Eastside Water District
Groundwater and Multiple Resource Integration Planning Study

Prepared for:
Eastside Water District

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Abbreviations

A	area
AFY	acre-feet per year
A1	adjusted acreage
Cu	consumptive use
CWD	crop water demand
DWR	California Department of Water Resources
E	irrigation efficiency
EP	effective precipitation
ESA	endangered species act
ETc	evapotranspiration
EWD	Eastside Water District
K	hydraulic conductivity
ITRC	Irrigation Training and Research Center
MAFA	million acre-feet annually
MGD	million gallons per day
NIR	net irrigation requirement
NPDES	national pollution discharge elimination system
P	precipitation
TDS	total dissolved solids
TID	Turlock Irrigation District
USGS	United States Geological Service
W	water use

Terminology and Definitions

Acre-foot	The quantity of water contained in one acre filled one foot deep, 43560 cubic feet, or 326,000 gallons.
Aquifer	A water bearing underground formation containing liquid water.
Basin	A drainage area or catchment.
Confined aquifer	An aquifer that is restricted in its upward movement by a layer of soil or rock that does not allow the movement of water through it..
Conjunctive management	Planning, management of storage and use of groundwater in coordination with surface water.
Consumptive use	Use of water that removes that water from further use of downstream use. For crops Cu refers to the quantity of water required to grow a crop.
Corcoran clay	A clay formation found throughout most of the Central Valley a few hundred feet beneath the ground surface. The clay acts as a confining layer creating a confined aquifer beneath it.
Evaporation	The change of state of water from liquid to vapor .
Evapotranspiration	The combination of transpiration, being the movement of water from plants into the atmosphere with evaporation.
Fully appropriated stream	A stream that has been designated by the State Water Resources Board as having all the available water from the stream utilized to the degree that any other withdrawals of water from the stream would require other users to give up water or require the environmental needs of the stream to be inadequately met by the remaining water.
Groundwater	Liquid water found within the voids of soil.
Hydrogeology	The study of the water resources and geology of an area and their relationships.
Industrial water use	Use of water by industry such as for manufacturing, and cooling.
In-lieu groundwater recharge	A method of recharging groundwater by foregoing removal of groundwater. i.e. using surface water instead of pumping water from wells, or not irrigating.
Intrusion	The penetration of water (usually groundwater) into another body of water. A significant concern when an inferior quality water penetrates into an aquifer of better quality.
Municipal water use	Use of water for meeting human needs and landscape needs. Typically within a city or municipality.

Overdraft	The condition of withdrawing more groundwater from a system than will return to the system on a continued or long term basis.
Point of diversion	The location where surface water is removed from its source.
Precipitation	Rainfall, snow, sleet, hail, or ay other form of moisture that falls from the sky.
Percolate	The movement of groundwater through the pores of the soil matrix.
Recharge	The introduction of water into a groundwater system.
Reclamation	The act of capturing excess applied water for reuse.
Safe yield	The quantity of water that can be safely withdrawn from an aquifer on a long term basis without depleting the quantity of water in the aquifer.
Saline aquifer	An aquifer that has water with elevated salt levels.
Surface water	Water that is standing or flowing upon the surface.
Tail water	Water that is drained from a field during irrigation or after it has been irrigated.
Transpiration	The movement of water from plants to the atmosphere.

Chapter 1

Introduction

Background

The Eastside Water District (EWD) is located on the eastern side of the San Joaquin Valley in California. The District is approximately 54,000 acres of agricultural farmland within Stanislaus and Merced Counties and within the Turlock Groundwater Basin. The District does not have surface water rights or contract water. Their sole source of supply is groundwater with the exception of purchasing some water from Turlock and Merced Irrigation Districts on an as-available basis.

EWD farmers produce high value, non-subsidized crops that are irrigated by highly efficient methods. Crops such as grapes, almonds, walnuts, and peaches predominate. This farming community contributes an estimated $300 million annually to the State’s agricultural economy.

The groundwater water level within the basin has fallen over the last thirty years. At the most depressed location the groundwater has fallen more than ninety feet. This depletion of groundwater is the concern of the farmers and others who depend on groundwater. The Eastside Water District was formed to unite water users in the search to solutions to the problems of the declining groundwater level.

History

The advent of sprinkler irrigation in the 1950’s made irrigation practical in the rolling hills of the area that is now Eastside Water District. In the 50’s and 60’s landowners invested in wells and sprinkler irrigation equipment to begin producing high value irrigated crops. As more lands were developed and more wells were drilled into the Turlock Groundwater Basin aquifer, groundwater levels began to drop. By the mid 1970’s concern began to grow about the declining water table. The concern was that if the water levels continued to drop, a day would come when the wells would either go dry or water levels would drop to the point that it would not be economically feasible to pump groundwater for irrigation. After much discussion, in 1985 the decision was made to form the Eastside Water District so that irrigators could unite in a search for solutions to the declining groundwater levels.

The groundwater within EWD apparently is declining at about two feet per year, which is creating an average annual deficit of about 80,000 acre-feet. The new district began its search for solutions.

The District retained the services of Boyle Engineering to prepare an Irrigation Water Master Plan. The plan, which was completed in 1990, examined options for reducing the decline and recommended that wells be drilled and that water be injected directly onto the aquifer. After further study and with the advent of new regulations it was determined that approach was not economically feasible. The search continued.

Statewide concern was developing regarding the status of groundwater in California, resulting in the California legislature enactment of the 1992 Groundwater Management Act (AB3030). AB3030 authorized agencies to prepare and adopt groundwater management plans to better manage groundwater resources within their jurisdictions. Subsequently, EWD joined the other agencies using groundwater from the Turlock Groundwater Basin in preparing a groundwater management plan covering the entire Basin. EWD adopted that plan in 1997 as an addendum to its 1994 plan.

In 1995 an incentive program to encourage irrigators to use available wet year water from the Turlock and Merced Irrigation Districts was developed and funded. Irrigators who signed up for the program were reimbursed $3.00 per acre-foot for actual water used. The program has been a success and has been extended on a year-by-year basis depending availability of water. Irrigators are advised of the availability of the program each year as the Irrigation Districts declare water available.

In 1996 EWD began investigation of the potential of recharging the aquifer using constructed recharge basins. After boring test holes at various locations in the EWD, a site adjacent to the TID Highline Canal, just South of Monte Vista Avenue was selected for construction of the Monte Vista Pilot Recharge Basin. Operation of the basin in 1998, 1999, and 2000 proved to be very successful. Consultants advised the Board that the average recharge rate of 2.7 acre-feet per acre per day, achieved in 2000, is a very good rate. It is anticipated that recharge rates in basins larger than the one-quarter acre pilot recharge basin may be somewhat reduced. Further investigations are needed to determine the economic feasibility of recharge and to identify an adequate supply of water for recharge.

EWD made several unsuccessful applications for study grants from the State. In 2001 the District retained Psomas to prepare a grant application for a grant. The grant application was successful. The District received a grant from the California State Department of Water Resources for preparing a study of solutions to remedy groundwater concerns within EWD and the Turlock Groundwater Basin. This report is the product of that study.

Purpose and Objectives

The EWD's purpose is to assure a reliable, long-term supply of water for the District. The EWD Board of Directors' objective to meet that purpose is to bring the supply and demand into balance and cease long-term over drafting of the groundwater resource. This study and report were performed and prepared to help achieve those objectives.

The study method used to prepare this report followed a plan to: review and analyze existing information; identify and define all plausible alternatives that had the potential to meet EWD's objectives; analyze the alternatives for their, benefits, detriments, costs, and implementability; identify the alternatives considered reasonable and rank them; and, recommend a course of action for implementation of the best alternative or alternatives. All of this was done with the intent of keeping stakeholders informed and incorporating input from stakeholders through the public outreach effort.

Additional objectives included: protecting water quality; integrating multiple resources into the solutions where possible and beneficial; and, providing environmental benefit where possible.

Alternatives initially identified as having potential to meet EWD's objectives included: groundwater recharge, groundwater storage, conjunctive management of groundwater, use of surplus water in-lieu of groundwater, irrigation efficiency improvements, cropping pattern changes, soil conservation practices and best management practices; and, use of reclaimed water.

Secondary benefits from project alternatives were considered in the crafting of the alternatives, the analysis of them and in the preparation of the recommendations. Those secondary benefits included: possible physical and biological habitat enhancement opportunities; flood control; and, soil conservation and stabilization improvements.

Public Outreach

EWD has an ongoing public outreach effort. During the performance of this study the public outreach program has published a newsletter and maintained a District Website at http://ewd.jbmj.com. Stakeholder input was sought at public workshops.

The district consulting staff has continued to work with members of the Turlock Groundwater Basin Association through their monthly meetings. Efforts of the two groups have and continue being coordinated to the extent possible. A summary of public outreach correspondence and public comments are included in Appendix D.

Setting

The Turlock Groundwater Basin is bounded on the North by the Tuolumne River, on the South by the Merced River, and on the West by the San Joaquin River as shown in Figure 1.1. For purposes of this study the groundwater basin was defined as having an eastern boundary at approximately the 500-foot elevation contour within the foothills. The Eastside Water District (EWD) is completely contained within this basin.

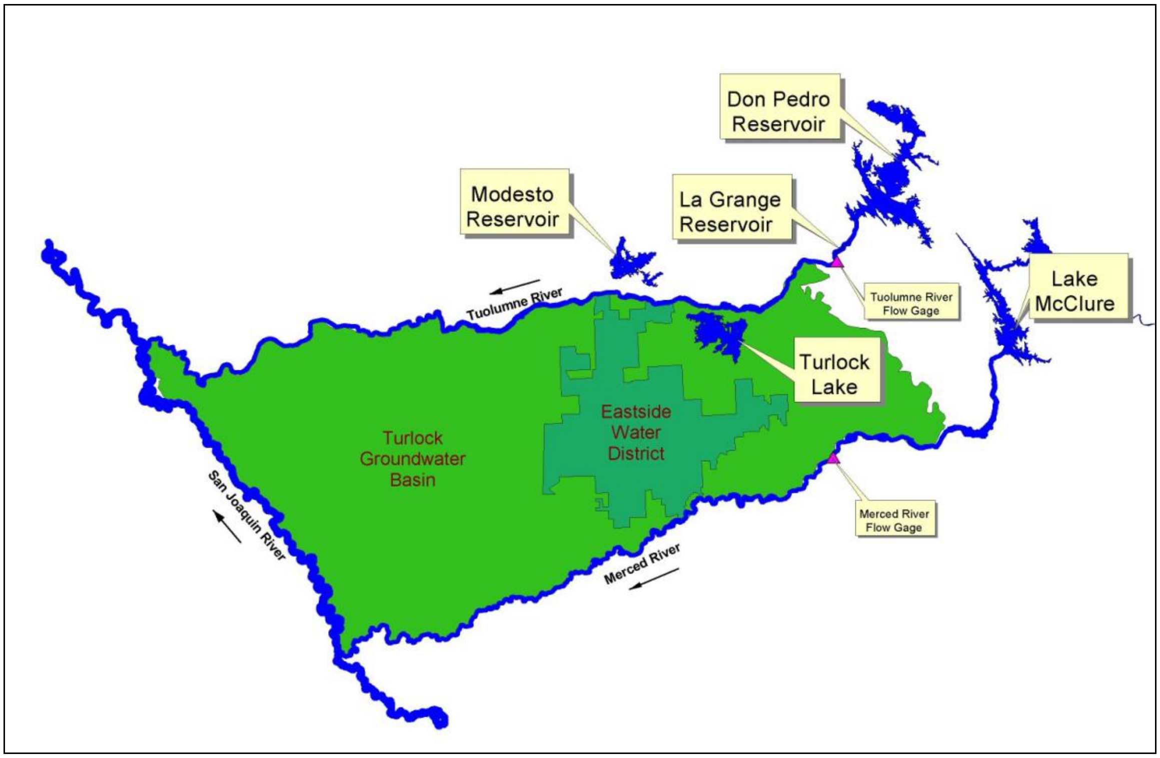

Figure 1.1 Major Hydrologic Features in and Around the Turlock Groundwater Basin

Water in the Basin originates from two major sources: the Tuolumne River and the Merced River. Other secondary sources include Dry Creek and direct precipitation.

The Tuolumne River is controlled by releases from Don Pedro Reservoir. After leaving Don Pedro Reservoir, flows are impounded in La Grange Reservoir. La Grange Reservoir is the point of diversion for each of the main canals of the Modesto Irrigation District and the Turlock Irrigation District.

The Merced River is controlled by releases from Lake McClure. Merced Irrigation District diverts water from the Merced River below Lake McClure. Merced Irrigation District has a main canal on the south side of the river and a canal (the Northside Canal) on the north side of the river

Chapter 2

Data Review and Summary

A review of existing information and data was conducted during the course of the study. From that review a bibliography was compiled. The bibliography summarizes the contents of the reports and lists the known reports that contain helpful information about this project.

A few pertinent reports were selected and reviewed in more detail. An extended summary of the following reports is below:

- Turlock Groundwater Basin Groundwater Management Plan (September 1997)
- Eastside Water District Groundwater Management Plan (September 1994)
- Eastside Water District Irrigation Water Master Plan (November 1990)
- San Joaquin River Group Agreement (1999)

The bibliography is found in this section following the extended summaries.

Turlock Groundwater Basin Groundwater Management Plan (September 1997)

This report was prepared by the Turlock Groundwater Basin Association (TGBA) for the purpose of developing a basin-wide groundwater management plan. The TGBA was created by the agencies that adopted a Memorandum of Understanding in hopes of preparing a groundwater management plan to guide the management of groundwater resources within the Turlock Groundwater Basin. The agencies included: Turlock Irrigation District, Merced Irrigation District, Delhi County Water District, City of Hughson, City of Turlock, Denair Community Services District, Eastside Water District (EWD), County of Merced, City of Ceres, Hilmar County Water District, City of Modesto, and Ballico-Cortex Water District. As agencies adopt groundwater management plans, the Turlock Groundwater Basin Groundwater Management Plan will continue to apply to those areas lying outside the agencies boundaries.

The groundwater management plan documents the following elements:

- Geological formation of the aquifer (describes the location of the freshwater confined and saline confined aquifers)
- Water supply within the basin (describes the water supplies available within the basin such as precipitation, surface water, groundwater, and reclamation)
- Water demand/usage within the basin (describes historical and projected demands for agricultural and municipals uses (Table 1 and Table 2); describes the irrigation practices and water conservation methods within the basin)
- Water balance/safe yield of the basin (describes the average water supply and demand trends within the basin; the resulting

overdraft is between 70,000 and 85,000 acre-feet per year and occurs mainly in the eastern area of the basin)

- Groundwater levels in the basin (describes the reduction in groundwater levels based on continuous monitoring of wells within the basin; discusses the groundwater levels in the east and west side of the basin and the influence of the Tuolumne and Merced Rivers on the basin.)
- Water quality of the groundwater (describes the constituents that currently or have the potential to impact the groundwater basin)

The groundwater management plan contains twelve components that are discussed in detail. The component includes action items for implementation into a plan. The components are:

- Control of saline water intrusion (salinity is a concern in the western portion of the basin, knowledge of the water quality zones and flow patterns is recommended)
- Identification and management of wellhead protection and recharge areas (control land use to minimize the possibility of groundwater contamination and review waste discharge permits)
- Regulating contaminant migration in the groundwater (support the RWQCB and understand the hydrogeology of the basin)
- Administration of well abandonment and well destruction program (develop a program to minimize contamination between aquifer layers)
- Mitigation of groundwater overdraft (identify recharge methods such as conjunctive use)
- Replenishment of groundwater extracted by producers (encourage recharge via irrigation)
- Monitoring and controlling groundwater levels quality and storage (identify areas of overdraft)
- Facilitating conjunctive use operations (develop a regional plan utilizing surface water to recharge the basin in wet seasons and using groundwater in dry seasons)
- Well construction (enforce well construction standards)
- Construction and operation of recharge, storage, conservation, water recycling, and extraction projects. (identify projects to improve water utilization within the basin)
- Development of relationships with local state and federal agencies (coordinate the management of activities and obtain mutual assistance)
- Review of land use plans and coordination with land use planning agencies (minimize groundwater threats by regulating land use)

The groundwater management plan also contains various figures and tables. The more important figures include: Figure 1 – Water Districts within the Basin, Figure 2 – Section through groundwater basin, Figure 5-9 – Groundwater elevations, and Figure 10-inflow and outflow to groundwater basin.

Eastside Water District Irrigation Water Master Plan (November 1990)

This report includes a review of soil types, cropping patterns and the existing state of the groundwater basin. The plan also analyzes and estimates overdraft quantities and identifies potential surface water sources for further investigation.

The Eastside Water District is within the Turlock Groundwater Basin and comprises of 54,000 acres in Merced and Stanislaus Counties. The District utilizes groundwater for irrigation and has no municipal customers. Historically the area was not farmland, however, overtime the area has developed into a productive agricultural region with a variety of crops. Land use includes orchards, row crops, irrigated pasture, and native pasture. Predominant crops of the area include almonds, apricots, peaches, nectarines, walnuts, vineyards, alfalfa, corn, dry beans, and grain.

Surveys were prepared to obtain information from farmers on sources of water supply, pumping rates, land use and crop pattern, methods of irrigation, and cropping history. The information gathered from the surveys was used to validate the land use and water balance calculations.

