions. Delivery of supplies are expected to be made through an existing turnout on Lateral 6.2 and connection pipeline located along the west section line of Section 32. The gravity pipeline could be siphoned under Root Creek and continue south as far as Avenue 9. Refer to Plate 15 for a preliminary plan of the distribution system.

A feasibility analysis of this option must consider the ability to offset the annual overdraft of 3,400 acre-feet. To offset this overdraft, Class II and Section 215 (flood) water-supplies (Table 2) must be available. Section 215 supplies are available for an average of five months per year in 17 of the past 35 years. Therefore, to eliminate overdraft, an in-lieu recharge program must be able to receive double the annual overdraft, or 6,800 acre-feet, in flood years. Removing Gateway Village (2,378 acres) and the areas covered by riparian rights and holding contracts (2211 acres) from the RCWD leaves about 4,700 acres for such a program. The 6,800 acre-feet would be delivered to these 4,700 acres (Plate 15) every other year for about five months, resulting in a flow rate of approximately 23 cfs. This would result in an annual application of 1.4 acre-feet per acre, which would be supplemented with groundwater to meet water demands of the orchards. A pipeline of 48-inches is estimated to deliver about 11,000 acre-feet. This amount is considered the maximum amount of water that an in-lieu program is capable on a bi-annual basis.

Future studies may indicate that temporary storage in the creek for surface supplies may provide a benefit. This has yet to be determined. The remaining 6,000 acres are envisioned to be interconnected between the creek and the existing irrigation systems, allowing for surface supplies to be used throughout the District when available.

IX. POTENTIAL FOR AUGMENTING WATER SUPPLIES BY RECHARGE

A. Top Soils

Within the study area, soils are classified by six associations, three of which are described below due to their significant extent and recharge potential. A portion of the USDA-SCS General Soil Map from the 1971 Soil Survey is shown in Plate 16. The part shown is for an area included in the proposed Village of Gateway. Following are brief summaries of the soils series and information pertinent to recharge taken from the aforementioned soil survey. The soils are listed in rank, beginning with the most desirable types for recharge by basins.

1. Hanford - Tujunga Association

This association includes mainly Hanford and Tujunga series soils that are classified as deep, well drained to excessively drained, dominantly loamy sands to fine sandy loams. The soils are found on benches in river valleys and on flood plains of minor streams.

The soils of the Hanford series consist of moderately coarse textured recent alluvium. The alluvial deposits were stratified and channeled during deposition. In places a hardpan, occurs at moderate depth, which can limit infiltration rates.

2. San Joaquin - Exeter - Ramona Association

This association is classified as sandy loams to loams that are shallow or moderately deep. Most soils of this association have a hardpan that is cemented with iron and silica, occurs at depths of one to four feet, and is relatively impermeable to roots and water. This hardpan is highly unfavorable for recharge, and is commonly excavated for recharge projects such as basins in Madera and Fresno. The Ramona series have a moderately restrictive subsoil, but lack the hardpan.

3. Whitney Series

The soils of the Whitney series developed in weakly consolidated sedimentary materials derived chiefly from granitic rocks. They occupy dissected, old, low terraces, chiefly in the eastern part of the San Joaquin Valley. The slopes are undulating to hilly, and drainage is good. The Whitney soils are associated with the older San Joaquin soils, which cap the low hilly areas of Whitney soils. The Rocklin soils usually have more clay in the upper part of the subsoil and a thin hardpan in the lower part. The Cometa soils are reddish brown and have a claypan subsoil, and the Trigo soils are shallow and light colored and have a softly consolidated, light-colored, silty substratum.

The soils in the north and northeastern part of the area are predominately loamy soils. These soils, identified as the Whitney and Cometa soil series, are all underlain by hardpan. The surface soils are generally brown to reddish-brown, and the subsoils are generally reddish-brown or yellowish-red sandy clay loam or clay loam. These soils have low to moderately low permeabilities, while their water holding capacities range from low to high. Natural vegetation for this part of the area consists entirely of annual grasses and forbs.

The soils to the south of the area belong to the Ramona and San Joaquin series. The surface soils are light brownish-gray to pale brown sandy loams and loams. The subsurface soils are similar to the surface soils in color and texture and are generally light clay loams, fine sandy loams, and heavy loams. These soils vary considerably in permeability and water holding capacity.

To the west of the study area, the soils have more depth and better drainage due to alluvial fan characteristics. These soils are primarily characterized by the Hanford series. Soils of the Hesperia, San Joaquin, and Exeter series are also present in much of the area. The surface soils are generally fine sandy loams and range in color from light brownish-gray to dark grayish-brown. The subsurface soils are similar in texture to the surface soils, ranging from coarse sandy loam to light loam. These soils are generally well drained, fertile, and moderately coarse textured. Nearly all the acreage of these soils is cultivated.

B. Subsurface Geologic Conditions

Most of the deposits south of Avenue 10 along Section A-A' above the water level are coarse grained. Beneath the northeast part of the this section (north of Avenue 12), fine-grained deposits are predominant above the water level, which averages about 250 feet deep along this part of the section. Coarse-grained deposits appear predominant above a depth of about 100 feet between Avenues 11 and 12 along the section, however, thick fine-grained deposits are present beneath these deposits and above the water level.

Section B-B' indicates that coarse-grained deposits are widespread within the uppermost 100 to 150 feet beneath much of the area south of Avenue 11. Some of the most favorable areas for basin recharge appear to be near Avenue 11 and Avenue 9 1/2 along this section. Depth to water averages about 200 feet beneath this section. Deposits below the water level generally become coarser grained to the southeast as the San Joaquin River is approached.

Along the floodplain of the San Joaquin River, hardpan layers are absent. On the north side of the river, the direction of groundwater flow is to the northwest. Two sites, west of Scout Island and near the Valley Children's Hospital, are considered favorable for exploration.

C. Recharge Potential

1. Site Selection Criteria

Following the initial data collection and some interviews, a list of selection criteria was prepared to begin narrowing prospective recharge areas. Hydrogeologic conditions limited the number of potentially favorable intentional recharge sites. However, in-lieu recharge can be used in these areas. The scarcity of favorable sites dictated that hydrogeologic considerations and the location of the water source be given preeminence, while other factors such as existing or planned land use, land, or improvement cost became secondary factors which would be utilized in comparing areas with equal geologic potential. The final site selection criteria are provided in Table 3.

Table 3
Site Selection Criteria

Primary Factors	• Surficial Conditions - permeability of top soil and shallow alluvium • Subsurface geologic conditions (nature of deep deposits) • Location with respect to groundwater flow patterns • Proximity to existing or future groundwater extraction facilities • Proximity to water source
Secondary Factors	• Depth to water • Contiguous parcels • Land costs • Water quality impacts • Proximity to potential WWTP

The first two primary factors relate to the potential infiltration rates, which are related to the vertical permeability of soils and the shallower alluvium above the water level. It is also very important to consider the direction of groundwater flow, so that recharge is practiced in an area that will be most beneficial to the project.

2. Expected Potential

Based upon the information reviewed, it is expected that up to twenty feet of material will need to be excavated to expose sands that have the potential intentional recharge benefits. Coarse-grained deposits of sufficient thickness are expected below this level, allowing adequate horizontal movement of recharged water. It is currently estimated that recharge rates may approximate 0.25 to 0.5 feet per day. Extending this rate to a five-month operation scheme results in about 25 acres capable of recharging about 1,000 af/yr. To accomplish 6,000 ACRE-FEET in one year, recharge facilities of about 150 acres would be required. Soil borings are needed to locate favorable areas and pilot tests with test basins are needed to refine these infiltration estimates.

There are four areas that appear to hold promise for intentional recharge activities. These general areas were sited mainly due to extensive coarse-grained deposits above the water level. Other issues that were identified consist of relatively thin clay hardpan or restrictive layers, shallow removal of existing earth strata, location up-gradient of potential water supply areas, and beneficial impact to water levels in the vicinity of the RCWD. These areas are shown on Plate 8, and include:

(1) Along the San Joaquin River at two locations
(2) In the southwest part of RCWD, south of Avenue 10 and west of Road 39
(3) Along Root Creek central to Root Creek Water District
(4) North of Avenue 12, adjacent to Madera Irrigation District Lateral 6.2

X. RECOMMENDED ACTIONS FOR INITIATING AN INTENTIONAL RECHARGE PROGRAM

A. In-Lieu Recharge

For this to be a viable program the District will need to have a contract or commitment from the USBR or a USBR Friant-division contractor to assure a surface water supply under certain conditions. Should this be accomplished, meetings with the Madera Irrigation District need to take place related to conveyance of water in the Lateral 6.2 canal. Also, conveyance in the Madera Canal needs to be arranged. Lastly, an engineering feasibility study needs to be completed addressing the physical facilities needed to convey water from the Lateral 6.2 canal into the District, and the needed infrastructure required to connect and distribute the water to lands within the District.

B. Intentional Recharge

It is recommended that the following actions outlined in Table 4 be initiated for each of the respective areas as time and funding will allow. Recommendations for soil borings and the estimated costs are included in Table 5.

Table 4
Action List

Site	Action
North, Root Creek	Conduct exploratory boring program, identify target parcels, and conduct pilot tests if supported by results of borings.
Avenue 9	Conduct exploratory boring program, identify target parcels, and conduct pilot tests if supported by results of borings.
San Joaquin River	Gain access for exploratory borings. Conduct exploratory boring program, and if favorable, conduct pilot tests.

Borings are required to verify the subsurface geologic conditions and identify any restricting layers such as hardpan, silt, or clay. The borings will probably be completed utilizing a bucket auger. The use of a bucket auger is recommended because it facilitates precise soil identification for a relatively low cost and can be used where hardpan or rocks are present. Soil borings for this project will be done under the supervision and review of Kenneth Schmidt and Associates, who will log the borings, prepare geologic logs, and provide a written summary of findings. The number and estimated cost of borings is shown in Table 5. Pilot infiltration tests would then be conducted to determine exact areas needed.

Table 5
Recommended Field Investigation

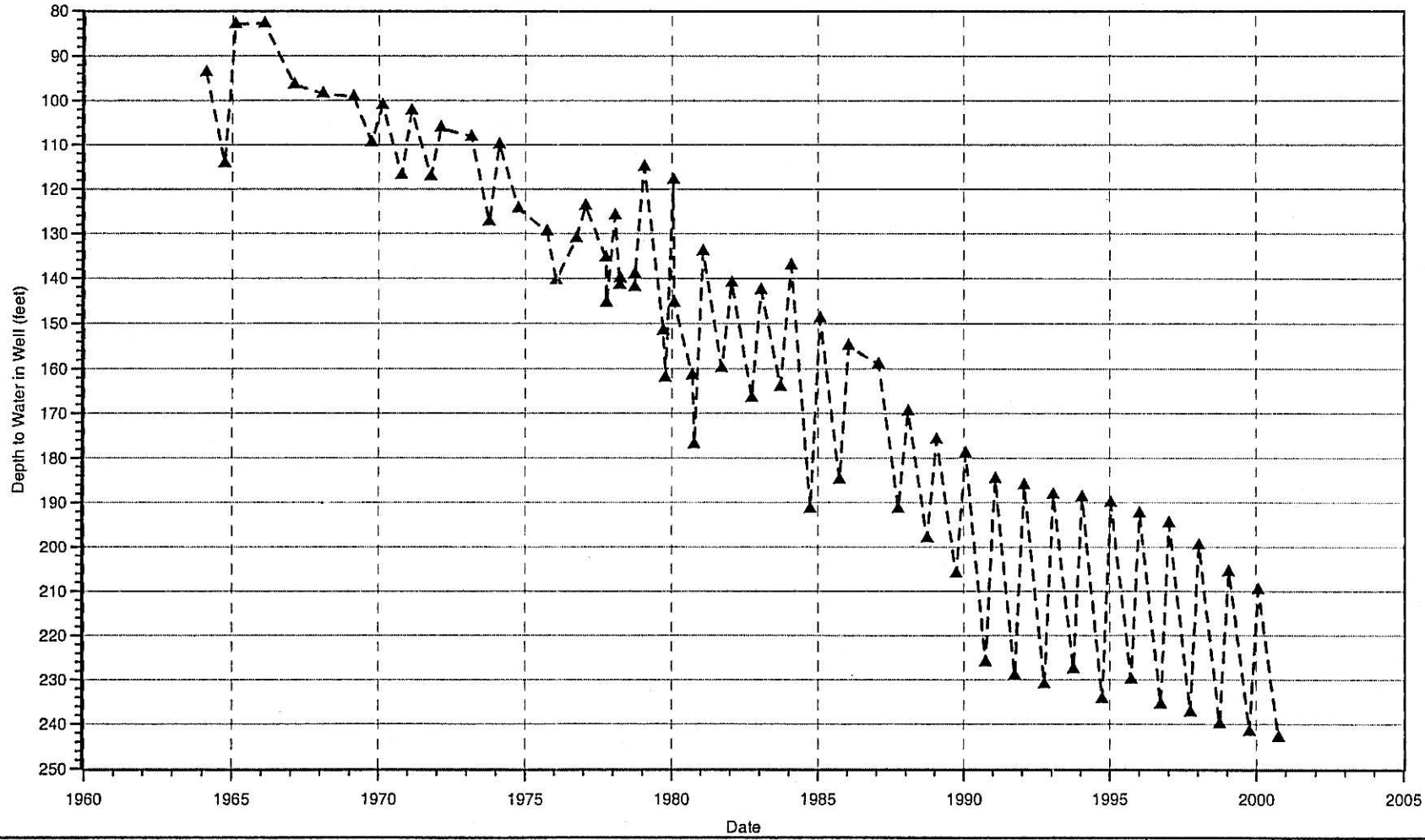
Item Description	North	Root Creek Central 4	San Joaquin River	Unit Price	Total Cost
Bucket Auger Borings or Casing Hammer	2	5	5	$1,500	$18,000

