DRAFT
Groundwater Management Plan

Prepared for
Reclamation District 2035

January 27, 1995

W E S T
Y O S T
& ASSOCIATES

018-95-05

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INTRODUCTION

AUTHORITY

Section 10753.7 of Division 6 of the California Water Code (Assembly Bill 3030) authorizes local agencies which provide water to a service area overlying a groundwater basin to adopt and implement a groundwater management plan for that basin. On June 2, 1993, Reclamation District 2035 (RD 2035) held a public hearing on the issue of whether or not to adopt a resolution of intention to draft a groundwater management plan. After that hearing, the Board of Trustees authorized the preparation of a groundwater management plan under the authority granted by AB3030.

RECLAMATION DISTRICT 2035

RD 2035 was formed in 1919 to provide flood protection, drainage, and irrigation water to Conaway Ranch and some adjoining lands in Eastern Yolo County. RD 2035 is governed by a board of three trustees elected by the landowners. The flood control and irrigation service areas of RD 2035 are shown in Figure 1. Major irrigation service facilities operated by RD 2035 are shown in Plate 1.

Irrigation water is furnished by the RD 2035 through a system of canals and ditches to approximately 17,600 acres of land. The water is diverted from the Sacramento River by a large pumping plant consisting of four 36-inch pumps located immediately upstream from the Vietnam Veterans Bridge on I-5. Irrigation is also supplemented by 25 wells which pump water into the irrigation system. The irrigation and drainage facilities and equipment are owned by the reclamation district. Additional irrigation water is also obtained from Cache Creek and Willow Slough.

In general, the production wells have casings ranging from 8 to 22 inches in diameter and are drilled from 175 feet to 500 feet deep. Of the 25 irrigation wells, 5 of the wells are diesel driven.

In addition to the main pumps on the Sacramento River, the District also owns 10 pumping plants consisting of a total of 32 pumps which vary in size from 2.5 to 300 horsepower. These pumps are used as lift, booster, or drainage pumps. The drainage pumps allow surface drainage from fields within RD 2035 to be captured and returned to the irrigation system. There are a number of pipes through the flood control levees as well as a large siphon under the Tule Canal and County Road 16 which are maintained and operated by the District.

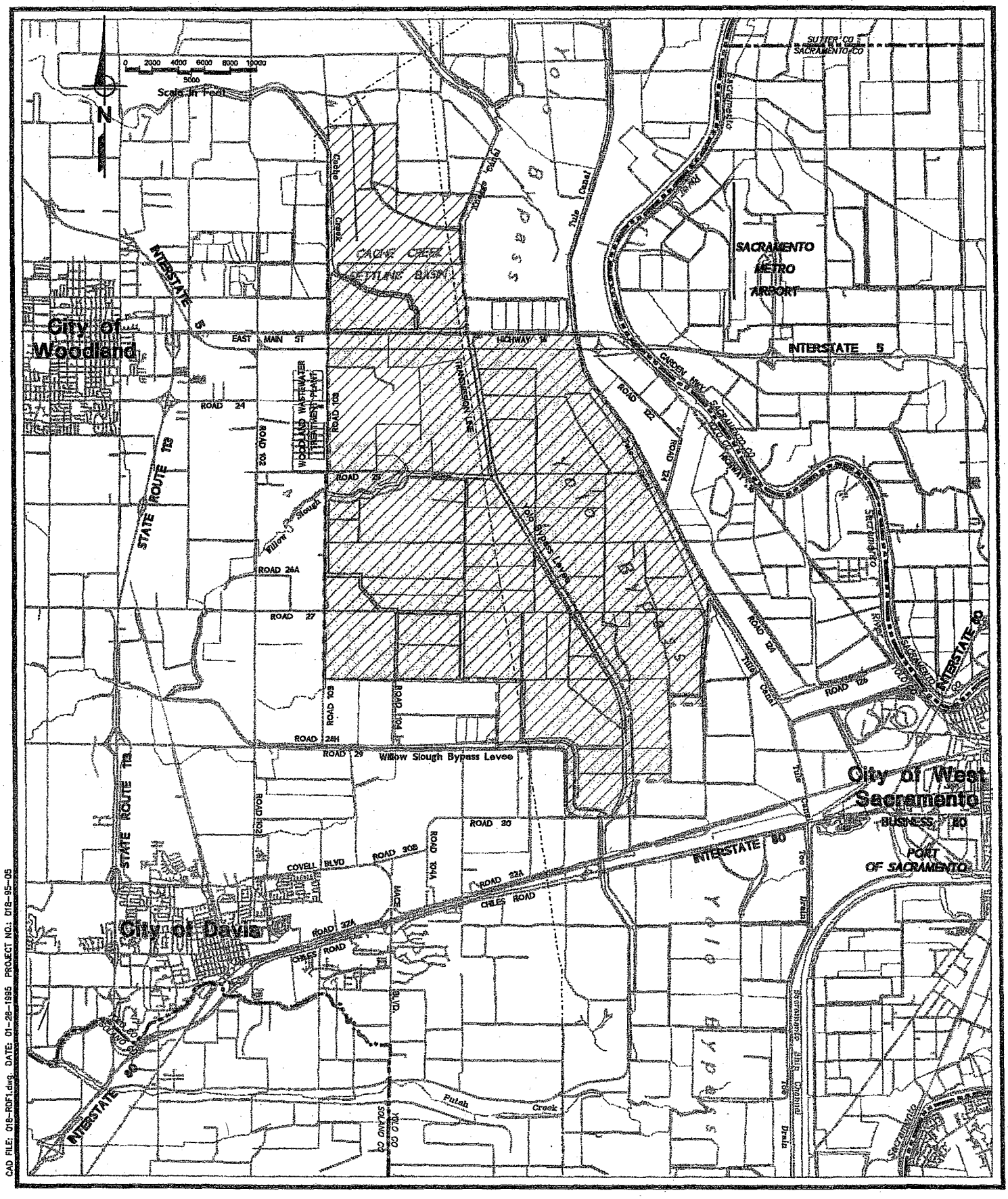

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Figure 1

Legend:

RECLAMATION DISTRICT 2035

RD2035 IRRIGATION SERVICE AREA (CONAWAY RANCH)

COUNTY BOUNDARY

WEST YOST & ASSOCIATES

Reclamation District 2035 Groundwater Management Plan

Location Map with Sevice Area Boundaries

DESCRIPTION OF GROUNDWATER BASIN

RD 2035 is part of the Sacramento Valley groundwater basin which extends from Red Bluff on the north down to the Delta. On a more local scale, the only major boundaries to groundwater flow are the Sacramento River and the Plainfield Ridge, which runs roughly north-south through the county approximately 4 miles west of Woodland. Effects of pumping in Yolo County in deeper aquifers can extend across the Sacramento River. For the purposes of this groundwater management plan, the groundwater basin will be defined as the aquifer system underlying the service area of RD 2035. The continuity of groundwater with lands adjacent to RD 2035 will be addressed in this plan where appropriate.

The sediments penetrated by water wells in the region were deposited in the past 12 million years and derived from three principal source areas — shed westward into the valley from the Sierra Nevada, shed eastward into the valley from the Coast Range, and transported southward from more distant sources by the ancient Sacramento and Feather Rivers. Throughout this depositional history, ancient streams in the valley changed their channels many times, and the channel of the Sacramento River was considerably west of its present location much of the time. In the vicinity of RD 2035, the depth of the continental formations is about 2,600 feet, and the base of fresh water is about 2,400 feet below the present land surface.

The hydrogeologic deposits to the west of RD 2035 are classified as alluvial fan deposits. Alluvial fan deposits consist of mixed sediments deposited by streams from the Coast Range and hills to the west. Deposits in the middle and western portions of RD 2035 are classified as flood basin deposits. Flood basin deposits consist of fine-grained materials which were deposited in the areas adjacent to major streams during periods of high runoff. Alluvium deposits are found in the area extending from the eastern portion of RD 2035 to the Sacramento River. These include stream channel and flood plain deposits which are composed of sand, gravel, silt and minor amounts of clay. The central and eastern portions of the district have significant deposits of coarse materials layered between the finer flood basin deposits. Most of the surface soils in RD 2035 are clay or silty clay.

As a result of geologic processes which deposited the sediments in the District, the distribution of sandy and clayey zones is highly variable, and deposits are discontinuous and of variable thickness. Most of the deeper aquifer zones penetrated by wells in and around RD 2035 behave as confined or semi-confined aquifers. Some of the shallow aquifers in the southeastern and far eastern portions of the District behave in a more unconfined fashion.

Seasonally, groundwater levels tend to be the highest in early spring and lowest in early fall. The groundwater gradient in the region generally tilts towards the Sacramento River in the winter and away from the river in the summer. Both the Sacramento River and Cache Creek are believed to be significant sources of net recharge to the eastern Yolo County groundwater basin.[1]

PURPOSE OF GROUNDWATER MANAGEMENT PLAN

The purpose of this groundwater management plan is to provide a framework for the protection and utilization of the aquifer system underlying RD 2035. The specific goals are as follows:

1. To define criteria for groundwater pumping and aquifer protection that will provide the flexibility to extract groundwater that is based on scientific analysis of monitoring results and allows use of groundwater as needed for agricultural production and/or water transfers or exchanges.

2. To integrate work already completed for RD 2035 and Conaway Conservancy Group which includes the existing groundwater monitoring program and technical studies on groundwater resources.

3. To establish the monitoring, recharge and evaluation programs necessary for actively managed conjunctive use within the RD 2035 service area.

4. To continue the joint conjunctive use planning for Eastern Yolo County with the California Department of Water Resources and local entities and individuals.

5. To establish standards which will help protect the aquifers underlying RD 2035 from water quality degradation.

6. To provide a document which can be used as a tool to provide public education about RD 2035, its functions and objectives, and available water resources.

GOALS FOR THE BASIN

PROTECTION AND ENHANCEMENT OF RECHARGE

The groundwater basin is well suited for storage and extraction of groundwater for irrigation and other uses. A primary goal is to encourage activities which will recharge the groundwater basin.

CONJUNCTIVE USE

Conjunctive use is the joint use of surface water and groundwater resources to maximize the amount and timely availability of water for beneficial use. This means using surface water when it is available to satisfy water needs and to induce groundwater recharge. Groundwater is then managed to provide supplemental water when needed and to provide storage for excess surface water. The groundwater basin underlying RD 2035 should be actively managed to provide the opportunity for conjunctive use and to utilize the available storage to the greatest practical extent.

SUBSIDENCE PREVENTION

Areas to the west and northwest of RD 2035 have shown evidence of subsidence due to groundwater pumping. Based on sensitive ground elevation measurements, permanent subsidence has not occurred in RD 2035 as a result of groundwater pumping since 1991. Because of the importance of maintaining the proper elevations of the flood control levees in RD 2035, the prevention of subsidence is a primary goal of this groundwater management plan.

PROTECTION OF GROUNDWATER QUALITY

Groundwater is a vital component of the water supply for agricultural irrigation in RD 2035 and may be utilized as a municipal water source in the future. Therefore, the protection of groundwater quality from degradation which would adversely affect its current and potential future uses is a goal of this groundwater management plan.

CONDITION OF THE BASIN

MONITORING NETWORK

Monitoring by RD 2035

Within the boundaries of RD 2035 there are 25 irrigation wells, 3 domestic wells, and 6 wells that are abandoned irrigation or domestic wells now used solely as monitoring wells. All the production wells have been used for groundwater level monitoring when they are accessible and not pumping.

Twelve additional monitoring wells were constructed within the District specifically to monitor groundwater. These wells consist of 12-inch bore holes drilled to a depth of between 250 and 400 feet. The wells were completed into separate shallow and deep zones by inserting two casings within each well, a 5½-inch diameter casing to a bottom depth of between 150 and 400 feet, and a 2-inch casing to a bottom depth generally less that 150 feet. Screened sections were installed in both casings opposite sand and gravel layers. Gravel pack was placed in the annular space between the casings and the bore hole. A grout plug was installed between the bottom of the 2-inch casing and the first screened section in the 5½-inch casing. Production wells and monitoring wells are shown on Plate 1.

Two types of water level meters are used to monitor groundwater. Both are manufactured by Solinst Canada Ltd. Model 101 is a flat white tape level meter and reads to 1/100 of a foot. This probe is used on agricultural water wells and monitoring wells. Model 102 is a coaxial cable water lever meter marked in one foot increments and is used in applications where small diameter access holes won't allow the use of the larger flat white tape.

There are five subsidence survey monuments within the boundary of Reclamation District 2035. These monuments are 8-inch diameter by 10-feet deep reinforced concrete, or 3/4 inch diameter copper clad bars driven to a depth of 10 feet. All monuments are capped with a 4-inch diameter aluminum monument disc. These monuments were used in 1991 and 1992 to measure ground surface elevations using GPS satellite survey receivers.

Monitoring by Other Agencies

An extensometer was constructed in 1991 in a joint effort by DWR and RD 2035 to monitor compaction within the upper 716 feet of geologic formations at the site of monitoring well 7. The extensometer consists of a 2-inch diameter galvanized steel pipe cemented in the bottom of a 716 foot deep bore hole. A recorder at the surface measures any vertical movement of the top of the pipe with respect to the ground surface. The recorder is mounted within a steel building, on a steel reference table supported by two 4-inch steel posts cemented in 20 foot deep bore holes.

DWR also maintains a data base of historical groundwater levels for wells throughout Yolo County. This data base includes wells actively monitored by the Yolo County Flood Control and Water Conservation District, the U.S. Bureau of Reclamation, and the California

Water Resources. The most recent summary report of this data[2] was produced in December, 1992.

ESTIMATED STORAGE AND PERENNIAL YIELD

Storage

There is a tremendous amount of groundwater storage beneath RD 2035, but only a small fraction is readily usable. The total amount of water in storage above 500 feet is estimated at 750,000 acre-feet (af) assuming a specific yield of 0.09[3] and an average water table depth of 25 feet. Usable storage is based on an assumed allowable drop in water levels and is much more difficult to quantify. Usable groundwater storage in RD 2035 under present economic conditions is probably less than 100,000 af.

The amount of usable storage is a function of the underlying hydrogeology in terms of the amount of storage space available and the ability of the sediments to transmit water to wells. Because of this, coarse grained sediments provide most of the usable groundwater storage. Plate 1 shows the location of 5 geologic cross sections through RD 2035 developed as part of the Eastern Yolo County Groundwater Investigation during the State Emergency Drought Water Bank[4]. Cross sections A-A' through F-F' are contained in the Appendix. As can be seen in the cross sections, there is a shallow aquifer system underlying much of the fine grained upper soils of the ranch to a depth of roughly 80 feet below ground surface. Below this, there are a number of deeper aquifers separated by fine grained aquitards down to a depth of at least 500 feet below ground surface. Assuming the shallow aquifer system averages 30 feet thick and has a specific yield of 0.1, it could store approximately 50,000 af. The shallow aquifer system is not currently directly tapped by most RD 2035 wells, so its storage could only be drained through seepage to deeper aquifers, unless shallow wells are constructed in the future.

Deeper aquifers have not been dewatered by RD 2035 wells, although it is conceivable that some of the shallowest screened aquifers could be partially dewatered by significant extraction. This could provide up to several tens of thousands of acre-feet from storage. Deeper aquifers which do not become partially dewatered during a pumping season currently provide very little usable groundwater storage. They act primarily as conduits to extend the lateral influence of wells and induce downward seepage from shallow aquifers over a wider area.

Historical Extraction

The estimated maximum amount of groundwater extracted by RD 2035 wells was 18,000 af in 1994. This amount of pumping in a season did not cause excessive drawdown or significant permanent subsidence.

Water Budget

Irrigation water use in RD 2035 varies from year to year depending upon the crop mix and actual amount of land planted. The total water used during the period of 1981 through 1990 is estimated to have ranged from 38,000 to 55,000 acre-feet per year (afa) and averaged approximately 43,000 afa. Water use declined in the late 1980's because of more participation

by growers in government set-aside programs. Water use in the 1990's has been affected by drought, participation in the State Emergency Drought Water Bank, and the increased acreage of rice in reaction to rising rice commodity values.

Surface Water Resources. RD 2035 diverts water from the Sacramento River under a contract held by Conaway Ranch with the US Bureau of Reclamation (USBR). The contract specifies a total allowable diversion of 50,852 af between April 1 and October 31, with a maximum total diversion of 13,442 af during the months of July through September. These entitlements can be reduced by the USBR by 25% in critically dry years.

Cache Creek is also a source of surface water for RD 2035. Unmeasured diversions of water from Cache Creek are estimated to have ranged from 0 to over 8,000 af per season, and averaged approximately 3,000 af during 1981 to 1990 based on RD 2035 water use calculations and Cache Creek flow measurements at the Yolo gage.

RD 2035 obtains an estimated 400 to 700 afa of surface water from diversions on Willow Slough and Willow Slough Bypass. Small amounts of drainage from the City of Woodland and from some adjacent farms to the west also enter the RD 2035 irrigation and drainage system.

Groundwater Pumping. Groundwater pumping has historically been necessary to meet irrigation needs during the July through September period to make up for inadequate diversion rights from the river. The average Sacramento River diversions under Conaway Ranch's USBR contract and estimated groundwater pumping by the District for the period of 1981 through 1990 are shown in Table 1.

Table 1. RD 2035 River Diversions and Groundwater Pumping, 1981-1990

Month	Sacramento River Diversions			Groundwater Pumping		
	Average	Max.	Min.	Average	Max.	Min.
April	1,600	3,600	0	0	0	0
May	6,400	12,500	400	0	0	0
June	7,500	12,500	400	3,000	7,600	20
July	6,600	7,400	3,700	2,700	5,400	1,300
Aug.	6,100	6,500	5,400	1,300	2,900	1,000
Sept.	400	1,200	0	3,800	9,000	0
Oct.	500	1,500	0	0	0	0
Annual Total	29,100			10,800	17,542	

Contadina holds a lease with the City of Woodland for 900 acres of land within the RD 2035 service area and immediately east of the Woodland Wastewater Treatment Plant which it uses for

treatment and disposal of cannery wastewater. During spring and early summer, Contadina irrigates the crops planted on this land with groundwater prior to application of cannery wastewater later in the summer. The total quantity of groundwater used by Contadina is not known, but it probably averages between 500 and 1000 afa based on typical regional crop irrigation demands.

Pumping on lands surrounding RD 2035 has an impact on water levels in RD 2035 wells. Most other land between the western boundary of RD 2035 and County Road 99 is irrigated with groundwater at an average rate of approximately 2.11 acre-feet per acre[1]. Lands to the north, south, and east of RD 2035 are irrigated by a combination of groundwater and surface water.

Spring groundwater levels have stayed relatively high over the years within RD 2035. This is a good indication that recharge to the aquifer system underlying RD 2035 has been more than enough to offset pumping during the irrigation season. Recharge sources and some very rough estimates of potential groundwater recharge to the aquifer system underlying RD 2035 is shown in Table 2.