The District's irrigation water demand was estimated using land use, crop type, and irrigation unit water use. Land use was tabulated (Table 4) per Department of Water Resources surveys of the area. Permanent crops make up 52% of the total land area, 28% of the area is used for annual crops and pasture, and 14% has remained native vegetation. This irrigation plan summarizes the results of the USDA Soil Conservation Service surveys for Merced and Stanislaus Counties. The plan discusses general soil characteristics and recommends an economic irrigation land classification study and irrigation suitability land classification analysis to determine economic feasibility and suitability of lands for particular crops.

A large portion of this plan is dedicated to the requirements of agricultural crops. The plan discusses the calculations for consumptive use of crops grown in EWD, effective precipitation, and net irrigation requirement. The irrigation methods used in EWD were then assigned an efficiency number (Table 7A). The crops were then assigned the same efficiency number as their irrigation method (Table 7B). Lastly, the irrigation water application requirement is calculated. In addition to crop consumptive use and cropping pattern, climatic data is used to evaluate the flow requirement for crops in EWD. The climatic data is used to calculate the unit peak water requirement that determines the greatest amount of water needed for a given crop over a specific amount of time.

The agricultural water demand was used in determining the hydrologic balance in the District's boundaries. The water balance again yielded an average overdraft condition of 77,000 – 80,000 acre-feet per year. This plan evaluates the potential for water supplies from local irrigation districts such as Turlock, Modesto, and Merced. The Tuolumne River and Stanislaus River were evaluated for a possible source of water supply. The plan describes the New Melones Project and the agencies that benefit from the project such as Stockton East Water District, Central San Joaquin Water Conservation District, South Delta Water Agency, Stanislaus River Fishery Study, Oakdale and South San Joaquin Irrigation Districts, and Bay Delta Estuary Hearings. The Stanislaus River has approximately 45,000 acre-feet per year of surplus water during wet years that could possibly be used by the District, however the conveyance alternatives to EWD are complex and expensive. Other sources of water are Montgomery Reservoir site, Dickenson Lake, Dry Creek, and Little John's Creek Reservoir.

This plan also evaluates the potential for a conjunctive use program. The program assumes water is available from the New Melones Reservoir or Don Pedro Reservoir and the District may utilize the drainage canals owned by Turlock Irrigation District. The following alternatives were evaluated:

Alternative 1 – 45,000 acre-feet/year surface water available (76 injection wells required at $19.6 million)
Alternative 2 – 80,000 acre-feet/year surface water available (134 injection wells required at $31.16 million)

The irrigation plan also discusses possible programs and grants that may be available for EWD to offset the costs of implementing a conjunctive use program. The plan also lists the tasks that need to be completed to obtain USBR financing.

Eastside Water District Groundwater Management Plan (September 1994)

The Eastside Water District Groundwater Management Plan is formulated after the Turlock Groundwater Management Plan and the Irrigation Water Master Plan. The twelve components discussed in the TSMP are included in this plan. The groundwater hydrologic characteristics are explained similar to the TSMP with perhaps additional detail in the EWD area. The groundwater elevations are mapped over time and also included in this plan.

The Eastside Water District is within the Turlock Groundwater Basin and comprises of 54,000 acres in Merced and Stanislaus Counties. The District utilizes groundwater for irrigation and has no municipal customers. During wet years, the Turlock Irrigation District provides water to farmers located near the Turlock Main and Highline Canals. The District offers a subsidy to encourage farmers to use Turlock Irrigation District surface water in lieu of their groundwater wells.

Water quality appears to be acceptable in the EWD area (eastern portion of the basin)

This plan summarizes the water balance by quantifying the amount of water recharging the basin and the amount of groundwater pumped out of the aquifer for EWD and Turlock Irrigation District. According to recent data, the groundwater levels beneath EWD are declining 2 feet per year, which is equivalent to approximately 80,000 acre-feet per year. The District adopted this groundwater management plan in an attempt to address the groundwater overdraft condition. Chapter 7 recommends 19 long-term tasks to implement the groundwater management plan and ultimately reduce the overdraft condition.

This plan discusses the management of groundwater extractions to control the overdraft condition. The most practical way to manage groundwater extraction is to improve the efficiency of irrigation methods. The efficiency of each crop grown in EWD was estimated by the irrigation method typically used in EWD (Table 6). Although EWD is considered fairly efficient, there are irrigation practices that could be enhanced to reduce the demand for irrigation. This reduction in demand would assist in depleting the overdraft condition. Irrigation measures that could improve efficiency include:

- Installation of flow meters (meters provide useful information to determine efficiency)
- Modify irrigation frequency and duration (consider soil conditions such as moisture when irrigating)
- Improve water application uniformity (minimize irrigation losses by nonuniformity in slopes and varying flow rates and pressures in sprinklers)
- Manage tailwater flow (minimize tailwater runoff)
- Reduce deep percolation losses (install, maintain, and operate the system properly)
- Implement farm-level irrigation water scheduling management (use a program to consider climatic variables, soil conditions, stage of crop growth, water use, and irrigation system capabilities to assist farmers in managing their irrigation schedules.)

Similar to the Turlock Groundwater Management Plan, conjunctive use of surface water is another practical alternative to reducing the overdraft condition. This plan evaluated the use of Stanislaus River water, Merced River water, and Tuolumne River water for a conjunctive use program. The most feasible source of water was the Tuolumne River. The water would reach EWD through existing Turlock Irrigation District canals. Other recharge alternatives were also evaluated such as settling basins and injection wells.

The conjunctive use program could potentially stabilize groundwater levels by establishing a relationship between various agencies. Agencies with surface water rights (Turlock Irrigation District, Modesto Irrigation District, City of San Francisco) could supply water on a seasonal basis during wet seasons and agencies with groundwater (EWD) could supply water during dry seasons. If a conjunctive use program is adopted, land use may shift from annually cropped lands or native vegetation to permanent crops. In many cases permanent crops are more productive, however native vegetation lands may not be suitable for agriculture.

The groundwater management plan also contains various figures and tables. The more important ones include: Figure 1 – District Location Map, Table 1 – existing land use within EWD, Table 3 – Summary of existing land use, and Table 7 – Summary of Water Requirements for Crops.

San Joaquin River Group Agreement (1999)

The San Joaquin River Group Agreement is made up of various agencies that control water flows within the San Joaquin River. The agreement proposes the agencies to share the flow requirements adopted by the State Water Resources Control Board in Decision D-1641. The agreement resulted in the Vernalis Adaptive Management Plan. The agreement's purpose is to implement protective measures for environmentally sensitive habitat in the San Joaquin River, gather scientific information on the effects of flows, pumping rates, and operation of fish screens on the survival of salmon, and provide environmental benefits to the river and delta.

In addition to the agreement, an Environmental Impact Statement/Environmental Impact Report was prepared for the project titled, Meeting Flow Objectives for the San Joaquin River Agreement 1999-2010. Appendix B of this report contains information exclusively on the Turlock Groundwater Basin. The historical groundwater production and surface water demands for various municipal agencies and irrigation agencies are included in Table B.1-1. Agricultural demands within the basin are approximately 881,000 acre-feet per year. Groundwater supplies approximately 47% of this demand and surface water supplies 53%.

In addition to the physical description of the basin and the water quality information, a water balance is included (Table B.1-2). The overdraft condition is estimated at 80,000 acre-feet per year and is located on the east side of the valley where surface water supplies are not available and groundwater pumping has intensified to support agriculture. The project water demands for the Turlock Basin area are summarized in Table B.1-3. It is anticipated that municipal demand will increase while agricultural demands will remain static.

Bibliography

	Document	Description
1	Merced County General Plan, Adopted December 1990.	Typical General Plan: Land use elements and density numbers per land use, circulation element, conservation element, noise element, safety element, housing element, and agricultural element, and initial study. Water supply including groundwater, water quality, is discussed. The general plan notes that principle recharge areas are not protected. Improvements in irrigation systems (unlined, old or weakened canals) could increase the availability of water.

2	Merced County General Plan, Adopted December 1990 - Chapter VII Agriculture	Discusses the amount of agriculture lands in Merced County. The average value of land per acre, quantity of water and costs required within the county. The conservation of agricultural lands and the conversion from agricultural to urban lands. Discussed the groundwater quality, flood damages, and water policies set by federal state and local governments.
3	Boyle Engineering, Irrigation Water Master Plan, 1990.	Includes a review of soil types, cropping patterns, and the existing state of the GW basin. Also analyzed and estimated overdraft quantities and identified potential surface water sources for further investigation. Includes irrigation water requirements for particular crops. Discuss the New Melones Project and recent New Melones Project reallocation activities to different water purveyors. Also discusses a preliminary economic study for the use of excess water from new Melones Reservoir to Don Pedro Reservoir during wet years.
4	Stanislaus County General Plan, adopted October 1994	Typical General Plan: Land use elements with specific goals and policies, circulation element, conservation element, noise element, safety element, housing element. Population trends, zoning details for units/acre. The Conservation/open space element includes policies and implementation measures t o protect groundwater aquifers and recharge areas, preserve vegetation to protect waterways from bank erosion, expand water monitoring program, and investigate additional sources of water for domestic and irrigation use.
5	The San Joaquin River Agreement, Vernalis Adaptive Management Plan (VAMP), 2000 Technical Report	this report includes the following information: the hydrologic chronicle; the management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier; results of the juvenile Chinook salmon smolt survival investigations; and, conclusions an recommendations. Discusses the scientific experiment to determine how salmon survival rates change in response to alterations in San Joaquin River flows and State Water Project/Central Valley Project exports and the installation of the Old River Barrier. The VAMP is a planned twelve year experiment and commitment by the parties to implement and monitor the flow requirements of SWRCB Decision 1641.
6	Eastside Water District, Turlock Groundwater Basin, Stanislaus and Merced Counties, California, Turlock Groundwater Basin Groundwater Management Plan, September 1997	Groundwater Management within the Turlock Groundwater Basin Includes description of the basin, water demands in the area, groundwater levels, water quality, describes key elements to the plan and steps to implement the key elements. Appendixes include agricultural water usage, municipal usage, MOU, water code, and Merced County wellhead protection program.

7	Boyle Engineering Corporation, <u>Eastside Water District Groundwater Management Plan,</u> September 1994.	Describes the water demands and sources of water for EWD, explains the hydrology of the basin and physical components, explains the issues facing the District, provides ideas for managing groundwater extractions, suggests conjunctive use of surface water, list 19 management tasks in implementing the Groundwater Management Plan
8	Eastside Water District, <u>Groundwater Recharge Master Plan/Feasibility Study</u>, Groundwater Recharge Facilities Program Feasibility Study Grant Application, February 2001	Provides a description of the past efforts and of the District, provides information on the recharge basins and hydrogeologic evaluation of the sites. Proposes for a Groundwater Recharge Master Plan with the work plan included.
9	Eastside Water District, <u>Groundwater Recharge Master Plan/Feasibility Study</u>, Local Groundwater Assistance Grant Application (AB 303), May 2001	Includes a description of the groundwater management plan, goals of the public outreach program, provides a description of the past efforts and of the District, provides information on the recharge basins and hydrogeologic evaluation of the sites. Proposes for a Groundwater Recharge Master Plan with the work plan included.
10	Stanislaus County Agricultural Element of the General Plan. April 1992	Contains information on agricultural economic values and multipliers. Discusses three goals for the County which include: Strengthen the agricultural Sector of Our Economy, Preserve our Agricultural Lands for Agricultural Uses, Protect the Natural Resources that Sustain our Agricultural Industry. Provides data on water usage = 3.5 acre-ft/water per acre of crop land and 4.5 acre-ft/water per acre of urban land
11	<u>Annual Report of Agriculture</u>, Merced County Department of Agriculture, 2001	This report addresses acreage of crops, production, and gross value of agricultural production in Merced County. It includes a brief Sustainable Agriculture Report which summarizes biological control, pest prevention, pest detection, pest eradication and organic farming activities in Merced County.
12	"Soil Survey. Merced Area California" US Department of Agriculture Soil Conservation Service, July 1962, revised March 1991.	This document identifies soil type and location. It also presents a table indicating relative suitability of crops to soils (Table 7). The information in this document is based on field work from the 1950's. It includes a section on the use and management of different types of soil
13	Marchand, Denis and Alan Allwordt. "Late Cenozoic Stratigraphic Unit, Northwestern San Joaquin Valley, California" US Geologic Bulletin 1407, 1981.	Good information about location of Mehrten Formation where it is exposed. Mehrten Formation is from Miocene and Pliocene age. Strike = N 45 W and Dip = 18.9 degrees. Copy table 1 & Figure 2 page 4&5
14	Piper, A.M., H.S. Gale, H.E. Thomas, and T.W. Robinson. "Geology and Groundwater Hydrology of the Mokelumne Area, California" US Department of the Interior, Geological Survey, 1939.	This reference has a map showing the area of interest to Stockton East. Shows Mehrten Formation within Mokelumne basin

15	Marchand, Denis. "Preliminary Geologic Maps Showing Cenozoic Deposits of the Smelling and Merced Falls Quadrangles, Merced and Stanislaus Counties, California." Open File Report 81-107, 1980, US Department of Interior, US Geological Survey	Describes the layers of soil and formations units
16	Marchand, Denis and Hugh Wagner. "Preliminary Geologic Maps Showing late Cenozoic Deposits of the Turlock Lake Geology, Merced and Stanislaus Counties, California." Open File Report 80-913, 1980, US Department of Interior, US Geological Survey	Describes the layers of soil and formations units
17	Water Management Plan for the Eastside Water District. Draft March 21, 2002	This Agricultural Management Plan is prepared in accordance with the Memorandum of Understanding Regarding Efficient Water Management Practices by Agricultural Water Suppliers in California (November 1996). The plan is consistent with DWR criteria for the preparation of the water master plan steps 1-9. Describes Eastside Water District, lists the essential elements of the study including possible solutions to the overdraft condition, describes soil conditions, discusses water supplies, tabulates uses of water by individual crops, and mentions possible solutions.
18	Stanislaus County Groundwater Coordination Advisory Committee (SCGCAC) - implementation of June 7, 2000 recommendations. (presentation)	The SCGCAC presented their recommendations for protecting groundwater by improving groundwater management and planning in Stanislaus County. Encouraged agencies without groundwater plans to adopt plans which are compatible with existing basinwide plans, directed Department of Environmental Resources to prepare a report on status of groundwater in Stanislaus County every three years, recommended DER to develop a schedule and budget for preparing a feasibility report for the incorporated and unincorporated areas not covered by a plan. The feasibility report will include discussion on surface water storage. The target for the feasibility report is May 2002
19	Allen, Richard and Luis Pereira, Dirk Raes, and Martin Smith. Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56. Food and Agriculture Organization of the United Nations Rome, 1998.	Chapter 6 - Etc - Single crop coefficient (Kc) discusses the length of crop development stages (total growing period) of various crops for various types of climates and locations. Includes a table from Drainage Paper No. 24.
20	Farmington Groundwater Recharge Wetlands Feasibility Study. Administrative Draft Report, US Army Corps of Engineers. November 2000 by Montgomery Watson	Example of layout of report. Information on major water supply and flood control facilities in the study area. Discusses recharge techniques: excavated pits, shallow spreading basins, flooded fields and others (page VI-5). Current land cost for san Joaquin county (VI-16)

21	Raker Act: Hetch Hetchy Reservoir Site - Hearing Before the Committee on Public Lands United States Senate Sixty-Third Congress First Session on H.R. 7207	The act granting the City and County of San Francisco certain rights of way through federal lands to the Hetch Hetchy Reservoir Site. Section 9 of the act is pertinent to this project. The Modesto Irrigation District and Turlock Irrigation District are to receive 2,350 cfs of the natural daily flow of the Tuolumne River measured at the La Grange Dam. SF shall never interfere with these rights. SF shall also recognize the rights of 4,000 cfs of water out of the natural daily flow of the Tuolumne River during the period of sixty days immediately following and including April 15 of each year.
22	Hetch Hetchy Water & Power Daily Operating Summary (http://sfwater.org/detail.cfm/MC-ID/5/MSC_ID/52/MTO_ID/NULL/_ID/1257)	Records reservoir storage and elevation for San Francisco reservoirs operated by the Public Utilities Commission.
23	The State Water Project Delivery Reliability Report Draft, DWR August 2002	This report was issued to assist the contractors of the State Water Project in the assessment of the adequacy of the SWP component of their overall water supplies. On the Merced River the minimum flow below the Crocker-Huffman Diversion Dam is 180-220 cfs from November 1 to April 1 as specified under the Davis-Grunsky Act and Cowell Agreement and the Minimum flow at Shaffer Bridge is 25-100 cfs based on FERC 2179. On the Tuolumne River the minimum flow at Lagrange bridge is 94-310 TAF/year based on FERC 2299-024, 1995.
24	United States of America Federal Energy Regulatory Commission - Order amending license and Dismissing rehearing requests. Project No 2299-024, July 1996	The proposed license amendment establishes new minimum flow releases from the New Don Pedro reservoir, based on fisheries studies conducted in the lower Tuolumne River. Gives a project background on the New Don Pedro Project. Article 37 of the license for the New Don Pedro Project issued March 10, 1964 is amended to maintain minimum streamflows in the e Tuolumne River at La Grange bridge (river mile 50.5) for fish purposes. The annual minimum water releases from the project will range from 94 thousand acre feet in the driest 6.4 percent of years to 301 thousand acre feet in the wettest fifty percent of years. Turlock and Modest Irrigation Districts have agreed to provide fish flows from their storage allocation
25	State Water Resources Control Board D-1641	This decision implemented the 1995 Bay/Delta Water Quality Control Plan and allocated flow responsibilities in the San Joaquin River to various major water rights holders tributary to the river. Defines the computation method for the 60-20-20 indicator
26	CALFED Final Programmatic EIS/EIR July 2000	Summarizes background of the Tuolumne River and Merced River. Discusses the fish flows and minimum requirements of flow at particular locations along the river. Provides average annual unimpaired runoff quantities and the diversions at some of the larger dams.