Appendix

Well hydrographs

Appendix

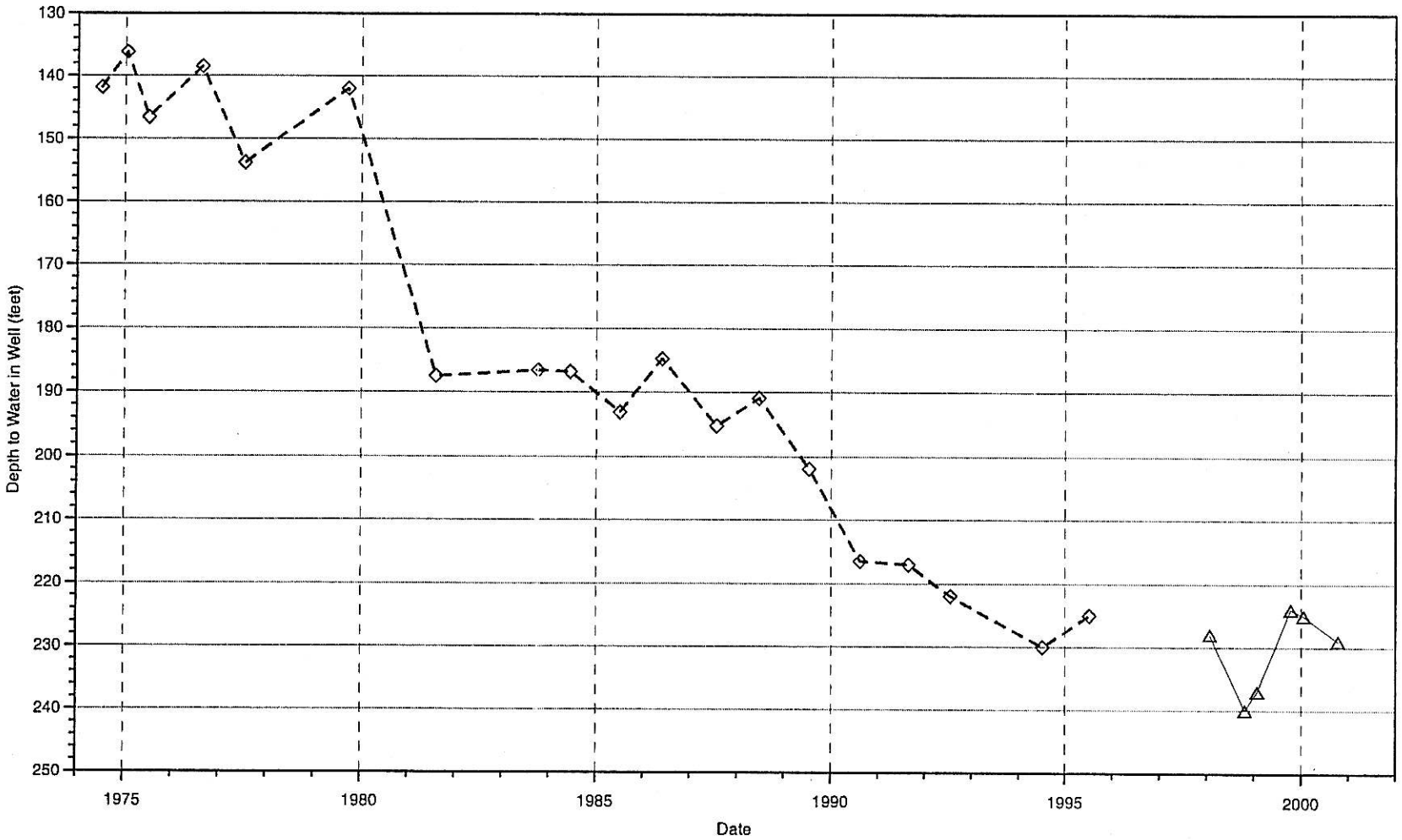
Well hydrographs



14340101-GW

Hydrogeologic Investigation

Southeastern Madera County
Water Level Hydrograph
Well T11S R19E 33 J1 (Madera ID)

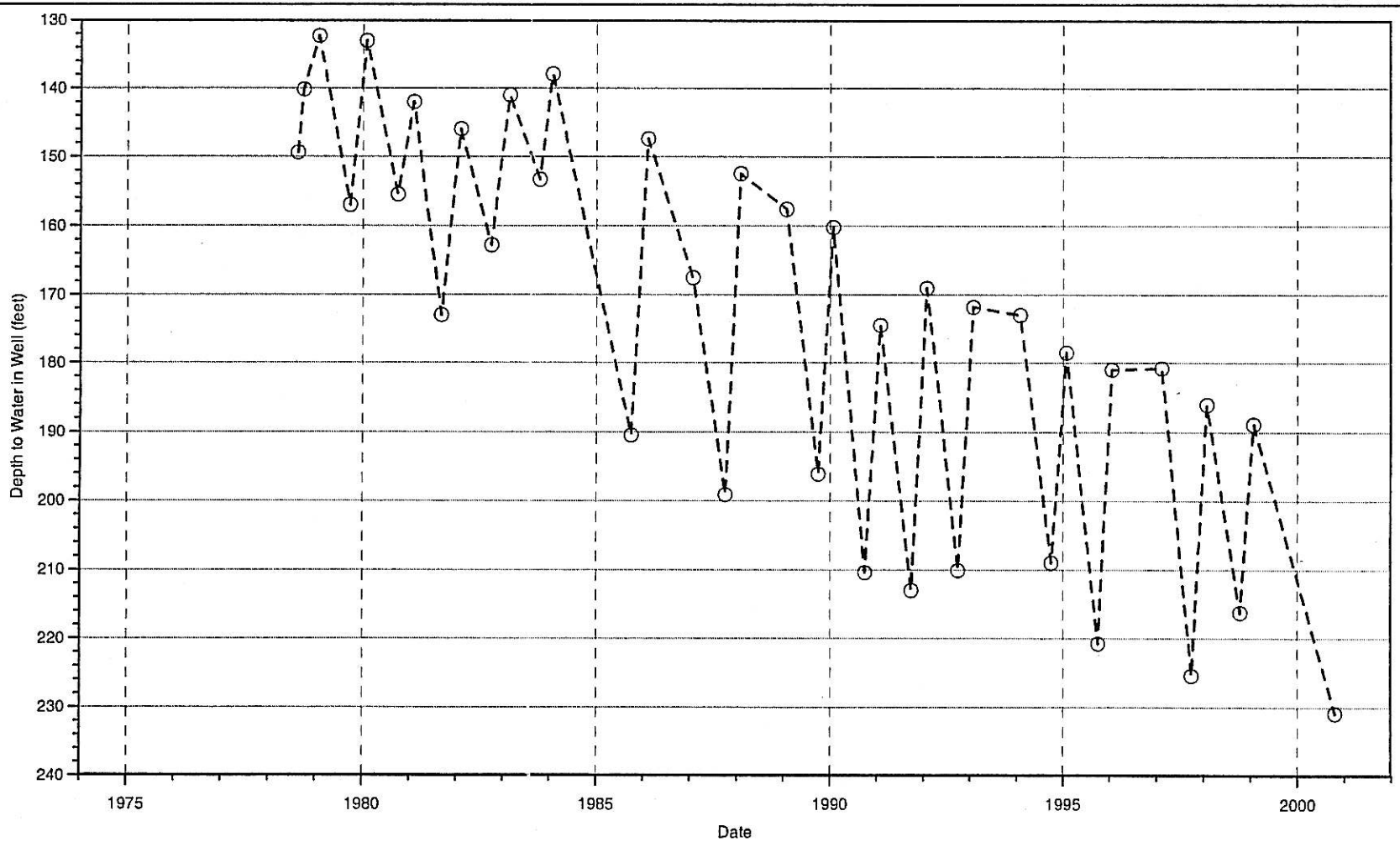


Legend
PG&E
S&J Ranch

14340101-GW

Hydrogeologic Investigation

Southeastern Madera County
Water Level Hydrograph
Well T12S R19E 01 Q (S&J Ranch # 77)