Table 2. Groundwater Recharge — Sources and Estimated Potential Annual Recharge

Recharge Source	Estimated Potential Quantity (afa)
Irrigation Deep Perc.	4,000
Rainfall Deep Perc.	2,000
Rice Field Winter Flooding	8,000
Cache Creek Settling Basin Flooding	500 - 1,000+
Yolo Bypass Flooding	highly variable
Sacramento River	variable
Other Lateral Inflow	variable

The irrigation deep percolation and rainfall deep percolation were assumed to be equal to approximately 10% of applied water based on general recommendations for drainage design for clay loam soil[5]. Winter season rice field flooding percolation was based on a test program within RD 2035 performed in fall of 1992 and winter of 1993[6], and an assumed area of 4,000 acres. Based on these and other general assumptions, the amount of potential recharge to the aquifer system underlying RD 2035 is probably on the order of 10,000 to over 20,000 afa. During years when there has been more groundwater recharge than groundwater pumping, the aquifer system underlying RD 2035 has a net outflow to surrounding areas and the Sacramento River.

The perennial yield of the aquifer system underlying RD 2035 is a function of groundwater recharge within RD 2035 and lateral inflow or outflow. Because of the difficulty in estimating the maximum potential lateral inflow and recharge due to Yolo Bypass flooding, additional monitoring and evaluation would be necessary to determine the maximum perennial yield.

However, it appears that the potential perennial yield is in excess of the historical average groundwater pumping by the RD 2035, and possibly in excess of the maximum historical pumping by RD 2035.

WATER QUALITY PROBLEMS

A comprehensive study of groundwater quality in Yolo County was published by the USGS in 1985[7]. A total of 188 domestic and agricultural wells within Yolo County were sampled to determine concentrations of general mineral and inorganic constituents. The study found that groundwater in the area is generally suitable for agricultural and domestic uses. However, many of the wells sampled had boron concentrations which exceeded tolerance levels for many crops. Many of the wells also had moderately elevated levels of total dissolved solids.

Wells in RD 2035 were also sampled in December, 1991 as part of the Eastern Yolo County Groundwater Investigation studies[3]. These were performed for Conaway and Cowell Ranches to fulfill their monitoring commitments during the State Emergency Drought Water Bank. Graphs showing the results of these samples are shown in the Appendix. The conclusions of the groundwater quality investigation were that many wells had moderately elevated (> 500 mg/L) levels of total dissolved solids, some had elevated boron levels (> 2 mg/L) and others had elevated levels of iron and manganese.

The source of the boron in the region is thought to be originally from geothermal springs in the Coast Range which discharge into Cache Creek. Wells with high boron levels were generally found in the vicinity of the Tule Canal. The sediments in this area were probably deposited from Cache Creek as it fanned out and entered the tule marsh conditions which used to be present in much of the present RD 2035 service area.

Wells with elevated salinity are scattered throughout RD 2035, but wells along the Tule Canal near Highway 16 produce water with the highest levels of salinity. Wells nearest the Sacramento River produce water with the lowest salinity, but higher levels of manganese.

LAND USE

The productive lands within RD 2035 are being used extensively for agriculture. Some tracts of land in the District are also used for wastewater treatment ponds or other related facilities by the cities of Woodland and Davis. However, water is only served for agricultural irrigation at the present. The most common crops grown in the district are rice, corn, safflower, tomatoes, alfalfa, wheat, and sugar beets. The average area planted to crops during the period of 1981 through 1990 was 12,900 acres.

DATA EVALUATION

Data from the monitoring program established in 1991 and continuing to the present have been evaluated on an annual basis, usually in spring. Running trend graphs of the water levels in wells have been plotted to evaluate effects over time and among wells. Examples of these trend graphs for monitoring wells MW-1 and MW-9 are shown in Figures 2 and 3. These trend graphs, referred to as hydrographs, are useful for considering the water level responses in shallow and

deep aquifer systems to pumping by RD 2035 wells and wells on land surrounding RD 2035. These graphs also provide an indication of the degree of confinement for the deeper aquifer system.

Spring water level trend graphs have also been plotted to evaluate long term trends in groundwater levels. An example is shown in Figure 4. As can be seen, spring groundwater levels have been generally level to slightly higher over the last few years. DWR also plots long term trend graphs for water levels in wells throughout Yolo County which are measured in spring and fall.

Subsidence data gathered at the extensometer have been plotted annually by DWR along with water levels in 4 different aquifer zones. An example of this is shown in Figure 5.

Groundwater elevation changes have been found to follow piezometric water level changes in the deeper aquifers closely. Only temporary, elastic subsidence has been evident in the measurements taken from late 1991 to the present.

Water quality data was only collected by RD 2035 in 1991. Graphs of these data are contained in the Appendix as was mentioned previously.

Figure 2. Water Level Hydrograph - Western Edge of District

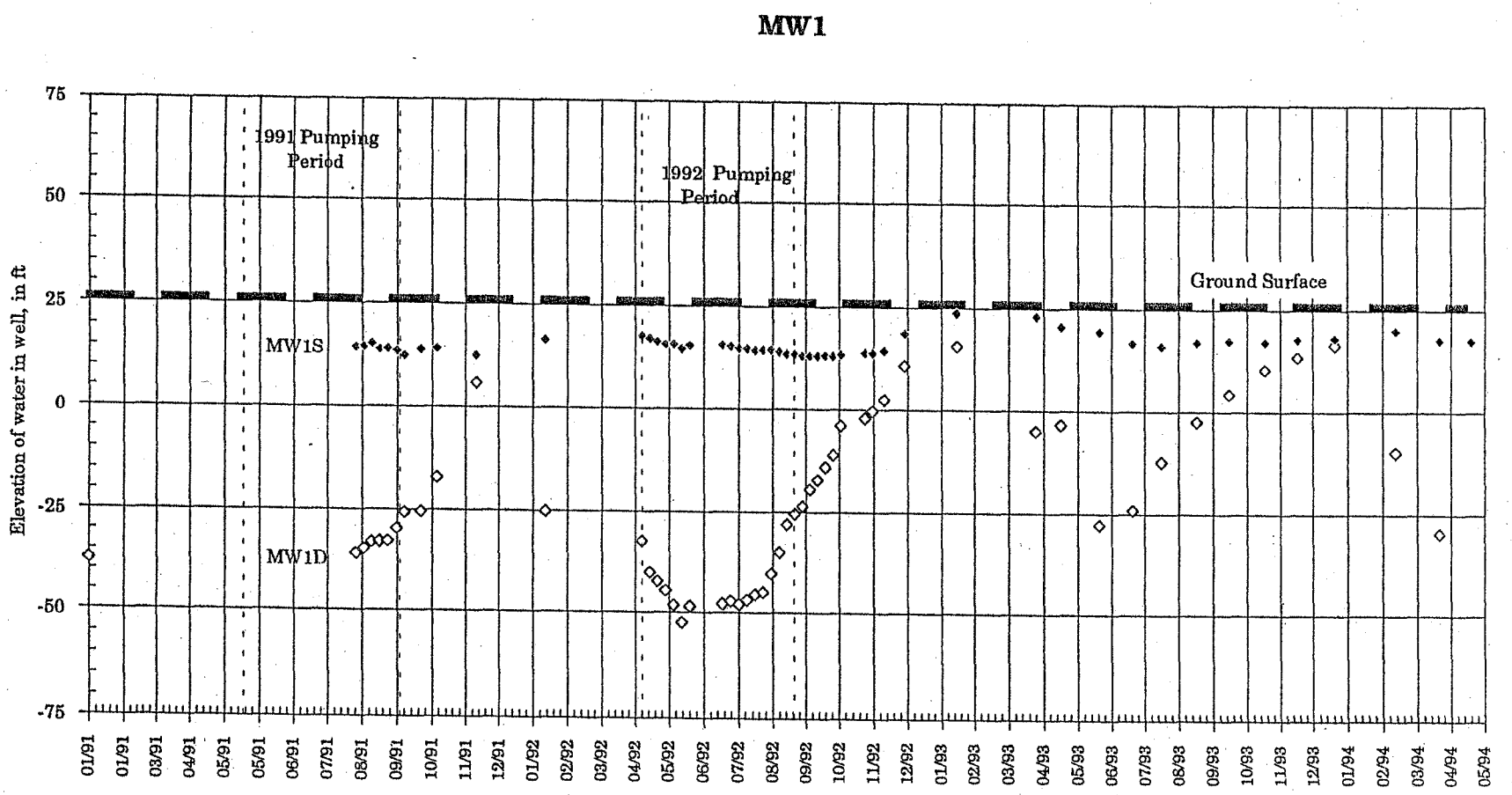
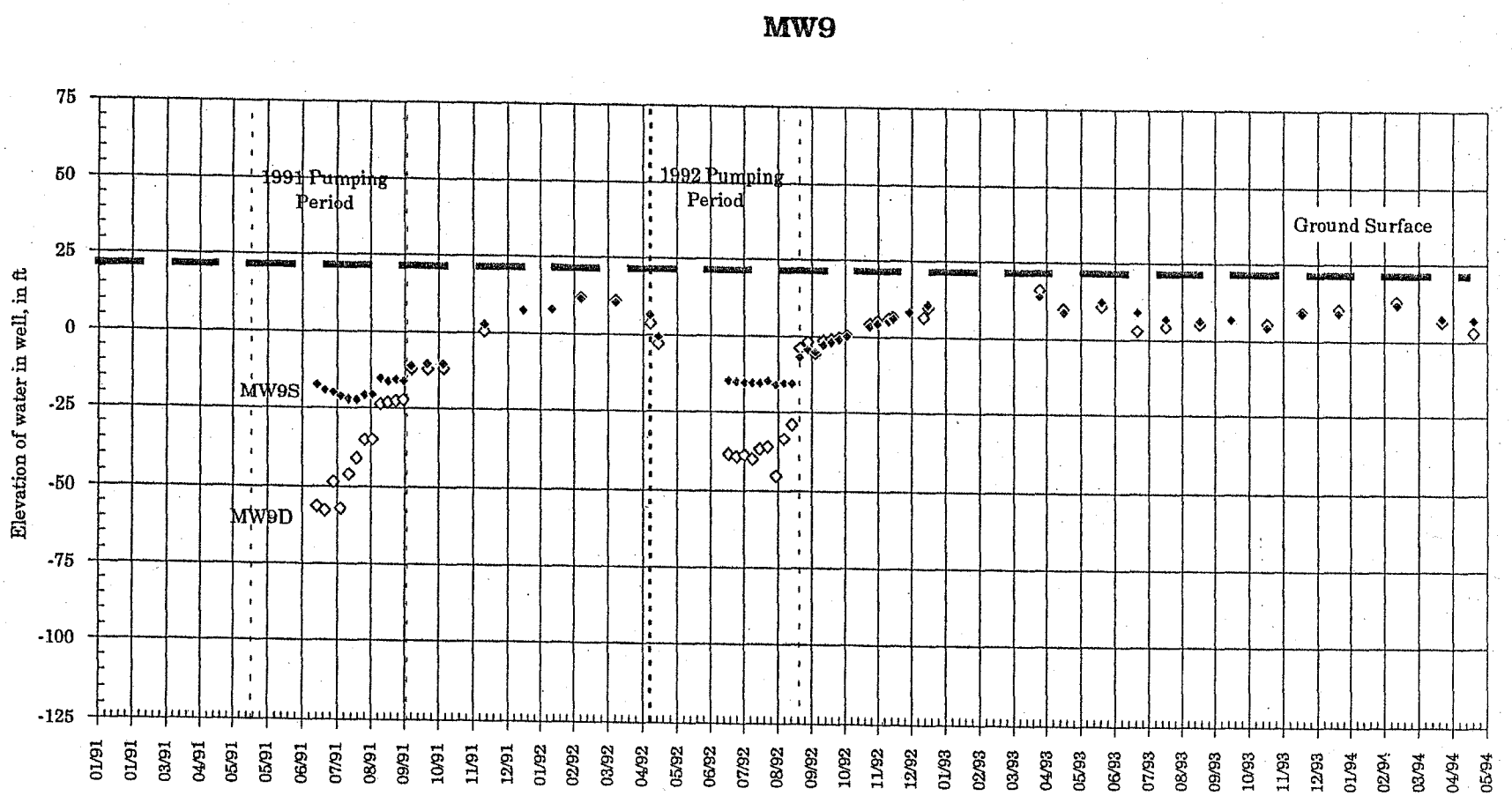


Figure 3. Water Level Hydrograph - Eastern Edge Well Cluster



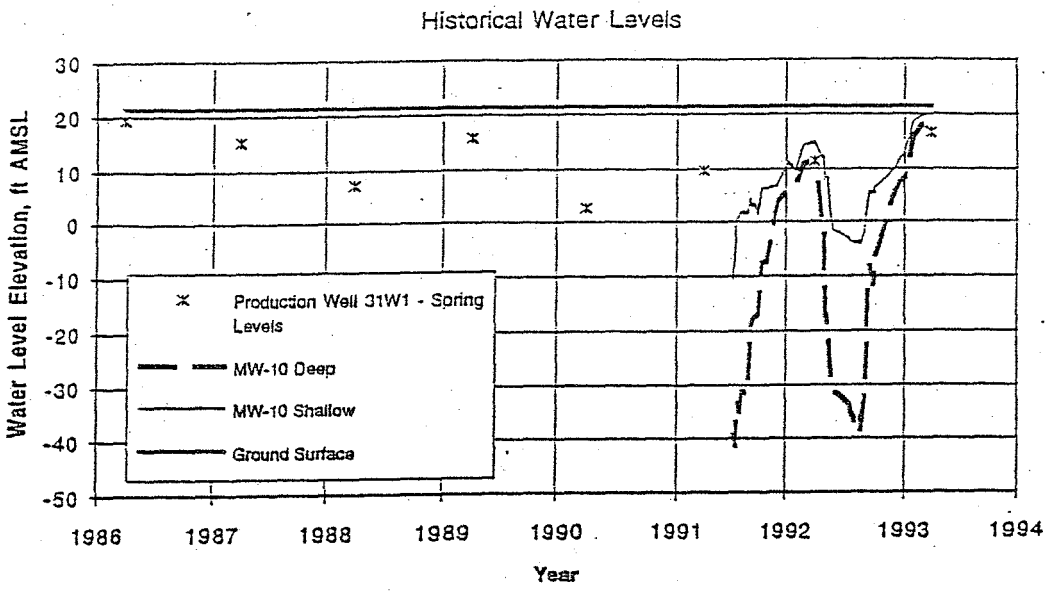


Figure 4. Production and Monitoring Well Spring Water Levels, 1986 - 1993

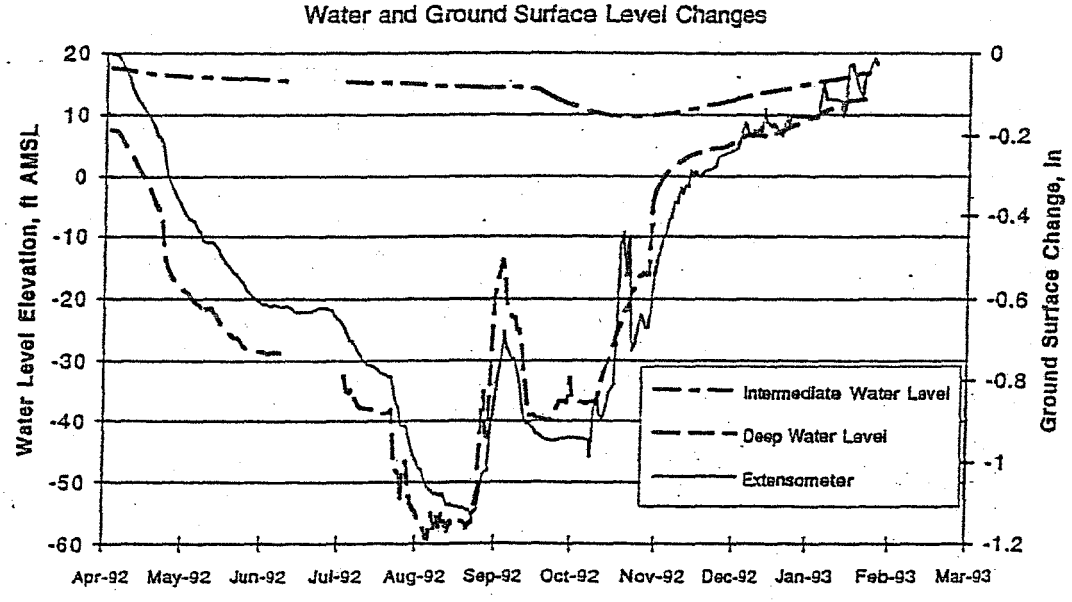


Figure 5. Water and Ground Surface Level Changes

FUTURE WATER DEMANDS

PROJECTED CHANGES IN WATER USE

Agricultural Use

Water use has fluctuated over time due to changes in cropping patterns. As world markets open up to crops grown in RD 2035, more land may be taken out of government set-aside programs and planted. This occurred for rice in 1993 and 1994. Although it is very difficult to predict, water demand for agricultural irrigation within RD 2035 will probably increase in the future.

Municipal Use

Conaway Ranch has submitted a proposed development plan for the northeast portion of the District to the City of Woodland. Development of this area has not been included in the revision of Woodland's General Plan at this time, but may become part of future planning. Groundwater would probably be used to supply the water needs of the proposed development in this portion of the RD 2035 service area.

Extraction for Conjunctive Use

Together with RD 2035, Conaway Ranch and other eastern Yolo County farmers, DWR has begun the evaluation of a potential conjunctive use project. This project would involve the storage of up to 25,000 afa of State Water Project water in groundwater in Eastern Yolo County during wet years and extraction of up to 30,000 afa of groundwater during dry years. Groundwater would be recharged in large part by supplying farmers with surface water in lieu of their normal pumping of groundwater. Groundwater would be extracted primarily from wells in RD 2035, with some limited extraction on other ranches in Eastern Yolo County.

RD 2035 will practice conjunctive use within its own boundaries and possibly with some farmers on adjacent lands. The extraction of stored groundwater would take place as part of a water transfer or just to make up for surface water allocation lost during a critically dry year.

Yolo County Flood Control and Water Conservation District (YCFCWCD) is considering conjunctive use measures using water from Clear Lake and Indian Valley Reservoir. Most of the initial measures would be too distant from RD 2035 to have any significant impact, but RD 2035 will cooperate with YCFCWCD in the future to coordinate planning and implementation of these programs.

Extraction for Water Transfers

During 1991, Conaway Ranch made 38,500 af of water available for transfer to the State Emergency Drought Water Bank by a combination of fallowing, crop substitution, groundwater substitution and groundwater pumping in RD 2035. In 1992, Conaway Ranch

transferred 17,000 af to the 1992 Water Bank made available through crop shifting and increased groundwater pumping (17,400 af).