27	CALFED Ecosystem Restoration Program Plan Volume 2: Ecological Management Zone Visions (appendix to EIS/EIR), July 2000	Discusses the decrease in salmon spawning along the San Joaquin River and it's tributaries. Provides background on the Tuolumne River and Merced River. Describes the visions for ecological processes that will enhance the habitat along the river. Provides the goals of the CALFED program within the San Joaquin basin
28	California Department of Water Resources, 1996 Stanislaus County and 1995 Merced County land Use Survey Data.	GIS layers and metadata provided from DWR website.
29	California Department of Water Resources, Bulletin 118-80, Groundwater Subbasins in California, October 1995	The DWR web page (wwwdpla.water.ca.gov/sjd/groundwater/118index.html) has a lot of information in regards to the groundwater basin. Includes hydrogeologic units for the consolidated and unconsolidated deposits in the Turlock Groundwater Basin. Includes data for the basin yield and water budget. The web page also provides information on groundwater levels,
30	A summary of the Habitat Restoration Plan for the lower Tuolumne River Corridor, prepared for The Tuolumne River Technical Advisory Committee by McBain & Trush, March 1999.	Most of this summary is about restoration efforts for salmon, however there are potential efforts that could aid in recharge along the banks of the river. The summary identifies the sensitive reaches and makes suggestions for improving the habitat in the river. Available at www.stillwatersci.com
31	Stillwater Sciences. 2002.Merced River Corridor Restoration Plan. Stillwater Sciences, Berkeley, CA.	This report provides extensive information about the ecosystem of the Merced River. The Restoration efforts may provide opportunities for additional recharge thought the riparian restoration. Gives reach specific conditions and alternatives. Available at www.stillwatersci.com
32	Merced Irrigation District, Merced River Simulation Model. Prepared by MBK Engineers, August 2001	This Merced River Model Documentation describes the simulation model. The model encompasses Lake McClure downstream to Cressey. There are nine nodes to the model. The document also summarizes the flow requirements and storage space of Lake McClure. Also, includes the operation of the river
33	2000 Urban Water Management Plan, Prepared for the City of Modesto and Modesto Irrigation District by Black & Veatch Corporation	Provides information on the City of Modesto and the Modesto Irrigation District water sources and projections for water use in the future. Includes water projects present and future for water use from Turlock Groundwater Basin = 4, 587 acre-ft/year

34	EWD, Preliminary Feasibility Study - Alternative Irrigation Water Distribution Facilities, 1992.	This report presents the findings of the alternative irrigation water distribution facilities study. The report reviews two alternatives 1) Provide surface water to certain parcels instead of groundwater and 2) provide surface water for groundwater injection. A detail cost estimate is included and assumes water is $8-25/acre-ft and land is $3,000/acre if taken out of production. Under Alternative one, the report summarizes subalternatives for delivery of water. Under Alternative two, the report addressed water treatment, water quality monitoring, and utilizing existing wells. In both cases the report summarizes the necessary components to implement the alternative.
35	J.M. Lord, Inc., Eastside Water District Ownership and Engineering Data Base Report, October 1986.	The purpose of the database is to provide information for making engineering decisions relative to importing surface water and to assist in district management. The report discusses the procedure of preparing the database - 1)data relative to establishment of the District (info on property owners) 2)surveying the property owners (questionnaire) 3)research and acquisition of public agency data (well pump test, electrical use data, well drillers logs). The finished product included an ownership database, district map, well drillers logs, and pump data.
36	EWD, Merced River Supplemental Irrigation Water Supply and Distribution Preliminary Feasibility Study, 1993.	This report was completed after Merced Irrigation District stated they could supply EWD with water periodically from the Merced River. This report analyzes the feasibility of diverting water from MID to EWD. The report suggest a diversion facility near Shaffer Bridge. Talks about Med's water rights and release obligations of FERC, Davis Grunsky program, and JJ Stevenson Company. The report discusses the specific facilities required to convey irrigation water to EWD and a cost estimate. Four drawings are included showing the preliminary layout and profile of reservoir and pipelines.
37	California Department of Water Resources, San Joaquin District, Water Supply and Demand in the Cooperstown and Monte Pelier Subareas, Eastern Stanislaus and Northern Merced Counties Report, June 1979.	This report summarizes the study of Coooperstown area and Montpelier area (contains EWD) to develop information that will assist in determining reasonable water demands. The study also will determine if surface water is warranted and how much should be delivered from the New Melones Reservoir Project. The report evaluates the rate agricultural development occurs, how much development the groundwater can support, and surface water alternatives (flood releases), and how to integrate the imported surface water with the groundwater use. The report compares present and project water demands with the present and project water supplies. Geological information on the basin is discussed along with the hydrogeological impact of prolonged pumping and subsequesnt recharge. Figure 5- shows the location of the Mehrten formation. The report concluded that no long-term overdrafts will occur in the foreseeable future (till 1990).

38	Merced County Soil Survey, 1950.	Updated, See Document #12
39	Turlock Irrigation District, Groundwater Management Plan, 1993.	This report mentions that the DWR Bulletin 118 applies to the Turlock Groundwater Basin; TID is a part of this area. This plan documents the existing activities of the District and provides a plan that can monitor and manage a conjunctive use, replenishment and preservation of groundwater within the basin. TID was formed in 1887 and was the first district organized under the Wright Act. The plan describes the basin, the sources of water supply, groundwater usage in the District, groundwater levels, groundwater quality, and water demand. Table 2 contains water demand and supply from 1972 to 1992. The plan also lays out the powers of the District and proposed programs, summarizing what the District can do to maintain and protect the basin.
40	Digital Model of the Unconsolidated Aquifer System In and Near the Modesto Area, USGS WR181-12, C.J. Lundquist, 1981.	The model was developed to determine the effects of increased pumping on future water levels in the aquifer. The model assumes two units. A lower and upper unit. The lower unit is either confined or unconfined aquifer depending on location. The aquifer is confined in the western part of the study area by a clay layer 20 to 100 feet think. There is also an unconfined aquifer above this clay layer.
41	Bureau of Reclamation, U.S. Fish and Wildlife Service, San Joaquin River Group Authority, Meeting Flow Objectives for the San Joaquin River Agreement 1999-2010 Environmental Impact Statement and Environmental Impact Report Final Contents, 1999.	Hydorlogical Report (appendix A) provides the division of VAMP flow commitments for the members of the San Joaquin River Authority. Available at http://www.sjrg.org. Talked to Lowell Ploss at San Joaquin River Group Authority (916-449-3957). The water right holders mentioned in D-1641 formulated the San Joaquin River Agreement to share the flow requirements adopted in D-1641. This agreement resulted in the Vernalis Adaptive Management Plan. This agreement collectively provides 62 to 110 thousand acre-feet annually to meet certain Delta water standards and for the purpose of conducting the VAMP experiment. The year 2000 was the initial year for implementing the Agreement. The following elements were attained: a target flow at Vernalis of 5, 700 cubic feet per second (cfs), a Delta export pumping target of 2,250 cfs, installation of the fish barrier at the head of Old River, and completion of the year 2000 fish monitoring program. Appendix B discusses groundwater conditions in the area.
42	http://www.waterrights.ca.gov	Water Rights Information Management Systems (WRIMS) provides online water rights information with maps. Also provides water rights decision and order information, a fully appropriated streams list.
43	http://ca.water.usgs.gov/archive/waterdata/ - Water Resources Data California by USGS.	1994 - 2001 Flow data for points along Merced and Tuolumne Rivers. Includes monthly mean flows for gage history.
44	Dan Madden, City of Turlock Water Resources Department	Turlock Waste Water Treatment Plant reclaimed water capacity information.

45	Page, R.W. and Gary O. Balding; Geology and Quality of Water in the Modesto-Merced Area, San Joaquin Valley, California with a brief Section on Hydrology. Water Resources Division, U.S. Geological Survey, 1973.	This report discusses the geology of the area, including the consolidated rocks and unconsolidated deposits. The report discusses water quality and the movement of groundwater including the decline in water levels in certain areas. Most of the findings in this report have been updated or included in more recent reports.
46	Contract between State of California Department of Water Resources and Merced Irrigation District for Recreation and Fish Enhancement Grants under the Davis-Grunsky Act. State of California The Resources Agency Department of Water Resources, Contract No. D-GGR 17 DWR No. 160282	Includes a description of the fish enhancement plan along the Merced River. Describes the facilities, channel modifications, and operation requirements of facilities to meet flushing flows for the migration of fish. Flows required under the Davis-Grunsky Act are also included and summarized in other reports.
47	California Department of Water Resources, Division of Planning and Local Assistance. Bulletin 160-93, November 1994, The California Water Plan Update.	This bulletin documents how population growth, land use, and water allocations for the environment are affecting water resource management. There are discussions on water quality standards, Endangered Species acts, the Central Valley Project Improvement Act of 1992, and the efforts to solve problems in the San Francisco Bay-Sacramento-San Joaquin River Delta estuary. The bulletin estimates the environmental water needs accounts for these needs along with urban and agricultural water demands; presents water demand management methods, including conservation and land retirement; and presents water balance scenarios for average and drought conditions. The bulletin is available at http://rubicon.water.ca.gov.
48	Alley, W.M, T.E. Reilly, and O.L. Franke; U.S. Geological Survey Circular 1186, Sustainability of Groundwater Resources, 1999.	This report illustrate the hydrologic, geologic, and ecological concepts that must be considered to assure the sustainability of groundwater sources. The report also addresses the effects of developing groundwater sources on the environment and surface water bodies. There is a great deal of discussion on water balances. resources. The report is located at http://water.usgs.gov/pubs/circ/circ1186/html/introl.html.
49	University of California Cooperative Extension, The following articles were used: Sample Costs to Establish an Alfalfa Stand and Produce Alfalfa, 1998 Sample Costs to Establish an Almond Orchard and Produce Almonds, 2002 Sample Costs to Establish an Apple Orchard and Produce Applies, 2001 Sample Costs to Produce Baby Lima Beans, 1998 Sample Costs to Produce Corn Silage, 2001 Sample Costs to Establish a Vineyard and Produce Wine Grapes, 2001	The webpage, www.agecon.ucdavis.edu/outreach/crop/cost.htm has a number of articles for determining the cost to establish and produce crops in the San Joaquin Valley.

	Sample Costs to Establish a Cling Peach Orchard and Produce Cling Peaches Sample Costs to Establish and Produce Sugar Beats, 2002 (Imperial County) Sample Costs to Produce Fresh Market Strawberries, 2001 (Central Coast) Sample Costs to Establish a Walnut Orchard and Produce Walnuts, 2001	
50	Natural Resources Conservation Service, NE Fact Sheet, Water Savings Section of Environmental Quality Incentives Programs, June 25, 2002.	This fact sheet describes the Nebraska Cost Share and Incentives Program through the Farm Security and Rural Investment Act of 2002. A special section of this program's legislation allows for additional water saving funding in the High Plains Aquifer. The purpose of this special section is to install "water savings" practices in agricultural operations, particularly on cropland. The fact sheet summarizes cost share for conversion from gravity/surface irrigation to sprinkler irrigation systems and incentive payment for conversion of irrigated cropland to non-irrigated cropland or to non-irrigated permanent cover. The fact sheet can be found at http://v2o.valmont.com/V2O/bulletins/eqip-ne-Nebraska%20Groundwater%20Fact%20Sheet-EQUIP.doc.
51	Hutmacher, R.B., Mead, R.M., Phene, C.J., Clark, D., Shouse, P., Vail, S.S., Swain, R., VanGenuchten, M., Peters, M.S., Hawk, C.A. , Donavan, T., & Jobes, J. Subsurface Drip and Furrow Irrigation of Alfalfa in the Imperial Valley. Proc 22nd California/Arizona Alfalfa Symposium. University of California and University of Arizona Cooperative Extension, December 9-10, Hetville, California.	A subsurface drip irrigation (SDI) and furrow irrigation study was installed in a silty clay loam soil at the USDA-ARS Irrigated Desert Research Station near Brawley, CA in early 1991 to evaluate the potential for water savings and yield improvements with subsurface drip irrigation of forage alfalfa as compared to furrow irrigation. During the first one and one-half year operation, approximately 20 percent higher yields were achieved in the drip plots with 94 percent of the water application amounts used in the furrow irrigated plots. This study can be found at http://alfalfa.ucdavis.edu/subpages/2001Symposium/Proceedings/CAS01DripandFurrow12.PDF

Chapter 3

Water Balance

Introduction

The water balance was prepared similar to a mass balance with the mass evaluated being strictly water. To prepare the balance we defined the boundary of the system then accounted for all water entering or leaving the system. The net difference being the change in quantity of water stored within the system.

This system type of water balance was chosen because it accurately and simply reflects actual conditions. The most important actual condition being: Only changes in quantities of water crossing the boundary of the system cause changes in the water quantity within the system.

Two simple water balances were created to model two systems: the Eastside system and the Turlock system. The Eastside system encompassed the surface and groundwater within the EWD boundaries. The Turlock system encompassed the surface and groundwater within the area of the Turlock groundwater basin. Each water balance was not limited to groundwater or surface water, but integrated ground and surface water into a single water balance. The intent here was to create a simple method of accounting for water supplied to or depleted from the system.

Calculations, data and details on the definition and development of the two water balance models are included in Appendix A.

Purpose

The purpose of the water balance was to create an analytical tool that could be used to estimate the effectiveness of each alternative. By altering the values of the different items of water that enter or leave the system as affected by each alternative the water balance could be used to predict the expected change in the status of the groundwater. Once created and calibrated, the water balance could be used to predict the benefit or impact each alternative provides.

Other objectives achieved during the preparation of the water balance were:

- Determine the current water demand within EWD.
- Determine the long-term water demand in EWD
- Determine the current water demand in the Turlock Groundwater basin.
- Determine the long-term water demand in the Turlock groundwater basin.
- Estimate the safe yield of groundwater for EWD.

- Estimate the safe yield of groundwater for the Turlock groundwater basin.
- Compare demands to the supplies and estimate the expected current and long-term groundwater conditions.

The first four of these were prepared prior to creation of the water balance and are presented next. The last three were prepared from the results of the water balance and are presented within this chapter after the section on the water balance

Estimates of Demand

EASTSIDE WATER DISTRICT CURRENT DEMANDS

The water requirements within Eastside water district are predominantly agricultural. Irrigation demands are evaluated using estimates of crop acreage, irrigation water requirements, irrigation efficiencies, and effective precipitation.

Crop Acreage

Cropping patterns were obtained from the 1995 Merced County Land Use Survey and the 1996 Stanislaus County Land Use Survey. The crop acreage was calculated for the following types of crops:

Rice
Alfalfa
Pasture includes clover, mixed pasture, native pasture, miscellaneous grasses, and turf farms.
Walnut
Almond
Miscellaneous mixed deciduous including apples, apricots, cherries, pears, plums, prunes, figs, pistachios, and other miscellaneous deciduous.
Peach/Nectarine
Citrus including grapefruit, lemons, oranges, dates, avocados, olives, kiwis, jojoba, eucalyptus, and other miscellaneous subtropical fruits.
Truck, nursery, and berry including artichokes, asparagus, green beans, cole crops, carrots, celery, lettuce, melons, squash, cucumbers, onions, garlic, peas, potatoes, sweet potatoes, spinach, tomatoes, flowers, nursery, Christmas tree farms, bush berries, strawberries, peppers, broccoli, cabbage, cauliflower, brussel sprouts, and other miscellaneous truck crops.
Vineyards
Corn
Other fields including cotton, safflower, flax, hops, sugar beats, grain sorghum, castor beans, sunflowers, and other miscellaneous.
Grain including barley, wheat, oats, and miscellaneous and mixed grain and hay.
Dry Beans

This acreage was reduced by a 5 percent to account for roads, canals, farmsteads, and other non-crop use.

Crop Consumptive Use and Irrigation Water Requirements

Consumptive use for the crops grown within the study area was determined strictly from plant evapotranspiration.

Irrigation demand was estimated using values of precipitation, effective precipitation, crop evapotranspiration (ETc), and irrigation efficiencies. The distinction between crop consumptive use and irrigation demand was made because construction of the water balance made this a simpler way to perform the accounting with the same level of accuracy.

The results of the crop consumptive use and irrigation demand analysis are presented in Table 3.1 below. The determination of crop consumptive use and irrigation demand is presented in detail in Appendix A.