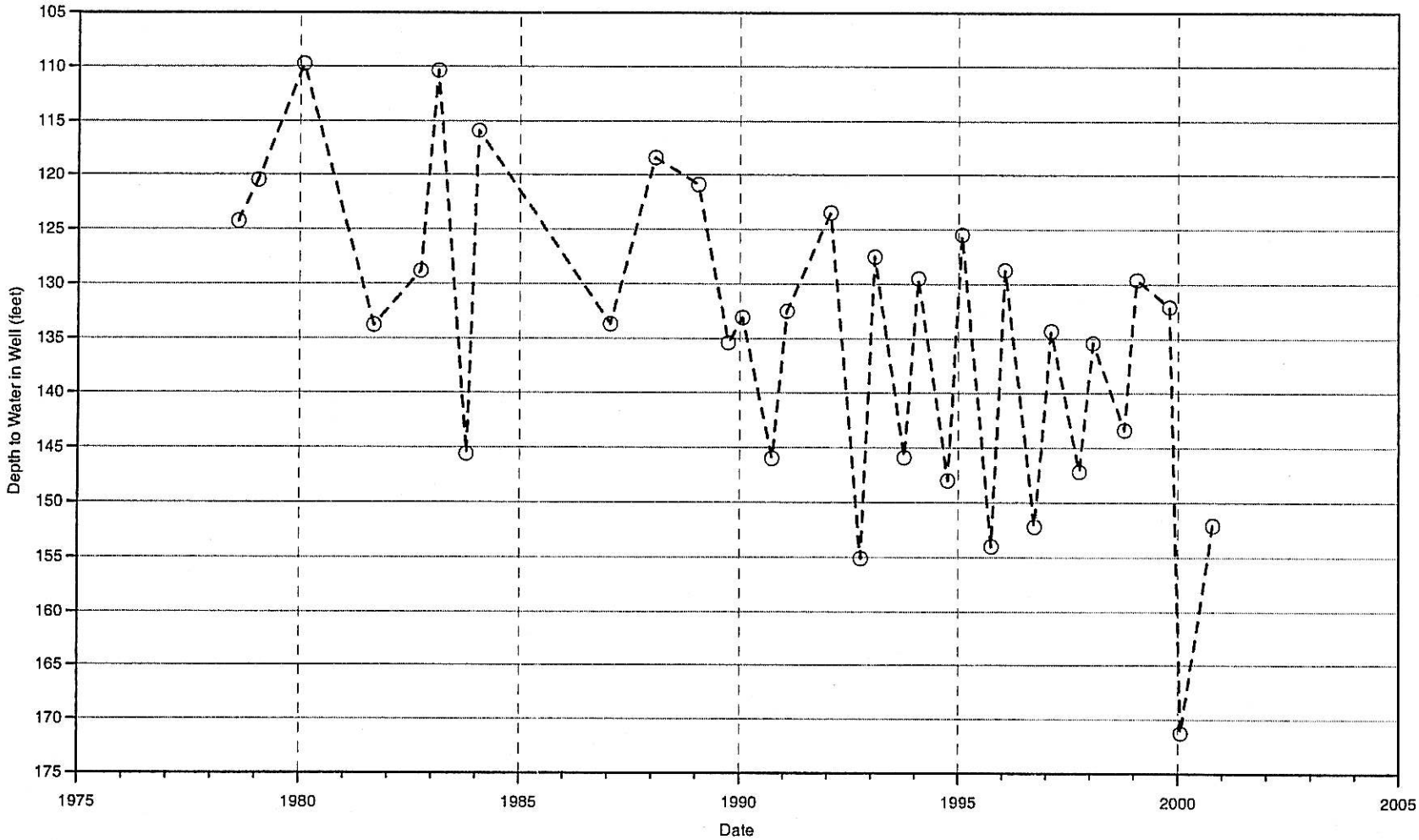


Legend
USBR

Hydrogeologic Investigation

Southeastern Madera County
Water Level Hydrograph
Well T12S R19E 13 E1

14340101-GW

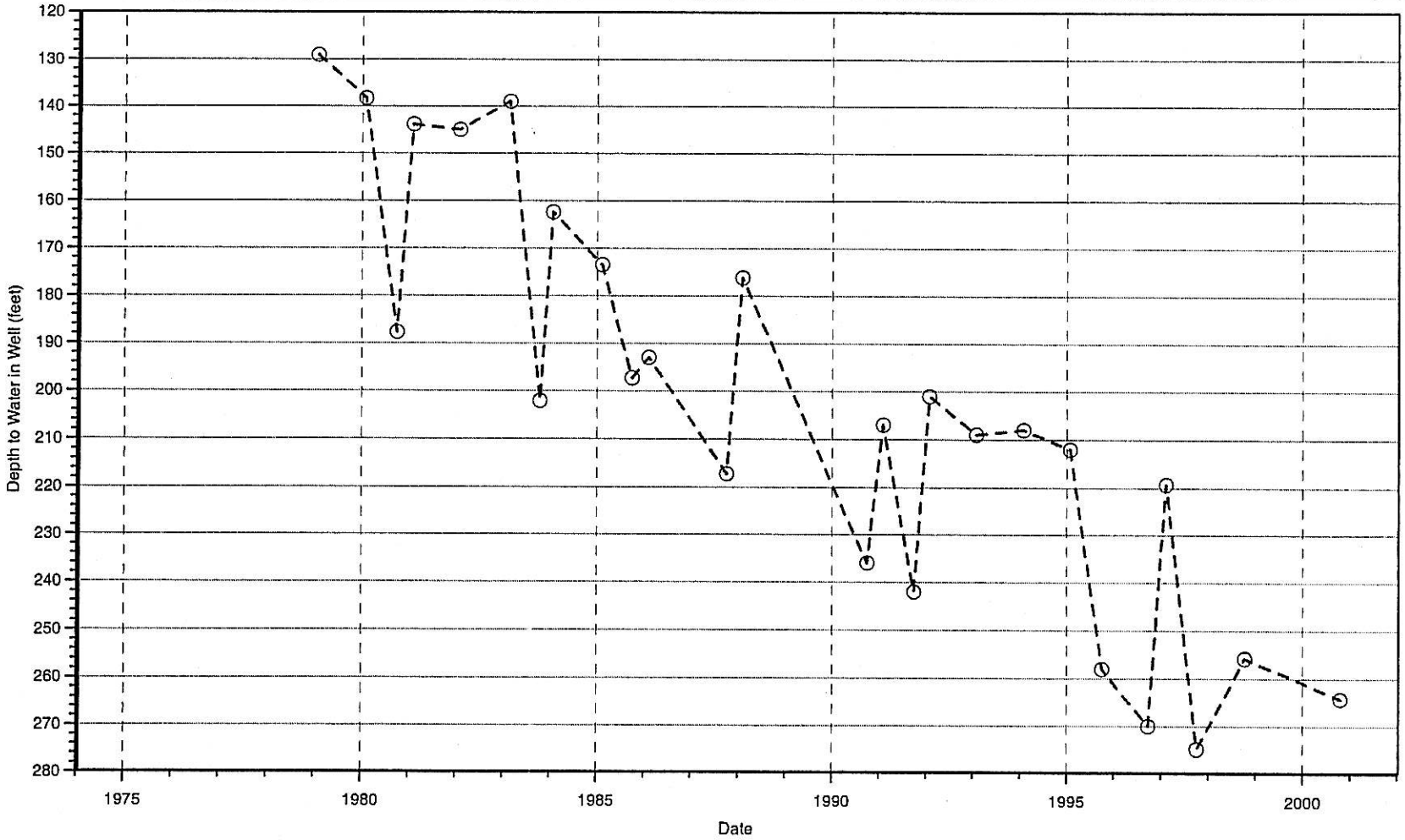


Legend
USBR

Hydrogeologic Investigation

Southeastern Madera County
Water Level Hydrograph
Well T12S R19E 23 K1

14340101-GW

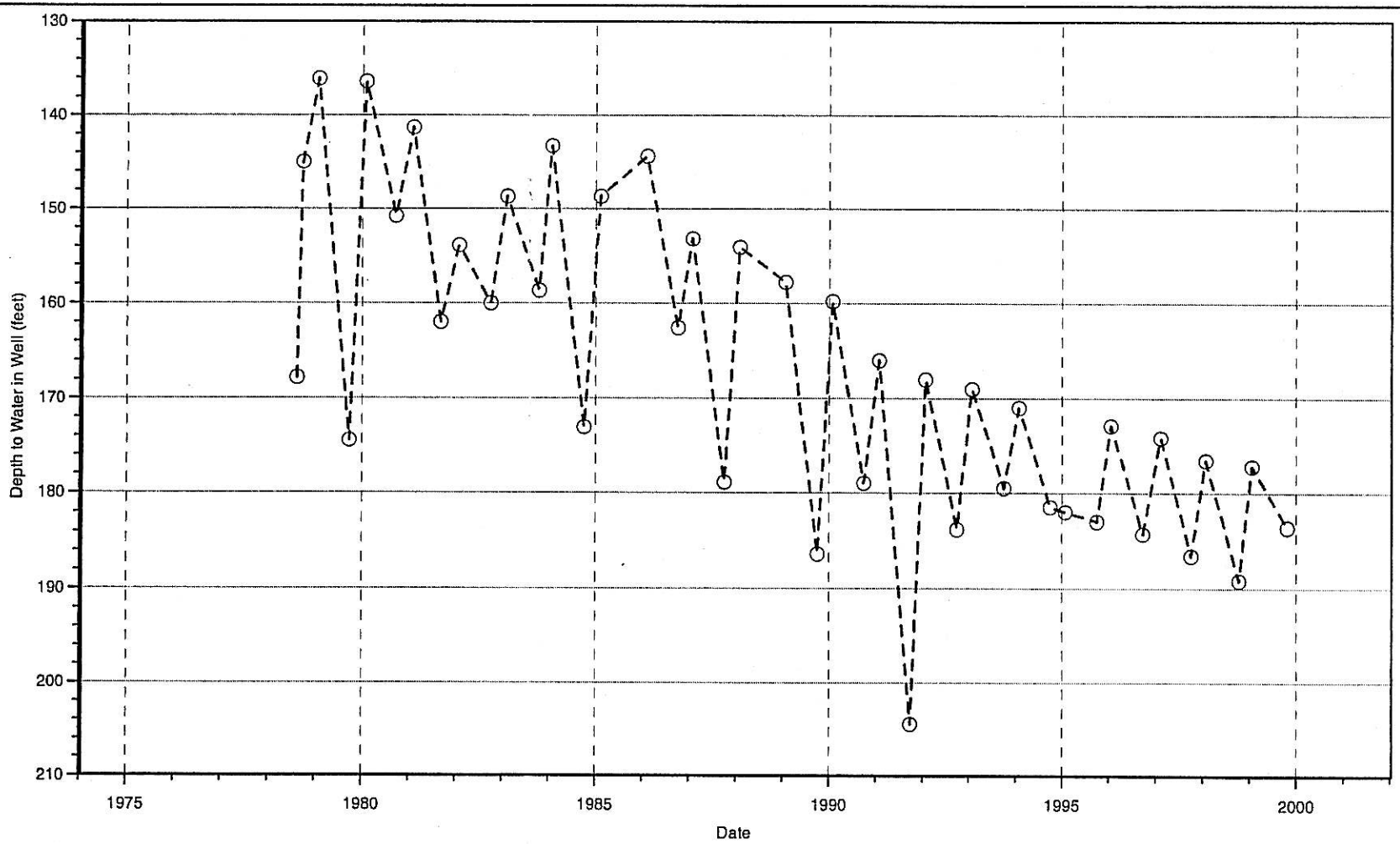


Legend
USBR

Hydrogeologic Investigation

Southeastern Madera County
Water Level Hydrograph
Well T12S R20E 5 P1

14340101-GW

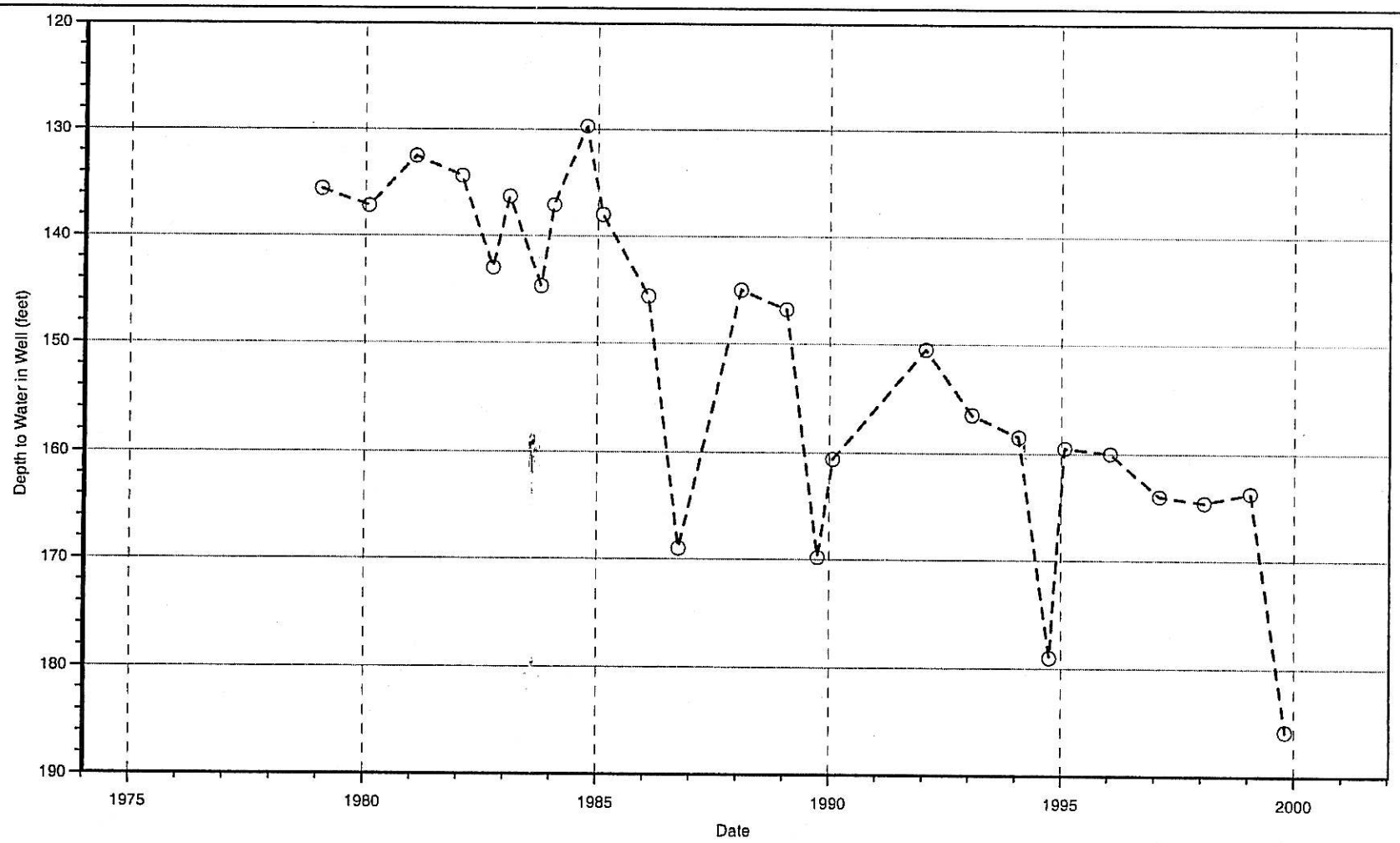


Legend
USBR

Hydrogeologic Investigation

Southeastern Madera County
Water Level Hydrograph
Well T12S R20E 17 A1

14340101-GW

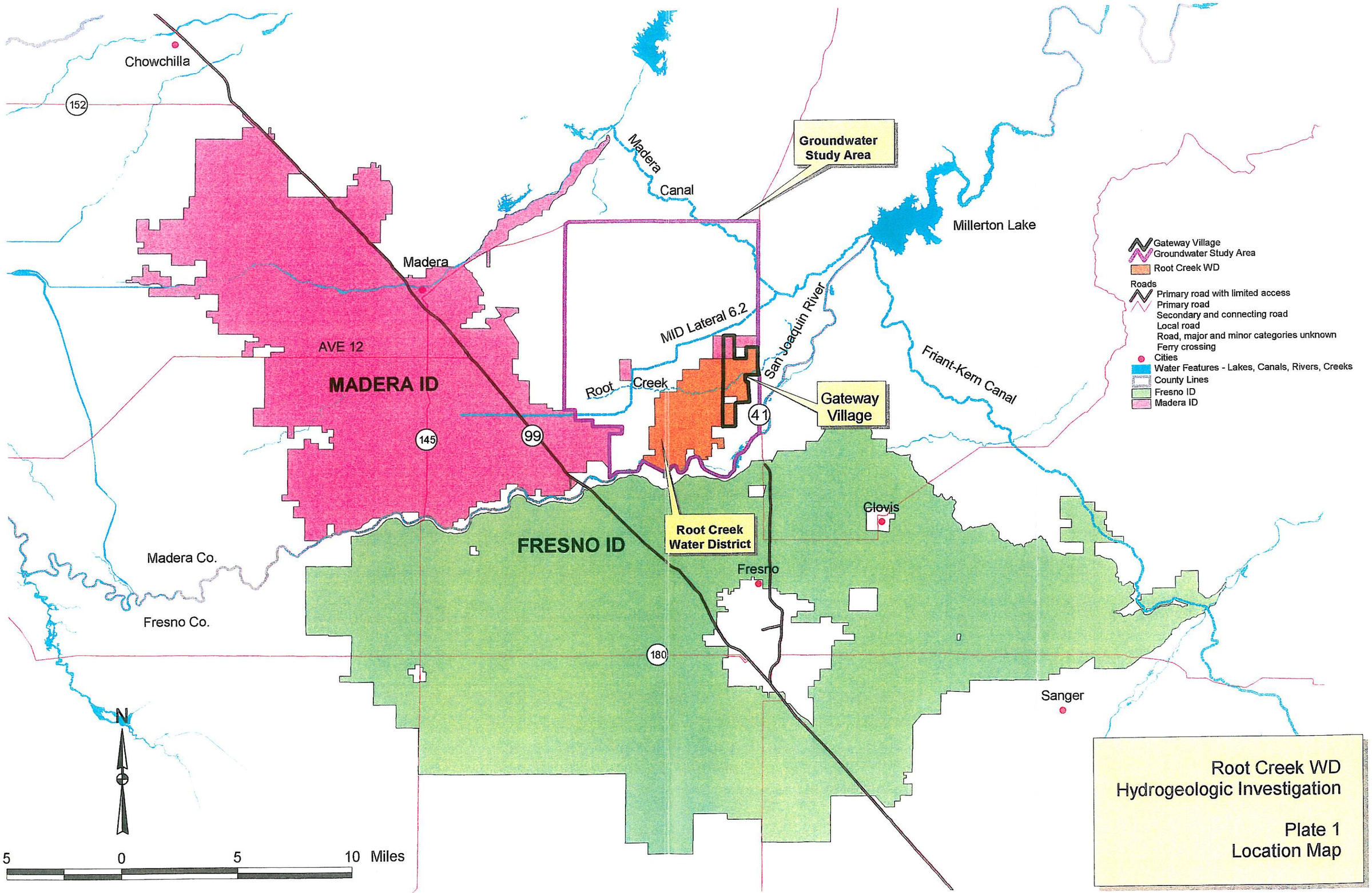


Legend
USBR

Hydrogeologic Investigation

Southeastern Madera County
Water Level Hydrograph
Well T12S R20E 18 N1

14340101-GW


Chowchilla
152
Madera
Madera Canal
Groundwater Study Area
Millerton Lake
AVE 12
MADERA ID
145
99
MID Lateral 6.2
San Joaquin River
Root Creek
41
Gateway Village
Friant-Kern Canal
Root Creek Water District
FRESNO ID
Clovis
Fresno
Madera Co.
Fresno Co.
180
Sanger
N
5 0 5 10 Miles
Gateway Village
Groundwater Study Area
Root Creek WD
Roads
Primary road with limited access
Primary road
Secondary and connecting road
Local road
Road, major and minor categories unknown
Ferry crossing
Cities
Water Features - Lakes, Canals, Rivers, Creeks
County Lines
Fresno ID
Madera ID
Root Creek WD
Hydrogeologic Investigation
Plate 1
Location Map