During future drought years, Conaway Ranch will likely again participate in water transfers and sell all or a portion of its surface water rights. Groundwater will be pumped in RD 2035 to meet the needs of irrigated crops plus any commitments to DWR as part of a conjunctive use program. The total amount could potentially exceed 30,000 af in a season. This amount will be limited by subsidence considerations or concern over impacts to groundwater levels outside of RD 2035.

Pumping on Lands Near RD 2035

Many of the lands surrounding RD 2035 use groundwater as their major source of irrigation water. The average pumping rate for crops irrigated with groundwater was estimated at 2.13 afa by DWR[1]. This is about 2.5 times the average amount of pumping for crops within RD 2035. Average groundwater pumping on lands near RD 2035 will probably stay relatively constant in the future, except for lands which cooperate in a conjunctive use project with DWR or YCFCWCD. Surface water may be supplied to lands in a conjunctive use program to accomplish in-lieu groundwater recharge.

IMPACTS ON THE BASIN

DWR performed groundwater modeling for several scenarios in the feasibility study for the Eastern Yolo County conjunctive use project[1]. The DWR model assumed pumping of approximately an extra 16,000 afa of groundwater from RD 2035 wells, and an extra 14,000 afa from wells on other ranches in Eastern Yolo County. Their model simulations indicated that groundwater pumping for the conjunctive use project would lower water levels an additional 10 to 30 feet in the project area during the irrigation season and have minimal long term groundwater level impacts.

The impacts of other potential future changes in groundwater uses have not been modeled, but the summer water level impacts should be roughly proportional to monthly pumping rates. Impacts from other future changes could be modeled more precisely using the DWR model for other potential scenarios.

MONITORING OF GROUNDWATER LEVELS AND STORAGE

Monitoring

Section 10753.7 of Division 6 of the California Water Code lists monitoring of groundwater levels and storage as one of the possible elements of a groundwater management plan. Groundwater storage is typically calculated from groundwater level data and estimated aquifer properties. Ongoing monitoring of groundwater levels and storage will help RD 2035 evaluate trends and potential management options.

Since the end of the 1992 Water Bank, the monitoring program has consisted of monthly monitoring of all accessible wells in RD 2035, usually performed in the first week of each month. Groundwater pumping has also been measured for some of the wells using flowmeters with totalizers. As part of this groundwater management plan, RD 2035 will continue the monthly groundwater monitoring and will institute monthly groundwater pumping measurements on all wells operated by RD 2035. Data collection and recording procedures developed during 1991 and 1992 will continue to be used.

DWR has continued to monitor subsidence with the extensometer and water levels in MW-7 (adjacent to the extensometer). These measurements are recorded with automatic data loggers. RD 2035 will continue to provide access and logistical support to DWR for these measurements.

Water quality samples have not been taken since the end of the 1992 Water Bank. Henceforth, water quality sampling for TDS, nitrate, boron, iron and manganese will be performed for representative wells throughout RD 2035 on a bi-annual basis. The purpose of this monitoring will be to detect long term groundwater quality trends.

Data Evaluation and Reporting

The data will be evaluated every spring, and an annual summary report will be prepared. This report will include water level hydrographs, subsidence graphs, a table of groundwater pumping and any other relevant monitoring data from the previous year. Data provided by DWR or YCFCWCD for wells from the area surrounding RD 2035 will also be included.

Evaluation of the data will include an estimate of groundwater in storage within the District, and discussion of any notable trends. Groundwater gradients in summer and spring will be plotted and discussed. Correlation of groundwater level changes in RD 2035 with groundwater levels and pumping outside of RD 2035 will also be evaluated. Correlation between groundwater pumping and subsidence will be evaluated, and any significant permanent subsidence will be noted. Discussion of these and other relevant issues will be contained in the annual report.

FACILITATING CONJUNCTIVE USE OPERATIONS

Conjunctive use can be described as the management of groundwater storage in a manner similar to the management of a surface water reservoir. Water is stored in the ground during times of high surface water availability and withdrawn during times of low surface water availability.

The RD 2035 river diversion, conveyance system and wells will be operated to facilitate conjunctive use. This will include planning and coordination for the timing of surface water diversions, groundwater extraction, enhancement of groundwater recharge and participation in DWR's conjunctive use project should it be implemented.

Surface Water Resources

The use of Cache Creek water will be maximized when it is available, recognizing that Sacramento River water and groundwater are of greater cost and value. Sacramento River diversions will be utilized to the greatest extent possible during the months of June and October, when its availability is greatest. If conjunctive use is practiced for lands outside of RD 2035, delivery of surface water to those lands should be maximized during the April through June period. If DWR furnishes additional water during July through September as part of its conjunctive use project, there should be adequate capacity in the RD 2035 system to accommodate it.

Groundwater Extraction Criteria

Groundwater pumping will be performed as is needed for crop irrigation to make up for any shortfall in normal surface water deliveries. However, groundwater pumping should be limited to that amount which will not cause significant permanent levee subsidence or excessive water level declines in and around RD 2035.

Significant permanent subsidence should be defined as one inch of permanent cumulative subsidence measured by the extensometer from spring 1992 to spring of any future year. If significant permanent subsidence has been caused during a pumping season, the lowest measured hydrostatic water levels during that season should be noted. These hydrostatic water levels would then serve as the minimum allowable level for any subsequent years. If significant permanent subsidence is measured at the extensometer, some additional subsidence measurements would also be warranted for areas in RD 2035 distant from the extensometer. Elevations at other points could be measured with an improved GPS survey system.

Excessive water level declines would be defined as declines resulting from pumping more groundwater in RD 2035 than typical groundwater irrigators in the area, which would have a significant adverse impact on the operation of wells outside of RD 2035. Since the average groundwater pumping by farmers outside of RD 2035 is 2.13 feet, pumping would not be considered excessive for up to 12,900 acres (average planted acreage) times 2.13 feet, or 27,500 acre-feet. Pumping greater than that amount would be considered excessive if it significantly adversely affected the operation of wells outside of RD 2035.

Development of Additional Groundwater Pumping Capacity

Additional wells may be necessary to provide flexibility and peak month capacity for RD 2035, especially for future water transfers and the DWR conjunctive use project. Geologically, the best area for new wells would be the southeast portion of the District. This area appears to have a low amount of confinement and excellent yielding capacity. Unfortunately, this is also the lowest part of the water service area. Drainage return pumps would have to be used to get water from wells in this area back into the main irrigation system. Other areas south of Willow Slough are generally favorable for groundwater development, as long as new wells are not installed so close to existing wells to cause excess interference. Based on the present understanding of the geology and irrigation system operation of the District, the preferred areas for new groundwater exploration and development are shown in Figure 6.

Enhancement of Groundwater Recharge

River water will be diverted during the months of November through February under Conaway Ranch's riparian water rights to provide waterfowl habitat, decompose rice stubble and provide enhanced incidental direct groundwater recharge. In years prior to 1991, approximately 2,000 to 3,000 acres of fields have been flooded for waterfowl. This amount will increase as rice stubble burning is phased out and rice acreage is increased. The average acreage flooded could exceed 5,000 acres in the future.

Joint Conjunctive Use Operations with DWR

The proposed SWP Conjunctive Use project for Eastern Yolo County would utilize the diversion and conveyance facilities of RD 2035 to carry water to farms west and southwest of RD 2035. This would be accomplished by diverting extra State Water Project water from the Sacramento River when it is available and sending it back up Willow Slough. Farmers currently using groundwater for irrigation would pump water from Willow Slough instead, thereby leaving extra groundwater in place.

RD 2035 wells would also provide over half of the extraction capacity for the State Water Project's stored water. RD 2035 is ideally located to provide extraction of the stored groundwater since it is located in high yield aquifers downhill (and generally downgradient) from where the in-lieu recharge would take place.

RD 2035 may also be able to use some of Conaway Ranch's water rights to perform off site in-lieu recharge for its own conjunctive use purposes.

WELLHEAD AND AQUIFER PROTECTION

Contamination within areas which supply water to the wells in RD 2035 could create a threat to the quality of water from these wells. Setting up a wellhead protection plan under the guidelines of Section 1428 of the Federal Clean Water Act would help maintain long term assurance of water quality. One of the key elements of a wellhead protection plan is the delineation of wellhead protection areas. This requires an understanding of well construction, aquifer characteristics and groundwater pumping and monitoring of groundwater quality. One of the

FIGURE 6

objectives of this groundwater management plan is to develop the necessary information to delineate wellhead protection areas and establish a wellhead protection program sometime in the future.

Wellhead Protection Plan Development

The U.S. Environmental Protection Agency has identified the following seven steps in a wellhead protection program:

1. Specify the roles and duties of State agencies, local governmental entities, and public water suppliers that will contribute to developing and implementing the wellhead protection program.

2. Delineate the wellhead protection area (WHPA) for each wellhead.

3. Identify potential sources of contaminants within each WHPA.

4. Develop management approaches to protect the water supply within WHPAs from contaminants.

5. Develop contingency plans for each public water supply system to respond to emergencies.

6. Site new wells properly to maximize yield and minimize potential contamination.

7. Ensure public participation.

Emphasis will initially be given to obtaining aquifer properties for the development of information which could be used in wellhead protection area delineation. This information will be derived from the evaluation of existing test data, the yearly monitoring data and future aquifer pumping tests.

Water quality trends will be evaluated as was specified in the monitoring section of this groundwater management plan. Adverse trends in water quality will be cause to accelerate the development of a wellhead protection plan and to begin sampling for additional constituents of potential concern.

Prevention of potential aquifer contamination from inadequately sealed wells will also be addressed even before the adoption of any specific wellhead protection plan. In particular, old wells in the northwest portion of the District which have short or nonexistent seals should be modified or abandoned. Because these wells are closest to the potential future residential / commercial development, groundwater quality protection is especially important.

Modification of the wellheads would involve overexcavation of the wells to a depth of 10 feet, injecting a lean bentonite/grout seal down into the well gravel below the excavation, and placing clay backfill and a grout seal to fill the excavation. Well drilling companies may have equipment to facilitate or improve upon this proposed method for retrofitting a seal to the existing wells.

New wells should be constructed to state guidelines and county standards, with seal depths as discussed in the next section.

WELL CONSTRUCTION AND ABANDONMENT POLICIES

Without proper planning and seal design, deep wells can inadvertently act as conduits to allow lower quality water from shallow aquifers to migrate to the deep aquifers. In conjunction with other agencies, RD 2035 will develop well construction guidelines to minimize the potential for the deterioration of water quality in deeper aquifers.

Well Construction/Abandonment Standards

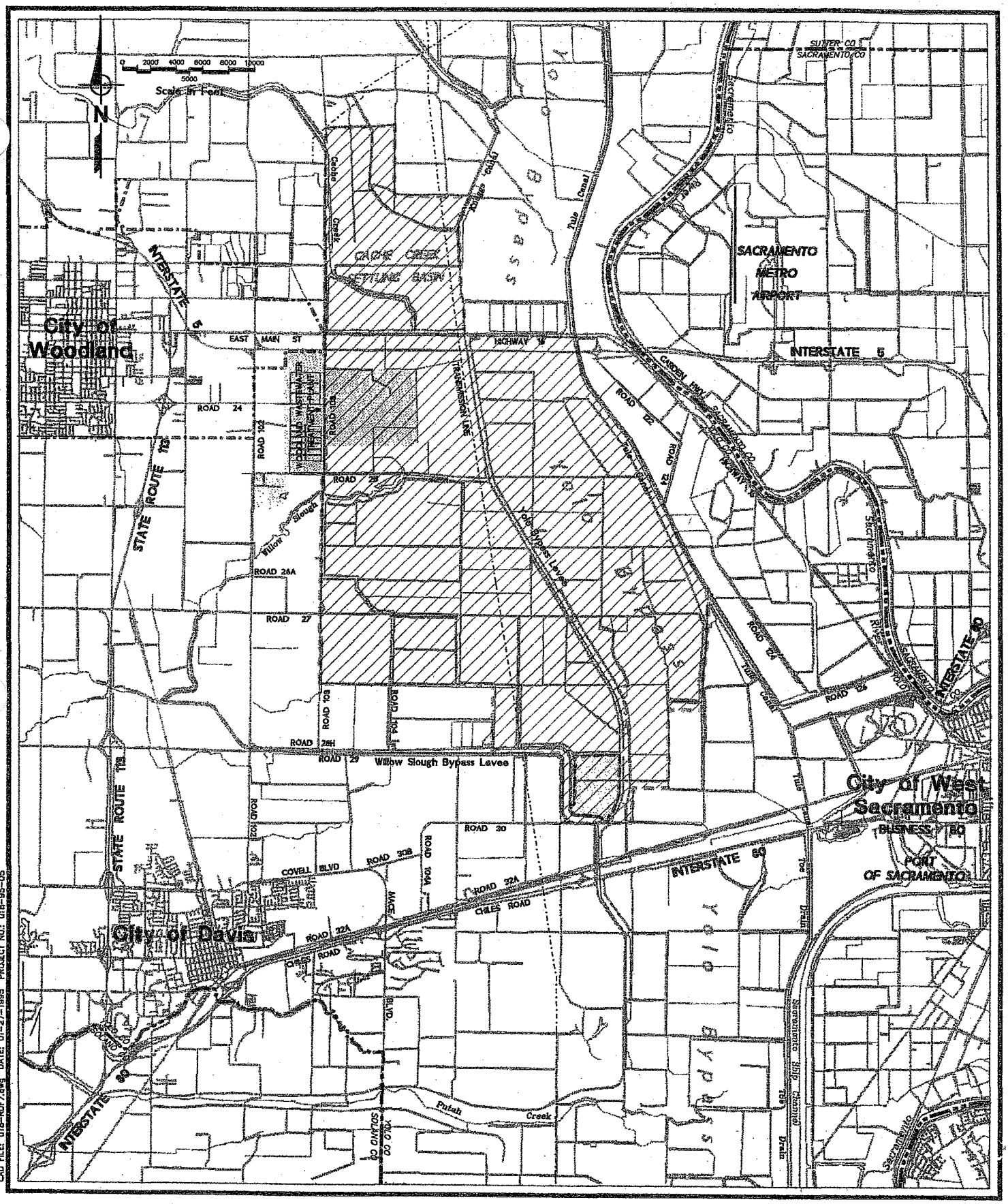
New wells should be designed in accordance with state guidelines and county standards. The seal depths should extend to at least 50 feet. If it is desirable to tap the shallow aquifer (and the shallow aquifer quality is reasonable), then a 50 foot seal depth would be appropriate. If there is not a good reason to tap the shallow aquifer, the seal should extend to at least 10 feet past the bottom of the shallow aquifer, or 100 feet, whichever is lesser. New wells in the southern and western portions of the District may also need 100 foot seals if reclaimed water is delivered to the District from the Cities of Davis or Woodland.

Wells should also be abandoned according to state and county standards. This includes filling the wells with grout throughout their depth.

COORDINATION WITH LAND USE PLANNING

The existing urban limit line for the City of Woodland is shown in Figure 7. The City of Woodland is currently in the process of updating its General Plan to include development on additional lands to the south and east of the current development limits. Conaway Ranch is currently in negotiations with the City regarding planning for eventual residential and commercial development of the portion of the ranch west of the Yolo Bypass between County Road 25 and Interstate 5. New wells installed by the City of Woodland to serve development close to or within RD 2035 may have an impact on and be impacted by RD 2035 wells. RD 2035 should encourage a joint evaluation of groundwater management strategies and impacts for new municipal wells in or near the western portion of RD 2035.

The City of Davis is currently negotiating with Conaway Ranch to purchase a 390 acre parcel in the southern portion of the ranch for a constructed wetlands project. The location of this project is also shown in Figure 7. This project may involve the installation of a new well by the City of Davis on the wetlands site. The impacts of a new well by the City of Davis should be considered in future RD 2035 groundwater planning, especially in locating of new RD 2035 wells.



Legend:

- RECLAMATION DISTRICT 2035
- CURRENT URBAN LIMITS (CITY of WOODLAND)
- WETLANDS RESTORATION PROJECT (CITY of DAVIS)
- CITY OWNED LAND OUTSIDE OF URBAN LIMITS (CITY of WOODLAND)
- COUNTY BOUNDARY

Figure 7

WEST YOST & ASSOCIATES

Reclamation District 2035
Groundwater Management Plan

Municipal Land Use Planning
Adjacent to RD2035

DEVELOPMENT OF RELATIONSHIPS WITH STATE, FEDERAL, AND OTHER AGENCIES

Federal Agencies

RD 2035 diverts water from the Sacramento River under a water rights settlement contract held by Conaway Ranch with the USBR. RD 2035 has worked with the USBR to develop estimates of the influence of wells on seepage from the Sacramento River. RD 2035 intends to continue to work with USBR to help resolve issues relating to water transfers, conjunctive use programs, and other issues related to diversions from the river.

State Agencies

Through its participation in the 1991 and 1992 State Emergency Drought Water Bank Programs and in a number of joint studies related to water resources in eastern Yolo County, RD 2035 has developed a strong working relationship with DWR. It is the intent of RD 2035 to continue working with DWR on the development of a joint Eastern Yolo County conjunctive use program. It is also the intent of RD 2035 to continue the sharing of monitoring data with DWR so that DWR can continue to develop and calibrate its groundwater model for Eastern Yolo County.

Other Agencies

The Water Resources Association of Yolo County was formed in 1993 to coordinate the collection and evaluation of information on surface and groundwater resources in Yolo County. The members of the Association are the Cities of Davis, Winters, Woodland and West Sacramento; Yolo County Flood Control and Water Conservation District; Dunnigan Water District; and U.C. Davis. The Water Resources Association is currently implementing a Water Resources Management Program as was outlined in a 1992 report by Borcalli and Associates[8]. This program includes gathering the information necessary to prepare a future potential joint groundwater management plan for all the areas served by the member agencies. A copy of the Association's groundwater management program tasks is shown in the Appendix. Representatives from RD 2035 have attended Water Resources Association meetings to stay abreast of local water management planning.

The Water Resources Association of Yolo County is interested in coordinating groundwater management planning with RD 2035. RD 2035 intends to cooperate with the Water Resources Association in the sharing and evaluation of groundwater related data which affects the interests of both organizations. It is also the intent of RD 2035 to pursue long term arrangements for the utilization of RD 2035 groundwater resources and water conveyance facilities which would provide benefits to both the District and members of the Water Resources Association.

IMPLEMENTATION

Implementation of this groundwater management plan will begin in June, 1995. Monitoring will continue as specified until the plan is modified. Additional monitoring may be performed from time to time as is necessary for other purposes.

RD 2035 will continue to coordinate the subsidence monitoring and conjunctive use planning with DWR. The District will also maintain communication with the Water Resources Association of Yolo County and its member agencies which adjoin RD 2035. This will allow an open dialog on groundwater management planning throughout Eastern Yolo County.

ENDNOTES

1. J. Fielden et al., *SWP Conjunctive Use — Eastern Yolo County.* California Department of Water Resources, February, 1994.