Table 3.1 Eastside Water District Annual Irrigation Demand Analysis

Crop	Crop Acreage (1995-1996)	Adjusted Acreage [1]	Net Irrigation Requirement (feet)	Irrigation Efficiency (%)	Irrigation Demand (acre-feet)
Grain	4,180	3,971	1.06	70	6,013
Alfalfa	475	451	3.55	70	2,287
Pasture	4,109	3,904	3.39	65	20,359
Dry Beans	2,117	2,011	0.95	70	2,719
Corn	1,713	1,627	2.03	70	4,719
Almond	23,036	21,884	2.94	75	85,786
Walnut	1,012	961	3.14	75	4,025
Peach/Nectarine	733	696	2.87	75	2,665
Misc. Mixed Deciduous	314	298	2.89	75	1,149
Vineyards	7846	7,454	2.00	75	19,877
Citrus	52	49	2.83	70	200
Other field	1303	1,238	1.81	70	3,201
Truck, Nursery, & Berry	168	160	2.79	70	636
Idle	473	473	0.21	NA	NA
Semi-Agricultural	991	991	NA	NA	NA
Urban	457	457	NA	NA	NA
Native Vegetation	6218	6218	NA	NA	NA
Water	366	366	NA	NA	NA
Total	55,563	53,209			153,636

1-reflects a 95% gross to net acreage reduction factor applied to gross cropped acreage to reflect roads, canals, farmsteads, and other non-crop urban/residential uses.

The values shown on Table 3.1 do not include the non- consumptive use portion of irrigation that occurs from irrigation inefficiencies. Inefficiency accounts for an additional 48,000 AFY of water applied to crops. In the water balance, we assumed the evaporation portion of inefficiency was half of the total inefficiency and is accounted for as leaving the system. The other half of inefficiency was water that percolated beyond the root zone. This portion remains within the system since it returns to the groundwater and is not explicitly shown in the water balance. However, it is accounted for correctly in the water balance.

There are no large municipal or industrial users of water within EWD. Therefore, no quantity is shown for such use.

The values here in the text give the quantity for all the water used for human needs and activities, the non-consumptive portion of that use (the portion that returns to the groundwater) and also the water consumed by use.

The current total yearly water usage within EWD is 173,600 AFY. Non-consumptive use accounts for 16,400 AFY of this total. Actual consumptive use by human needs/activities is 157,200 AFY.

EASTSIDE WATER DISTRICT LONG-TERM DEMANDS

EWD has limited area for additional expansion of croplands. Approximately 6,220 acres of native vegetation is remaining in the district according to the 1995/1996 Land Use Survey. In the five years prior to the land use survey 5,030 acres were converted from native vegetation to croplands. This represents a twelve percent growth in five years.

At this rate all land within the district would soon be converted to agriculture. However, not all of the remaining land may be suitable for agriculture. Therefore, not all land may be converted to cropland. For the sake of estimating future demands, we assumed all of this land becomes irrigated. In that case the additional irrigation demand would be between 11,100 and 20,800 AFY depending upon the crops planted. The corresponding recharge component from this demand would be between 4200 and 7800 AFY for a net additional overdraft of groundwater between 6,900 and 13,000 AFY.

The complete conversion of all suitable lands within EWD to irrigated agriculture is expected to occur in five years

TURLOCK GROUNDWATER BASIN CURRENT DEMANDS

An analysis similar to the EWD analysis was performed for the entire Turlock Groundwater Basin to determine the demands within the basin. Table 3.2 gives the results of that analysis.

Table 3.2 Turlock Groundwater Basin Irrigation Demand Analysis

Crop	Turlock Basin Crop Patterns (1995-1996)	Adjusted Acreage[1]	Net Irrigation Requirement (Feet)	Irrigation Efficiency (%)	Crop Water Demand (acre-feet)
Grain	6,462	6,139	1.06	65	10,014
Alfalfa	19,505	18,530	3.55	65	101,201
Pasture	25,003	23,753	3.39	60	134,204
Dry Beans	4,190	3,981	0.95	65	5,794
Corn	45,677	43,393	1.99	65	132,549
Almond	84,820	80,579	2.94	70	338,432

Crop	Turlock Basin Crop Patterns (1995-1996)	Adjusted Acreage[1]	Net Irrigation Requirement (Feet)	Irrigation Efficiency (%)	Crop Water Demand (acre-feet)
Walnut	6,669	6,336	3.14	70	28,419
Peach/Nectarine	8,299	7,884	2.87	70	32,325
Misc. Mixed Deciduous	4,245	4,033	2.89	70	16,649
Vineyards	15,454	14,681	2.00	75	39,150
Citrus	305	290	2.83	70	1,171
Other field	5,596	5,316	1.81	65	14,804
Truck, Nursery, & Berry	5,562	5,284	2.79	70	21,060
Idle	3,066	3,066	NA	NA	NA
Semi-Agricultural	11,465	11,465	NA	NA	NA
Urban	23,514	35,103	NA	NA	NA
Native Vegetation	68,825	68,825	NA	NA	NA
Water	6,152	6,152	NA	NA	NA
Total	344,809	344,809			875,773

1-reflects a 95% gross to net acreage reduction factor applied to gross cropped acreage to reflect roads, canals, farmsteads, and other non-crop urban/residential uses.

The Turlock groundwater basin does have municipal and industrial water use. That amount is estimated to be 36,000 AFY with 7,000 AFY of that returning to groundwater through percolation.

The current total yearly water usage within the Turlock Groundwater Basin is 943,500 AFY. Non-consumptive use accounts for 120,300 AFY of this total. This non-consumptive use water returns to the groundwater from percolation past the root zone of crops. Actual consumptive use created by human needs/activities is 823,200 AFY.

TURLOCK GROUNDWATER BASIN LONG-TERM DEMANDS

Within the Turlock Groundwater Basin are large tracts of non-irrigated land currently used for livestock grazing. Portions of these lands have the capability of sustaining crops. If these lands are converted to irrigated agricultural lands an increase in water demands will occur.

The area of lands currently in non-irrigated agricultural use is approximately 83,000 acres. The recent rate of land being converted from non-irrigated to irrigated agricultural use is approximately 1000 acres per year within EWD. This rate of conversion is assumed to approximate the rate that will occur for the lands within the Turlock groundwater basin.

A crop consumptive use for these converted lands would be between 1.8 and 3.3 AFY. With that increased demand, the increase in recharge of groundwater would be between 0.7 and 1.3 AFY.

Based upon the additional demand of 1,000 acres per year the increase in demands for agricultural use would be 1,800 to 3,300 AFY. The corresponding recharge component from the increased demand would be between 700 and 1,300 AFY for a net additional depletion of groundwater between 1,100 and 2,000 AFY.

Table 3.3 has been constructed to show the potential changes in water demand, groundwater recharge and overdraft over a fifty year period.

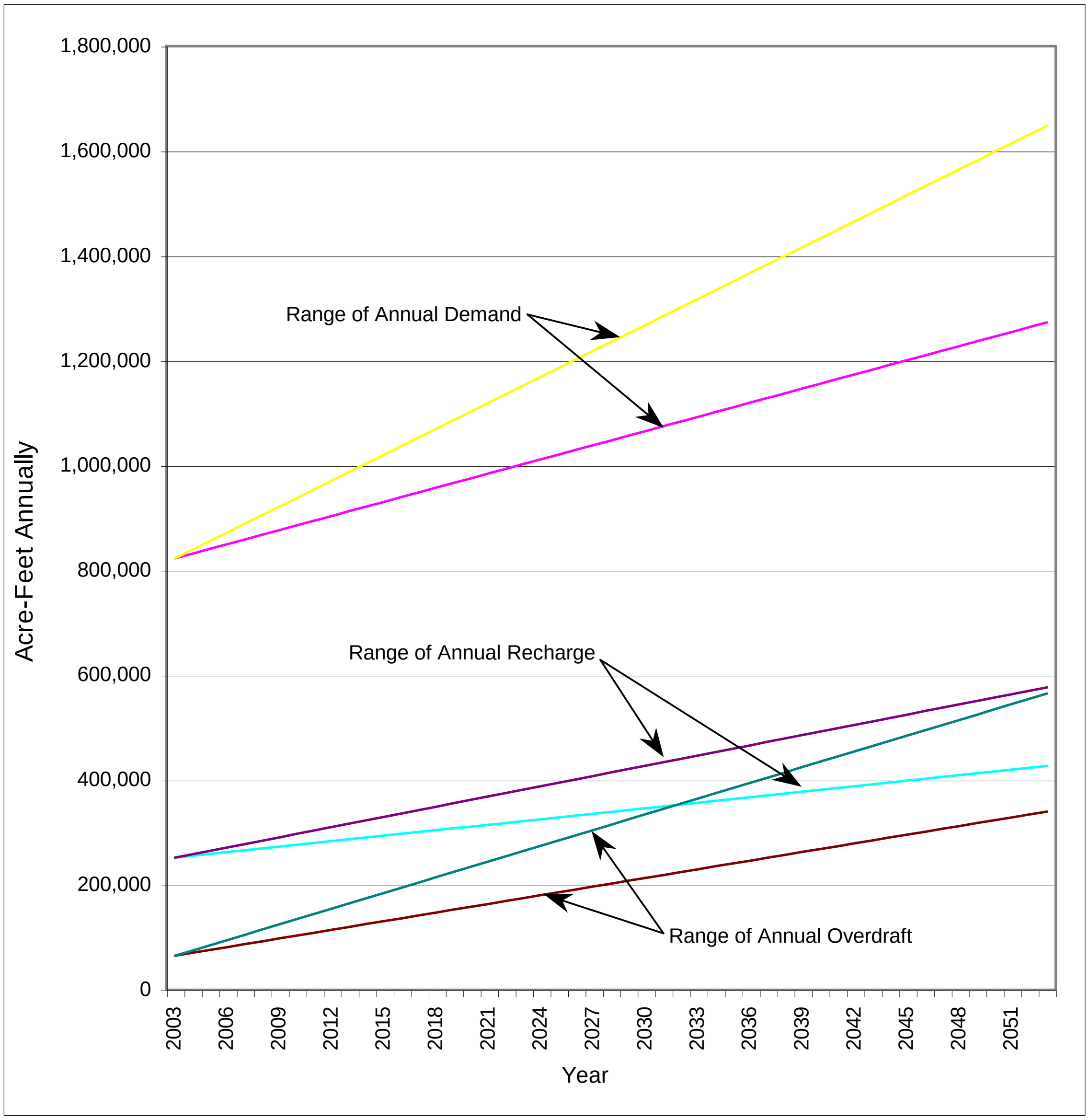

Figure 3.1 Potential Changes to Demand, Recharge, and Overdraft in the Turlock Groundwater Basin

Changes to cropping patterns on lands that are currently under irrigated agriculture also could affect water demands within the Turlock Groundwater Basin. One alternative for supplying water to EWD presents a detailed analysis of how cropping pattern changes may conserve water within the Turlock Groundwater Basin and other areas. The potential to conserve water within basin could result in a reduction in water demand as high as 120,000 AFY.

The conversion of high consumptive use crops to lower consumptive use crops will be largely driven by growers choosing to convert to these crops in order to increase profits by converting to higher value crops. Thus this conversion will be driven by economics. As such a rate of conversion of lands and a projection of the rate of change in demands has not been estimated.

However, detailed information on the potential decrease in demands, cost to change crops, and increase in farm revenues from cropping pattern changes is presented in Chapters 4 and 5 and their appendices.

Water Balance

EASTSIDE SYSTEM RESULTS

The Eastside system water balance is presented here as Table 3.3. This water balance was constructed with limits set to approximate EWD. As such the model indicates the conditions within the Eastside system. It also points to conditions immediately outside the system boundary, specifically when considering horizontal and vertical groundwater movements.

TURLOCK SYSTEM RESULTS

The Turlock system water balance is presented here as Table 3.4. The Turlock system water balance represents the entire Turlock Groundwater Basin including EWD.

Table 3.3 Eastside System Annual Water Balance

	Annual Water Balance - EWD System	EXISTING SYSTEM						
		Parameters				Supply	Demands	Balance
	Description/Activity	Inches	Feet	Acreage	Acre-Feet	Acre-Feet	Acre-Feet	Acre-Feet
	SOURCES							
1	Precipitation	11	0.9	54,000	49,500	49,500		49,500
	Run on - Detail below					5,134		54,634
2	Run on from precipitation (0.3 x 11 inches)	3.30	0.28	4,122	1,134			54,634
3	Imported water				4,000			54,634
4	Percolation from Significant Creeks Canals and Impoundments - Detail below					55,261		109,895
	Dry Creek				14,600			109,895
	Turlock Main Canal				18,051			109,895
	Highline Canal				17,255			109,895
	Impoundments				5,356			109,895
	Groundwater movement in - Detail below					31,714		141,609
5	Horizontal GW movement in	k=	6,294	(ft/year)	26,964			141,609
6	Vertical GW movement in				4,750			141,609
	DEMANDS							141,609
	Evaporation - Detail below						436	141,173
7	Evaporation from barren land	10	0.83	473	394			141,173
8	Evaporation from surface impoundments	50	4.17	10	42			141,173
9	Evaporation from creeks and canals	n/a						141,173
10	Evaporation from irrigation water - Detail below							141,173
	Grain	4.03	0.34	4,180	1,405		1,405	139,768
	Alfalfa	9.55	0.80	475	378		378	139,390
	Pasture	12.39	1.03	4,109	4,243		4,243	135,146
	Dry Beans	0.21	0.02	2,117	37		37	135,109
	Corn	5.36	0.45	1,713	765		765	134,344
	Almond	6.54	0.54	23,036	12,545		12,545	121,799
	Walnut	6.94	0.58	1,012	585		585	121,214
	Peach/Nectarine	6.37	0.53	733	389		389	120,825
	Misc. Mixed Deciduous	6.40	0.53	314	167		167	120,658
	Vineyards	4.35	0.36	7,846	2,843		2,843	117,815
	Citrus	8.44	0.70	52	37		37	117,778
	Other field	5.46	0.45	1,303	593		593	117,186
	Truck, Nursery, & Berry	7.97	0.66	168	112		112	117,074
	Runoff - Detail below.						15,984	101,091
11	Runoff from precipitation (C=.3)	3.30	0.28	54,000	14,850			101,091
12	Runoff from Run on	3.30	0.28	4,122	1,134			101,091
13	Runoff from drainages originating within the system.				-			101,091
14	Exported water				-			101,091
	Groundwater movement out - Detail below						-	101,091
15	Horizontal GW movement out				-			101,091
16	Vertical GW movement out				-			101,091
17	Consumptive use by crop/vegetation - Detail below							101,091
	Grain	18.82	1.57	4,180	6,556		6,556	94,535
	Alfalfa	44.58	3.72	475	1,765		1,765	92,770
	Pasture	45.26	3.77	4,109	15,498		15,498	77,273
	Dry Beans	11.38	0.95	2,117	2,008		2,008	75,265
	Corn	25.02	2.09	1,713	3,572		3,572	71,693
	Almond	39.21	3.27	23,036	75,270		75,270	(3,577)
	Walnut	41.62	3.47	1,012	3,510		3,510	(7,087)
	Peach/Nectarine	38.21	3.18	733	2,334		2,334	(9,421)
	Misc. Mixed Deciduous	38.40	3.20	314	1,005		1,005	(10,425)
	Vineyards	27.71	2.31	7,846	18,118		18,118	(28,543)
	Citrus	39.38	3.28	52	171		171	(28,714)
	Other field	25.47	2.12	1,303	2,766		2,766	(31,479)
	Truck, Nursery, & Berry	37.18	3.10	168	521		521	(32,000)
	Native vegetation - grasses		-	6,218	-		-	(32,000)
	Native vegetation - trees		-		-		-	(32,000)
18	Municipal and Industrial Use - Detail below						-	(32,000)
	None							(32,000)
	Safe Yield				**Total Supply:**	141,609		
	Consumptive Use	157,189	acre-ft			**Total Demand:**	173,609	
	Imported Water	(4,000)	acre-ft					
	Current Overdraft	(63,714)	acre-ft	Change in Groundwater in Storage beneath EWD:				(32,000)
	Safe Yield	89,476	acre-ft					
				Net GW inflow across boundary of EWD system				(31,714)
				Total Overdraft				(63,714)