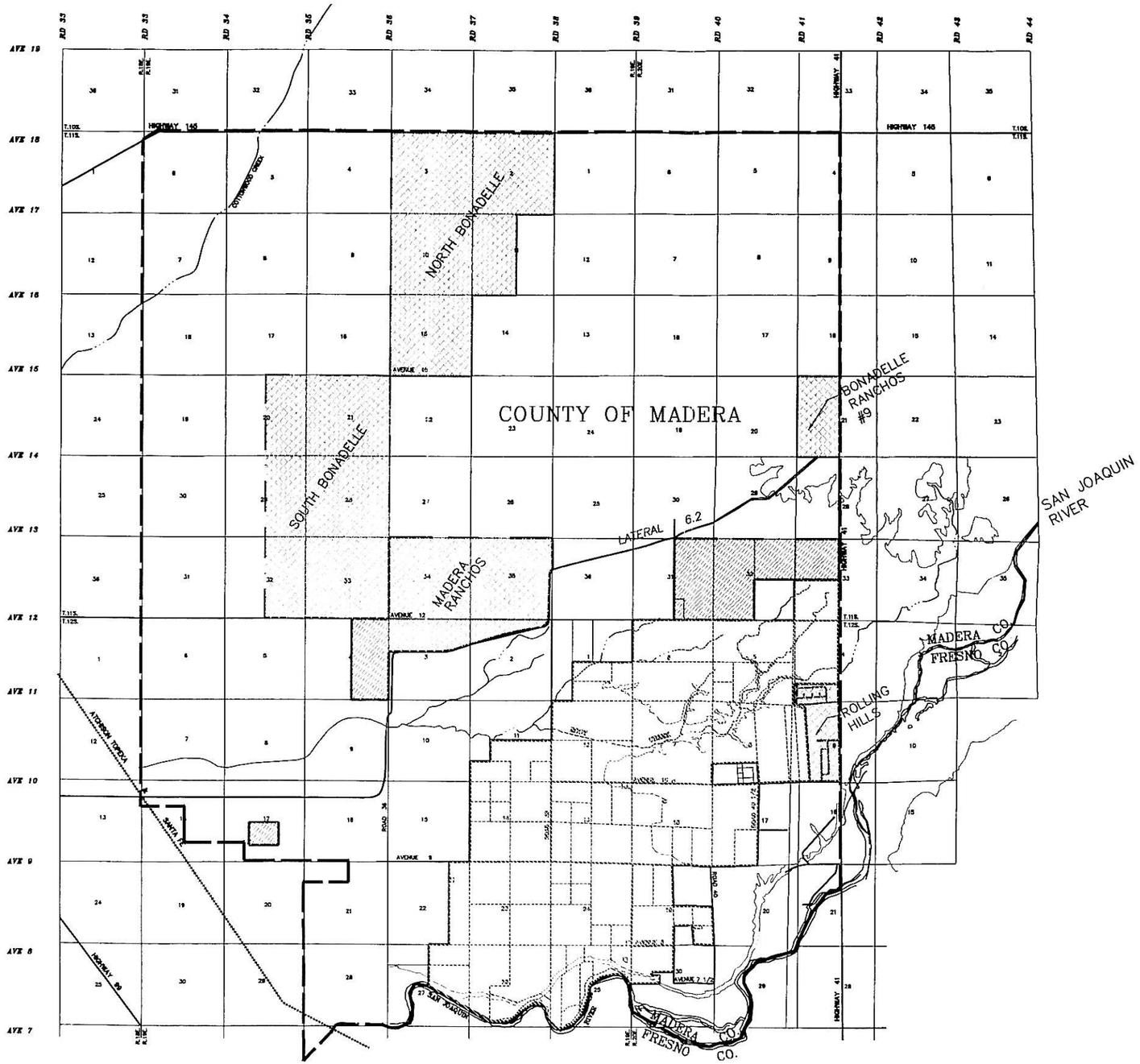


PLATE 2

SOUTHEASTERN MADERA COUNTY
DEVELOPMENTS AND AGENCIES
WITHIN STUDY AREA

LEGEND

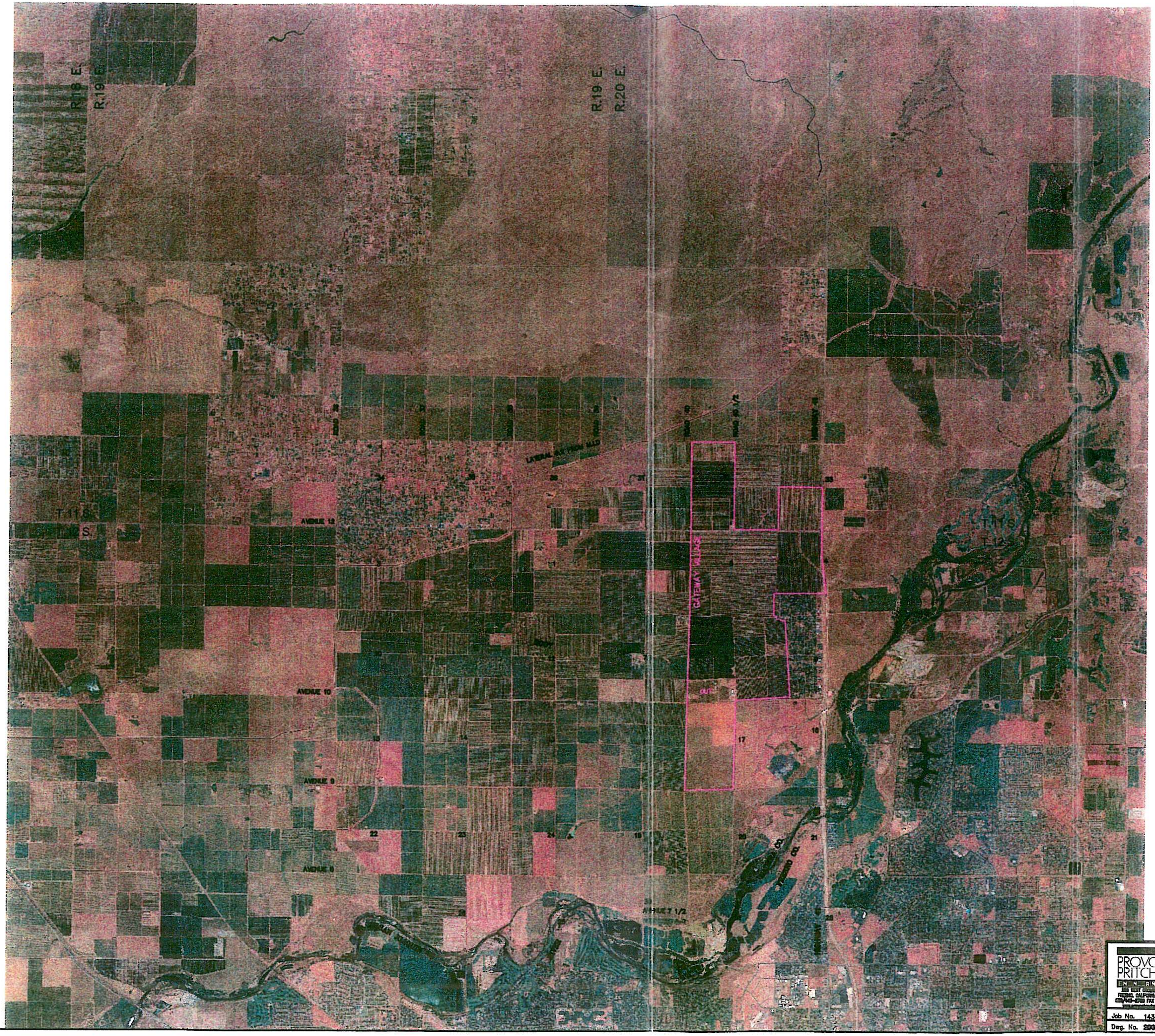
- MADERA IRRIGATION DISTRICT
- ROOT CREEK WATER DISTRICT
- RURAL RESIDENTIAL
- SECTION LINES
- ROADS
- STUDY AREA BOUNDARY

GRAPHIC SCALE

0 1/2 MILE 1 MILE 2 MILES

Job 9840500/14340101, Dwg. #98-0215

EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP
286 WEST CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
559/449-2700 FAX 559/449-2715

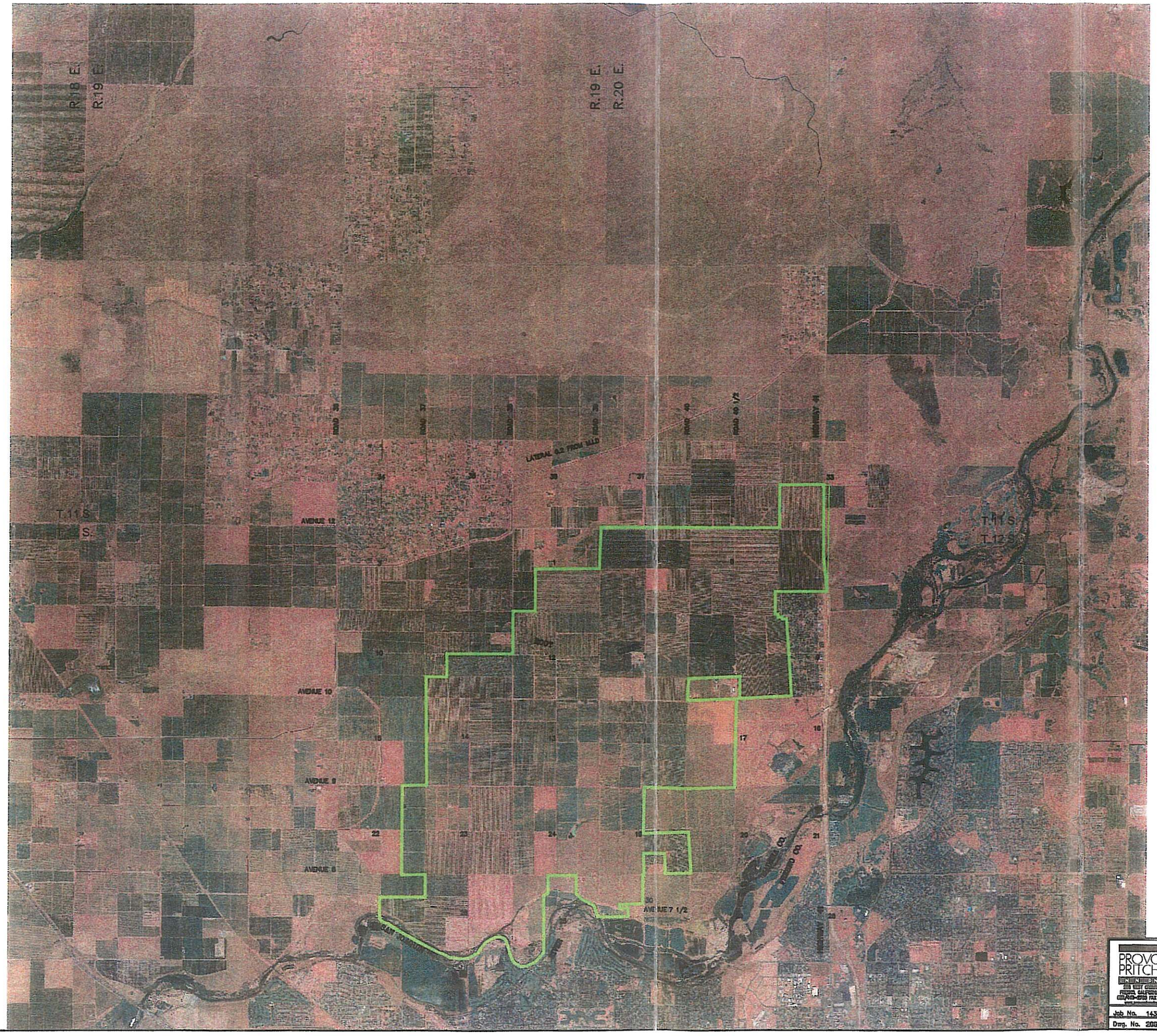


GATEWAY VILLAGE

GRAPHIC SCALE

PLATE 3

PROVOST & PRITCHARD	**Hydrogeologic Investigation** Root Creek Water District Madera County, CA	SCALE AS SHOWN
		DRAWN BY EAA
	August 2000 **Aerial Photography**	REVISED
	DESIGN ENGINEER Brian E. Ehlers DATE 10/18/01 C.E. LICENSE NO.	SHEET ___ OF ___ SHEETS
Job No. 14340101-GW	Date Revised	
Dwg. No.	Approval	



GRAPHIC SCALE

PLATE 4

PROVOST & PRITCHARD ENGINEERING	Hydrogeologic Investigation Root Creek Water District Madera County, CA	SCALE AS SHOWN DRAWN BY EAA REVISED
	August 2000 Aerial Photography	SHEET ___ OF ___ SHEETS
Job No. 14340101-GW Dwg. No. 20010820	DESIGN ENGINEER Brian E. Ehlers DATE 10/18/01 C.E. LICENSE NO. ____ Date Revised Approved	

PLATE 5

PROVOST & PRITCHARD ENGINEERING GROUP 286 WEST CESAR CHAVEZ AVENUE FRESNO, CALIFORNIA 93706-2832 (559) 445-0293 FAX (559) 445-0718 www.provostandpritchard.com	Hydrogeologic Investigation Root Creek Water District Madera County, CA	SCALE AS SHOWN DRAWN BY EAA REVISED
	August 2000 Aerial Photography	SHEET ___ OF ___ SHEETS
Job No. 14340101-GW Dwg. No. 2000-0230	DESIGN ENGINEER Brian E. Ehlers DATE 10/18/01 C.E. LICENSE NO. ____ Date Revised Approval	