2. Senter, E. and M. Collins under the direction of T. Dudley and H. Mann, *Historical Ground Water Levels in Yolo County.* California Depart of Water Resources, Central District, December, 1992.

3. Lorens, P.J., under the direction of W. Gentry, *Evaluation of Ground Water Resources: Sacramento Valley.* California Department of Water Resources Bulletin 118-6, August, 1978.

4. *Eastern Yolo County Groundwater Investigation Summary Report*, West Yost & Associates, January, 1992.

5. *Design, Construction and Maintenance of Subsurface Drains in Arid and Semiarid Areas.* Engineering Practice EP463, American Society of Agricultural Engineers, St. Joseph, Michigan, 1988.

6. *Groundwater Recharge Program, Fall 1992 through Winter 1993.* Prepared by West Yost & Associates for Reclamation District 2035, April, 1993.

7. U.S.G.S., *Chemical Quality of Ground Water in Yolo and Solano Counties, California.* 1985

8. *Yolo County Water Plan Update*, Borcalli and Associates, December, 1992.

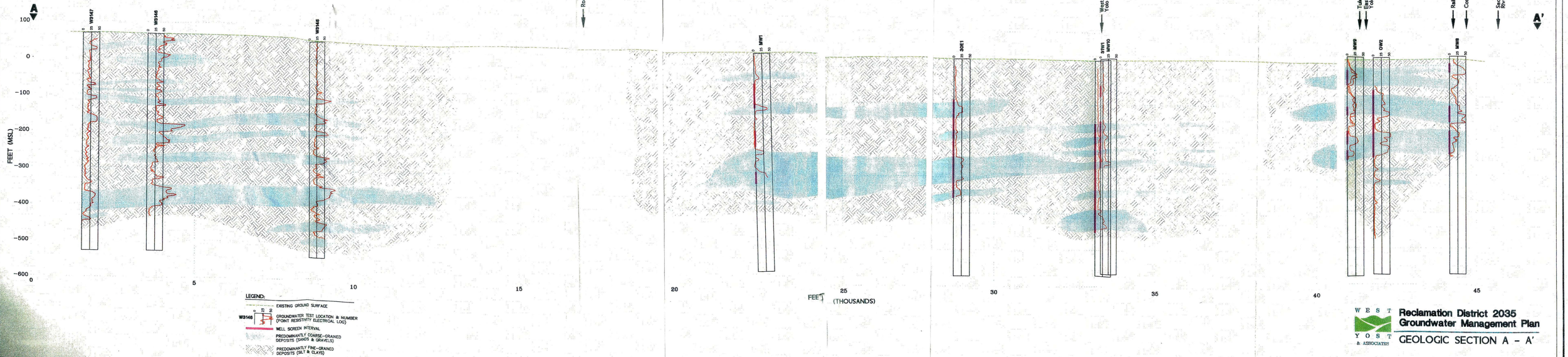
APPENDIX

RD 2035 Well Data

Reclamation District 2035 Well Data

Well No.	Other No.	Eaton No.	DWR No.	Use	Perforated Top	Depth Bottom	Depth Drilled	Depth to Suction	Casing Diam.	Capacity (ac-ft\wk)
13N1	NA	2547	9N/2E-13N1	M	207	218	350	NA	8	
13N2	NA	5471	9N/2E-13N2	D	450	470	500		8	
13N3	NA	5471	9N/2E-13N3	M	340	360	500	NA	2	
13N4	NA	5471	9N/2E-13N4	M	200	220	500	NA	2	
13N5	NA	NA	9N/2E-13N5	M				NA	8	
30A1	30A1	2144	10N/3E-30A1	I	130	400	528	113	20	
30E2	30E2	2130	10N/3E-30E1	I	119	389	455	103	20	
31W1	32E1	2110	10N/3E-32E1	I	180	480	500	93	20	80
31W2	6G1	2137	9N/3E-6H1	I	138	618	623	123	20	72
32NW1	32A1	2119	10N/3E-32A1	I	110	510	510	83	20	58
33NW1	33D1	2887-3	10N/3E-33D1	I	90	290	310	90	20	53
33NW2	33C2	2887-2	10N/3E-33C1	I	95	295	310	90	20	100
33NW3	33C1	2887-1	10N/3E-33C1	I	102	276	310	90	20	105
33NW4	33B1	2108	10N/3E-33B1	I	70	285	500	90	20	100
33NW5	W-3373	7T-426-3	10N/3E-33G1	I	120	310	354	125	20	85
33NW6	W-3387	7T-426-5	10N/3E-33G2	I	104	280	300	125	20	85
33NW7	W-3291	7T-319-2	10N/3E-33J1	I	96	344	375	125	20	65
33NW8	W-3368	7T-426-2	10N/3E-33R1	I	110	150	324	125	20	55
3W1	4A1	2122	9N/3E-4A1	I	97	343	343	83	20	75
5N1	NA	2732	9N/3E-5N1	D	126	150	220	NA	8	
5N2	NA	2732	9N/3E-5N2	M	134	278	278	NA	8	
6N1	NA	NA	9N/3E-6N1	D	317	381	381	NA	6	
7D1	586	NA	9N/3E-7D1	M	162	174	177	NA	8	
7W1	7D1	2101	9N/3E-7D2	I	144	390	501	83	16	51
OW1	28Q3	2869	10N/3E-28Q1	I	76	283	305	90	20	91
OW2	28Q1	2203	10N/3E-28Q2	I	105	280	500	102	20	120
OW3	NA	2824-4	10N/3E-28Q3	I	135	273	280	90	22	120
OW4	28Q4	2870	10N/3E-28Q4	I	76	283	300	90	22	62
OW5	NA	2824-3	10N/3E-28Q5	I	120	270	280	90	22	71
8-1	NA	6076	9N/3E-8	I	120	300	310		16	90
8-2	NA	6083	9N/3E-8NE	I	120	470	490		16	93
16-2	NA	6082	9N/3E-16	I	170	400	400		20	110
17-3	NA	6077	9N/3E-17	I	200	420	430		16	115
20-1	NA	6078	9N/3E-20Q1	I	150	470	470		16	75
21-3	NA	6080	9N/3E-21Q3	I	150	450	450		16	86
MW-1S	NA	5930		M	90	360	360	NA	2	NA
MW-1D	NA	5930		M	220	360	360	NA	5.5	NA
MW-2S	NA	5931		M	80	375	375	NA	2	NA
MW-2D	NA	5931		M	260	375	375	NA	5.5	NA
MW-4S	NA	5933		M	70	300	300	NA	2	NA
MW-4D	NA	5933		M	110	300	300	NA	5.5	NA
MW-5S	NA	5934		M	50	305	305	NA	2	NA
MW-5D	NA	5934		M	150	305	305	NA	5.5	NA
MW-7S	NA			M	80	700	700	NA	2	NA
MW-7I	NA			M	140	700	700	NA	5.5	NA
MW-7D	NA			M	240	700	700	NA	5.5	NA
MW-8S	NA	5937		M	30	280	280	NA	2	NA
MW-8D	NA	5937		M	140	280	280	NA	5.5	NA
MW-9S	NA	5938		M	40	285	285	NA	2	NA
MW-9D	NA	5938		M	140	285	285	NA	5.5	NA
MW-10S	NA	5939		M	80	300	300	NA	2	NA
MW-10D	NA	5939		M	180	300	300	NA	5.5	NA
MW-15	NA			M	20.5	30.5	45	NA	5.5	NA
MW-16	NA			M	37	47	50	NA	5.5	NA
MW-17S	NA			M	40	120	124	NA	2	NA
MW-17D	NA			M	110	120	124	NA	5.5	NA
MW-18S	NA			M	40	141	146	NA	2	NA
MW-18D	NA			M	131	141	146	NA	5.5	NA

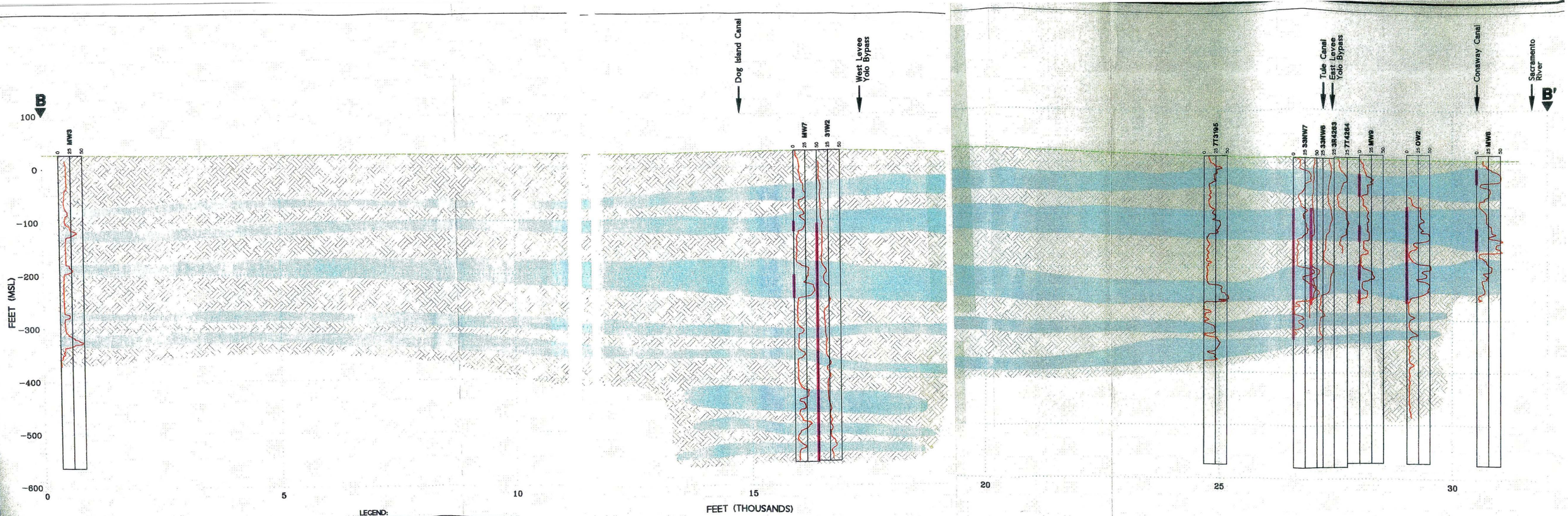
Geologic Cross Sections



WEST YOST & ASSOCIATES

Reclamation District 2035 Groundwater Management Plan

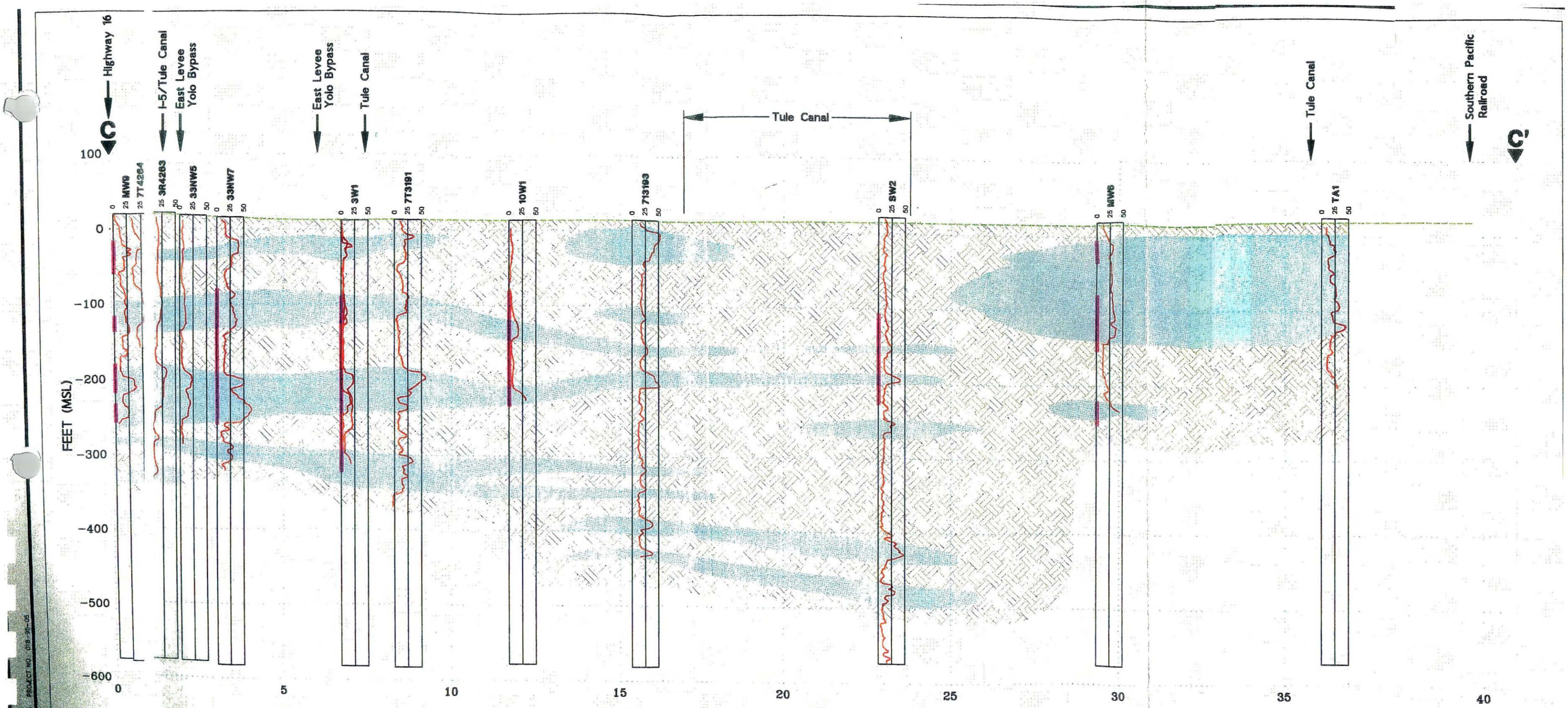
GEOLOGIC SECTION A - A'



WEST YOST & ASSOCIATES

Reclamation District 2035 Groundwater Management Plan

GEOLOGIC SECTION B - B'



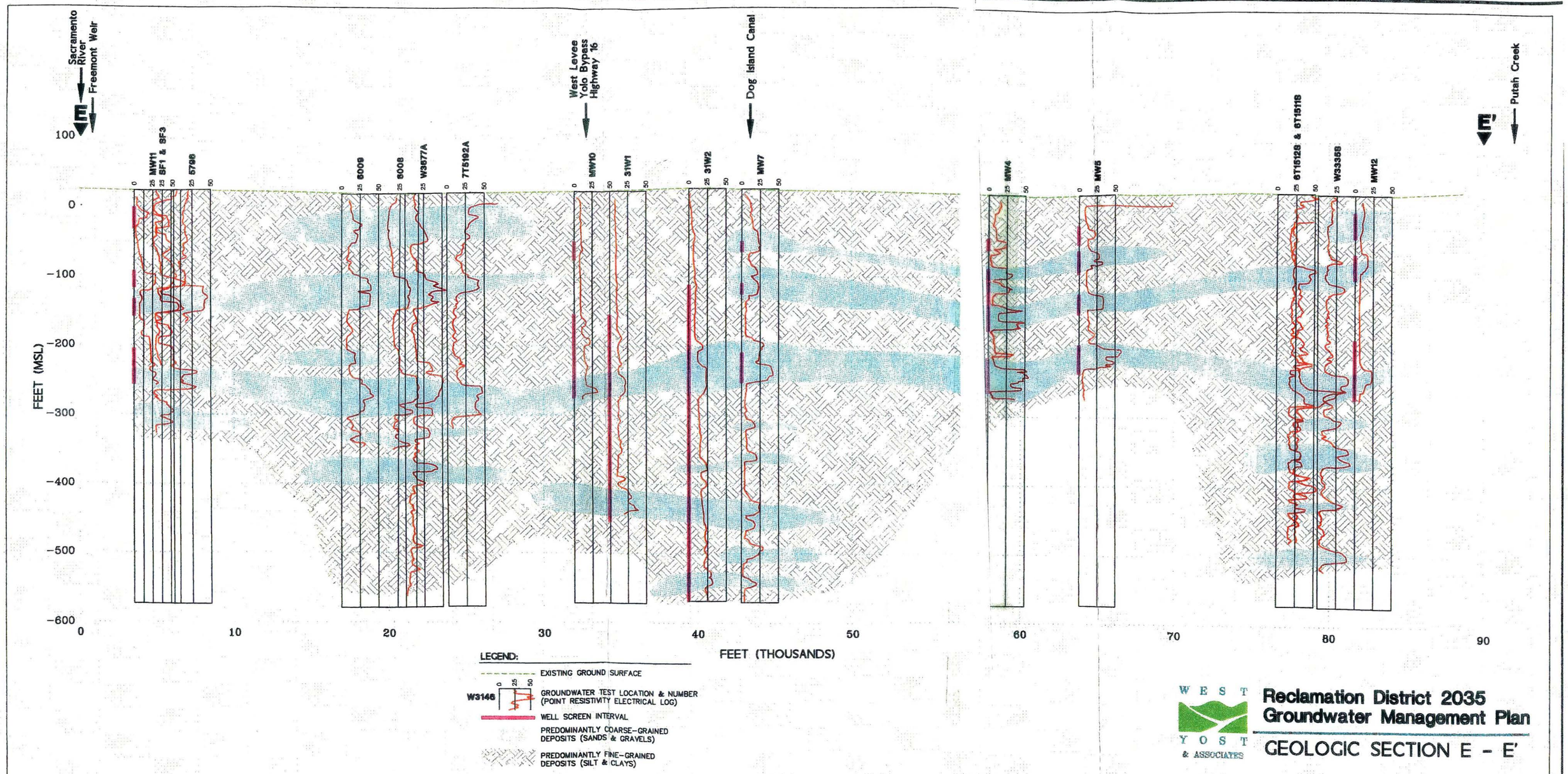
LEGEND:

- EXISTING GROUND SURFACE
- W3146 — GROUNDWATER TEST LOCATION & NUMBER (POINT RESISTIVITY ELECTRICAL LOG)
- WELL SCREEN INTERVAL
- PREDOMINANTLY COARSE-GRAINED DEPOSITS (SANDS & GRAVELS)
- PREDOMINANTLY FINE-GRAINED DEPOSITS (SILT & CLAYS)

WEST YOST & ASSOCIATES

Reclamation Districtrict 2035 Groundwater Manaanagement Plan

GEOLOGIC SECTICTION C - C'