Table 3.4 Turlock System Annual Water Balance

	Annual Water Balance - Turlock System – Description/Activity	EXISTING SYSTEM – Parameters – Inches	Parameters – Feet	Parameters – Acreage	Acre-Feet	Supply Acre-Feet	Demands Acre-Feet	Balance Acre-Feet
	SOURCES							
1	Precipitation	11	0.9	348,000	319,000	319,000		319,000
	Run on - Detail below					506,000		825,000
2	Run on from precipitation (zero because water shed boundary assumed to be basin boundary)							825,000
3	Imported water (486,0001 + 20,000 assumed for riparian users near rivers.)				506,000			825,000
4	Percolation from Significant Creeks Canals and Impoundments - Detail below					14,600		839,600
	Dry Creek				14,600			839,600
	Turlock Main Canal (9,025 AFA included in imported water)							839,600
	Highline Canal (8,627 AFA inlcuded in imported water)							839,600
	Turlock Lake (10,000 AFA included in imported water)							839,600
	Groundwater movement in - Detail below					39,056		878,656
5	Horizontal GW movement in	k=	6,294	(ft/year)	34,306			878,656
6	Vertical GW movement in				4,750			878,656
	DEMANDS							878,656
	Evaporation - Detail below						27,744	850,912
7	Evaporation from barren land	10	0.83	473	394			850,912
8	Evaporation from surface impoundments	50	4.17	3,300	13,750			850,912
9	Evaporation from creeks and canals				13,600			850,912
10	Evaporation from irrigation water - Detail below							850,912
	Grain	4.03	0.34	6,139	2,063		2,063	848,848
	Alfalfa	9.55	0.80	18,530	14,751		14,751	834,097
	Pasture	12.39	1.03	23,753	24,530		24,530	809,567
	Dry Beans	0.21	0.02	3,981	70		70	809,498
	Corn	5.36	0.45	43,393	19,387		19,387	790,110
	Almond	6.54	0.54	80,579	43,882		43,882	746,228
	Walnut	6.94	0.58	6,336	3,662		3,662	742,566
	Peach/Nectarine	6.37	0.53	7,884	4,184		4,184	738,382
	Misc. Mixed Deciduous	6.40	0.53	4,033	2,151		2,151	736,231
	Vineyards	4.35	0.36	14,681	5,319		5,319	730,912
	Citrus	8.44	0.70	290	204		204	730,708
	Other field	5.46	0.45	5,316	2,418		2,418	728,290
	Truck, Nursery, & Berry	7.97	0.66	5,284	3,508		3,508	724,782
	Runoff - Detail below.						83,800	640,982
11	Runoff from precipitation (C=.2)	2.20	0.18	348,000	63,800			640,982
12	Runoff from Run on							640,982
13	Runoff from drainages originating within the system.				-			640,982
14	Exported water (wasted from 92,000 AFA drainage water)				20,000			640,982
	Groundwater movement out - Detail below						28,768	612,214
15	Horizontal GW movement out				28,768			612,214
16	Vertical GW movement out				-			612,214
17	Consumptive use by crop/vegetation - Detail below							612,214
	Grain	18.82	1.57	6,139	9,628		9,628	602,586
	Alfalfa	44.58	3.72	18,530	68,838		68,838	533,748
	Pasture	45.26	3.77	23,753	89,588		89,588	444,160
	Dry Beans	11.38	0.95	3,981	3,775		3,775	440,386
	Corn	25.02	2.09	43,393	90,475		90,475	349,911
	Almond	39.21	3.27	80,579	263,292		263,292	86,619
	Walnut	41.62	3.47	6,336	21,974		21,974	64,645
	Peach/Nectarine	38.21	3.18	7,884	25,104		25,104	39,541
	Misc. Mixed Deciduous	38.40	3.20	4,033	12,905		12,905	26,636
	Vineyards	27.71	2.31	14,681	33,902		33,902	(7,265)
	Citrus	39.38	3.28	290	951		951	(8,216)
	Other field	25.47	2.12	5,316	11,284		11,284	(19,500)
	Truck, Nursery, & Berry	37.18	3.10	5,284	16,371		16,371	(35,871)
	Native vegetation - grasses		-		-		-	(35,871)
	Native vegetation - trees		-		-		-	(35,871)
18	Municipal and Industrial Use - Detail below						28,960	(64,831)
	Turlock, Modesto (36,200 * 80%, 20 % allowed to percolate during lawn irrigation)				28,960			(64,831)
	Safe Yield				**Total Supply:**	878,656		
	Consumptive Use	823,174	acre-ft			**Total Demand:**	943,487	
	Imported Water	(506,000)	acre-ft					
	Current Overdraft	(75,119)	acre-ft				**Change in Groundwater in Storage:**	(64,831)
	Safe Yield	242,056	acre-ft					
							Net GW inflow across boundaries of TGW system:	(10,288)
							Total Overdraft:	(75,119)

Groundwater Safe Yield

The term "safe yield" as defined by the USGS is the amount of water that can be withdrawn from an aquifer on a long-term basis without serious water quality, net storage, environmental, or social consequences (USGS, 1999). As used here, the safe yield is the average quantity of groundwater that may be withdrawn without causing decline in the groundwater elevations on a continual basis over many years.

This method assumes that continual annual reductions in groundwater storage are not acceptable. This method does not address conjunctive management of the basin.

Conjunctive management may allow reduction in groundwater storage in some years with replenishment of the aquifer occurring in other years. Preparation and implementation of a conjunctive management plan would alter the safe yield from year to year and may alter the safe yield on a long-term basis, depending upon the plan.

A passive plan would allow overdraft to occur some years through pumping, and recharge to occur by in other years through foregoing pumping. An active plan would allow overdraft to occur during dry years and would replenish groundwater in wet years through the supply of other sources of water to the groundwater system

EASTSIDE WATER DISTRICT SAFE YIELD

Current safe yield of groundwater within EWD is estimated to be 89,500 AFY with an overdraft of 63,700 AFY occurring in and around EWD.
Previous values for the overdraft of the area ranged between 70,000 AFY and 90,000 AFY. The variation can be attributed to 1) Assumptions about the porosity or void space within the soil matrix. Fifteen percent void space is assumed here. 2) The lesser amount of groundwater elevation data available when earlier estimates were prepared.

TURLOCK GROUNDWATER BASIN SAFE YIELD

The current safe yield of groundwater within the Turlock Groundwater Basin is estimated to be 242,000 AFA with an overdraft of 75,000 AFY. Most of this overdraft is occurring in the area east of the Turlock Irrigation District’s Highline Canal, in and around the Eastside Water District.

PREVIOUS ANALYSIS OF TURLOCK GROUNDWATER BASIN

Safe yields for Turlock Basin have previously been presented in the California Water Plan Update and Bulletin 118. Table 3.5 summarizes the safe yields reported in those sources, along with estimates of groundwater extraction, overdraft, and storage.

Table 3.5 Prior Safe Yield Estimates

	California Water Plan Update 1994 (Acre-Feet)	Bulletin 118 Summary - Turlock Groundwater Basin 1995 (Acre-Feet)
Extraction	397,000	452,000
Safe Yield	379,000	379,000
Overdraft	18,000	73,000
Storage	2,443,000	2,443,000

Note: The basin safe yield estimated in the 1994 California Water Plan Update was based on a study in 1982 of 293 wells, normalized to 1990 level of development.

Demands Versus Supplies

EASTSIDE WATER DISTRICT

The actual consumptive use demand of 157,200 AFY is met by groundwater, 153,200 AFY and imported water, 4,000 AFY. The imported water is purchased from Turlock and Merced Irrigation Districts on an as available basis. The safe yield for EWD is 89,500 AFA. This indicates a groundwater overdraft of 63,700 AFA.

TURLOCK GROUNDWATER BASIN

This actual consumptive use demand of 823,000 AFY is met by 506,000 AFY of imported water, and 317,000 AFY of groundwater. The imported water is water supplied by Turlock Irrigation District and Merced Irrigation District. The safe yield of the TGB is 242,000 AFA. This indicates an overdraft in the TGB of 75,000 AFA.

Groundwater levels in the western end of the TGB have remained relatively stable. While groundwater levels in the middle and eastern portions of the TGB have declined over the last 30 plus years. The overdraft identified here is occurring in the eastern portion of the TGB.

Expected Groundwater Conditions

EASTSIDE WATER DISTRICT CURRENT EXPECTED CONDITIONS

Under the current water balance conditions the EWD is expected to see a decline in the groundwater levels beneath and surrounding the District. At the current rate of overdraft, 63,700 AFY, the water table will continue to decline at a rate averaged over the District and surrounding areas of 4.0 feet per year.

TURLOCK GROUNDWATER BASIN CURRENT EXPECTED CONDITIONS

The Turlock Groundwater Basin is currently overdrafted by 75,000 AFY. This overdrafting primarily occurs in the area not served by surface water. This is the area beneath EWD and adjacent to EWD. The west portion of the Turlock Groundwater Basin, i.e. the lower basin, has a relatively stable groundwater level and appears to have adequate water supplies.

EASTSIDE WATER DISTRICT LONG-TERM EXPECTED GROUNDWATER CONDITIONS

If the current overdraft of 63,700 AFY continues for the long-term, the EWD is expected to see the groundwater levels beneath and surrounding the District to continue to decline. As the decline continues the slope of the groundwater surface will increase, increasing recharge. Eventually a point of equilibrium may be reached.

The water balance model indicates the point of equilibrium would occur when the groundwater declines to an elevation of approximately 70 feet below sea level at its lowest point. This represents a decline of approximately 100 feet below current levels. This is estimated to occur in approximately 25 years. This value is determined by calculating the theoretical slope of the groundwater surface at which the movement of groundwater into the water balance system would match the demand for groundwater. This value is a theoretical calculation and may differ significantly from actual conditions.

These are a rough estimates of the future impacts and do not include details that would affect the estimate such as the impact of increasing groundwater withdrawals, and reduction in recharge due to restrictions to groundwater movement such as differing soil conditions that may be encountered as the cone of depleted groundwater expands.

TURLOCK GROUNDWATER BASIN EXPECTED LONG-TERM GROUNDWATER CONDITIONS

If current conditions continue in the Turlock Groundwater Basin, the upper basin will continue to be overdrafted, increasing the costs of pumping groundwater. The lower basin will continue to have adequate supplies and it will be necessary to continue pumping groundwater to control water levels from saturating the root zones of the most low lying lands.

The transition zone of the basin, between the lower basin where surface water is available, and the upper basin where groundwater is the only source of water, will see decreasing groundwater levels. However these levels will recede at slower rates than the upper basin that will be most heavily impacted.

Chapter 4

Alternatives

Introduction

The total imbalance between supply and demand within and around EWD is approximately 63,700 acre-feet annually. Therefore, the objective in this chapter is to identify and define as many possible alternatives, which may balance EWD's supply with demand.

There are two major elements comprising the possible alternatives. The first element is the items that are the sources of water or supplies, which might be made available for EWD through transfer, purchase, conservation, or appropriation.

The second major element comprising the alternatives is the facilities needed to convey, store, and deliver the water for use within EWD or within such places that benefit EWD.

The supplies section of this chapter describes the potential sources of water and defines the quantity and location of these sources. The facilities section of this chapter describes the facilities for conveyance, storage, and delivery; and defines the sizes, locations, capital costs, and operating costs of these facilities and the service areas associated with the facilities.

DEFINITION OF ELEMENTS OF ALTERNATIVES

The alternatives are all made up of elements that combine to comprise an alternative. The main elements are supply, conveyance, storage, and use. Most alternatives require the main elements of supply, conveyance, and use, although in-lieu recharge alternatives may be complete with only the in-lieu recharge element. The element of storage is only required where the time of availability is not compatible with the time of use. Other elements of the alternatives include the points of diversion, transfer or exchange agreements, and wheeling services. These elements are defined here.

Supply

Supply is the water itself. The supply is defined by the quantity available, time it is available (season), location where it is available (point of diversion), the frequency it is available (reliability), and the quality available (quality).

Conveyance

Conveyance is the element that is required to alter the place of availability. Conveyance may be canals or open channels, pipelines or conduits, and natural drainages. The parameter that critically defines conveyance is the flow rate that it can convey.

Storage

Storage is the element that is required to alter the time of availability. Storage can be in tanks, reservoirs, or in the underground aquifer. Storage will be required if water supplies are available before the time when the water is put to use. The parameter of storage that defines it is the volume of water that can be held and later released.

Use

Use is the application of the water. In this planning study the physical element of use is to apply water directly to agricultural, i.e. irrigation, or apply water to the groundwater aquifer, i.e. recharge. Use is defined by the quantity that is needed, the frequency or schedule it is needed, and the quality that is needed.

In-lieu recharge is a type of recharge wherein water demands historically met by groundwater pumping are met by supplying surface water or by decreasing groundwater demands through increased irrigation efficiency, thus reducing groundwater pumping.

Points of Diversion

Points of Diversion are the locations where water is diverted from the conveyance system into the distribution system, storage, or use.

Transfer or Exchange Agreements

Transfer or Exchange Agreements are the agreements whereby entitlement to use water change hands. As used here, transfers would be agreements where water is purchased by financial compensation or other compensation excluding trades of water. Exchanges would be agreements where water is traded. Typically water at one location is exchanged for water at a different location.

Wheeling

Wheeling is the conveyance of water through a facility that is owned and operated by an entity other than the owner of the water. Many of the alternatives here identify Turlock Irrigation District or Merced Irrigation District as a wheeler of water to the Eastside Water District. Wheeling is possible when capacity exists, or can be created by improvements, in the facilities conveying the water.

Supplies

The following descriptions identify and define alternatives for supply and in-lieu supply.

The alternatives listed are ideas. It is believed some of these ideas will work while some may not. But for this chapter all ideas count and are presented. In the next chapter the alternatives are subjected to analysis including economic feasibility, implementability, institutional suitability, and social suitability.

Some of the ideas discussed herein contemplate approaches that would involve incentive programs to encourage the adoption of different irrigation and/or cultural practices in order to free up water that could be transferred to other uses. The EWD recognizes that rights to the water rest with the irrigation districts and that any such programs would be subject to the approval and cooperation of the said districts. An example could be that the EWD could approach an irrigation district with a proposal to finance a program that the district would manage to offer incentives to farmers, thereby creating a pool from which conserved water could be transferred to EWD.

The alternatives or possible ideas are as follows:

SUPPLY ALTERNATIVE 1 – IRRIGATION EFFICIENCY

Improved irrigation efficiency offers the opportunity to maintain yields of current crops while increasing the availability of water by reducing the demand for water for those current crops through improved efficiency.

The decision to improve irrigation efficiency will be left to the farmer. EWD could consider creating and offering an incentive program to appeal to the District's farmers to willingly convert to more efficient irrigation systems. This incentive may encourage farmers who would like to convert by assisting with the cost of conversion. The intent of the irrigation efficiency alternative proposal is for conversion to occur on a voluntary basis only.

Improvements to irrigation efficiency can be made by:

- Adding tailwater recovery to flood/furrow irrigation,
- Converting flood irrigation to sprinkler, microsprinkler, or drip irrigation,
- Converting furrow irrigation to sprinkler, microsprinkler, or drip irrigation,
- Converting sprinkler irrigation to microsprinkler or drip irrigation.

Table 4.1 shows the typical efficiencies of different irrigation systems.

Table 4.1 California Department of Water Resources – Irrigation System Efficiencies

System	Efficiency
Drip/Microsprinkler	90-95
New, well maintained sprinklers	75-85
Older sprinklers	65-80
Flood, small basins	75-80
Contour flood	60-65
Furrow	40-60
Furrow with tailwater recovery	60-75

The irrigation efficiencies within the District are already high. Because the District already has highly efficient irrigation practices, the potential to decrease water demands through improved irrigation efficiency is small.

Appendix B contains the detail of the analysis used to determine the potential conserved water.

EWD Improved Irrigation Efficiency

EWD growers, with a majority of their lands in permanent crops and limited water supplies, already have high irrigation efficiency. In addition any water that is surplus to the uptake of the plants and the evaporation will percolate into the groundwater. For this reason, improved irrigation efficiency has reduced benefit within the District. The potential for savings has been estimated to be very low and is not considered a reasonable means of increasing available water supply.

A minor amount of tail-water recovery could be implemented. The estimated amount of water that could be recovered from furrow tailwater recovery in EWD is approximately 1,500 acre-feet.

Local Neighboring Districts Improved Irrigation Efficiency

The study briefly contemplated the prospect of approaching neighboring irrigation districts with a concept of EWD funding an incentive program (through the district) to encourage irrigators to voluntarily install or convert to more efficient irrigation systems such as tail water recovery systems, sprinklers, or drip/micro-sprinkler with the concept that conserved water could be made available to EWD. As discussed below, such a concept has many complex ramifications.

The assumption that improvements in irrigation efficiency within the neighboring districts will provide significant water is unlikely. The majority of the options for improving irrigation efficiency involve permanent crops moving to drip and micro systems. However, the existing irrigation practices within these districts are currently providing the majority of the groundwater recharge that in turn supplies drinking water for local cities, and small domestic systems, as well as irrigation water for local growers. Within the Turlock Groundwater Basin this proposal would result in a reduction in recharge on the eastern side of the TID, where much of the permanent crops are grown, to supply water to EWD. It would be expensive, produce no net benefit to the basin, and could potentially shift overdraft conditions to areas within TID.

To further complicate matters, current surface water delivery systems, many of which were built 75-100 years ago, were not designed to accommodate pressurized systems. A change in irrigation practices as proposed in the study, would not only require the development of new on-farm systems, but also many new distribution systems to deliver water to the farm. An additional concern for these types of systems is the aquatic weed growth in the canals clogging screens and other components, creating potential maintenance problems.

To resolve these problems, a change in irrigation practices sometimes includes a conversion from surface water to groundwater. This would further exacerbate the groundwater problem and shift the overdraft conditions to areas within the respective basins.

Changes in irrigation practices are also unlikely on the west side of the TID where corn, oats and alfalfa are grown to support the dairy industry. Drip, micro and sprinkler irrigation systems do not work well for these types of crops, particularly when the growers are utilizing nutrient water from the dairies for fertilizer.

Given the above, this alternative is not recommended for further consideration.

SUPPLY ALTERNATIVE 2 – CROPPING PATTERN CHANGES

Much of the lands throughout California's San Joaquin Valley are planted into low value field crop that require 3 to 6 acre-feet per acre per year (AF/A/Y) of water for irrigation. Some of these lands and micro-climates of those lands are well suited for permanent crops requiring 2 to 3 AF/A/Y for irrigation. Table 4.2 shows the potential demand reductions from cropping pattern changes.

EWD could consider offering an incentive program to encourage farmers to voluntarily convert their lower value and higher water consumption crops, to higher value and lower water consumption crops. Water conserved within EWD would contribute to balancing supplies with demands through in-lieu recharge.