GROUNDWATER STUDY AREA, LAND USE 1995

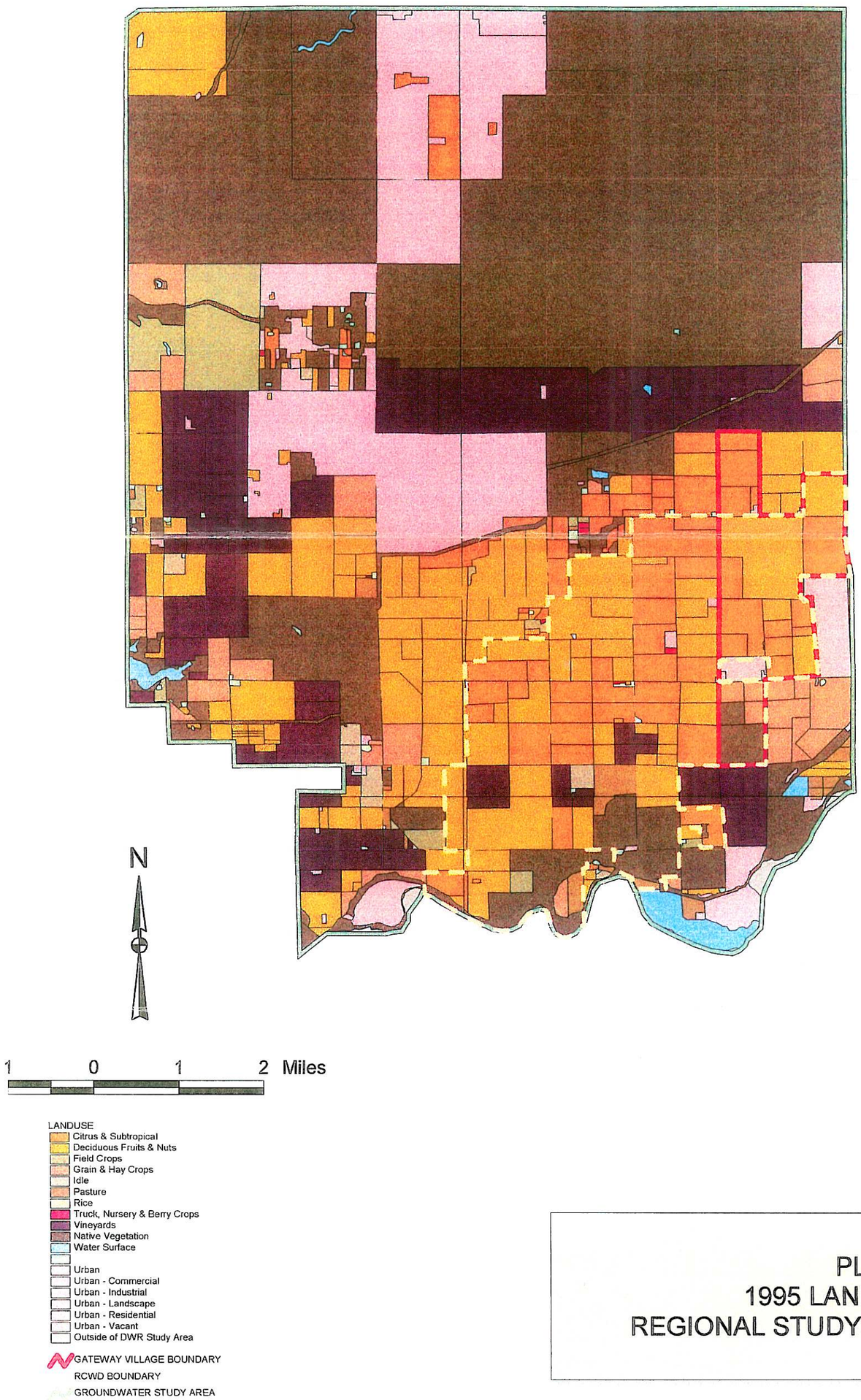
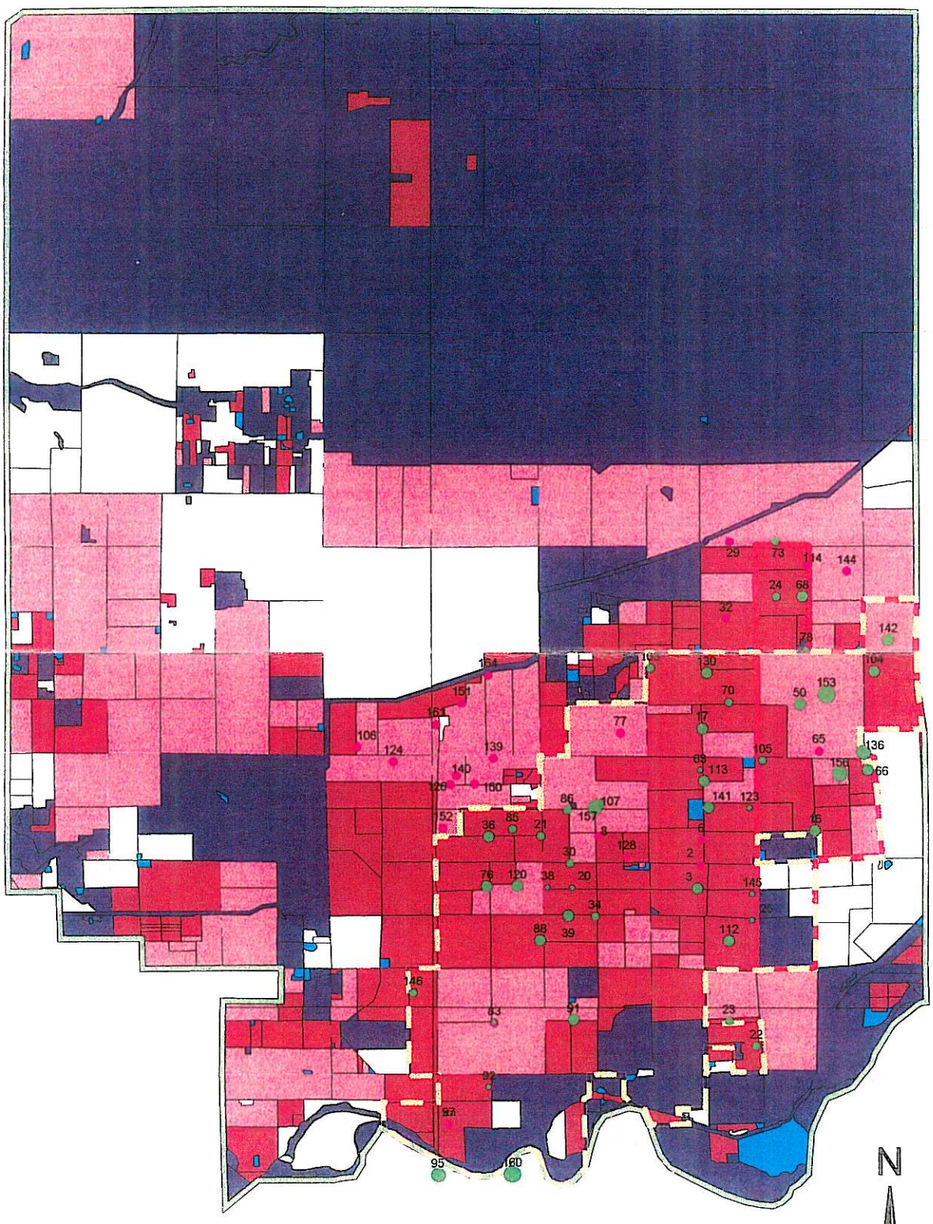


PLATE 6
1995 LAND USE
REGIONAL STUDY AREA

SOURCE: DWR Land Use Survey Data Division of Planning & Local Assistance

CROP WATER USE (1995 AF/ACRE)



N

1 0 1 2 Miles

S & J Pumps (1995 AF/Pump)
- 0 - 150
- 150 - 300
- 300 - 600
- 600 - 1200
- 1200 - 1400

S & J Pumps (No data or pumping, 1995)

Root Creek WD Boundary
Gateway Village Boundary
Groundwater Study Area Boundary
Section lines

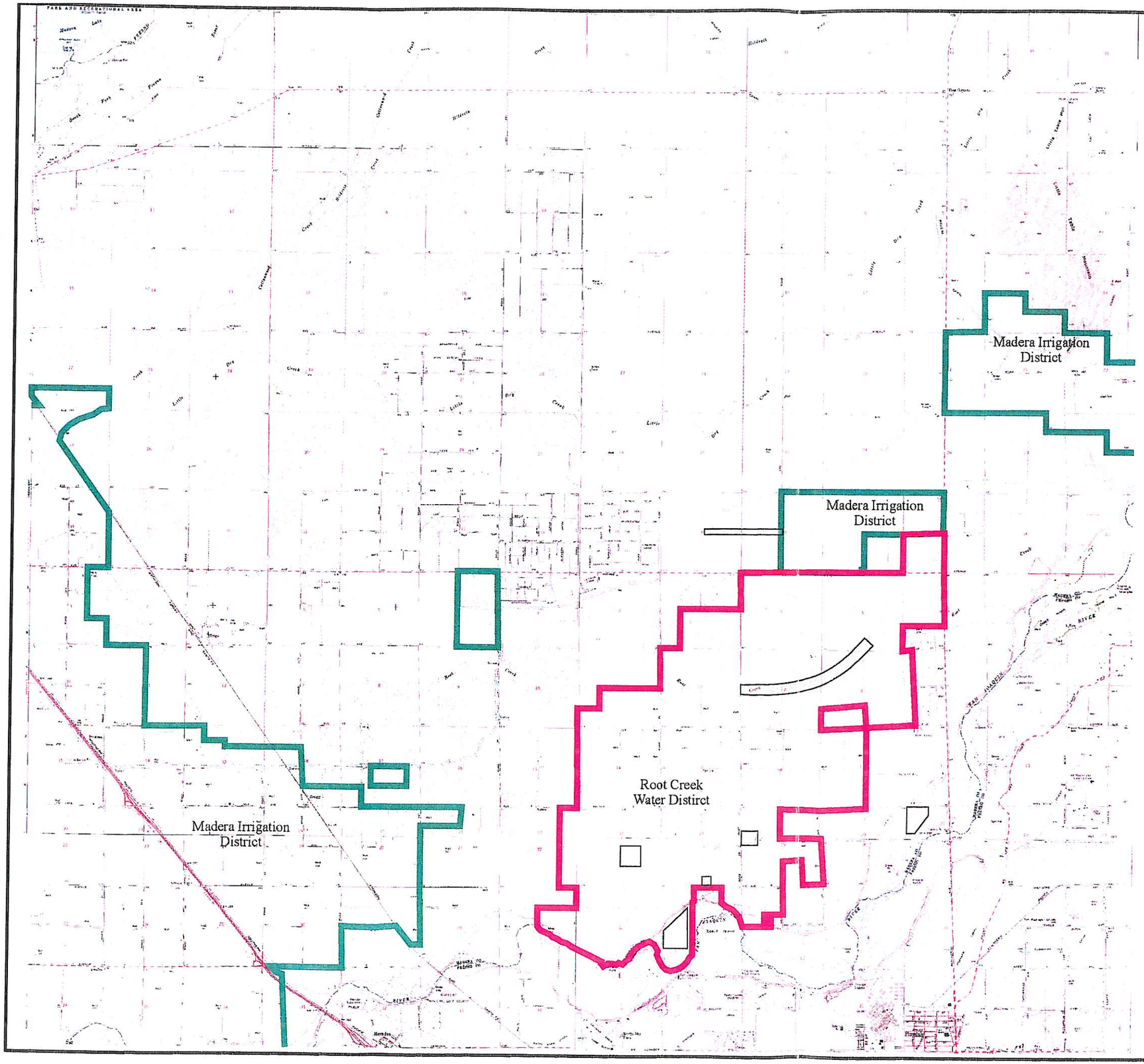
Crop Water Use - (1995 AF/Acre)
- 0.00 - 0.99
- 1.00 - 1.99
- 2.00 - 2.99
- 3.00- 3.99
- 4.00 - 5.03

- ETcrop/0.75
- ITRC ETcrop data, (typical water year, sprinkler irrigation)
- DWR 1995 Land Use Data used for Crop type