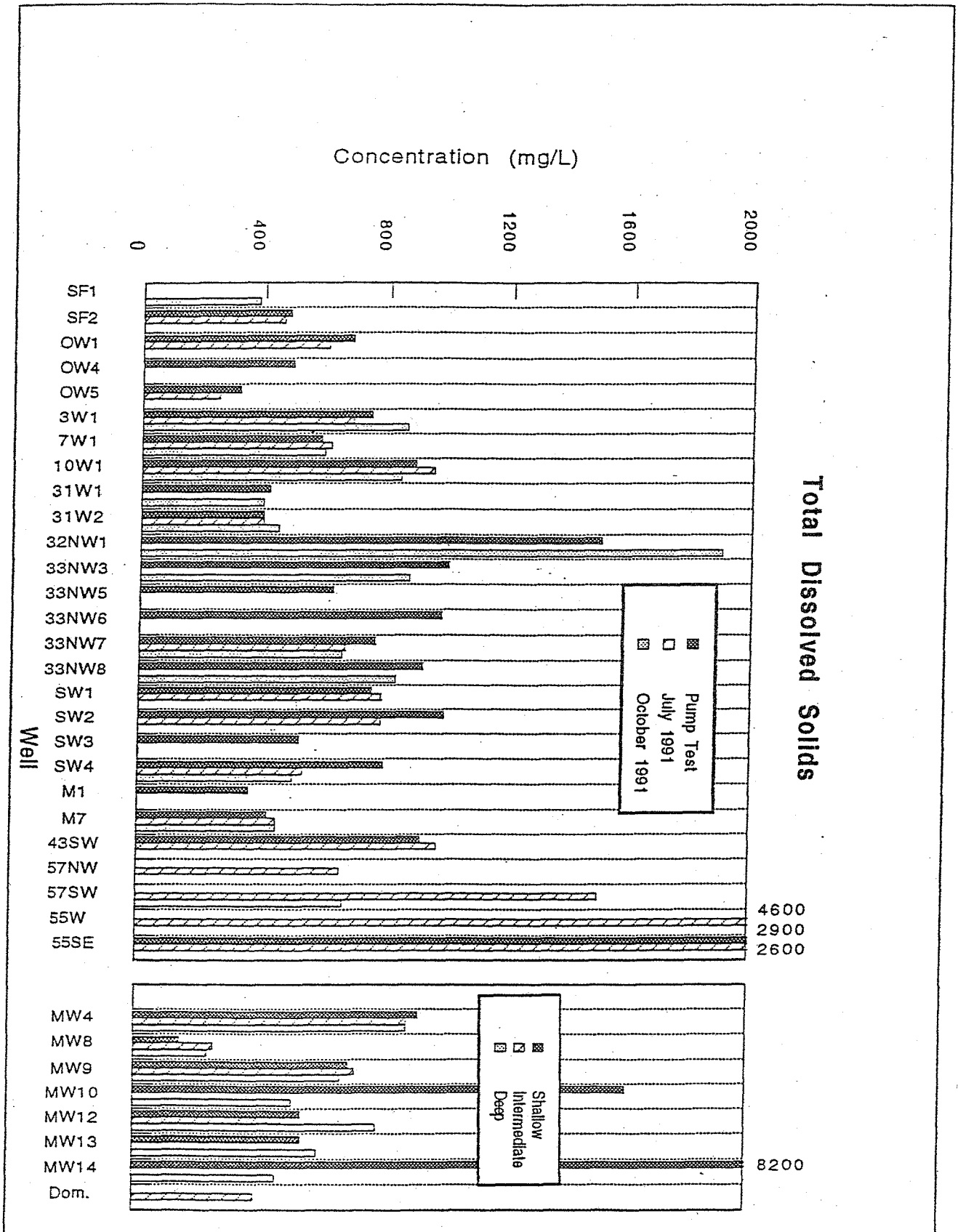
CAD FILE NO. 01-26-1995 PROJECT NO.: 018-05-05 DATE: 01-26-1995

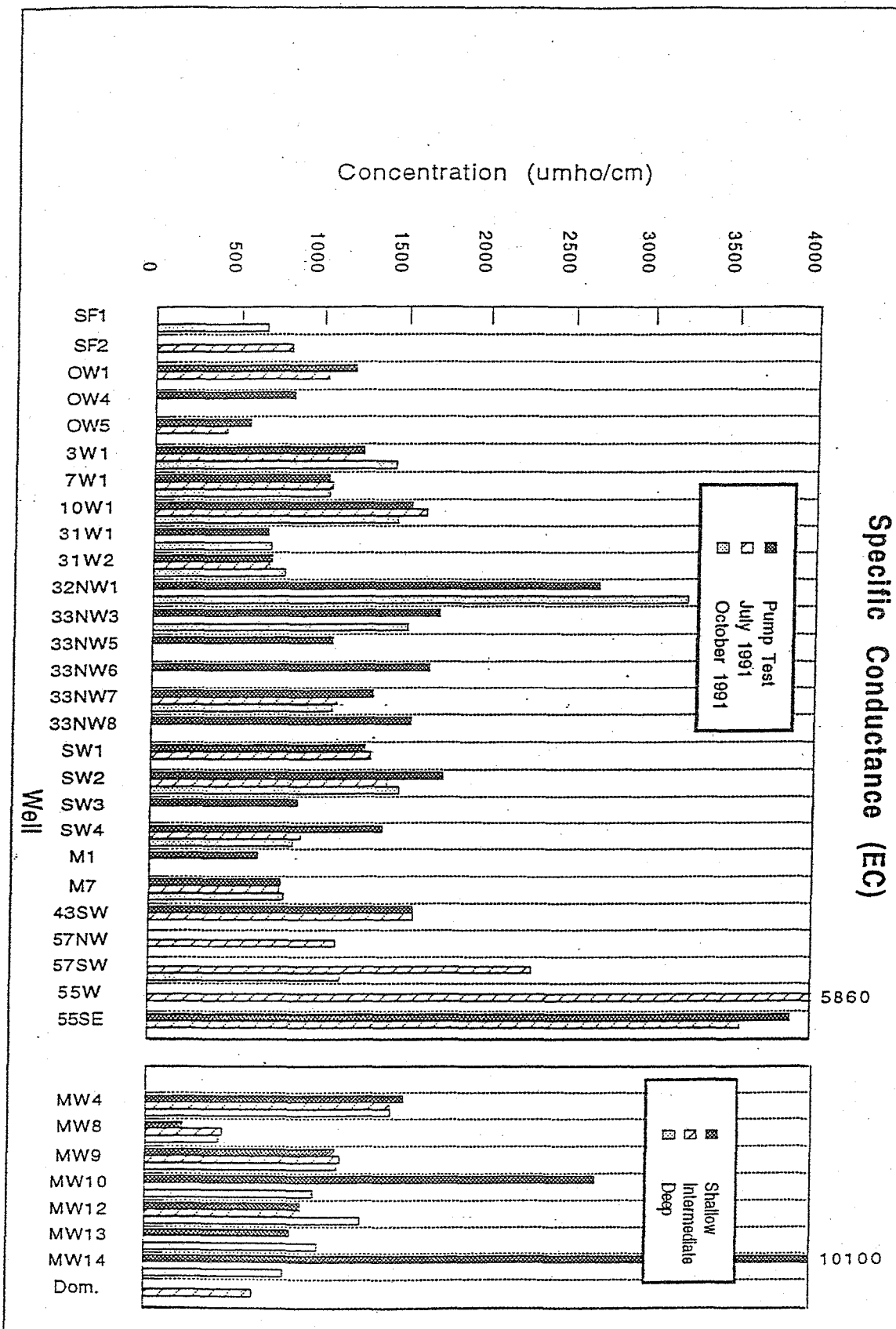
WEST YOST & ASSOCIATES

Reclamation District 2035 Groundwater Management Plan

GEOLOGIC SECTION E - E'

Groundwater Quality Data


Concentration (mg/L)
0
400
800
1200
1600
2000
Well
SF1
SF2
OW1
OW4
OW5
3W1
7W1
10W1
31W1
31W2
32NW1
33NW3
33NW5
33NW6
33NW7
33NW8
SW1
SW2
SW3
SW4
M1
M7
43SW
57NW
57SW
55W
55SE
Pump Test
July 1991
October 1991
4600
2900
2600
MW4
MW8
MW9
MW10
MW12
MW13
MW14
Dom.
Shallow
Intermediate
Deep
8200
Total Dissolved Solids


Specific Conductance (EC)
Concentration (umho/cm)
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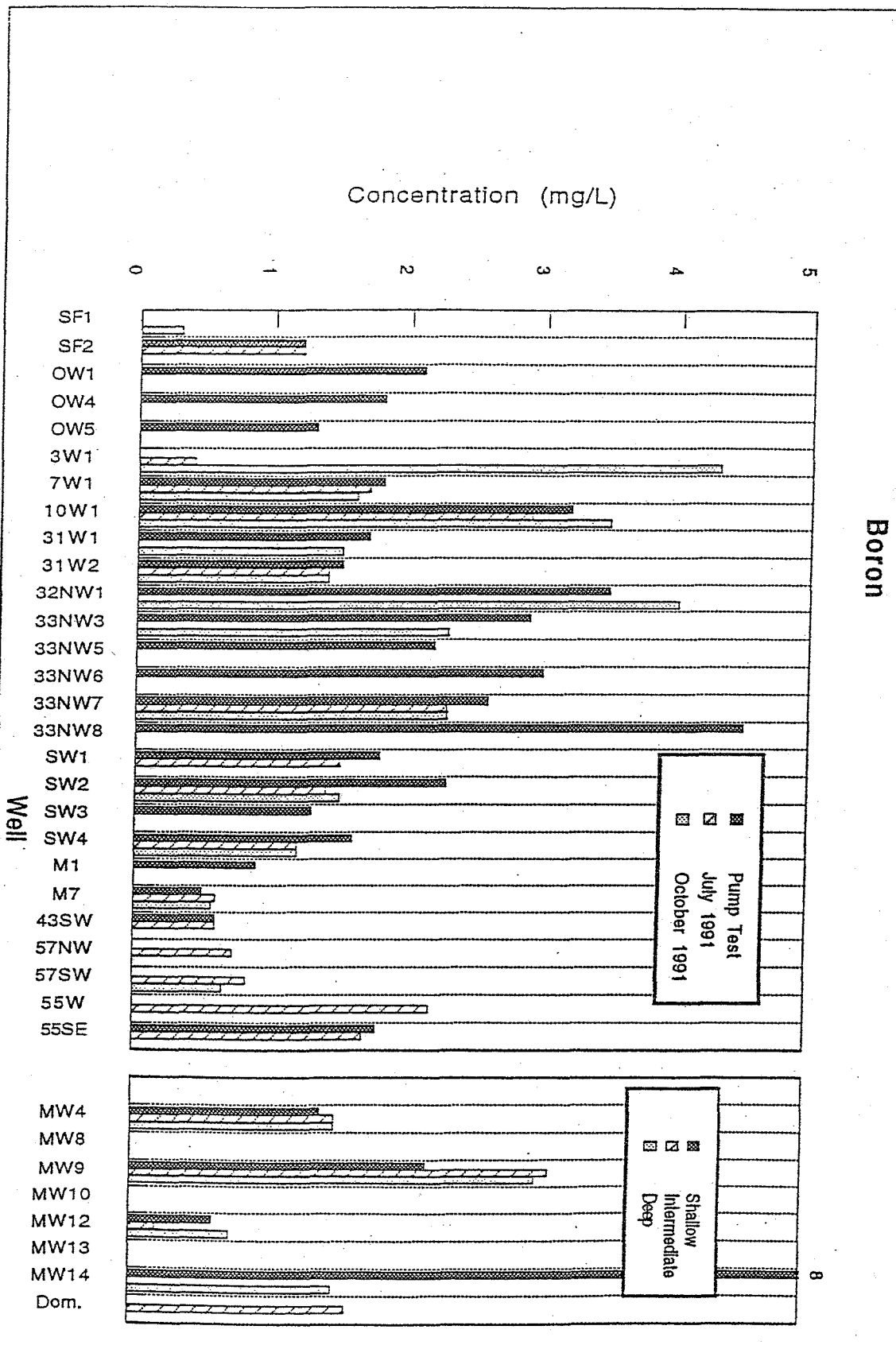
500
1000
1500
2000
2500
3000
3500
4000
Well
SF1
SF2
OW1
OW4
OW5
3W1
7W1
10W1
31W1
31W2
32NW1
33NW3
33NW5
33NW6
33NW7
33NW8
SW1
SW2
SW3
SW4
M1
M7
43SW
57NW
57SW
55W
55SE
Pump Test
July 1991
October 1991
5860
MW4
MW8
MW9
MW10
MW12
MW13
MW14
Dom.
Shallow
Intermediate
Deep
10100


Concentration (mg/L)
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1
2
3
4
5
SF1
SF2
OW1
OW4
OW5
3W1
7W1
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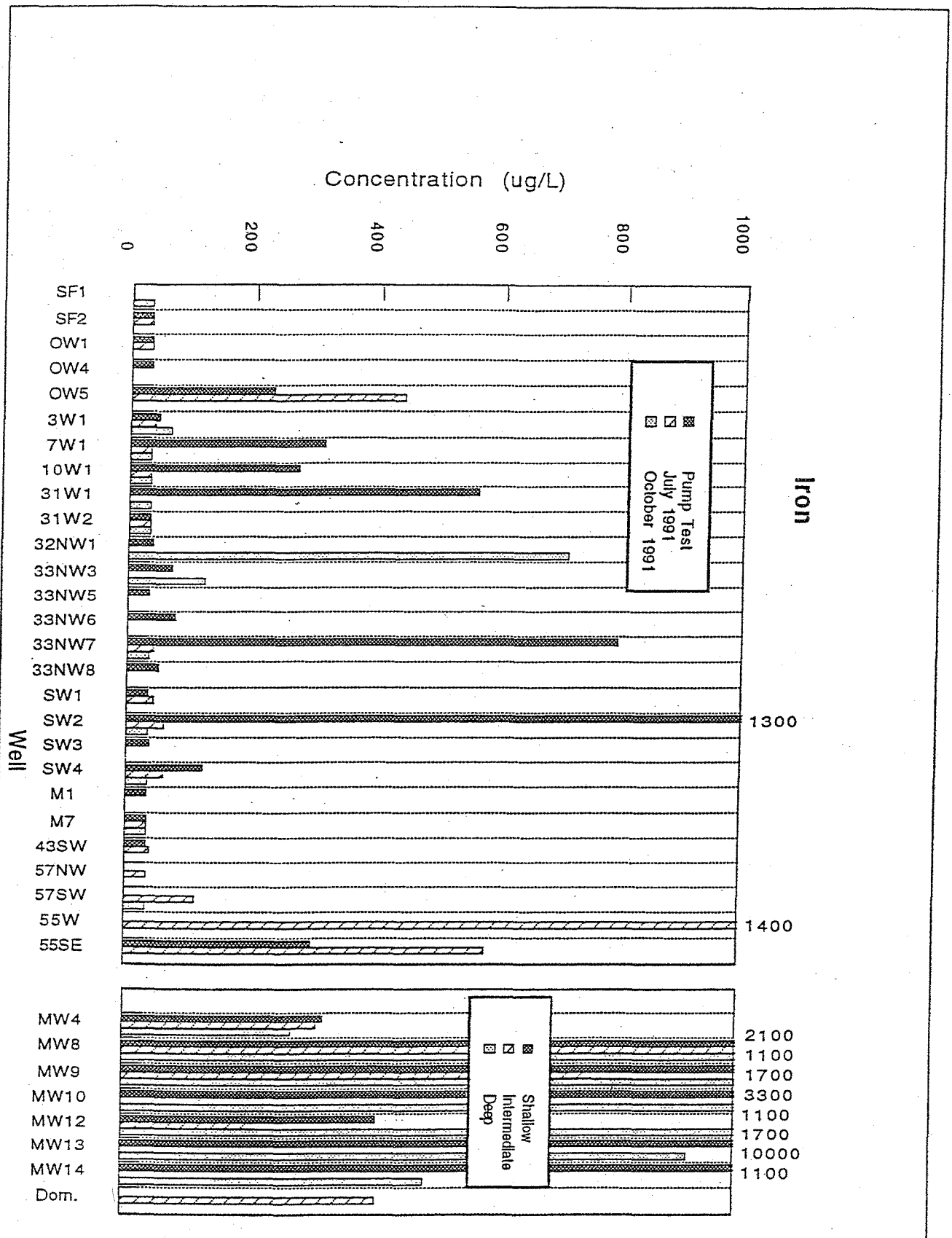
31W2
32NW1
33NW3
33NW5
33NW6
33NW7
33NW8
SW1
SW2
SW3
SW4
M1
M7
43SW
57NW
57SW
55W
55SE
Well
Pump Test
July 1991
October 1991
MW4
MW8
MW9
MW10
MW12
MW13
MW14
Dom.
Shallow
Intermediate
Deep
Boron
8


Concentration (ug/L)
0
200
400
600
800
1000
SF1
SF2
OW1
OW4
OW5
3W1
7W1
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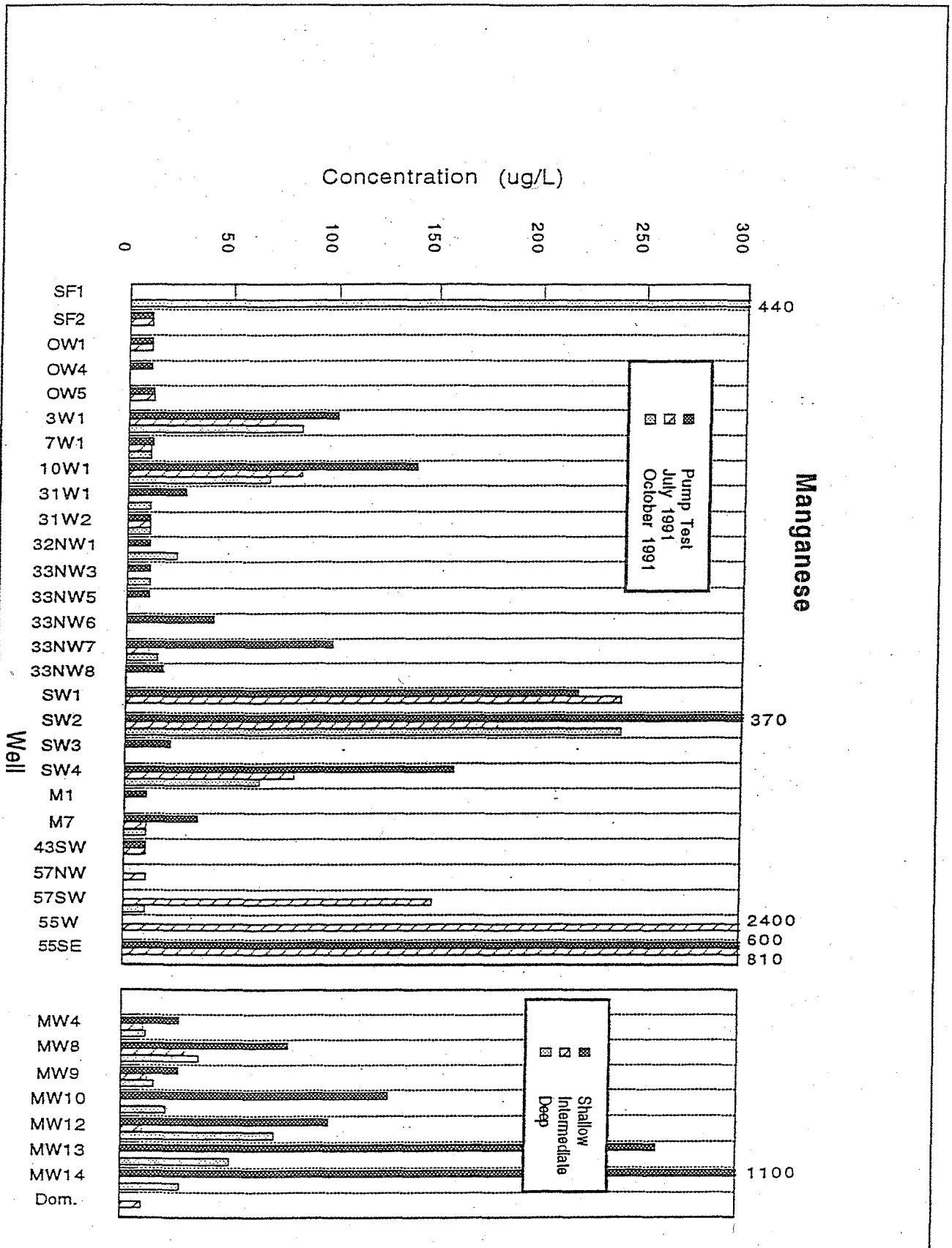
31W1
31W2
32NW1
33NW3
33NW5
33NW6
33NW7
33NW8
SW1
SW2
SW3
SW4
M1
M7
43SW
57NW
57SW
55W
55SE
Well
Pump Test
July 1991
October 1991
Iron
1300
1400
MW4
MW8
MW9
MW10
MW12
MW13
MW14
Dom.
Shallow
Intermediate
Deep
2100
1100
1700
3300
1100
1700
10000
1100