The "low value" field crops identified are mainly comprised of alfalfa, pasture, corn and grain all of which are not grown for their individual value, but to support the local dairy industry - a much higher value crop. Another complicating factor is that the dairy industry utilizes nutrient water, produced by the dairy, to fertilize these crops. Thus, the shift in cropping suggested by this alternative is extremely unlikely. Given these considerations this alternative is not recommended for further consideration.

Table 4.2 Cropping Pattern Changes

	Existing Crop		Alternate Crops Potential for Water Demand Conservation (Acre-Feet)											
	Area (Acres)	Consumptive Use (Acre-Feet per Acre)	Alfalfa	Pasture	Walnut	Almond	Misc. Mixed Deciduous	Peach/ Nectarine	Citrus	Truck, Nursery, & Berry	Vineyards	Corn	Other field	Grain
Eastside ID														
Alfalfa	451	3.55		72	185	275	298	307	325	343	699	704	785	1,124
Pasture	3,904	3.39			976	1,757	1,952	2,030	2,186	2,342	5,426	5,465	6,168	9,095
Walnut	961	3.14				192	240	260	298	336	1,096	1,106	1,279	2,000
Almond	21,884	2.94					1,094	1,532	2,407	3,283	20,571	20,790	24,729	41,142
Misc. Mixed Deciduous	298	2.89						6	18	30	265	268	322	546
Peach/Nectarine	696	2.87							28	56	606	613	738	1,260
Citrus	49	2.83								2	41	41	50	87
Truck, Nursery, & Berry	160	2.79									126	128	156	276
Vineyards	7,454	2.00										75	1,416	7,006
Corn	1,627	1.99											293	1,513
Other field	1,238	1.81												928
Grain	3,971	1.06												
Dry Beans	2,011	0.95												

For example, conversion of all the 961 acres of walnuts to almonds in EWD would save 192 AFY of water

SUPPLY ALTERNATIVE 3 – WINTER SURPLUS FLOWS

The Turlock Groundwater Basin is bounded on the North by the Tuolumne River, on the South by the Merced River, and on the West by the San Joaquin River. The EWD is completely contained within this basin as shown in Figure 4.1. Flows in the Tuolumne and Merced Rivers are significant sources of irrigation water used within the Basin. This alternative considers the availability of excess water that may be present within these rivers at certain times of the year.

Figure 4.1 Major Rivers in the Turlock Groundwater Basin

The Tuolumne River is the Northern boundary of the groundwater basin. Flows into this river are controlled by releases from Don Pedro Reservoir. After leaving Don Pedro Reservoir, flows are diverted at La Grange Dam. Two canals receive water from this point of diversion and the remaining water continues downstream towards the San Joaquin River.

Figure 4.2 shows the average monthly flow volume for the river at La Grange Reservoir. Included in these flows are diversions by both TID and Modesto ID, as well as fish flows and other requirements.

The Merced River forms the Southern boundary of the groundwater water basin. The majority of the water in the river comes from releases from Lake McClure. Flows in the river are monitored by the California Department of Water Resources. Historical average monthly flow volumes are shown in Figure 4.3.

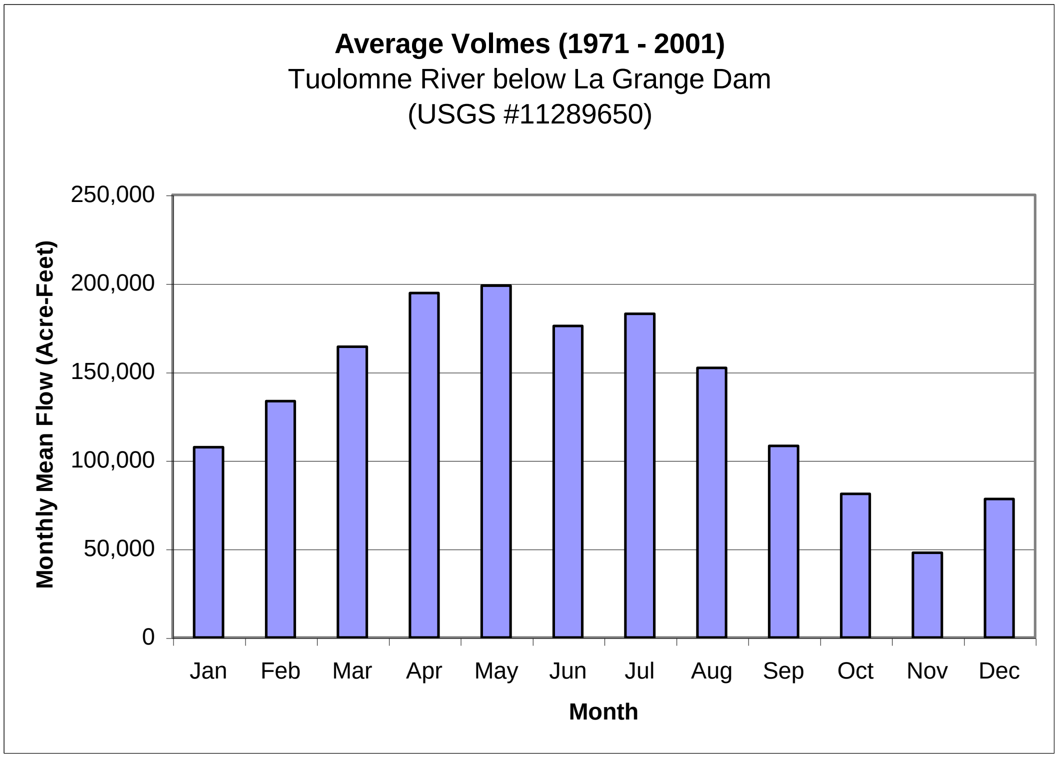

Figure 4.2 Tuolumne River Flows at La Grange Dam

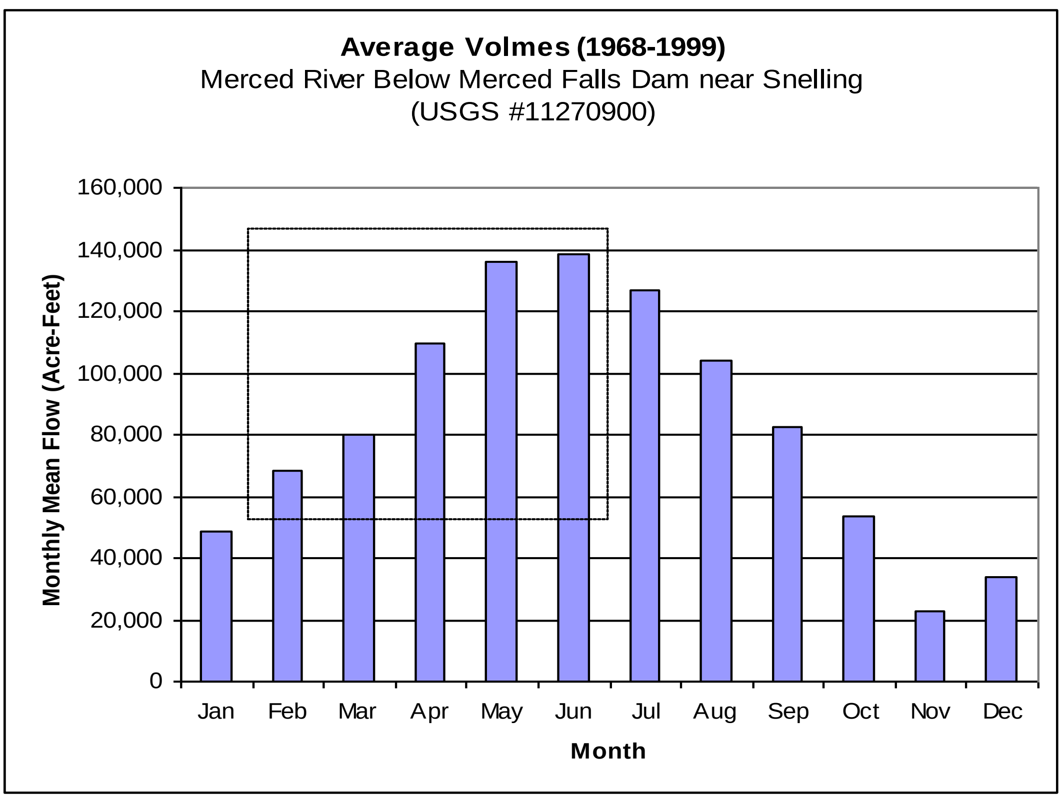

Figure 4.3 Merced River Flows

Pursuant to the State Water Resources Control Board's fully appropriated streams list, it has been determined that these two rivers are both "fully appropriated" during the months of March though September. This indicates that the state will not accept any requests for additional water rights during these months. It does leave the time period between October and February open, when water may be appropriated.

Supply Alternative 3a – Tuolumne River Winter Water

This alternative considers the possibility of using surplus water in the Tuolumne and Merced Rivers that may be available during months when crop irrigation is not typically occurring. Such surplus water would be stored for later use and require appropriate storage facilities. Alternatively, the water could be used for groundwater recharge. This recharge could be achieved through the use of constructed spreading basins or by flooding agricultural lands.

Tuolumne River records indicate that flood releases do occur, though not every year. Historically flood releases down the Tuolumne River have not occurred on a regular basis. For example, flood releases did not occur in 1977and 1987 through 1993. In addition, due to increases in fish flow requirements in recent years and changes in reservoir operations throughout the Tuolumne River watershed, current operations will not include releases as often as in the past.

It is important to note that flood releases are extremely variable in nature. To comply with reservoir operation ional requirements, flood releases typically occur over a very short period time The majority of flood flows released in any given month occurs over a period of days. For example, during the 1997 flood event the District released 1,158,457 AF down the river in 54 days, The remainder of the year was the driest in history. As a result , any plan to utilize flood releases would have to be deigned to accommodate the extreme fluctuations in flows, enabling large amounts of water to be captures over a very short period of time.

When facilities are developed to divert and store water for EWD these winter flows can be captured and utilized in several of the effective alternatives.

Supply Alternative 3b - Merced River Winter Water

There may be some winter flows available in the Merced River for diversion to EWD providing there is direct usage or storage available.

If the flow in excess of 50,000 AF each month was captured during the months of January through May an average of 193,000 AFA would become available. See the flows within the dashed line in figure 4.3.

Supply Alternative 3c – Eastside Water District Winter Water

This alternative would capture water from storm flows within EWD. This water may be used for groundwater recharge. The water balance indicates that precipitation provides 49,500 AFA of water and surface runon from areas outside of the District provides another 1,134 AFA. A large portion of this already percolates into the ground thus becoming groundwater.

The portion that currently runs off is estimated to be 15,984 AFA. This is not adequate to balance the demands with supplies. However, this would make a significant improvement over current conditions if this were captured and put to use or recharged.

The alternatives for soil stabilization and conservation practices would improve the capture of this water. However, it does not capture all of this runoff. Because of the multiple drainage paths leaving EWD this alternative can be implemented on several scales. On-farm practices or District wide projects can be developed in the many drainages in the District. With the result being increase in groundwater. Impacts from implementation of this alternative will be a reduction in surface water and a possible change in wildlife habitat.

SUPPLY ALTERNATIVE 4 – EWD SOIL STABILIZATION AND WATER AND CONSERVATION PRACTICES

The watershed within EWD offers the opportunity to construct soil stabilization and water conservation practices. Such practices might include:

Drainage Channel Drop Dams – Create several small dams along the length of a stream, in stair-step fashion, so that as water flows it is impounded behind the dam until the water reaches the top of each structure, at which point the water will spill into the next basin downstream. Pooled water will allow for greater amounts of groundwater recharge than flowing water.

Retention/Detention dams and reservoirs – Create large and small reservoirs that will serve two purposes. First they can store water when it becomes available. Thereby, making it available for use later. Second, groundwater recharge is accomplished while the water is impounded

Culverts and Drop Boxes – Various stormwater control measures can be used to divert storm flows from existing drainage into sumps that recharge groundwater directly.

Drainage diversion (outside EWD) to EWD – By accepting flows from outside the district, EWD will have more water that may be used for groundwater recharge. Once obtained, this water could be stored in a reservoir, recharge basin, or used for crop irrigation.

Map 3 shows the areas where these soil stabilization and water conservation practices may be implemented. Diagrams of the types of improvements are included on that map.

Using the EWD system water balance, it was estimated that approximately 7,400 acre-ft of run off water is available for this alternative. The development of this alternative could utilize a portion of this available run off to increase the recharge by an estimated 5,600 AFY.

SUPPLY ALTERNATIVE 5 – CONSTRUCTED MEANDERS IN DREDGER TAILINGS

On the Tuolumne River there are areas of approximately 1,000 acres, of dredger tailings. These tailings are the result of gold mining operations. The result of this process is a disturbed area that is no longer aesthetically pleasing or suitable for wildlife or vegetation.

An alternative was considered to make use of this area and to restore it to a more attractive and beneficial state would be to construct meanders within the river bottom. Meanders will serve to lengthen the stream course, thereby creating additional surface area along the river bottom. The additional length of river will improve groundwater recharge.

Consultation with TID revealed that assumptions for this alternative are inaccurate for a variety of reasons. First, the assumption that the Tuolumne River is a "losing" stream in the vicinity of Turlock Lake, and would therefore provide groundwater recharge, is inaccurate. Previous studies have shown that Turlock Lake provides recharge to this area and the river. As a result, this section of the river is a "gaining" reach, and such a project will not likely have a significant effect on the groundwater basin.

Secondly, a master plan has been developed for the lower Tuolumne River, designed to assist in the recovery of fisheries and habitat throughout the length of the river. This multi-million dollar project, developed in consultation with fishery agencies, environmental groups, and other interested parties, is currently being implemented. The plan does include expansion of the meander pattern, but not to the extent proposed.

Lastly, any project that would pull water from the stream and into the groundwater system would result in reduced stream flows and could adversely impact downstream fisheries. These impacts would have to be mitigated.

Given the above, this alternative is not recommended for further consideration.

SUPPLY ALTERNATIVE 6 – RECLAMATION OF MUNICIPAL & INDUSTRIAL WASTE WATER

The Eastside Water District's AB 303 study takes into consideration mutual neighboring concerns regarding reclaiming treated municipal wastewater reuse for irrigation purposes. Municipalities are facing new waste discharge requirements regarding NPDES permit renewals for effluent disposal. In addition in order to address existing and projected developed water short-falls within the State, The Governor, several years ago established a goal of increasing reclaimed water usage from 0.6 million acre feet annually (mafa) to approximately 1.3 mafa. Reclamation in California is governed by title 22 of the State Health Department.

Reclamation in the Turlock area can meet title 22 requirements. But major concerns and issues do exist. Major issues with most reclamation programs are:

- Project capital and operational costs.
- A willingness of the agricultural community to use reclaimed water.
- Crop and reclaimed water suitability.
- Winter usage, storage or discharge.
- Other alternatives for reuse and or disposal.
- Economic feasibility of alternatives.
- State and Federal sources of funding.
- NPDES or Waste Discharge permits and working with the Regional Water Quality Control Board and staff.
- Environmental issues and requirements.

Reclamation of municipal and industrial water for irrigation or recharge of the aquifer presents special concerns. The discharge of this water will be regulated by the State in order to protect users, indirect user, the environment, and consumers of crops irrigated with this water.

Irrigation water will be subject to restrictions based upon the quality of the water. Use of the water for recharge raises strong concerns that the quality of the water is adequately controlled such that recharge using it does not introduce contaminants into the groundwater. This alternative does have the potential to degrade groundwater if it is not managed well and monitored diligently.

In summary, the above issues and others need to be addressed to determine alternatives available to EWD and the City of Turlock. But it is believed this reclaimed water source could be made available to EWD. EWD would help pay for the cost of reclamation and reuse in exchange for a similar quantity of water.

SUPPLY ALTERNATIVE 7 - WATER MARKET

Turlock, Merced, and Modesto Irrigation Districts may have water available on an occasional basis or have the potential to implement water conservation programs that could conserve enough water to make water available in all years except dry years. The cropping pattern alternative is only one example of many measures that could conserve water.

Working with these Districts to reach agreements whereby, intermittent supplies of conserved water are available to the District in the short term and firm supplies become available in the long-term is paramount to solving the groundwater problems within the Turlock groundwater basin. Alternatives for capturing winter water are the only other real alternatives to providing long-term sustainable water supplies to the eastern portions of the Turlock groundwater basin.

Other Water Markets

EWD may consider purchasing water from other water districts in central and northern California. Psomas and other firms will identify and help negotiate agreements between willing sellers and buyers of water. To date there has been few long-term transfers. However over the last 10 years there have been many annual transfers of water. The SWRCB is working on requirements for long-term transfers and have recently supported such a transfer from the Imperial Irrigation District to the City of San Diego. A difficulty for EWD and water transfers is their having to make an exchange with Turlock Irrigation District for water delivered through the Highline Canal for their purchased water. This would result in at least a three party agreement, which may be complex and difficult to arrange.

The water purchased under this alternative would be exchanged for water delivered by Turlock Irrigation District or Merced Irrigation District.