PLATE 7
1995 CROP WATER USE
REGIONAL STUDY AREA

PLATE 8

RECHARGE POTENTIAL



AREAS FOR INVESTIGATION

N

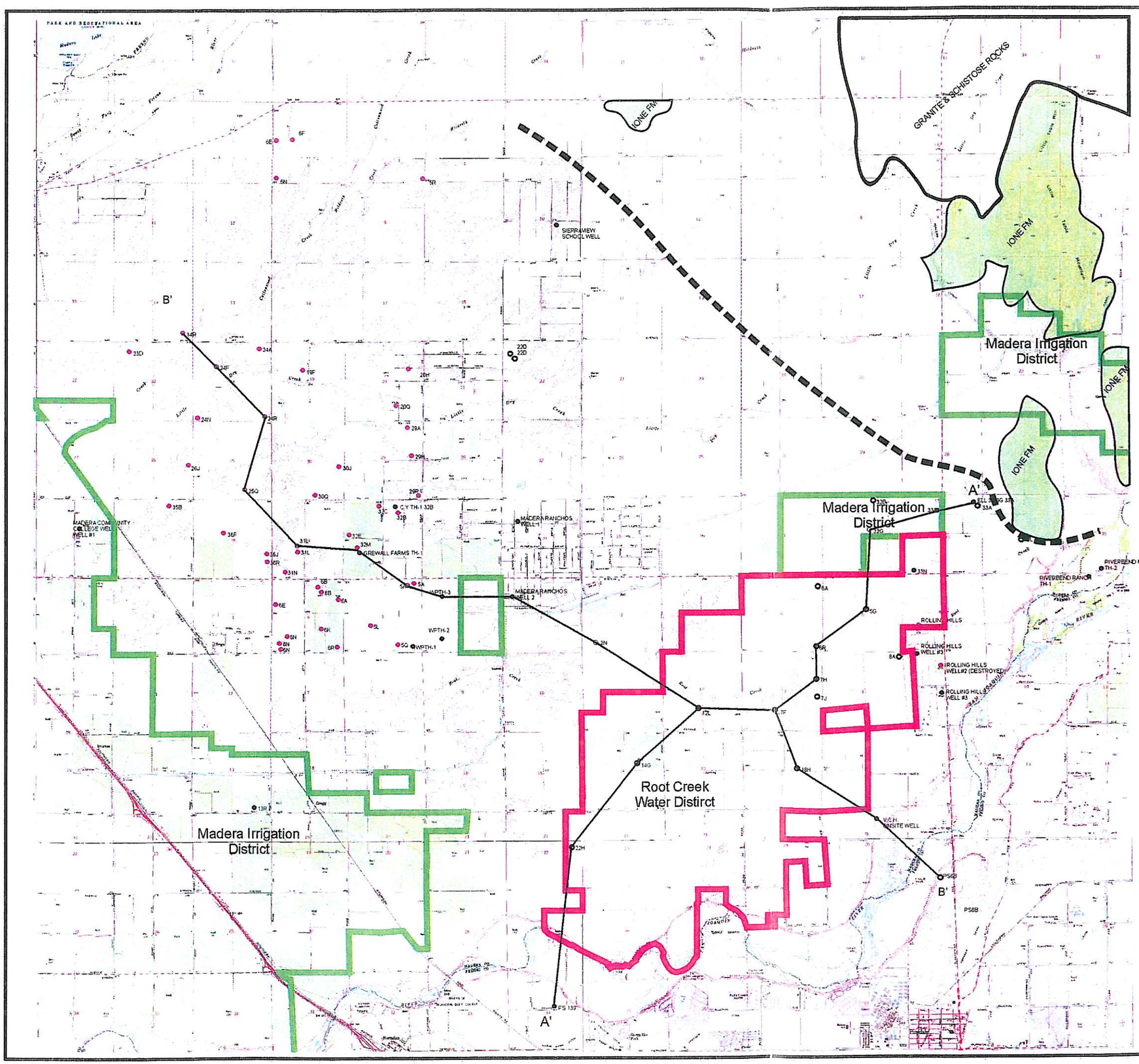
0 ½MILE 1MILE 2MILES

EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP

DATE MAY 5 ,1998
JOB # 9840500
DWG # RECHARGE

PLATE 9

STUDY AREA
HYDROGEOLOGIC FEATURES



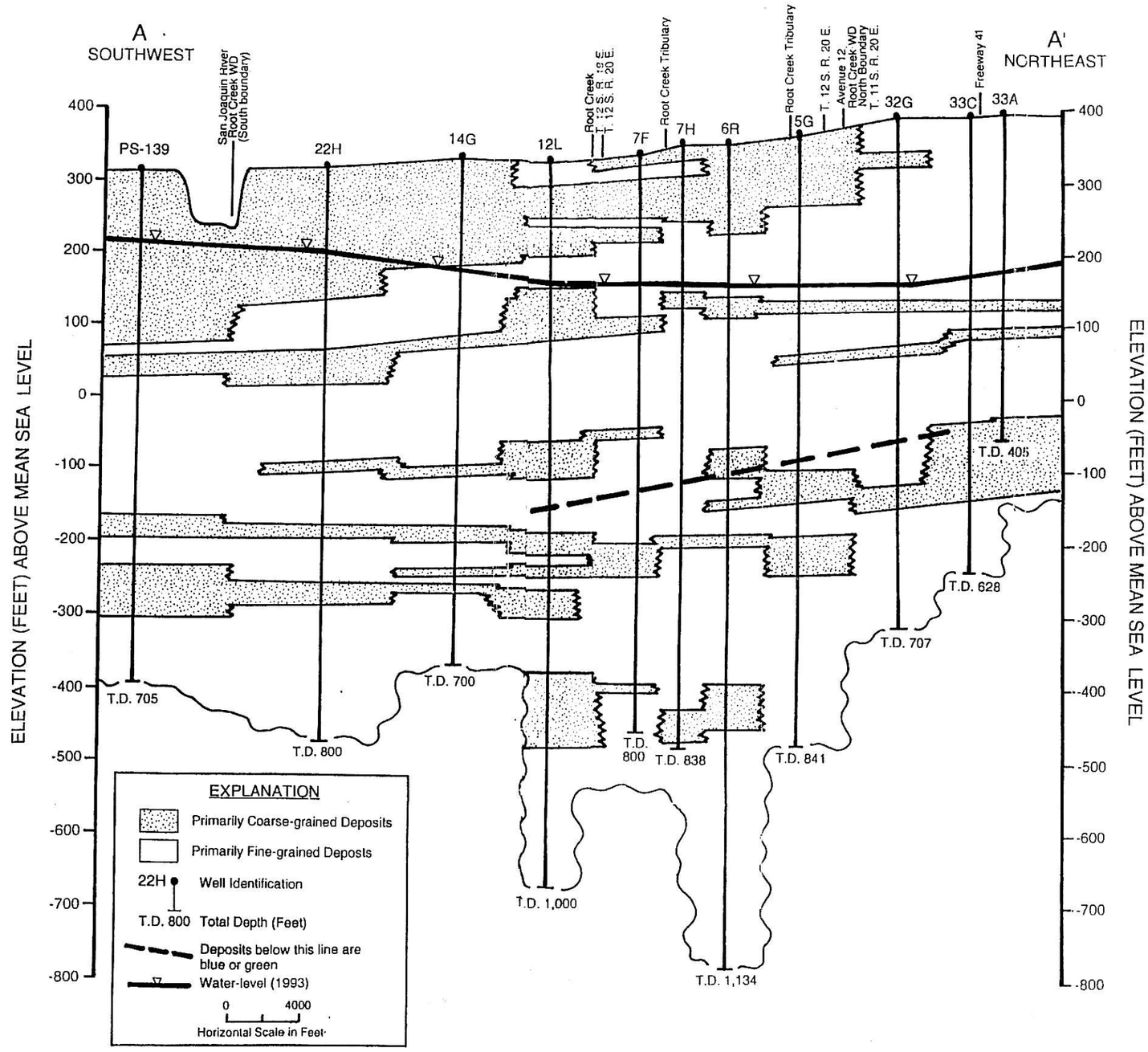
LEGEND

- MADERA IRRIGATION DISTRICT BOUNDARY
- ROOT CREEK WATER DISTRICT BOUNDARY
- APPROX. LOCATION OF ALLUVIAL-HARDROCK BOUNDARY
- WELLS GREATER THAN 400' WITH LOGS IN SELECTED AREAS
- TEST HOLES OR WELLS WITH E-LOGS
- S & J WELLS
- WELL SITE ID NUMBER (PS6B)
- CONSOLIDATED ROCK OUTCROP (APPROXIMATE LOCATION)

N

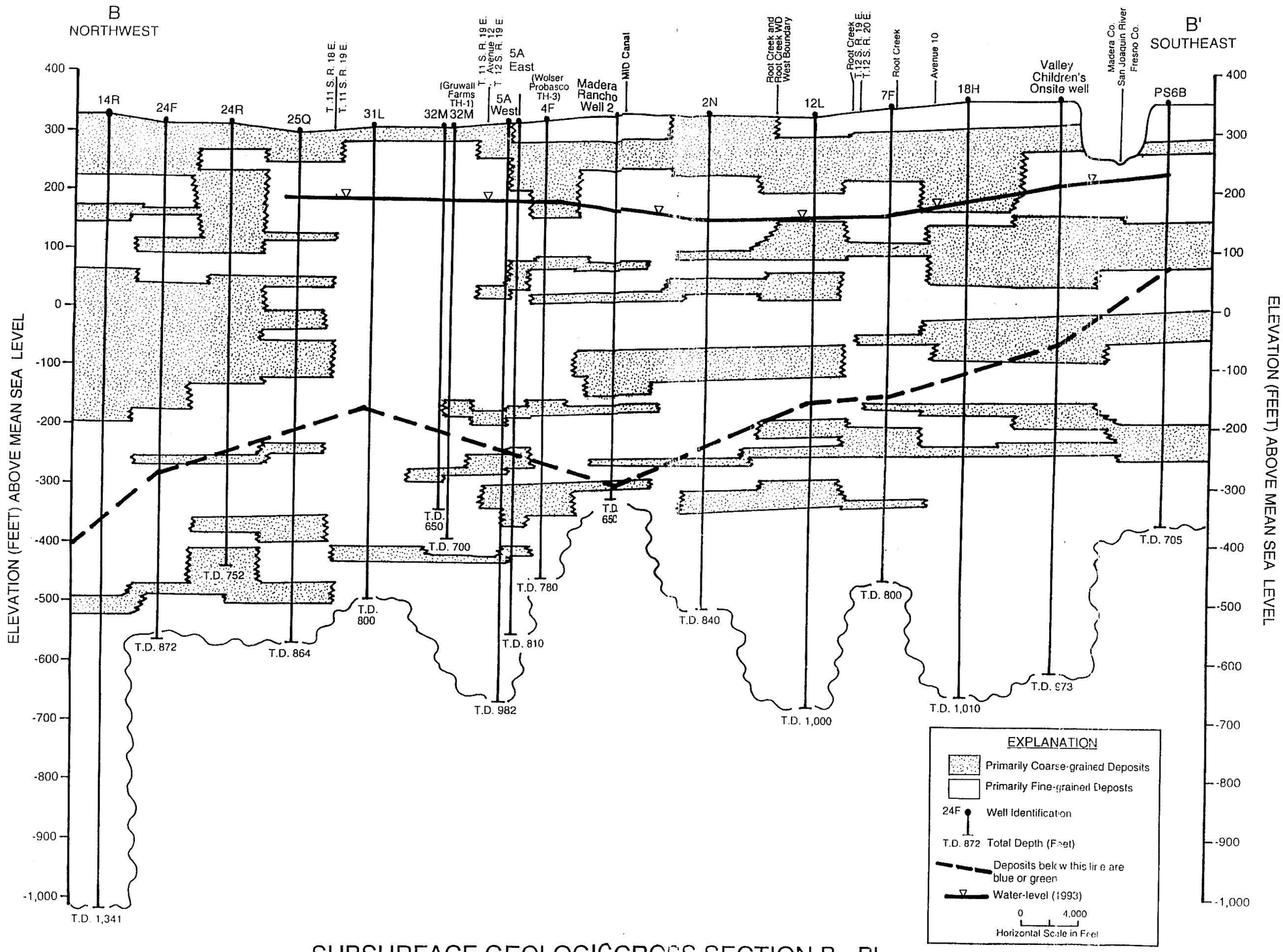
EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP

DATE May 4 ,1998
JOB # 9840500
DWG # CROSSSEC



SUBSURFACE GEOLOGIC CROSS SECTION A - A'

PLATE 11

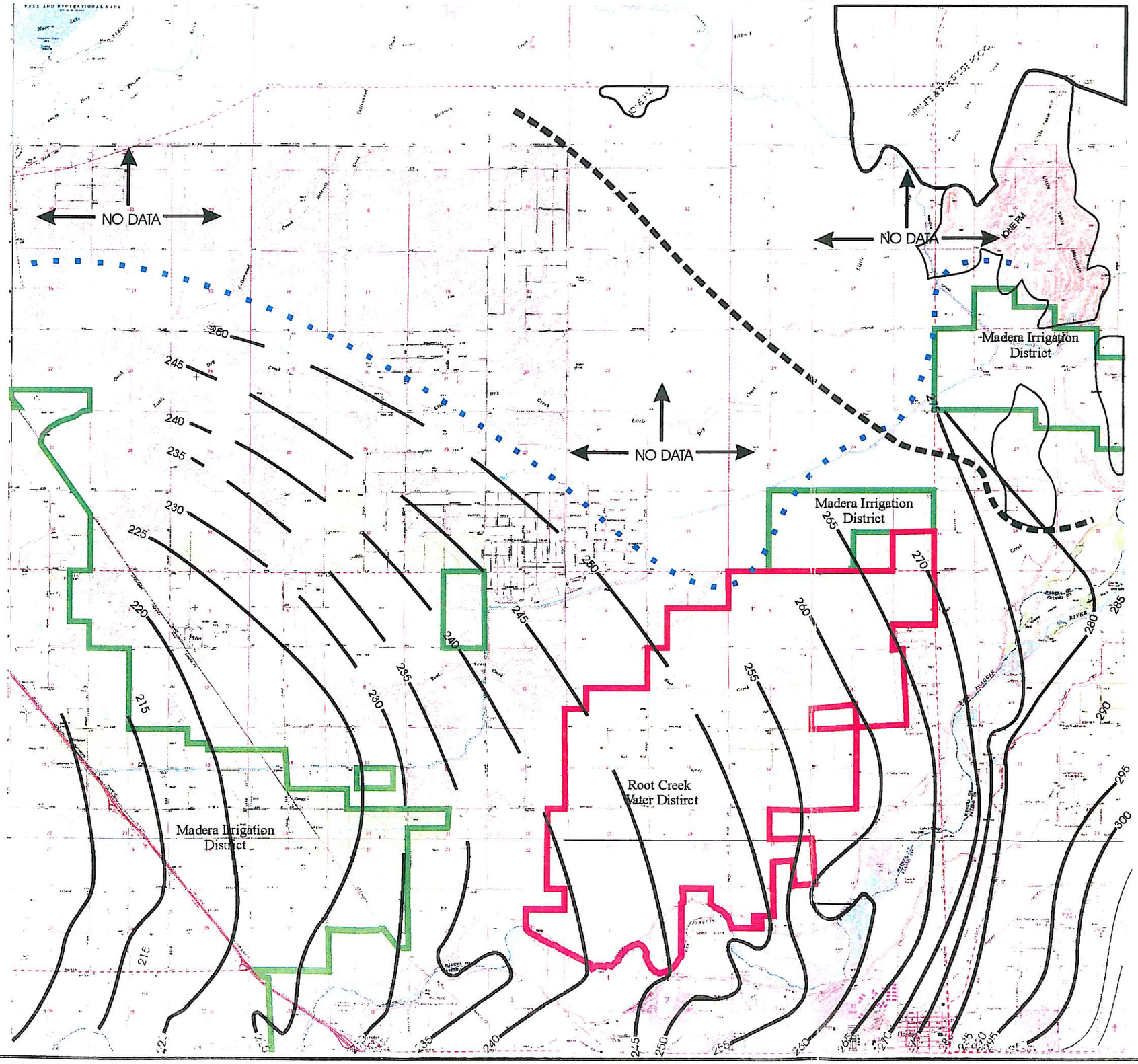


SUBSURFACE GEOLOGIC CROSS SECTION B - B'

Plate 12

STUDY AREA

GROUNDWATER-LEVEL ELEVATIONS &
GROUNDWATER FLOW DIRECTION
FALL 1936



LEGEND

- MADERA IRRIGATION DISTRICT BOUNDARY
- ROOT CREEK WATER DISTRICT BOUNDARY
- WATER LEVEL ELEVATIONS
- GROUNDWATER FLOW DIRECTION
- APPROX. LOCATION OF ALLUVIAL-HARDROCK BOUNDARY
- WELL LOCATION AND WATER SURFACE ELEV.