Concentration (ug/L)
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50
100
150
200
250
300
Well
SF1
SF2
OW1
OW4
OW5
3W1
7W1
10W1
31W1
31W2
32NW1
33NW3
33NW5
33NW6
33NW7
33NW8
SW1
SW2
SW3
SW4
M1
M7
43SW
57NW
57SW
55W
55SE
Pump Test
July 1991
October 1991
Manganese
440
370
2400
600
810
MW4
MW8
MW9
MW10
MW12
MW13
MW14
Dom.
Shallow
Intermediate
Deep
1100

Water Resource Association of Yolo County —
Groundwater Management Program Tasks

Water Resources Association of Yolo County

Groundwater Management Program Tasks

Activity	Description	Budget, $
Formulate and Implement a Groundwater Management Program	A groundwater management program is essential for dealing rationally with water transfers, the effective conjunctive use of existing and new surface water and groundwater supplies, and for administering a drought emergency action program. Sufficient information exists to formulate an interim program for guiding the management and utilization of available supplies to foster the understanding and the cooperation and participation of agencies and individual water users. The process of formulating an interim program will facilitate the preparation of specific monitoring and data gathering activities that will provide for refinement with time. Particular items that should be addressed in formulating a groundwater management program for Yolo County include the following: a. Establishing specific goals and objectives. b. Establishing a Supervisory Control and Data Acquisition System (SCADA) for monitoring and retrieving information from key monitoring stations. c. Establishing a comprehensive surface water/groundwater monitoring program. d. Establishing a comprehensive surface water/groundwater quality monitoring program. e. Reviewing the Yolo County Groundwater Investigation with respect to aquifer and basin characteristics. f. Developing a groundwater model for managing the water balance throughout the groundwater basin, and for formulating the groundwater recharge project proposed by the Yolo County Flood Control & Water Conservation District on Cache Creek, including the operational criteria and assessing impacts. g. Establishing the basis for effectively measuring groundwater extraction for agriculture. h. Establishing a comprehensive subsidence monitoring program. i. Establishing the mechanism for effecting an increase or reduction in groundwater extraction in particular areas consistent with established management or research goals and objectives. j. Delineating the subsidence hazard potential throughout the groundwater basin. k. Establishing a process for coordination of groundwater management activities with Solano, Colusa, and Sacramento counties.	500,000
Formulate and Implement a Drought Emergency Action Program	Irrespective of how accurately future water demands are forecast, and how well hydrologic studies are performed, chances are that drought conditions will occur that are more severe than any yet experienced in this century. In this regard, a program that provides for dealing with the allocation of water supplies under such conditions can prevent catastrophic occurrences. Particular items that should be addressed in formulating a drought emergency action program for Yolo County include the following: a. Establishing specific goals and objectives. b. Identifying specific and more general geographic locations where shortages or deficiencies occur, together with the conditions that "trigger" such shortages. c. Identifying the mechanisms for implementing the program in an equitable manner.	40,000

GROUNDWATER MANAGEMENT PLAN

Prepared for

Reclamation District 2035

Adopted April 25, 1995

TABLE OF CONTENTS

RECLAMATION DISTRICT 2035
GROUNDWATER MANAGEMENT PLAN

INTRODUCTION

AUTHORITY

Section 10753 of Division 6 of the California Water Code (Assembly Bill 3030) authorizes local agencies which provide water to a service area overlying a groundwater basin to adopt and implement a groundwater management plan for that basin. On June 2, 1993, Reclamation District 2035 (RD 2035 or District) held a public hearing on the issue of whether or not to adopt a resolution of intention to draft a groundwater management plan. After that hearing, the Board of Trustees authorized the preparation of a groundwater management plan under the authority granted by AB3030.

RECLAMATION DISTRICT 2035

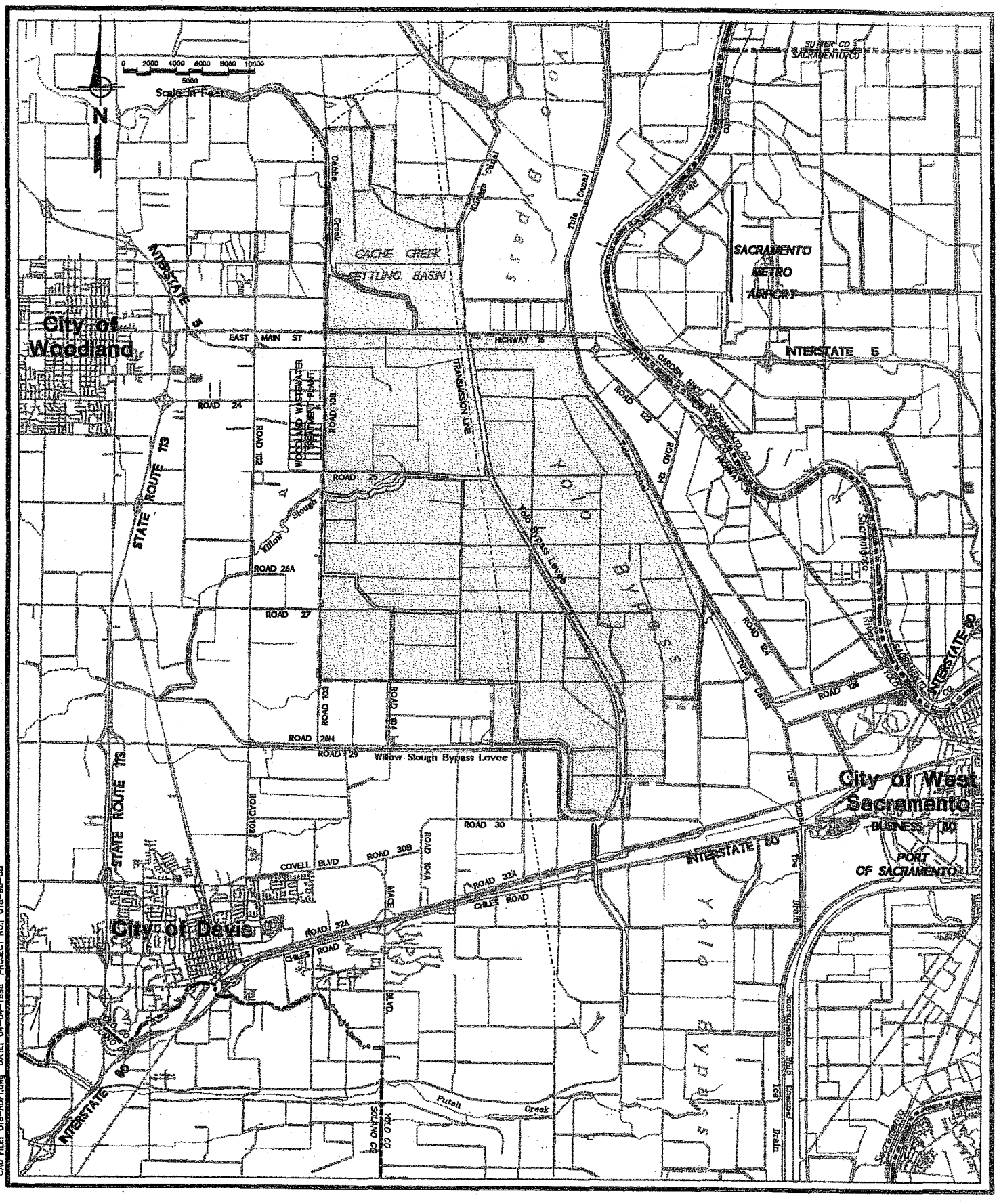
RD 2035 was formed in 1919 to provide flood protection, drainage, and irrigation water to Conaway Ranch and some adjoining lands in Eastern Yolo County. RD 2035 is governed by a board of three trustees elected by the landowners. The service area of RD 2035 is shown in Figure 1.

Reclamation District 2035 provides flood protection and/or water delivery services to 20,780 acres. For irrigation activities, water is diverted from the Sacramento River by a large pumping plant consisting of four 36-inch pumps located immediately upstream from the Vietnam Veterans Bridge on I-5. Additional surface water is also obtained from Cache Creek and Willow Slough. Irrigation is also supplemented by 24 wells operated by the District which pump water into the irrigation system.

In addition to the main pumps on the Sacramento River, the District also operates 10 pumping plants consisting of a total of 32 pumps which vary in size from 2.5 to 300 horsepower. These pumps are used as lift, booster, or drainage pumps. During the growing season the drainage pumps allow surface drainage from fields within RD 2035 to be captured and returned to the irrigation system for reuse. There are a number of pipes through the flood control levees as well as a large siphon under the Tule Canal and County Road 16 which are maintained and operated by the District for flood control and irrigation purposes.

DESCRIPTION OF GROUNDWATER BASIN

RD 2035 is part of the Sacramento Valley groundwater basin which extends from Red Bluff on the north down to the Delta. On a more local scale, the only major boundaries to groundwater flow are the Sacramento River and the Plainfield Ridge, which runs roughly north-south through the county approximately 4 miles west of Woodland. Effects of pumping



CAD FILE: 018-RDF1.dwg DATE: 04-04-1995 PROJECT NO.: 018-95-05

Figure 1

Legend:

RECLAMATION DISTRICT 2035

COUNTY BOUNDARY

WEST YOST & ASSOCIATES

Reclamation District 2035 Groundwater Management Plan

Location Map with Sevice Area Boundary

in Yolo County in deeper aquifers can extend across the Sacramento River. For the purposes of this groundwater management plan, the groundwater basin is defined as the aquifer system underlying the service area of RD 2035. The continuity of groundwater with lands adjacent to RD 2035 is addressed in this plan where appropriate.

The sediments penetrated by water wells in the region were deposited in the past 12 million years and derived from three principal source areas — shed westward into the valley from the Sierra Nevada, shed eastward into the valley from the Coast Range, and transported southward from more distant sources by the ancient Sacramento and Feather Rivers. Throughout this depositional history, ancient streams in the valley changed their channels many times, and the channel of the Sacramento River was considerably west of its present location much of the time. In the vicinity of RD 2035, the depth of the continental formations is about 2,600 feet, and the base of fresh water is about 2,400 feet below the present land surface.

The hydrogeologic deposits to the west of RD 2035 are classified as alluvial fan deposits. Alluvial fan deposits consist of mixed sediments deposited by streams from the Coast Range and hills to the west. Deposits in the middle and western portions of RD 2035 are classified as flood basin deposits. Flood basin deposits consist of fine-grained materials which were deposited in the areas adjacent to major streams during periods of high runoff. Alluvium deposits are found in the area extending from the eastern portion of RD 2035 to the Sacramento River. These include stream channel and flood plain deposits which are composed of sand, gravel, silt and minor amounts of clay. The central and eastern portions of the district have significant deposits of coarse materials layered between the finer flood basin deposits. Most of the surface soils in RD 2035 are clay or silty clay.

As a result of geologic processes which deposited the sediments in the District, the distribution of sandy and clayey zones is highly variable, and deposits are discontinuous and of variable thickness. Most of the deeper aquifer zones penetrated by wells in and around RD 2035 behave as confined or semi-confined aquifers. Some of the shallow aquifers in the southeastern and far eastern portions of the District behave in a more unconfined fashion.

Seasonally, groundwater levels tend to be the highest in early spring and lowest in early fall. The groundwater gradient in the region is generally flat with some tilting towards the Sacramento River in the winter and away from the river in the summer.

PURPOSE OF GROUNDWATER MANAGEMENT PLAN

The purpose of this groundwater management plan is to provide a framework for the protection and utilization of the aquifer system underlying RD 2035. The specific goals are as follows:

1. To define criteria for groundwater pumping and aquifer protection that is based on scientific analysis of monitoring results and provides the flexibility to use groundwater as needed for agricultural production, recreation, wetland restoration, wildlife management, industrial and residential use, and/or water transfers or exchanges.

2. To compile data based on work performed within the District service area which includes an existing groundwater and subsidence monitoring program and technical studies on groundwater resources.

3. To establish the monitoring, recharge and evaluation programs necessary to actively manage conjunctive uses of groundwater and surface water supplies within the RD 2035 service area.

4. To explore joint conjunctive use planning for Eastern Yolo County.

5. To establish standards which will help protect the aquifers underlying RD 2035 from water quality degradation.

6. To provide a document which can be used as a tool to provide public education about the groundwater basin underlying the service area of RD 2035, and the management of that basin.

GOALS FOR THE BASIN

PROTECTION AND ENHANCEMENT OF GROUNDWATER RECHARGE

The groundwater basin is well suited for storage and extraction of groundwater for irrigation and other uses. A primary goal is to encourage activities which will maximize the recharge of the basin for beneficial use.

CONJUNCTIVE USE

Conjunctive use is the joint use of surface water and groundwater resources to maximize the amount and timely availability of water for beneficial use. This means using surface water when it is available to satisfy water needs, inducing direct groundwater recharge through surface flooding, and performing in-lieu recharge by reducing pumping demands on groundwater by substituting surface water when it is available. Groundwater can then be managed to provide supplemental water when needed and to provide storage for excess surface water which can be retrieved at a later date. The groundwater basin underlying RD 2035 could be actively managed to provide the opportunity for conjunctive use and to utilize the available storage to the greatest practical extent.

SUBSIDENCE PREVENTION

Areas to the west and northwest of RD 2035 have shown evidence of subsidence due to groundwater pumping by other parties. Based on sensitive ground elevation measurements since 1991, no permanent subsidence has been measured in RD 2035 as a result of groundwater pumping by the District. Because of the importance of maintaining the proper elevations of the flood control levees in RD 2035, the prevention of permanent subsidence is a primary goal of this groundwater management plan.

PROTECTION OF GROUNDWATER QUALITY

Groundwater is a vital component of the water supply for agricultural irrigation in RD 2035 and may be utilized as a municipal water source in the future. Therefore, the protection of groundwater quality from degradation which would adversely affect its current and potential future uses is a goal of this groundwater management plan.

CONDITION OF THE BASIN

MONITORING NETWORK

Monitoring by RD 2035

Within the boundaries of RD 2035 there are 26 irrigation wells (24 operated by the District), 3 domestic wells, and 7 wells that are abandoned irrigation or domestic wells now used solely as monitoring wells. All the production wells have been used for groundwater level monitoring when they are accessible and not pumping.

Twelve additional monitoring wells were constructed within the District in 1991 specifically to monitor groundwater. These wells consist of 12-inch bore holes drilled to a depth of between 250 and 400 feet. The wells were completed into separate shallow and deep zones by inserting two casings within each well, a 5½-inch diameter casing to a bottom depth of between 150 and 400 feet, and a 2-inch casing to a bottom depth generally less that 150 feet. Screened sections were installed in both casings opposite sand and gravel layers. Gravel pack was placed in the annular space between the casings and the bore hole. A grout plug was installed between the bottom of the 2-inch casing and the first screened section in the 5½-inch casing. Production wells and monitoring wells are shown on Figure 2.