Facilities

This section of the chapter defines the conveyance, storage, and delivery systems that could be developed for the District. Several different facilities are proposed here. Which of these facilities will be developed depends upon which source of water is procured and on which facilities produce the best improvement for the cost. This section identifies the, size, cost to construct, cost to operate, quantity of water to be handled, and area serviced for each proposed facility. Appendix B has detailed cost estimates for each facility.

Following this section in this chapter is a section that explains the options regarding which facilities are used with which water supply. In Chapter 5, Alternative Analysis, the combinations of supplies and facilities are analyzed for their effects, costs and implementability.

Map 2 shows the proposed facilities and the service areas associated with each. Figure 4.4 is a hydrologic element diagram that shows schematically those same existing and proposed facilities.

It should be noted that use of any existing facility requires the availability of capacity or improvement of that facility to make additional capacity available as well as an agreement with the owner of the facility for the use

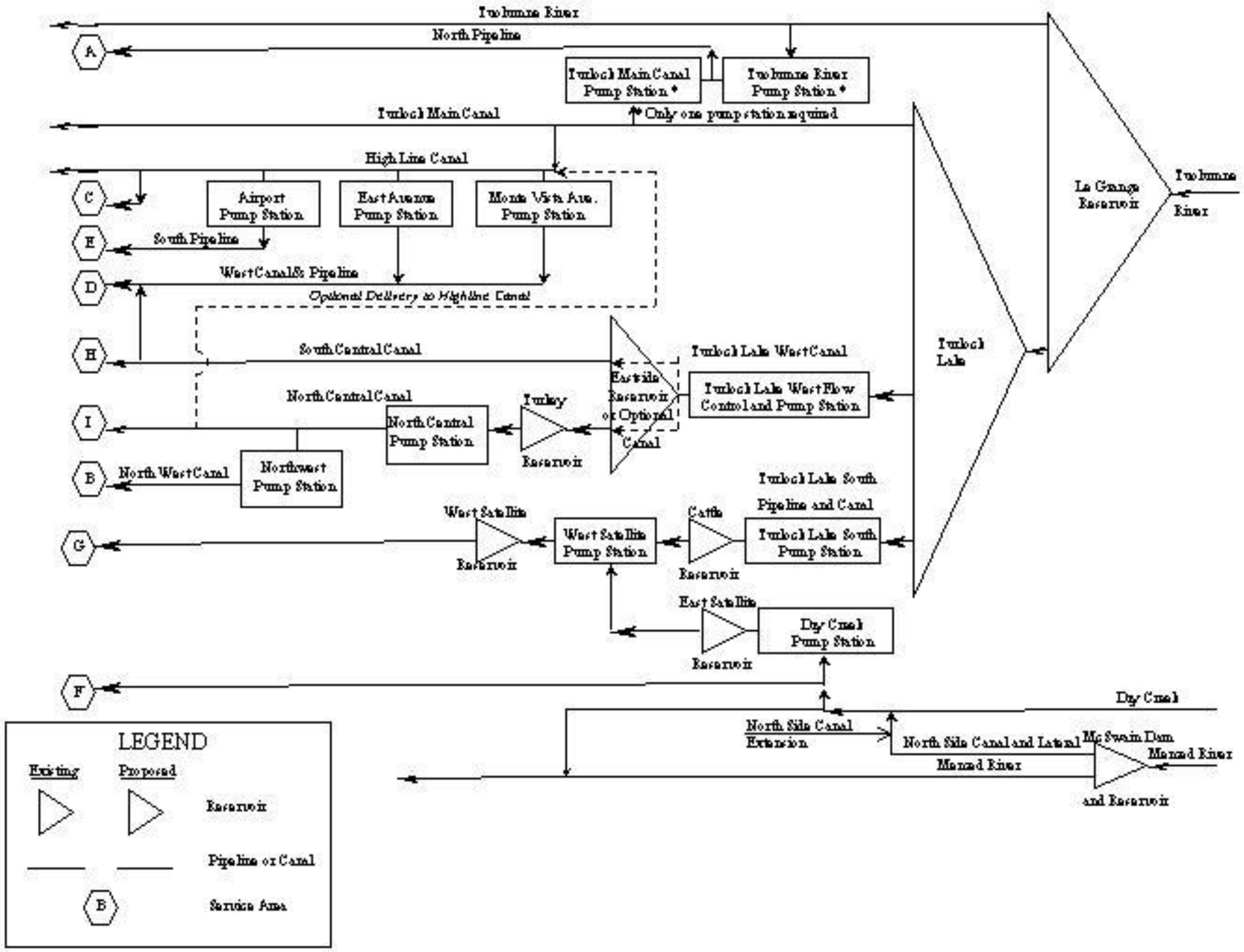

Figure 4.4 Hydrologic Elements Diagram

DISTRIBUTION FACILITIES

Turlock Main Canal (Existing)

Turlock Main Canal is an existing canal owned and operated by Turlock Irrigation District. The canal transits the north side of EWD making it a potential facility to convey water to the District. However, use of this facility or any other existing facility requires that capacity exists or may be created by improvements for additional water.

Highline Canal (Existing)

Highline Canal is an existing canal owned and operated by Turlock Irrigation District. The canal transits the west side of EWD making it a potential facility to convey water to the District.

North Side Canal and Lateral (Existing)

The North Side Canal and lateral are existing facilities owned and operated by Merced Irrigation District. These facilities are located slightly south of EWD and have the potential to convey water to proposed District facilities. They also have the potential to convey flood release water to any retention /drop dam type facilities in Dry Creek in order to increase groundwater recharge.

Tuolumne River Pump Station/Turlock Main Canal Pump Station and Pipeline

This is a single pump station that could be located either along the Turlock Main Canal or on the Tuolumne River, depending upon the source that is procured. One pump station has been defined here based upon pumping from the river. A pump station along the Turlock Main Canal would have a slightly lower cost to construct and operate due to a reduced head that would be required.

The Tuolumne River pump station would provide 13,000 AF of water during the irrigation season to service area A, 4,350 acres. The pump station would have 1,860 horsepower of pumps, pumping water at 68 cfs at a head of 181 feet. The main distribution of water from this pump station would be through a 54 inch diameter pipeline 20,600 feet long.

Turlock Lake South Pump Station, Pipeline, and Canal

The Turlock Lake south pump station, pipeline and canal would provide 4,800 AF of water during the irrigation season to service area G, 1,600 acres. The pump station would have 174 horsepower of pumps, pumping water at 25cfs at a head of 46 feet. The main distribution of water from this pump station would be through a 36 inch diameter pipeline 5,300 feet long, then into a canal with a crossectional area of 17 square feet. The canal would incorporate an existing stock pond, Cattle Reservoir, into the conveyance system. A second lift of the water would be required to move water into an existing stock pond, West Satellite Reservoir, for conveyance to service area G. Those facilities, West Satellite Pump Station, Pipeline, and Canal are described later.

The Dry Creek pump station could also provide water to the same service area as this pump station. Only one of these facilities would be constructed to irrigate service area G.

West Satellite Pump Station, Pipeline, and Canal

The West Satellite pump station, pipeline, and canal would provide 4,800 AF of water during the irrigation season to service areas G. The pump station would have 205 horsepower of pumps, pumping water at 25 cfs at a head of 54 feet. The pumps would be fed by the Turlock Lake South Pump Station, Pipeline and Canal or the Dry Creek Pump Station, Pipeline, and Canal. The West Satellite pump station would discharge into a 36 diameter by 3700 length pipeline that would discharge into a canal with a crossectional area of 17 square feet and length of 9,000 feet. This system would use an existing stock reservoir, West Satellite, as part of the conveyance.

Turlock Lake West Flow Control/Pump Station and Canal or Reservoir

The Turlock Lake west flow control/pump station (hereafter referred to as pump station) and canal has the potential to operate two different ways. The pump station would operate with the proposed Eastside Reservoir or without it.

With reservoir operation, the pump station would feed the Reservoir. The canals and pipelines would then be fed from the reservoir. With direct operation, i.e. no reservoir, the canals and pipelines would be fed directly by the pump station. With either operation service areas B, D, H, & I having acreages of 2,900, 3,900, 11,650, 10,800, respectively could potentially be served.

The irrigation requirements for the four service areas would be 88,000 AFA. The evaporation and seepage losses from the reservoir would be 4,300 and 3,300 respectively. Reservoir operation would then require 95,600 AFA. With reservoir operation winter water could be captured into Turlock Reservoir then transferred to Eastside Reservoir. With direct operation the water requirement to serve the four service areas would be only the irrigation requirement of 88,000 AFA. Water for direct operation would need to be from storage in, or wheeled through, Turlock Lake.

When Turlock Lake is high, water would flow by gravity through the flow control structure into Eastside Reservoir or a canal. At other times the water would be lifted into the reservoir or canal by the pump station. The pump station has been sized here to serve the four services areas and to pump the water required for the four service areas during the irrigation season. In other words the pump station is sized for direct operation. If reservoir operation is developed, the pump station may be reduced in size, since non irrigation season pumping could occur.

The pump station would provide 88,000 AF of water during the irrigation season. The pump station will have 2,760 horsepower of pumps, pumping water at 456 cfs at a head of 40 feet.

The Eastside Reservoir would impound 14,300 AF, require an earth dam of approximately 55 feet in height and 175 feet in width, containing

510,000 cubic yards of material. A canal with a crossectional area of 300 square feet and length of 3,200 would be required from the pump station to the reservoir.

If direct operation is developed a canal, Eastside Canal and pipeline (inverted siphon), would be required from the pump station to the points where the South Central and North Central Canals begin. The Eastside Canal would have a cross-sectional area of 300 square feet and a length of 26,400 feet. The inverted siphon would have a diameter of 120 inches and length of 2,100 feet.

South Central Canal

The South Central canal would provide 47,000 AF of water during the irrigation season to service areas H and D with, 11,650 and 3,900 acres respectively. The canal would be fed from Eastside Reservoir or Canal. The cross-sectional area of the canal would be 162 square feet.

North Central Pump Station, Pipeline, and Canal

These facilities would provide water to service area I and to the Northwest pump station, pipeline, and canal which will provide water to service area B. These facilities have the option of conveying water to the Turlock Irrigation District's Highline Canal above the proposed points of diversion for service areas C, D, and E. The facilities are sized here to provide water for service areas B and I with acreages of 2,900 and 10,800, respectively.

The North Central pump station would provide 41,000 AF of water during the irrigation season to service areas B and I. The pump station would be fed water from the Eastside Reservoir or Canal through a canal that incorporates an existing reservoir, Turkey Reservoir, into the conveyance.

The pump station would have 1250 horsepower of pumps, pumping water at 214 cfs at a head of 39 feet. The pumps would be fed by a canal from the Eastside reservoir or canal, having a cross-sectional area of 142 square feet and a length of 4,200. The pump would discharge into a 90 inch diameter by 5,300 feet length pipeline that would discharge into a canal with a cross-sectional area of 142 square feet and length of 32,000 feet.

Northwest Pump Station, Pipeline, and Canal

These facilities will provide water to service area B. The Northwest pump station would provide 8,600 AF of water during the irrigation season to service areas B, 2,900 acres. The pump station will have 300 horsepower of pumps, pumping water at 45 cfs at a head of 44 feet. The pumps would draw water from the North Central Canal. The pump would discharge into a 42 inch diameter by 5,300 feet length pipeline that would discharge into a canal with a cross-sectional area of 30 square feet and length of 17,000 feet.

North Side Canal Extension

North Side Canal Extension would be an extension of an existing unnamed lateral of the Merced Irrigation District's North Side Canal. This proposed facility would provide irrigation water to service area F, 7,900 acres and may also provide irrigation water to service area G, 1,600 acres. Each case is defined here.

The North Side Canal Extension serving only area F would convey water from an existing lateral of Merced ID's North Side Canal to Dry Creek. Dry Creek would then be used as a conveyance to service area F. Water would be withdrawn along Dry Creek using pumps installed in the creek by farmers.

The proposed North Side Canal Extension, to serve only area F, would be a canal conveying 125 cfs with a cross-sectional area of 82 square feet and a length of 17,400 feet.

To serve areas F and G the North side canal extension would be larger and would include the Dry Creek pump station, pipeline and canal.

The proposed North Side Canal Extension, to serve both areas F and G would be a canal conveying 148 cfs with a cross-sectional area of 98 square feet and a length of 17,400 feet.

Dry Creek Pump Station, Pipeline, and Canal

The Dry Creek pump station, pipeline, and canal would provide 4800 AF of water during the irrigation season to service areas G, 1,600 acres. The pump station would have 240 horsepower of pumps, pumping water at 25 cfs at a head of 64 feet. The pumps would be fed by the North Side Canal Extension at Dry Creek. The pump would discharge into a 36 inch diameter by 3,200 feet length pipeline that would discharge into a canal with a cross-sectional area of 17 square feet and length of 7,400 feet. This system would use an existing stock reservoir, East Satellite, as part of the conveyance.

A second of water via the West Satellite pump station, pipeline and canal is required to move water to service area B. Those facilities were defined previously.

Monte Vista Avenue Pump Station, Pipeline and Canal

The Monte Vista Avenue pump station, pipeline, and canal would provide 12,000 AF of water during the irrigation season to service areas D, 3,900 acres. The pump station would have 500 horsepower of pumps, pumping water at 61 cfs at a head of 55 feet. The pumps would be fed by the Highline Canal or the North Central Canal.

The Monte Vista Avenue pump station would discharge into a 48 inch diameter by 13,000 feet length pipeline that would discharge into a canal with a cross-sectional area of 20 and length of 17,000 feet.

Service area D may also be served by the South Central Canal system or by the East Avenue Pump Station system.

East Avenue Pump Station Pipeline, and Canal

This pump station would serve the same service area, D, 3,900 acres, as the Monte Vista Avenue facilities. The size of these facilities would be very similar to the Monte Vista Avenue Facilities. However, this facility would require water from the Highline Canal.

The East Avenue pump station would discharge into a 48 inch diameter by 10,500 feet length pipeline that would discharge into a canal with a cross-sectional area of 20 square feet and length of 17,000 feet.

Airport Pump Station and Pipeline

The Airport pump station and pipeline would provide 8,600 AF of water during the irrigation season to service areas E, 2,900 acres. The pump station would have 320 horsepower of pumps, pumping water at 45 cfs at a head of 47 feet. The pumps would be fed by the Highline Canal.

The Airport pump station would discharge into a 42 inch diameter by 14,000 feet length pipeline.

RESERVOIRS

Turlock Lake (Existing)

Turlock lake is owned and operated by the Turlock Irrigation District. The lake is approximately 3 miles northeast of EWD. The storage capacity of Turlock Lake is 45,600 acre-ft. The reservoir was completed in 1915.

Eastside Reservoir

Eastside Reservoir is a proposed reservoir located south of Turlock Lake. Water delivered to the Eastside Reservoir would be diverted from the Tuolumne River and wheeled through Turlock Irrigation District's Main Canal and Turlock Lake to the reservoir or would come from storage in Turlock Lake. The description of these facilities is found with the description of the Turlock Lake West Flow Control/Pump Station and Canal or Reservoir.

Cattle Reservoir (Existing)

Cattle Reservoir is an existing stock pond that is incorporated into the Turlock Lake South Pipeline and Canal system. It is estimated that this reservoir has a capacity of 2,600 acre-ft.

East Satellite Reservoir (Existing)

East Satellite is an existing stock pond that would be incorporated into the conveyance system of the Dry Creek Pump Station system. The stock pond has a surface are of 20 acres and is estimated to hold 30 AF.

RECHARGE BASINS

The proposed recharge basins have been designed to compensate the entire estimated overdraft of 63,700 AFY. Initial recharge rates demonstrated by the pilot project were very good. During the first year of operation the average daily recharge rate for the year was 1.5 feet per day. With improved management, during the third and final year of operation, the average daily recharge rate for the year was 2.7 feet per day. The area of the Pilot Recharge Basin was one-quarter acre. It is recognized that the daily recharge rate in larger basins will likely be less. Further it is also recognized that the geology and attendant recharge rates will vary between sites. Thus, it is difficult to estimate what the annual recharge might be. For planning purposes we will assume an average daily recharge rate of 0.75 feet per day. With a recharge season of 200 days per year, the estimated average annual recharge achievable would be 150 acre-feet/acre annually. To achieve a complete balance of supply vs. demand for the 63,700 AF of annual overdraft would require approximately 467 acres of recharge facilities.

The location of the recharge basins would depend on permeability conditions and proximity to a water source. Twelve borings were made at potential sites for recharge basins. The logs of the borings and a letter prepared by Ken Schmidt discussing the findings from the borings is included Appendix B.

The sites for recharge basins were ranked for suitability based on Ken Schmidt's findings. They are presented below in Table 4.3

Table 4.3 Ranking of Borings

Borings Ranked Favorable	BH-25, BH-26, BH-29, BH-30
Borings Ranked Intermediate	BH-23, BH-27, BH-28, BH-32
Borings Ranked Unfavorable	BH-22, BH-24, BH-31, BH-33

The borings ranked favorable have predominately sandy soil above forty feet in depth and have groundwater level that are at least forty-five feet below the ground surface.

The borings ranked unfavorable have clay or silt layers within twenty-eight feet of the surface or have groundwater within twenty-five feet of the ground surface.

The borings ranked intermediate had silt or clay at levels between twenty-eight feet and forty feet below the ground surface or had groundwater twenty and forty-five feet below the ground surface.

The locations of borings ranked favorable will have the least overburden to remove to develop recharge basin and therefore, will have the least cost to develop. These sites warrant first consideration for recharge sites over the others.