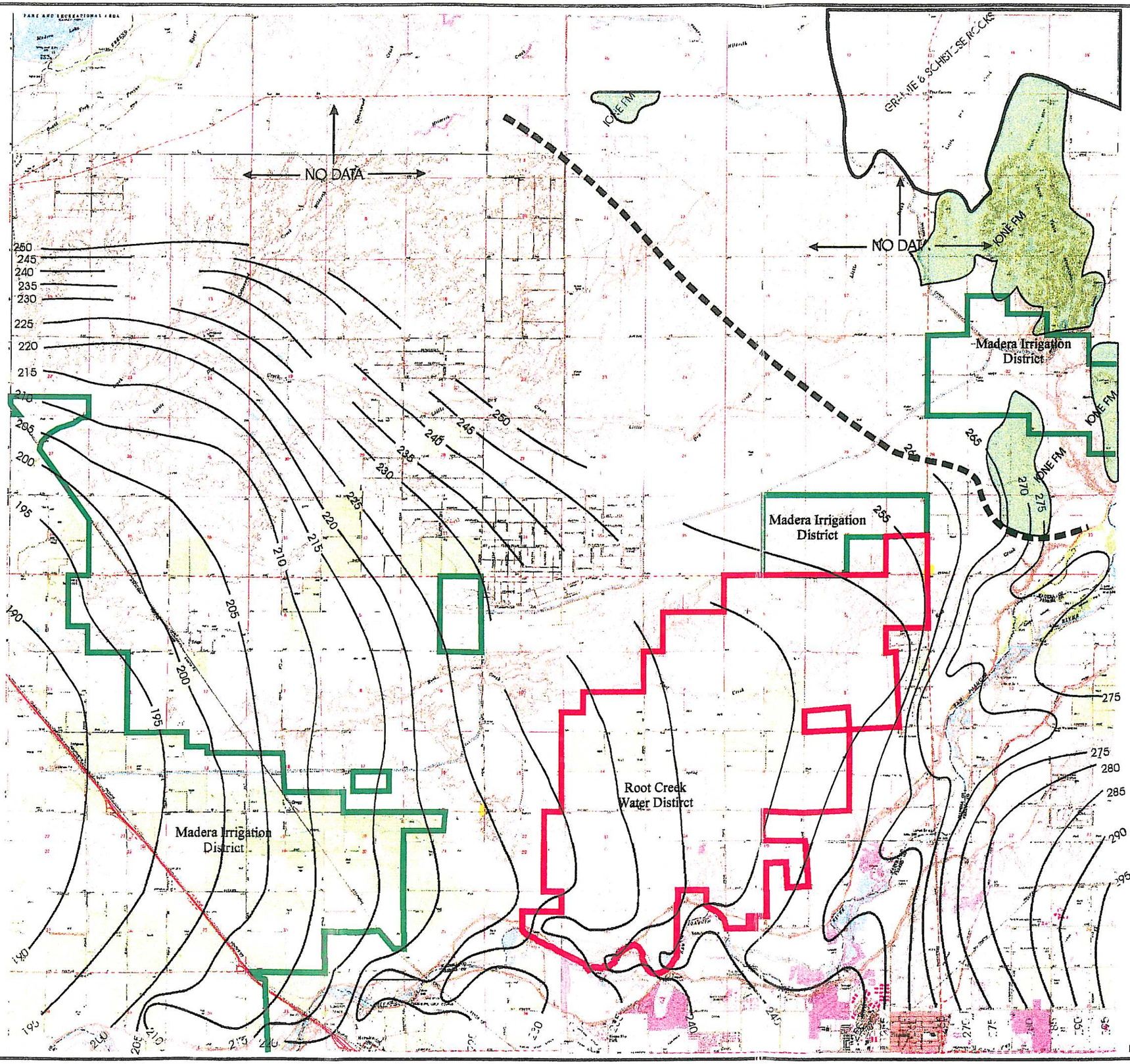
EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP

DATE
JOB #
DWG #

PLATE 13

STUDY AREA

GROUND WATER-LEVEL ELEVATIONS
SOURCE - DEPARTMENT OF WATER RESOURCES
SPRING 1960



LEGEND

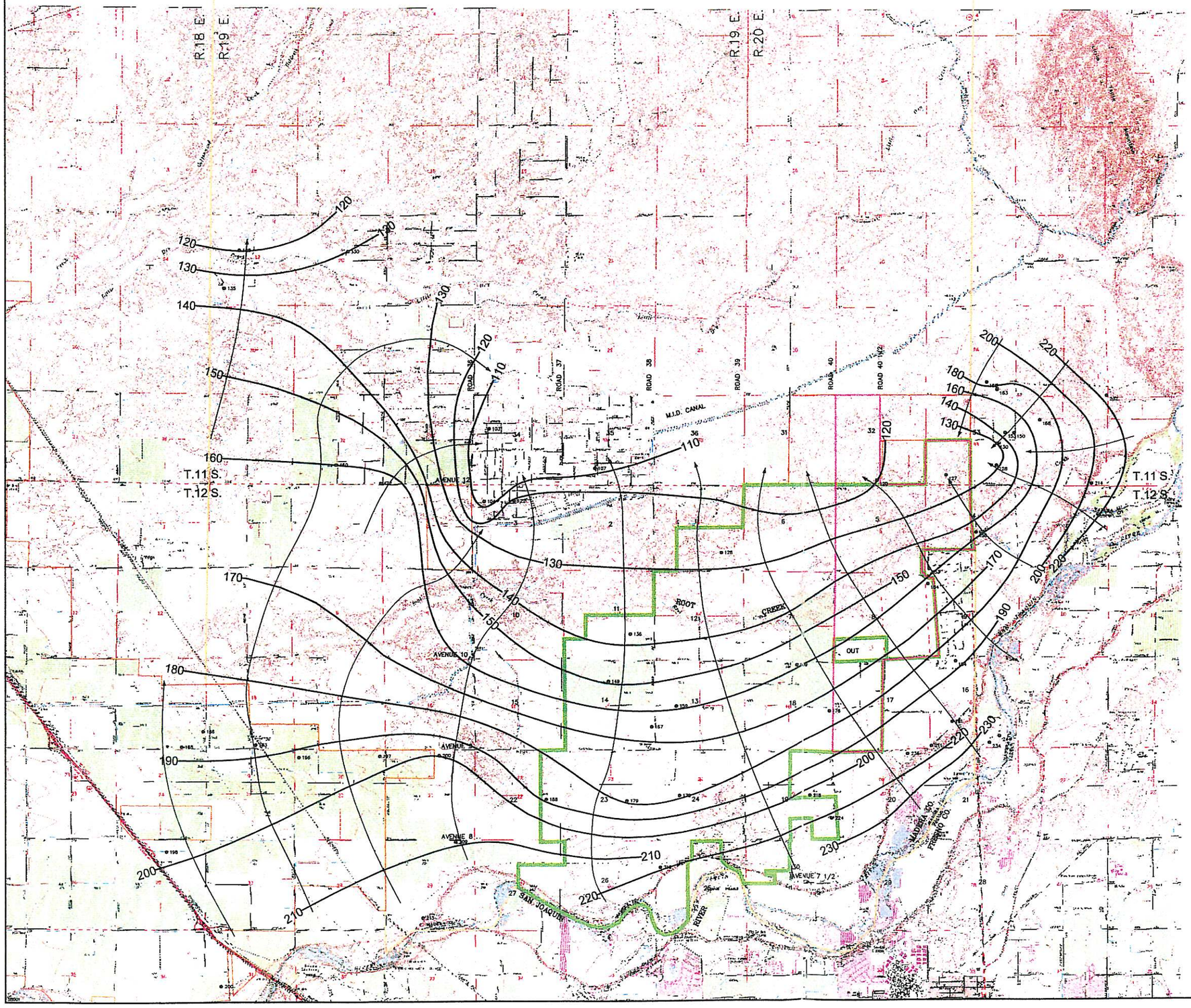
- MADERA IRRIGATION DISTRICT BOUNDARY
- ROOT CREEK WATER DISTRICT BOUNDARY
- APPROX. LOCATION OF ALLUVIAL-HARDROCK BOUNDARY

1MI 1/2MI 0 1MI

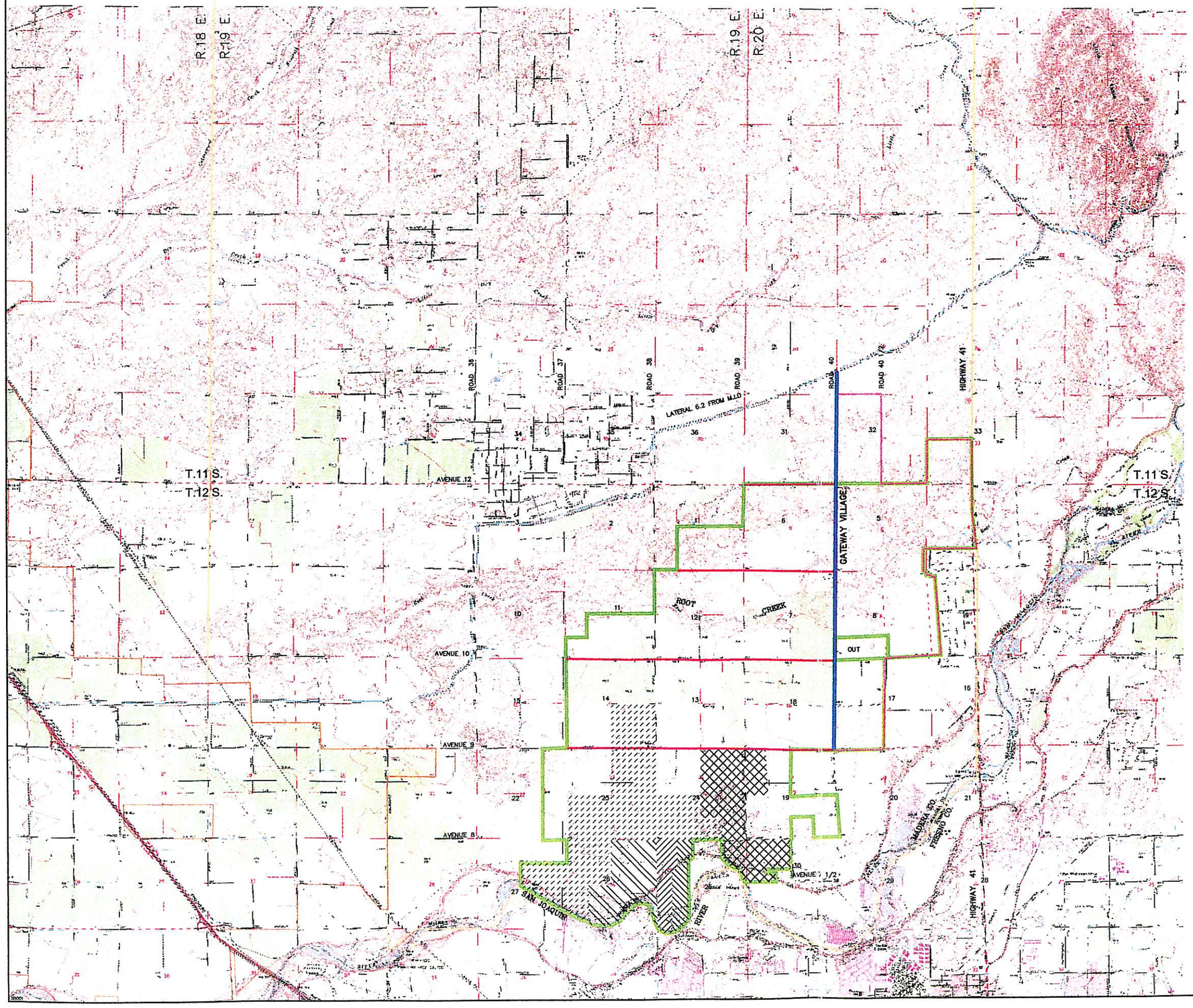
MAPPING - UNITED STATES GEOLOGICAL SURVEY

EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP

DATE May 4, 1998
JOB # 9840500
DWG # Sprg1960



PROVOST & PRITCHARD ENGINEERING GROUP EST. 1968 286 WEST CROMWELL AVENUE FRESNO, CALIFORNIA 93711-6162 559/449-2700 FAX 559/449-2715 www.provostandpritchard.com	Hydrogeologic Investigation Root Creek Water District Madera County, CA Water Level Elevations for Spring 2001 **Plate 14**	SCALE AS SHOWN DRAWN BY EAA REVISED
	DESIGN ENGINEER Brian E. Ehlers DATE _____ C.E. LICENSE NO. _____	SHEET ___ OF ___ SHEETS
Job No. 14340101-GW Dwg. No. 20010219	Date Revised Approval	



MAIN PIPELINE – 48"

LATERALS – 12"

RIPARIAN, NO CONTRACT
S&J RANCH, 307 ACRES

HOLDING CONTRACT 65
B. COULTHARD, 512 ACRES

HOLDING CONTRACT 67
M. COULTHARD, 93 ACRES

HOLDING CONTRACT 69
M. COULTHARD, 124 ACRES

HOLDING CONTRACT 74
APACHE GROVE LAND, 1134 ACRES
B. COULTHARD, 40 ACRES

ROOT CREEK WATER DISTRICT

GATEWAY VILLAGE

STUDY AREA

MADERA ID

WATER LEVEL ELEVATION IN FEET
ABOVE MEAN SEA LEVEL

GENERALIZED DIRECTION OF
GROUNDWATER FLOW

N

GRAPHIC SCALE
0 1000' 2000' 4000'

Hydrogeologic Investigation

Root Creek Water District
Madera County, CA

Proposed In-Lieu Recharge Surface
Water Delivery Plan

Plate 15

PROVOST & PRITCHARD ENGINEERING GROUP
CIVIL ENGINEERS
305 WEST OSWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
559/449-2700 FAX 559/449-2715
www.provostandpritchard.com