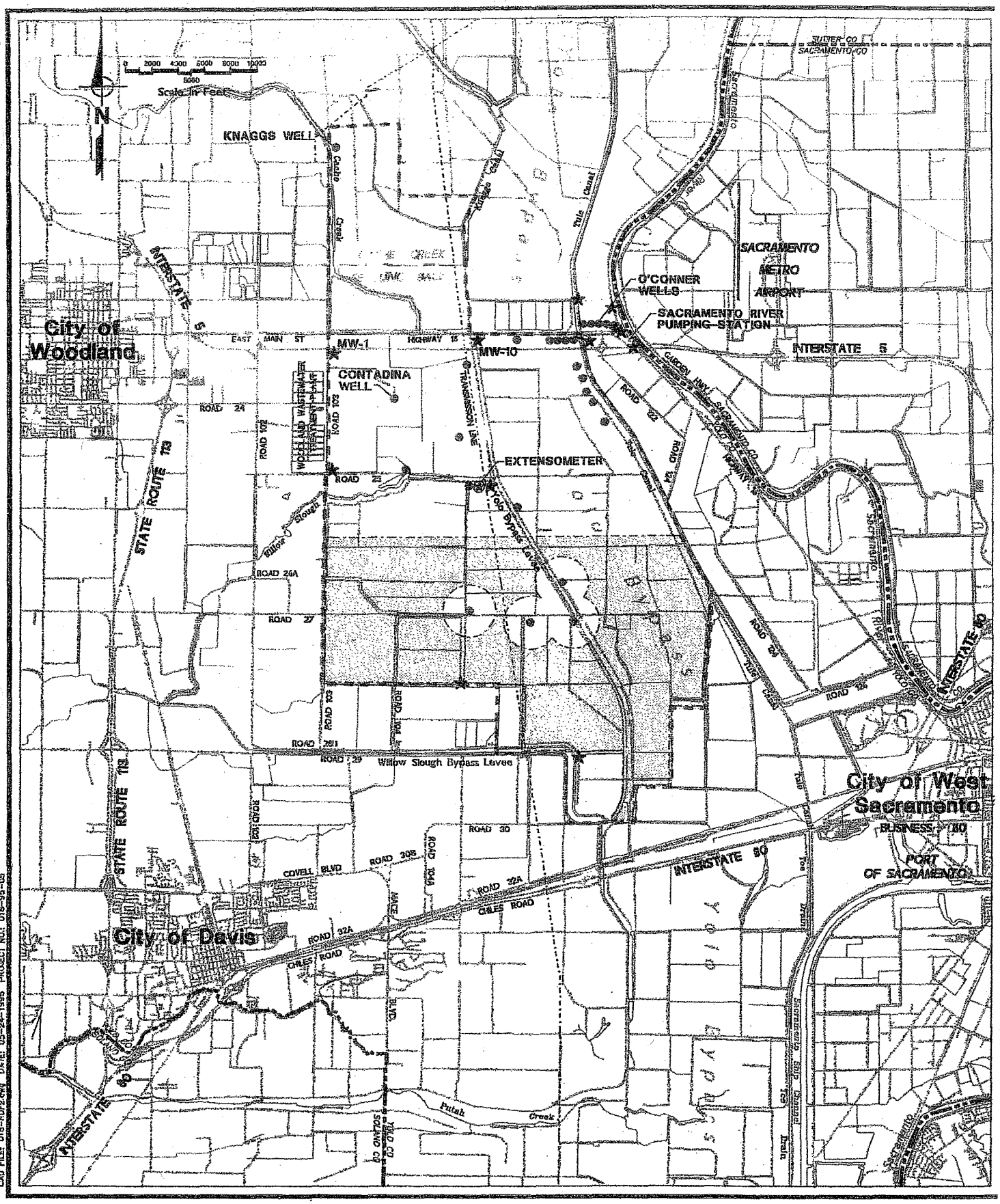
Two types of water level meters are used to monitor groundwater. Both are manufactured by Solinst Canada Ltd. Model 101 is a flat white tape level meter and reads to 1/100 of a foot. This probe is used on agricultural water wells and monitoring wells. Model 102 is a coaxial cable water lever meter marked in one foot increments and is used in applications where small diameter access holes won't allow the use of the larger flat white tape.

There are five subsidence survey monuments within the boundary of Reclamation District 2035. These monuments are 8-inch diameter by 10-feet deep reinforced concrete, or 3/4 inch diameter copper clad bars driven to a depth of 10 feet. All monuments are capped with a 4-inch diameter aluminum monument disc. These monuments were used in 1991 and 1992 to measure ground surface elevations using GPS satellite survey receivers.

Monitoring by Other Agencies

An extensometer was constructed in 1991 in a joint effort by the California Department of Water Resources (DWR) and RD 2035 to monitor compaction within the upper 716 feet of geologic formations at the site of monitoring well 7. The extensometer consists of a 2-inch diameter galvanized steel pipe cemented in the bottom of a 716 foot deep bore hole. A recorder at the surface measures any vertical movement of the top of the pipe with respect to the ground surface. The recorder is mounted within a steel building, on a steel reference table supported by two 4-inch steel posts cemented in 20 foot deep bore holes.

DWR also maintains a data base of historical groundwater levels for wells throughout Yolo County. This data base includes wells actively monitored by the Yolo County Flood Control



Legend:

- RECLAMATION DISTRICT 2035 BOUNDARY
- PREFERRED AREA FOR FUTURE GROUNDWATER EXPLORATION AND DEVELOPMENT
- GROUNDWATER SUPPLY WELL
- GROUNDWATER MONITORING WELL
- COUNTY BOUNDARY

Figure 2

WEST YOST & ASSOCIATES

Reclamation District 2035 Groundwater Management Plan

Existing Wells & Preferred Areas for Future Groundwater Development

and Water Conservation District (YCFCWCD), the U.S. Bureau of Reclamation (USBR), and DWR. The most recent summary report of this data[1] was produced in December, 1992.

There are two wells within the District's boundaries which are not operated by the District. One is north of the Cache Creek Settling Basin and is owned by Layton Knaggs Farms. Water levels in this well are monitored semi-annually by the Department of Water Resources. The other well is located on property owned by the City of Woodland and operated by Contadina. No monitoring records have been made available for this well.

ESTIMATED WATER AVAILABILITY

Groundwater Storage

There is a tremendous amount of groundwater storage beneath RD 2035, but only a portion is readily usable. The total amount of water in storage above 500 feet is estimated at 750,000 acre-feet (af) assuming a specific yield of 0.09[2] and an average water table depth of 25 feet. Usable storage is based on an assumed allowable drop in water levels and is much more difficult to quantify. Usable groundwater storage in RD 2035 under present economic conditions could exceed 100,000 af.

The amount of usable storage is a function of the underlying hydrogeology in terms of the amount of storage space available and the ability of the sediments to transmit water to wells. Because of this, coarse grained sediments provide most of the usable groundwater storage. There is a shallow aquifer system underlying much of the fine grained upper soils of the ranch to a depth of roughly 80 feet below ground surface. Below this, there are a number of deeper aquifers separated by fine grained aquitards down to a depth of at least 500 feet below ground surface. Assuming the shallow aquifer system averages 30 feet thick and has a specific yield of 0.1, it could store approximately 50,000 af. The shallow aquifer system is not currently tapped by most RD 2035 wells, so its storage could only be drained through seepage to deeper aquifers, unless wells constructed in the future are screened in the shallow aquifer.

Water Budget

Water Requirements. Irrigation water delivered by RD 2035 varies from year to year depending upon the crop mix and actual amount of land planted. The amount of water delivered during the period of 1981 through 1994 is estimated to have ranged from approximately 24,000 to 57,000 acre-feet per year (afa). Water use declined in the late 1980's because of more participation by growers in government set-aside programs. Water use in the 1990's has been affected by drought, participation in the State Emergency Drought Water Bank (Water Bank), and the increased acreage of rice in reaction to rising rice commodity values.

Surface Water Sources. RD 2035 diverts water from the Sacramento River under a contract with the US Bureau of Reclamation (USBR). The contract specifies a total allowable diversion of ~~50,862~~ af between April 1 and October 31, with a maximum total diversion of ~~13,452~~ af during the months of July through September. These entitlements can be reduced by the USBR by 25% in critically dry years, as determined by inflows to Shasta Reservoir. 13,442

Cache Creek is also a source of surface water for RD 2035. Diversions of water from Cache Creek are not metered, but estimated to have ranged from 0 to over 8,000 af per season, and averaged approximately 2,600 af during 1981 to 1994 based on RD 2035 water use calculations and Cache Creek flow measurements at the Yolo gage.

RD 2035 obtains an estimated average of 600 afa of surface water from rights originating on Willow Slough. Small amounts of drainage from the City of Woodland and from some adjacent farms to the west also enter the RD 2035 irrigation and drainage system.

Groundwater Pumping. RD 2035 has historically found it necessary to pump groundwater to meet irrigation needs during the July through September period to make up for restrictive surface water rights from the Sacramento River. Groundwater is also pumped to irrigate the 900 acre Contadina parcel and the Layton Knaggs Farms parcels which do not take water from the RD 2035 irrigation system. The total quantity of groundwater used by Contadina is not known, but it probably averages between 500 and 1,000 afa based on typical regional crop irrigation demands. The quantity of groundwater used by Layton Knaggs Farms is not known.

Pumping on lands surrounding RD 2035 may have an impact on water levels in RD 2035 wells. Most other land between the western boundary of RD 2035 and County Road 99 is irrigated with groundwater at an average rate of approximately 2.11 acre-feet per acre.[3] Lands to the north, south, and east of RD 2035 are irrigated by a combination of groundwater and surface water.

Groundwater Recharge. Spring groundwater levels within RD 2035 have stayed relatively high over the years. This is a good indication that recharge to the aquifer system underlying RD 2035 has been more than enough to offset groundwater pumping during the irrigation season. Recharge sources to the aquifer system underlying RD 2035 include:

- Irrigation Deep Percolation
- Rainfall Deep Percolation
- Rice Field Winter Flooding
- Cache Creek Settling Basin Flooding
- Yolo Bypass Flooding
- Sacramento River
- Other Lateral Inflow

Some information is available as to how much recharge is provided by these sources. For example, irrigation deep percolation and rainfall deep percolation are assumed to be equal to approximately 10% of applied water based on general recommendations for drainage design for clay loam soil.[4] Some information on the effects of winter season rice field flooding percolation has been developed through a test program within RD 2035 performed in fall of 1992 and winter of 1993.[5] Based on these and other general assumptions and future data collection, the amount of potential recharge to the aquifer system underlying RD 2035 will be developed. Potential recharge is substantially greater than the average historical groundwater pumping within RD 2035; however, the full recharge capacity of the basin will be determined through further investigation.

Perennial Yield. The perennial yield of the aquifer system underlying RD 2035 is a function of groundwater recharge within RD 2035 and lateral inflow or outflow. Because of the difficulty in estimating the maximum potential lateral inflow and recharge due to Yolo Bypass flooding, additional monitoring and evaluation would be necessary to determine the maximum perennial yield.

WATER QUALITY

A comprehensive study of groundwater quality in Yolo County was published by the USGS in 1985.[6] A total of 188 domestic and agricultural wells within Yolo County were sampled to determine concentrations of general mineral and inorganic constituents. The study found that groundwater in the area is generally suitable for agricultural and domestic uses. However, many of the Yolo County wells sampled had boron concentrations which exceeded tolerance levels for many crops. Many of the wells also had moderately elevated levels of total dissolved solids.

Wells in RD 2035 were also sampled in December, 1991 as part of the Eastern Yolo County Groundwater Investigation studies.[7] These were performed for Conaway and Cowell Ranches to fulfill their monitoring commitments during the State Emergency Drought Water Bank. The conclusions of the groundwater quality investigation were that many Yolo County wells had moderately elevated (>500 mg/L) levels of total dissolved solids, some had elevated boron levels (>2 mg/L) and others had elevated levels of iron and manganese.

The source of the boron in the region is thought to be originally from geothermal springs in the Coast Range which discharge into Cache Creek. Wells with high boron levels were generally found in the vicinity of the Tule Canal. The sediments in this area were probably deposited from Cache Creek as it fanned out and entered the tule marsh conditions which used to be present in much of the present RD 2035 service area.

Wells with elevated salinity are scattered throughout RD 2035, with wells along the Tule Canal near Highway 16 producing water with the highest levels of salinity. Wells nearest the Sacramento River produce water with the lowest salinity, but higher levels of manganese.

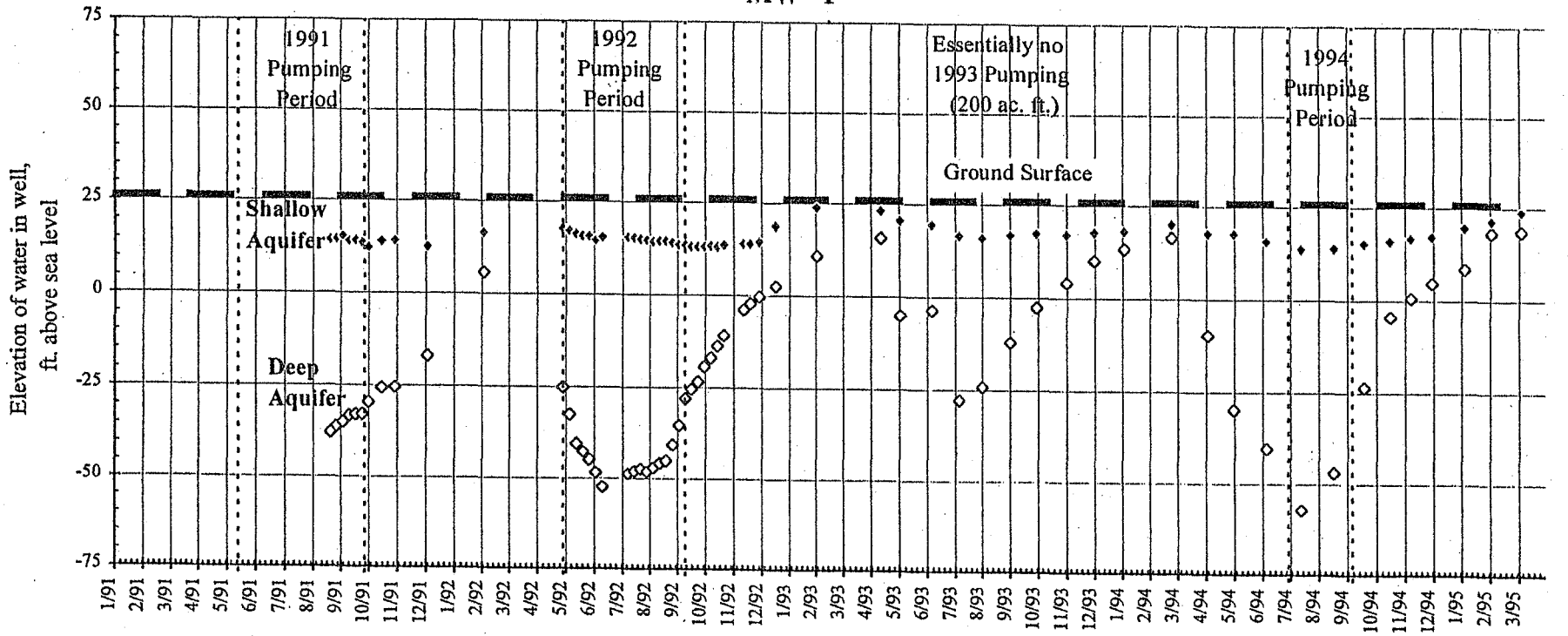
LAND USE

The productive lands within RD 2035 are being used extensively for agriculture. Some tracts of land in the District are also used for wastewater treatment ponds or other related facilities by the cities of Woodland and Davis. However, water is only supplied for agricultural irrigation at the present. The most common crops grown in the District are rice, corn, safflower, tomatoes, alfalfa, wheat, and sugar beets.

DATA EVALUATION

RD 2035 established a groundwater level monitoring program in 1991 which it has continued to carry out through the present. Data from the monitoring program has generally been evaluated every spring. Running hydrographs of the water levels in wells have been plotted to evaluate effects over time and among wells. An example of a hydrograph for monitoring well MW-1 at the western edge of the District is shown in Figure 3. The hydrographs are useful for evaluating

Figure 3
Water Level Hydrograph - Western Edge of District
MW - 1



the water level responses in shallow and deep aquifer systems to pumping by RD 2035 wells and wells on land surrounding RD 2035. For example, the 1993 and 1994 data show a high degree of influence from wells operated by others on lands outside the District. This is particularly evident for 1993 when only 200 af of groundwater was pumped by the District.

Spring water level trend graphs have also been plotted to evaluate long-term trends in groundwater levels. An example is shown in Figure 4. As can be seen, spring groundwater levels have remained relatively high over the last 10 years. This is an indication that the aquifer system is fully recharged every year. DWR also plots long-term trend graphs for water levels in wells throughout Yolo County which are measured in spring and fall.

In 1991, DWR and RD 2035 installed an extremely accurate extensometer for measuring ground surface subsidence near the east end of County Road 25 at the Yolo Bypass levee. Subsidence data at the extensometer have been plotted annually by DWR along with water levels in four different aquifer zones. Figure 5 shows the data through January, 1995 for ground surface elevation and water levels in two aquifer zones (second and third aquifers). Small groundwater elevation changes have been found to follow piezometric water level changes in the deeper aquifers closely. Only temporary, elastic ground surface changes have been evident in the measurements taken from late 1991 to the present.