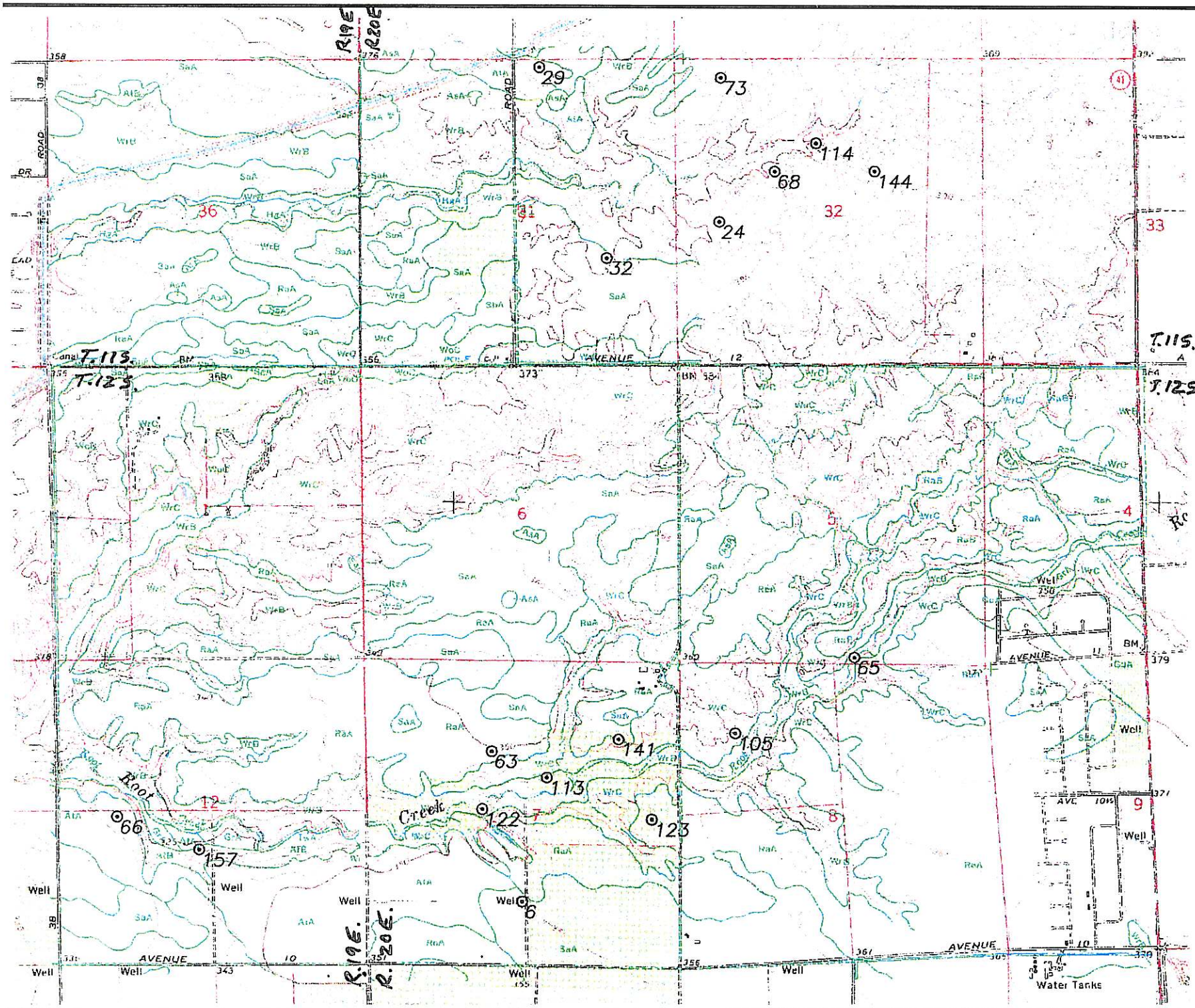
DESIGN ENGINEER Brian E. Ehlers
DATE _____ C.E. LICENSE NO. _____

Job No. 14340101-GW
Dwg. No. 20010219

Date Revised
Approval

SCALE AS SHOWN
DRAWN BY JSM
REVISED
SHEET ___ OF ___ SHEETS

10/17/2001 11:22:01 AM G:\Clients\Castle & Cook - 1434\14340101\20010219.dwg - jseven



SOILS

PLATE 16

DATE: 03/05/98
JOB NO. 9840500-GW
DWG. NO. dwg\temp\c&cook.dwg

EST. 1969
PROVOST & PRITCHARD INC.
ENGINEERING GROUP

San Joaquin River Flows at Friant Dam greater than 992 AF/day, or 500 cfs (approximating Section 215)
from the US Department of the Interior (USBR-CVP)
(Acre-feet)

Calendar Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Calendar Year Total
1944	N/A	N/A	64,152	120,081	121,810	129,037	150,747	141,788	116,642	79,735	32,442	0	956,433
1945	58,679	154,519	139,661	253,044	316,887	275,739	226,160	173,282	118,701	102,287	85,611	89,155	1,993,725
1946	143,301	67,017	111,086	129,189	282,364	175,230	172,357	161,616	113,531	90,561	32,500	32,381	1,511,132
1947	49,714	48,516	94,769	151,490	133,785	133,521	156,689	144,455	95,521	60,143	0	0	1,068,602
1948	0	0	46,924	61,701	111,690	119,964	182,748	171,791	142,101	76,735	0	0	913,653
1949	0	38,559	55,943	149,078	125,245	175,478	169,506	128,579	93,713	61,925	0	0	998,025
1950	0	0	94,100	112,517	122,109	136,749	153,024	127,041	94,074	60,020	0	145,853	1,045,486
1951	152,991	162,493	87,102	119,366	109,779	135,084	126,172	91,640	0	37,501	0	0	1,022,127
1952	0	192,163	234,042	454,370	479,025	381,558	109,373	101,186	55,880	39,065	0	0	2,046,663
1953	0	32,842	55,210	50,682	0	0	0	0	52,919	48,116	0	0	239,770
1954	0	0	0	0	81,334	0	0	0	0	0	0	0	81,334
1955	0	0	0	0	0	0	0	0	0	0	0	79,845	79,845
1956	315,931	222,629	99,414	76,125	168,399	162,423	0	0	0	44,889	0	0	1,089,810
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	65,847	404,645	388,068	234,151	0	0	0	0	0	0	1,092,711
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1965	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1966	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1967	0	63,752	0	209,551	486,686	357,465	79,246	0	0	0	0	0	1,196,700
1968	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1969	59,945	389,104	470,165	260,825	460,146	469,620	56,771	0	0	0	0	0	2,166,575
1970	0	30,241	0	0	0	0	0	0	0	0	0	0	30,241
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	59,038	0	118,622	0	36,784	0	0	0	0	0	0	214,444
1974	32,490	0	0	0	0	0	0	0	0	0	0	0	32,490
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	97,909	289,846	418,186	331,793	155,911	0	0	0	0	0	0	1,293,645
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	122,166	188,219	244,500	101,930	140,871	0	83,295	0	0	0	0	0	880,981
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	408,284	230,941	79,941	0	0	0	0	92,028	227,708	1,038,902
1983	222,114	280,946	436,632	465,094	379,231	525,947	306,609	81,354	118,709	72,981	75,686	132,812	3,098,116
1984	240,554	0	0	0	0	0	0	0	0	0	0	0	240,554
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	198,776	415,408	287,712	0	0	0	0	0	0	0	0	901,896
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	72,028	56,567	63,392	41,909	0	0	0	0	0	233,895
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	227,571	340,142	450,935	156,372	317,281	0	0	0	0	0	1,492,302
1996	0	0	115,575	62,980	99,537	0	0	0	0	0	0	63,366	341,457
1997	523,763	352,840	80,038	0	0	0	0	0	0	0	0	0	956,641
1998	0	175,761	147,015	272,250	251,955	392,535	266,268	0	0	0	0	33,397	1,539,181
1999	0	0	0	0	0	0	32,783	0	0	0	0	0	32,783
2000	0	0	53,763	0	0	0	0	0	0	0	0	0	53,763
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003													
Totals over Period	1,921,647	2,755,322	3,628,762	5,099,894	5,329,156	4,296,901	2,630,937	1,322,731	1,001,791	773,956	318,267	804,518	29,883,883
Averaged Annual Totals	32,570	46,700	61,504	86,439	90,325	72,829	44,592	22,419	16,980	13,118	5,394	13,636	506,506

San Joaquin River Flows at Friant Dam greater than 992 AF/day, or 500 cfs (approximating Section 215)
from the US Department of the Interior (USBR-CVP)
(Acre-feet)

% of 215 Supply = **10%**

Calendar Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Calendar Year Total
1944	N/A	N/A	6415.2	12008.11	12180.96	12903.66	15074.73	14178.78	11664.18	7973.46	3244.23	0	95,643
1945	5867.928	15451.92	13966.13	25304.4	31688.71	27573.88	22615.96	17328.17	11870.1	10228.68	8561.124	8915.544	199,373
1946	14330.05	6701.706	11108.59	12918.91	28236.38	17523	17235.7	16161.55	11353.122	9056.124	3249.972	3238.092	151,113
1947	4971.384	4851.594	9476.874	15148.98	13378.46	13352.13	15668.93	14445.49	9552.114	6014.25	0	0	106,860
1948	0	0	4692.402	6170.076	11168.98	11996.42	18274.81	17179.07	14210.064	7673.49	0	0	91,365
1949	0	3855.852	5594.292	14907.82	12524.49	17547.75	16950.58	12857.92	9371.34	6192.45	0	0	99,802
1950	0	0	9409.95	11251.75	12210.86	13674.87	15302.43	12704.08	9407.376	6001.974	0	14585.27	104,549
1951	15299.06	16249.27	8710.218	11936.63	10977.91	13508.35	12617.15	9164.034	0	3750.12	0	0	102,213
1952	0	19216.3	23404.19	45437.04	47902.54	38155.79	10937.32	10118.59	5587.956	3906.54	0	0	204,666
1953	0	3284.226	5521.032	5068.206	0	0	0	0	5292	4811.598	0	0	23,977
1954	0	0	0	0	8133.444	0	0	0	0	0	0	0	8,133
1955	0	0	0	0	0	0	0	0	0	0	0	7984.548	7,985
1956	31593.08	22262.92	9941.382	7612.506	16839.9	16242.34	0	0	0	4488.858	0	0	108,981
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	6584.688	40464.47	38806.81	23415.08	0	0	0	0	0	0	109,271
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1965	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1966	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1967	0	6375.204	0	20955.13	48668.6	35746.52	7924.554	0	0	0	0	0	119,670
1968	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
1969	5994.45	38910.37	47016.49	26082.54	46014.61	46962.04	5677.056	0	0	0	0	0	216,658
1970	0	3024.054	0	0	0	0	0	0	0	0	0	0	3,024
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	5903.766	0	11862.18	0	3678.444	0	0	0	0	0	0	21,444
1974	3248.982	0	0	0	0	0	0	0	0	0	0	0	3,249
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	9790.902	28984.63	41818.59	33179.26	15591.11	0	0	0	0	0	0	129,364
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	12216.6	18821.88	24450.03	10193.04	14087.11	0	8329.464	0	0	0	0	0	88,098
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	40828.39	23094.13	7994.052	0	0	0	0	9202.842	22770.79	103,890
1983	22211.44	28094.62	43663.16	46509.41	37923.14	52594.74	30660.89	8135.424	11870.892	7298.082	7568.55	13281.25	309,812
1984	24055.42	0	0	0	0	0	0	0	0	0	0	0	24,055
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	19877.62	41540.8	28771.18	0	0	0	0	0	0	0	0	90,190
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	7202.844	5656.662	6339.168	4190.868	0	0	0	0	0	23,390
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	22757.13	34014.22	45093.51	15637.25	31728.11	0	0	0	0	0	149,230
1996	0	0	11557.46	6297.984	9953.658	0	0	0	0	0	0	6336.594	34,146
1997	52376.35	35284	8003.754	0	0	0	0	0	0	0	0	0	95,664
1998	0	17576.06	14701.5	27225	25195.5	39253.5	26626.84	0	0	0	0	3339.666	153,918
1999	0	0	0	0	0	0	3278.286	0	0	0	0	0	3,278
2000	0	0	5376.294	0	0	0	0	0	0	0	0	0	5,376
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003													
Totals over Period	192,165	275,532	362,876	509,989	532,916	429,690	263,094	132,273	100,179	77,396	31,827	80,452	2,988,388
Averaged Annual Totals	3,257	4,670	6,150	8,644	9,032	7,283	4,459	2,242	1,698	1,312	539	1,364	50,651

Phase 1 - MONTHLY DIVERSIONS OF SECTION 215 FOR BROCKMAN FLOOD CONTROL BASIN(ac-ft)

REQUIRED DIVERSION CAPACITY =	0.5	CFS
BASIN CAPACITY =	32.8	AF
BASIN DEPTH =	8	FT
BASIN INFILTRATION RATE =	0.3	FT/DAY
BASIN ACREAGE =	4.1	ACRES
DAILY RECHARGE VOLUME =	1.23	AF/DAY

	Indicates Section 215 Water
	Indicates months with no available water supply for program.

MONTHLY MAXIMUM DIVERSIONS IN ACRE-FEET (BASED ON FLOWRATE ABOVE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
DAYS	31	28	31	30	31	30	31	31	30	31	30	31	365
VOLUME & INFILTRATION	71	67	71	70	71	70	71	71	70	71	70	71	843
INFILTRATION ONLY	38	34	38	37	38	37	38	38	37	38	37	38	449

Yr. of Op.	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1	1988	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1989	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1990	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1991	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1992	0	0	0	0	0	0	0	0	0	0	0	0	0
6	1993	0	0	0	70	38	37	38	0	0	0	0	0	183
7	1994	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1995	0	0	71	37	38	37	38	0	0	0	0	0	221
9	1996	0	0	71	37	38	0	0	0	0	0	0	71	217
10	1997	38	34	38	0	0	0	0	0	0	0	0	0	111
11	1998	0	67	38	37	38	37	38	0	0	0	0	71	326
12	1999	0	0	0	0	0	0	71	0	0	0	0	0	71
13	2000	0	0	71	0	0	0	0	0	0	0	0	0	71
14	2001	0	0	0	0	0	0	0	0	0	0	0	0	0
15	2002	0	0	0	0	0	0	0	0	0	0	0	0	0
16	2003	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals over Period		38	102	289	180	153	111	185	0	0	0	0	142	1,200
Averaged Annual Totals		2	6	18	11	10	7	12	0	0	0	0	9	75