Figure 4
Production and Monitoring Well Spring Water Levels, 1986 - 1995

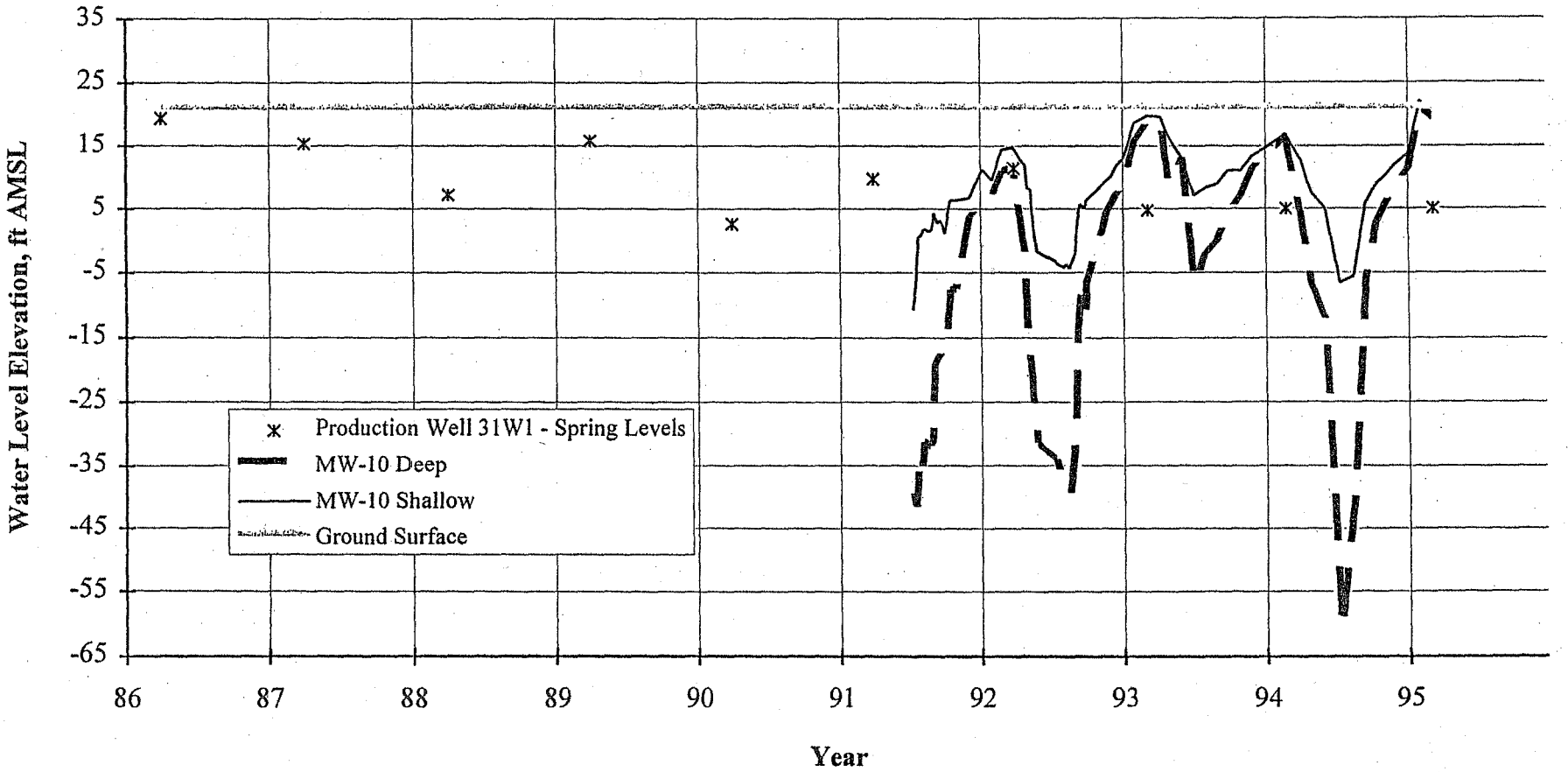
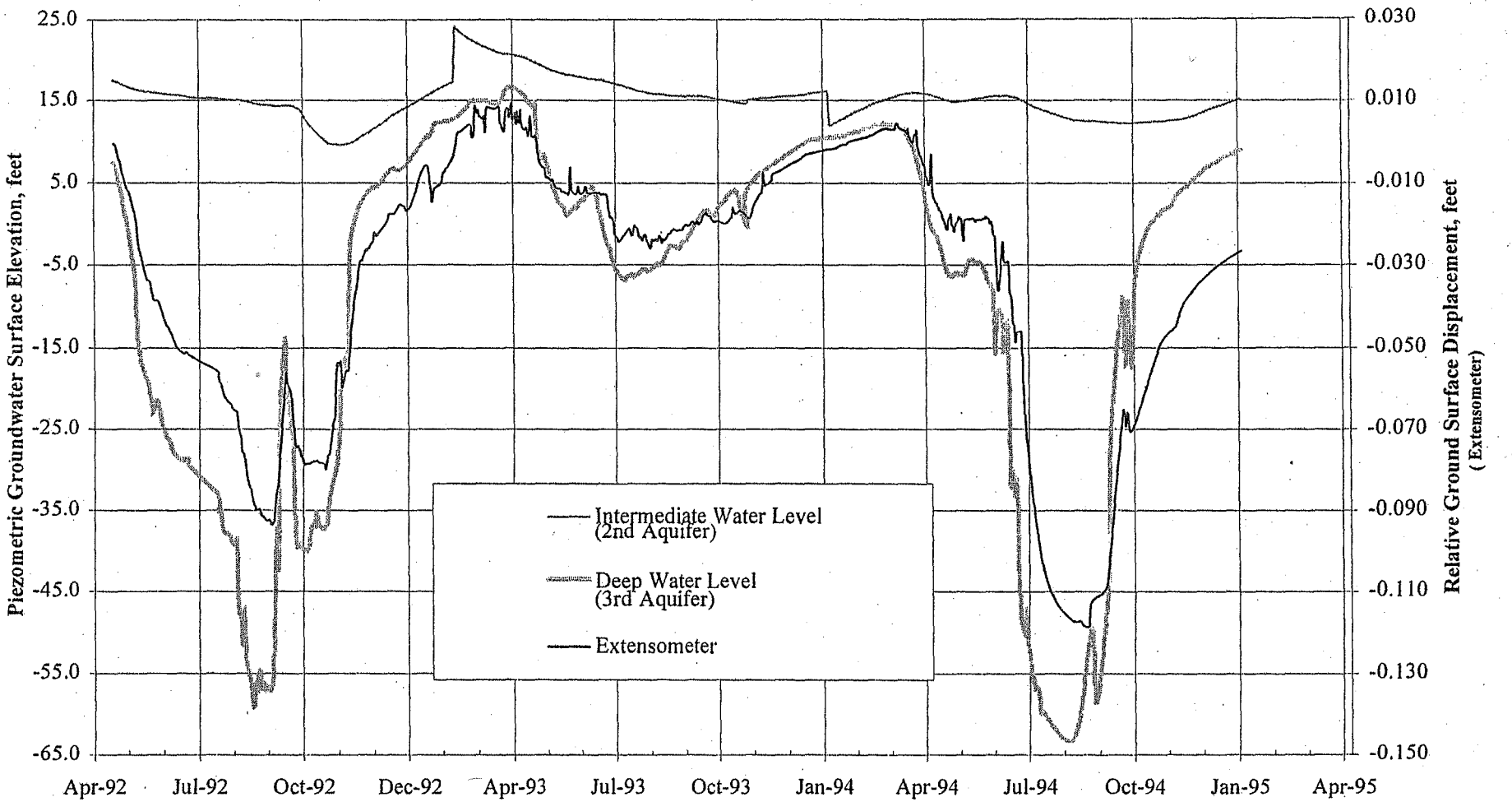


Figure 5
Water and Ground Surface Level Changes



FUTURE WATER DEMANDS

PROJECTED CHANGES IN WATER USE

Agricultural Use

Water use has fluctuated over time due to changes in cropping patterns. As world markets open up to crops grown in RD 2035, more land may be taken out of government set-aside programs and planted. This occurred for rice in 1993 and 1994. Although it is very difficult to predict, water demand for agricultural irrigation within RD 2035 will probably increase in the future.

Municipal Use

Conaway Ranch and the City of Woodland may develop the northeast portion of the District north of Willow Slough and south of the Cache Creek Settling Basin. Groundwater may be used to supply some of the water needs of development in this portion of the RD 2035 service area.

Conjunctive Use

Together with RD 2035, Conaway Ranch and other eastern Yolo County farmers, DWR has begun the evaluation of a potential conjunctive use project. This project would involve the storage of water in Eastern Yolo County groundwater during wet years and extraction of the stored groundwater during dry years. Groundwater would be recharged in large part by supplying farmers with surface water in lieu of their normal pumping of groundwater. Groundwater would be extracted primarily from wells in RD 2035, with some limited extraction on other ranches in Eastern Yolo County. RD 2035 is independently considering conjunctive use of surface water and groundwater resources within its own boundaries and possibly with some farmers on adjacent lands.

Pumping on Lands Near RD 2035

Many of the lands surrounding RD 2035 use groundwater as their major source of irrigation water. The average pumping rate for crops irrigated solely with groundwater was estimated at 2.11 afa by DWR.[3] This is about 2.5 times the average amount of pumping for crops within RD 2035. Average groundwater pumping on lands near RD 2035 will probably stay relatively constant in the future unless surface water is supplied to lands in a conjunctive use program to accomplish in-lieu groundwater recharge.

IMPACTS ON THE BASIN

DWR modeled groundwater reactions for several scenarios in the feasibility study for the Eastern Yolo County conjunctive use project.[3] The DWR model assumed pumping of approximately an extra 16,000 afa of groundwater from RD 2035 wells, and an extra 14,000 afa from wells on other ranches in Eastern Yolo County. Their model simulations indicate

that groundwater pumping for the conjunctive use project would have no significant adverse impacts on long-term groundwater level.

ELEMENTS OF THE GROUNDWATER MANAGEMENT PLAN

MONITORING OF GROUNDWATER LEVELS AND STORAGE

Monitoring

Section 10753.7 of Division 6 of the California Water Code lists monitoring of groundwater levels and storage as one of the possible elements of a groundwater management plan. Groundwater storage is typically calculated from groundwater level data and estimated aquifer properties. Ongoing monitoring of groundwater levels and storage will help RD 2035 evaluate trends and potential management options.

Since the end of the 1992 Water Bank, the monitoring program has consisted of monthly monitoring of all accessible wells in RD 2035, usually performed in the first week of each month. Groundwater pumping has also been measured for some of the wells using flowmeters with totalizers. As part of this groundwater management plan, RD 2035 will continue groundwater monitoring and data collection and recording procedures.

DWR has continued to monitor subsidence with the extensometer and water levels in MW-7 (adjacent to the extensometer). These measurements are recorded with automatic data loggers. RD 2035 will continue to provide access and logistical support to DWR for these measurements.

Water quality samples have not been taken since the end of the 1992 Water Bank. Henceforth, water quality sampling for TDS, nitrate, boron, iron and manganese will be performed for representative wells throughout RD 2035. The purpose of this monitoring will be to detect long-term groundwater quality trends.

Data Evaluation and Reporting

The data will be evaluated every spring, and an annual summary report will be prepared. This report will include water level hydrographs, subsidence graphs, a table of groundwater pumping and any other relevant monitoring data from the previous year. Data provided by DWR or YCFCWCD for wells from the area surrounding RD 2035 will also be included.

Evaluation of the data will include an estimate of groundwater in storage within the District, and discussion of any notable trends. Groundwater gradients in summer and spring will be plotted and discussed. Correlation of groundwater level changes in RD 2035 with groundwater levels and pumping outside of RD 2035 will also be evaluated. Correlation between groundwater pumping and subsidence will be evaluated, and any significant subsidence will be noted.

FACILITATING CONJUNCTIVE USE OPERATIONS

Conjunctive use can be described as the management of groundwater storage in a manner similar to the management of a surface water reservoir. Water is stored in the ground during

times of high surface water availability and withdrawn during times of low surface water availability.

The RD 2035 river diversion, conveyance system and wells could be operated to further facilitate conjunctive use. This may include planning and coordination of surface water resources, groundwater pumping, and enhancement of groundwater recharge.

Surface Water Resources

The use of Cache Creek water could be maximized when it is available, recognizing that Sacramento River water and groundwater are of greater cost and value. If conjunctive use is practiced for lands outside the RD 2035 service area, delivery of surface water to those lands should be maximized during the April through June period.

Development of Additional Groundwater Pumping Capacity

Additional wells may be necessary to provide pumping flexibility and peak month capacity for RD 2035. Geologically, the best area for new wells would be the southeast portion of the District. This area appears to have a low amount of confinement, potentially high well yields and good water quality. Unfortunately, this is also the lowest part of the water service area. Drainage return pumps would have to be used to get water from wells in this area back into the main irrigation system. Other areas south of Willow Slough are generally favorable for groundwater development, as long as new wells are not installed so close to existing wells as to cause excess interference. The preferred areas for new groundwater exploration and development were shown along with existing District facilities in Figure 2.

Winter Water Use

Sacramento River water has been diverted during the months of November through March under Conaway Ranch's riparian water rights to provide waterfowl habitat and decompose rice stubble. These activities incidentally enhance direct groundwater recharge. In recent years, approximately 4,000 to 6,000 acres of fields have been flooded for rice straw degradation and/or waterfowl. This amount will increase as rice stubble burning continues to be phased out and rice acreage is increased. The average acreage flooded could exceed 7,000 acres in the future.

Joint Conjunctive Use Operations with DWR

The proposed SWP Conjunctive Use project for Eastern Yolo County was based on the use of the diversion and conveyance facilities of RD 2035 to carry water to farms west and southwest of RD 2035. This would be accomplished by diverting extra State Water Project water from the Sacramento River when it is available and sending it back up Willow Slough. Farmers currently using groundwater for irrigation would pump water from Willow Slough instead, thereby leaving extra groundwater in place.

RD 2035 wells would also provide over half of the extraction capacity for the stored water. RD 2035 is ideally located to provide extraction of the stored groundwater since it is located in high

yield aquifers downhill (and generally downgradient) from where the in-lieu recharge would take place.

GROUNDWATER EXTRACTION CRITERIA

Groundwater pumping will be performed as is needed for crop irrigation to make up for any shortfall in normal surface water deliveries. However, since groundwater pumping should not cause permanent levee subsidence or permanent groundwater overdraft, the District will develop groundwater extraction criteria.

In 1992, groundwater pumping was voluntarily limited to that amount which would not cause a temporary seasonal ground surface decline of more than 0.2 feet. The 0.2 feet was assumed to be the maximum amount of elastic subsidence that could be experienced before permanent subsidence was initiated, based on monitoring at an extensometer in Zamora.

For purposes of this plan, the maximum allowable amount of temporary ground surface elevation decline would initially be defined as 0.2 feet within any single year. Spring ground surface elevations would continue to be compared year to year to determine if any significant amount (greater than 0.1 feet) of permanent subsidence has resulted. Based on future comparisons of spring ground surface elevations, the maximum allowable ground surface elevation decline during a season could be revised up or down in the future. If significant permanent subsidence has been caused during a pumping season, the lowest measured piezometric water levels and ground surface decline during that season should be noted. These lowest measured piezometric water levels and mid-season ground surface declines would then guide the determination of the allowable levels for any subsequent years. If significant permanent subsidence is measured at the extensometer, some additional subsidence measurements would also be warranted for areas in RD 2035 distant from the extensometer. Elevations at other points could be measured with a GPS survey system using the more advanced equipment and procedures that have been developed since the 1991 and 1992 surveys.

WELLHEAD AND AQUIFER PROTECTION

Contamination within areas which supply water to the wells in RD 2035 could create a threat to the quality of water from these wells. Setting up a wellhead protection plan consistent with the guidelines of Section 1428 of the Federal Clean Water Act would help maintain long-term assurance of water quality. One of the key elements of a wellhead protection plan is the delineation of wellhead protection areas. This requires an understanding of well construction, aquifer characteristics and groundwater pumping, and monitoring of groundwater quality.

One of the objectives of this groundwater management plan is to develop the necessary information to delineate wellhead protection areas and establish a wellhead protection program sometime in the future.

Wellhead Protection Plan Development

The U.S. Environmental Protection Agency has identified the following seven steps in a wellhead protection program:

1. Specify the roles and duties of State agencies, local governmental entities, and public water suppliers that will contribute to developing and implementing the wellhead protection program.

2. Delineate the wellhead protection area (WHPA) for each wellhead.

3. Identify potential sources of contaminants within each WHPA.

4. Develop management approaches to protect the water supply within WHPAs from contaminants.

5. Develop contingency plans for each public water supply system to respond to emergencies.

6. Site new wells properly to maximize yield and minimize potential contamination.

7. Ensure public participation.

Emphasis will initially be given to obtaining aquifer properties for the development of information which could be used in wellhead protection area delineation. This information will be derived from the evaluation of existing test data, the yearly monitoring data and future aquifer pumping tests.

Water quality trends will be evaluated as was specified in the monitoring section of this groundwater management plan. Adverse trends in water quality will be cause to accelerate the development of a wellhead protection plan and to begin sampling for additional constituents of potential concern.

New wells should be constructed to state guidelines and county standards, with seal depths as discussed in the next section.

WELL CONSTRUCTION AND ABANDONMENT POLICIES

Without proper planning and seal design, deep wells can inadvertently act as conduits to allow lower quality water from shallow aquifers to migrate to the deep aquifers. In conjunction with other agencies, RD 2035 will develop well construction guidelines to minimize the potential for the deterioration of water quality in deeper aquifers.

Well Construction/Abandonment Standards

New wells should be designed in accordance with state guidelines and county standards. The seal depths should extend to at least 50 feet. If it is desirable to tap the shallow aquifer (and the shallow aquifer quality is acceptable), a 50 foot seal depth would be appropriate. If there is not a good reason to tap the shallow aquifer, the seal should extend to at least 10 feet below the bottom of the shallow aquifer, or 100 feet below the ground surface, whichever is lesser. New wells may also need 100 foot seals if reclaimed water is delivered to the District from the Cities of Davis or Woodland.

Wells should also be abandoned according to state and county standards. This includes filling the wells with grout throughout their depth.

DEVELOPMENT OF RELATIONSHIPS WITH STATE, FEDERAL, AND OTHER AGENCIES

Federal Agencies

RD 2035 diverts water from the Sacramento River under a water rights settlement contract held by Conaway Ranch with the USBR. RD 2035 has worked with the USBR to develop estimates of the influence of wells on seepage from the Sacramento River. RD 2035 intends to continue to work with USBR to help resolve issues relating to water transfers, conjunctive use programs, and other issues related to diversions from the Sacramento River.

State Agencies

Through its participation in the 1991 and 1992 Water Banks and in a number of joint studies related to water resources in eastern Yolo County, RD 2035 has developed a cooperative working relationship with DWR. It is the intent of RD 2035 to continue working with DWR on the development of a joint Eastern Yolo County conjunctive use program. It is also the intent of RD 2035 to continue the sharing of monitoring data with DWR so that DWR can continue to develop and calibrate its groundwater model for Eastern Yolo County.

Other Agencies

The Water Resources Association of Yolo County was formed in 1993 to coordinate the collection and evaluation of information on surface and groundwater resources in Yolo County. The members of the Association are the Cities of Davis, Winters, Woodland and West Sacramento; Yolo County Board of Supervisors; Yolo County Flood Control and Water Conservation District; Dunnigan Water District; and U.C. Davis. The Water Resources Association is currently implementing a Water Resources Management Program as was outlined in a 1992 report by Borcalli and Associates.[8] This program includes gathering the information necessary to prepare a future potential joint groundwater management plan for all the areas served by the member agencies. The District is interested in coordinating groundwater management planning with the Water Resources Association of Yolo County.

IMPLEMENTATION

Implementation of this RD 2035 groundwater management plan will begin in June, 1995. Monitoring will continue as specified until the plan is modified. Additional monitoring may be performed from time to time as is necessary for other purposes.

RD 2035 will continue to coordinate the subsidence monitoring and conjunctive use planning with DWR. The District will also maintain communication with the Water Resources Association of Yolo County and its member agencies which adjoin RD 2035. This will allow an open dialog on groundwater management throughout Eastern Yolo County.

In accordance with California law, RD 2035 may adopt rules and regulations for the implementation and enforcement of this groundwater management plan and, where necessary, may modify the plan to assimilate additional information and to accommodate changing conditions. In adopting rules and regulations, RD 2035 will minimize, as required by California law, the impact of the rules and regulations on business and agricultural activities, consistent with the protection of the groundwater resources subject to the groundwater management plan. The District intends to protect and enhance the groundwater resources available to it consistent with the goals and objectives set forth in this plan. The elements of this groundwater management plan, including monitoring (groundwater use, groundwater levels, and ground surface elevation changes at the extensometer), the development of guidelines for well construction and abandonment, and the investigation of potential conjunctive use operations, will be implemented in an orderly and sequential process through the annual budgetary planning of the District.

ENDNOTES

1. Senter, E. and M. Collins under the direction of T. Dudley and H. Mann, *Historical Ground Water Levels in Yolo County*. California Department of Water Resources, Central District, December, 1992.

2. Lorens, P.J., under the direction of W. Gentry, *Evaluation of Ground Water Resources: Sacramento Valley*. California Department of Water Resources Bulletin 118-6, August, 1978.

3. J. Fielden, et. al., *SWP Conjunctive Use — Eastern Yolo County*. California Department of Water Resources, February, 1994.

4. *Design, Construction and Maintenance of Subsurface Drains in Arid and Semiarid Areas*. Engineering Practice EP463, American Society of Agricultural Engineers, St. Joseph, Michigan, 1988.

5. *Groundwater Recharge Program, Fall 1992 through Winter 1993*. Prepared by West Yost & Associates for Reclamation District 2035, April, 1993.

6. U.S.G.S., *Chemical Quality of Ground Water in Yolo and Solano Counties, California*. 1985.

7. *Eastern Yolo County Groundwater Investigation Summary Report*, West Yost & Associates, January, 1992.

8. *Yolo County Water Plan Update*, Borcalli and Associates, December, 1992.