In considering locations which warrant further investigation two of the four favorable borings are near the highline canal, which would be the best conveyance facility to deliver water.

Chapter 5

Project Alternatives and Analysis

Project Alternatives

Project alternatives are those that, by a combination of supply and facilities, can produce benefit to the District through the construction and operation of facilities, or are alternatives that by means other than a supply and facilities, produce benefit to the District.

For example, the alternatives such as improved irrigation efficiency and cropping pattern changes when implemented within EWD have the potential to improve conditions in and around EWD without the construction or operation of facilities other than changes in on-farm operations or soil conservation practices.

Using the criteria that a benefit is created by an alternative, regardless of whether the alternative utilizes supplies or facilities in the alternative, twenty one alternatives were identified as project alternatives that can produce benefit to EWD.

Table 5.1 is a list of all the project alternatives and the wheeling facilities needed. It is followed by a description of each alternative. The facilities locations and areas served are shown on Map 2.

Following the descriptions of alternatives is Table 5.2 indicating the potential quantity of water each alternative can provide, and the costs associated with each alternative.
Please note that use of any existing facilities requires the availability of capacity or improvement of that facility to make additional capacity available as well as an agreement with the owner of the facility for the use.

Table 5.1 Project Alternative and Wheeling Facilities Needed

	Project Alternatives	Water Delivered Through TID Facilities*	Water Delivered Through MID Facilities*
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.		
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	x	
PA-3	Use existing highline canal. Serves area C.	x	
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	x	
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	x	
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	x	
PA-7	Northside canal extension. Serves area F.		x
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.		x
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	x	
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	x	
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	x	
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	x	
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	x	
PA-14	Serves areas HDIB served by east side canal.	x	
PA-15	Serves areas HDIB served by east side reservoir.	x	
PA-16	Recharge Basins.	TBD	TBD
PA-17	EWD Improved Irrigation Efficiency.	Not Applicable	Not Applicable
PA-18	Cropping Pattern Changes within EWD.	Not Applicable	Not Applicable
PA-19	EWD Soil Stabilization and Water Conservation Practices.	Not Applicable	Not Applicable
PA-20	Constructed Meanders in Dredger Tailings.	Not Applicable	Not Applicable
PA-21	EWD Winter Water.	Not Applicable	Not Applicable
PA-22	No Action.	Not Applicable	Not Applicable

PA-1. TUOLUMNE RIVER PUMP STATION AND PIPELINE

This alternative consists of a pump station on the Tuolumne River and a pipeline delivering water to the service area "A". Water could be purchased from TID. TID diverts water upstream of the proposed pump station, and could leave water in the river for EWD to pump out. TID could also conserve water on its own land and sell the river water it did not use to EWD. Water could also be purchased from MID to meet TID's VAMP obligations and the water TID did not use could be diverted to EWD. Since the Tuolumne River is fully appropriated during the irrigation season, applying for water rights would not be a supply option for this alternative. It should also be noted that due to the higher elevation of the service area, energy costs make this an expensive alternative.

PA-2. TURLOCK MAIN CANAL PUMP STATION AND PIPELINE

This alternative is similar to PA-1 except its pump station is located on the Turlock Main Canal. It also serves area "A" and is less costly to operate due to reduced pumping distance and elevation.

PA-3. USE OF EXISTING HIGHLINE CANAL

No major facilities need to be built for this alternative, which serves area "C". Since the Highline Canal passes through the service area, it is proposed that water be purchased as described in PA-1 and used by the farmers directly from the canal.

PA-4. EAST AVENUE PUMP STATION, PIPELINE, AND WEST CANAL

Area "D" is served by this alternative. Water purchased from TID or MID, as described in PA-1, would be pumped out of the Highline Canal at East Avenue and pumped through a pipeline to the western part of Area "D". A canal serves the eastern part of the area since it has a lower elevation.

PA-5. MONTE VISTA PUMP STATION, PIPELINE, AND WEST CANAL

This alternative also serves Area "D" in a similar way to PA-3, except for the location of the pump station. The source would also be Highline canal, but at Monte Vista Avenue.

PA-6. AIRPORT PUMP STATION AND PIPELINE

This alternative's pump station would be located near the Airport on Branch Canal, which branches off Highline Canal. A pipeline would serve Area "E" by purchasing water from TID or MID as described in PA-1.

PA-7. NORTHSIDE CANAL EXTENSION

Area "F" would be served by this alternative, which proposes the Northside Canal to be extended to meet and discharge into Dry Creek. Water would have to be purchased from MID or TID as described in PA-1 and Dry Creek would be used as a conveyance system. Since only a canal has to be constructed and no pumping is required, PA-6 is the lease expensive alternative.

PA-8. NORTHSIDE CANAL EXTENSION WITH DRY CREEK PUMP STATION, EAST SATELLITE RESERVOIR AND CANAL, WEST SATELLITE PUMP STATION, PIPELINE, AND CANAL

Areas "F" and "G" would be served by this alternative that is an extension of PA-6. Dry Creek Pump Station would be placed at or downstream of the Northside Canal discharge point on Dry Creek. Water would be conveyed to Eastside Reservoir by a pipeline and canal, and from Eastside reservoir to the West Satellite Pump Station via Eastside Canal. West Satellite Pipeline and Canal would take water from the same pump station to the West Satellite Reservoir, from where a canal would distribute it to Area "G". The energy cost is significantly higher for the increase in service area compared to alternative PA-6, but could still be affordable.

PA-9. TURLOCK LAKE SOUTH PUMP STATION, PIPELINE, AND CANAL, CATTLE RESERVOIR, AND WEST SATELLITE FACILITIES

This alternative serves area "G" only and used the West Satellite facilities described in PA-7. Water would be delivered to the West Satellite Pump Station from Turlock Lake via a pump station, pipeline, and canal. The canal would discharge into the northern end of the Cattle Reservoir and pick up again on its southern end to continue to West Satellite pump station. This alternative would require water to be purchased from TID or MID as described in PA-1, and is relatively expensive due to two pump stations and energy costs.

PA-10. SOUTH CENTRAL CANAL SERVED BY EASTSIDE CANAL. USES EAST AVENUE PUMP STATION AND WEST CANAL FLOWING EAST TO WEST.

This alternative proposes to serve areas "H" and "D", with water from Turlock Lake purchased as described in PA-1. Turlock Lake West Flow Control and Pump Station would send water down Eastside Canal and onto the South Central Canal, which serves area "H". At the end of the South Central Canal, the facilities describes in PA-3 (East Avenue Pump Station, Pipeline, and West Canal) would take over with a modification. South Central Canal would empty its water into the West Canal, which would now flow from east to west. The West Canal would serve the eastern part of area "D" and also deliver water to the East Avenue Pump Station moved slightly north. The pipelines would further distribute water to the western part of area "D".

PA-11. SOUTH CENTRAL CANAL SERVED BY EASTSIDE RESERVOIR. USES EAST AVENUE PUMP STATION AND WEST CANAL FLOWING EAST TO WEST.

The proposed Eastside Reservoir would take the place of the Eastside Canal in PA-9, the rest of which is the same in this alternative. Creation of the Eastside Reservoir would involve mitigation of environmental impacts. However, it would be exempt from certain safety laws since it would not be in the direct path of a stream. An added benefit of the reservoir would be storage for winter water and storage for dry years and increased recharge of ground water.

PA-12. NORTH CENTRAL PUMP STATION AND CANAL SERVED BY EASTSIDE CANAL.

Area “I” would be served by this alternative, and would use the Eastside Canal described in PA-10. The Eastside Canal would flow into Turkey reservoir, from where the North Central Pump Station would pump water through a pipe to the North Central Canal. The North Central Canal would serve the entire area “I” and connect to the Highline Canal.

PA-13. NORTH CENTRAL AND WEST PUMP STATIONS, PIPELINES, AND CANALS.

As an extension of PA-11, both areas “I” and “B” would be served by this project alternative. The North West Pump Station would be placed on the North Central Canal and the North West Pipeline and Canal would supply water to area B. The unit cost of this alternative is slightly lower than PA-11.

PA-14. COMPLETE HDIB SERVED BY EASTSIDE CANAL

This alternative serves areas “H”, “D”, “I”, and “B”. It is a combination of PA-9 and PA-12. The unit cost of water is significantly reduced due to the combination of the two alternatives.

PA-15. COMPLETE HDIB SERVED BY EASTSIDE RESERVOIR

This alternative serves areas “H”, “D”, “I”, and “B”. It is a combination of PA-10 and PA-12. The unit cost of water is significantly reduced due to the combination of the two alternatives.

PA-16. RECHARGE BASINS

Recharge basins will directly replenish the groundwater, as described in more detail in Chapter 4. The success of this alternative largely depends on the recharge rates achievable. The facility can be constructed in phases, depending on the amount of external water the District is able to obtain annually. The phases may be located in more than one area, depending on local seepage and supply conditions.

PA-17. EWD IMPROVED IRRIGATION EFFICIENCY

Please see the Supplies section of Chapter 4 for details on this alternative.

PA-18. CROPPING PATTERN CHANGES WITHIN EWD

Cropping pattern changes with EWD have the potential to reduce water demands by 33,000 AFY. This reduction in demands would not bring the supply in balance with demands. However, this is an increment of improvement in balancing the supply with demand. There is limited acreage within the District that could convert and since this will be a voluntary program with an incentive offered by the District, the actual amount of farm acreage that changes cropping will probably be less than all the lands with the potential. Also this estimate assumes the lands are converted to the lowest consumptive use crop that will provide an increase in the farm income.

PA-19. EWD SOIL STABILIZATION AND WATER CONSERVATION PRACTICES

This alternative has the potential to improve groundwater recharge by an estimated 5,600 AFY. This clearly does not balance the supply with demands. However it is does contribute toward reducing the imbalance of supply and demand.

PA-20. CONSTRUCTED MEANDERS IN DREDGE TAILINGS

This alternative has significant costs due to earthwork and has the potential to require significant environmental impacts during construction of the meanders due to grading and excavating in the river bottom. The complete project would have environmental benefits such as improved re-vegetation and habitat for wildlife and fish. However, these would be accompanied by significant impacts during construction.

PA-21. EWD WINTER WATER

Please see the Supplies section of Chapter 4 for details on this alternative.

PA-22. NO ACTION

No action would make ground water prohibitively expensive to pump in the future and render agriculture economically unfeasible. Also, the groundwater quality could deteriorate by contamination with saline water upwelling from the lowest aquifers.

Analysis Process

The project alternatives were proposed and defined in the previous chapters of this study.

All of the project alternatives were analyzed. The findings from the analysis of each project alternative are presented in this chapter.

The overall rankings for the project alternatives are presented in Chapter 6. Recommendations for development of project alternatives are presented in Chapter 7.

LIFE EXPECTENCY

Life expectancies were checked for all alternatives. The study parameters set fifty years as the minimum duration for an alternative to meet the project needs. The life expectancy of all alternatives was determined to meet or exceed the project planning period of fifty years.

EFFECTIVENESS BY DELIVERED OR RECHARGED WATER

The Eastside System water balance was used to predict the effectiveness of each project alternative,

Table 5.2 gives the results of the analysis indicating the quantity of water supplied or recharged by each of the project alternatives. An explanation of the costs shown follows Table 5.2.

Table 5.2 Cost Analysis of Facilities

	Project Alternatives	Area Served	Service Area (Acres)	Delviered or In Lieu Water, AF	Capital Costs of Main Conveyance Facilities	Annual Payment for Capital and Amoritization @ 6%, 20 years	Annual Operations, Maintenance Repair, and Replacement	Annual Energy Costs for Pumping	Total Annual Cost for Capital payments, O&M, and Energy for main conveyance facilities	Cost per Acre-ft for end-user delivery (from main conveyance facility to field)	Cost per Acre-ft of Appropriated or In-lieu water	Cost per Acre-ft of water purchased at $50/Acre.ft
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	A	4,350	13,100	$11,100,000	$970,000	$19,000	$600,000	$1,589,000	$34	$155	$205
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	A	4,350	13,100	$8,300,000	$730,000	$8,000	$250,000	$988,000	$34	$109	$159
PA-3	Use exisiting highline canal. Serves area C.	C	1,600	4,800						$68	$68	$118
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	D	3,900	11,700	$3,800,000	$340,000	$5,700	$150,000	$495,700	$68	$110	$160
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	D	3,900	11,700	$4,440,000	$390,000	$5,700	$160,000	$555,700	$68	$115	$165
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	E	2,880	8,700	$3,800,000	$340,000	$3,000	$100,000	$443,000	$68	$119	$169
PA-7	Northside canal extension. Serves area F.	F	8,000	24,000	$290,000	$30,000	$1,800		$31,800	$68	$69	$119
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	F,G	9,600	28,800	$2,280,000	$200,000	$6,300	$144,000	$350,300	$68	$80	$130
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	G	1,600	4,800	$2,400,000	$210,000	$6,100	$122,000	$338,100	$68	$138	$188
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	H,D	15,550	46,700	$9,700,000	$850,000	$51,600	$570,000	$1,471,600	$68	$100	$150
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	H,D	15,550	46,700	$14,200,000	$1,240,000	$84,100	$570,000	$1,894,100	$68	$109	$159
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	I	10,820	32,500	$9,550,000	$840,000	$55,500	$730,000	$1,625,500	$68	$118	$168
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	I,B	13,700	41,100	$11,940,000	$1,050,000	$63,500	$859,000	$1,972,500	$68	$116	$166
PA-14	Serves areas HDIB served by east side canal.	H,D,I,B	29,250	87,800	$16,540,000	$1,450,000	$74,600	$1,429,000	$2,953,600	$68	$102	$152
PA-15	Serves areas HDIB served by east side reservoir.	H,D,I,B	29,250	87,800	$21,040,000	$1,840,000	$107,100	$1,429,000	$3,376,100	$68	$106	$156
PA-16	Recharge Basins.			63,700	$3,738,000	$330,000	$37,380		$367,380		$6	$56
PA-17	EWD Improved Irrigation Efficiency.			29,000	$29,600,000	$2,590,000			$2,590,000		$89	n/a
PA-18	Cropping Pattern Changes within EWD.			33,000	$298,300,000	$26,100,000			$26,100,000		$791	n/a
PA-19	EWD Soil Stabilization and Water Conservation Practices.			5,600	$150,000	$20,000	$750		$20,750		$4	n/a
PA-20	Constructed Meanders in Dredger Tailings.			11,000	$2,800,000	$250,000			$250,000		$23	n/a
PA-21	EWD Winter Water.			5,600	$150,000	$20,000	$750		$20,750		$4	n/a
PA-22	No Action.											

UNIT COSTS

The unit cost of water provided by each project alternative was determined according to:

- The water delivered or recharged (derived from the water balance spread sheet), annually,
- The annual cost of capital improvements for the main conveyance facilities based upon a twenty year amortization at six percent interest,
- The annual cost for operations, maintenance, repair and replacement,
- The annual cost for energy assuming an energy cost of $0.15 per kilowatt-hour.
- The annual cost of delivery systems (from the main conveyance facilities to the fields) based upon a twenty year amortization at six percent interest and the annual operations, maintenance, repair, replacement and energy.

The costs to purchase water were not included first column of unit costs. Another column in the table shows the unit costs if water is purchased at fifty dollars per acre foot. Fifty dollars per acre foot was set based upon the current market. This year water has been purchased from farmers and irrigation Districts by Metropolitan Water District for as much as $150 per acre foot. Local sales of water within basin to neighboring water users has been in the range of $25 per acre foot. The assessment of the market is that higher priced water will not all be sold, leaving it available on the market at a lower price that we have estimated to be $50 per acre foot.

Long-term water requirements may be on an as-available or “wet” year basis since EWD has the capacity of managing their water conjunctively and using groundwater in dry years.

The costs for delivery systems were reported in a separate column to facilitate the consideration of different forms of institutions to construct and operate the facilities, e.g. EWD, landowners, special districts.

Other analyses of the costs of the project alternatives have been prepared and can be found in Appendix C.

CROP LOSS OR GAIN AND AGRICULTURAL PRODUCTION

The majority of project alternatives do not affect crop values. Those that do affect crop values were analyzed to determine the value of crop loss or gain.

The notable crop value changes are associated with the Cropping Pattern Changes within EWD alternative and the No Action alternative.

Cropping pattern changes within neighboring Districts also has the potential to change agricultural production. However, implementation of these alternatives is not identified as stand-alone project alternatives. As such the change in crop production was not analyzed in this chapter.

The effect of cropping pattern changes occurring within EWD were selected to produce the maximum conservation of water and produce a positive change in crop value. Under the selected cropping pattern changes the District would realize an increase in annual crop value of $258 million.

The No Action alternative has a definite effect on crop production. Based upon the current trend in groundwater conditions the availability of groundwater will decrease or require greater inputs of energy to maintain the current supply. Over time the quantity of groundwater available will become prohibitively expensive or will degrade as the salinity of groundwater increases. Both of these conditions will contribute to a decrease in the crop value.

GROUNDWATER YIELD AND PUMPING WATER LEVEL CHANGES

Project alternatives were analyzed to estimate the change in the groundwater yield and level as a result of implementation of each alternative. With the estimate of groundwater level change, estimates of the change in energy required for pumping from the changed level can be made.

Figure 5.1 presents the estimated changes in groundwater level per year for each alternative.

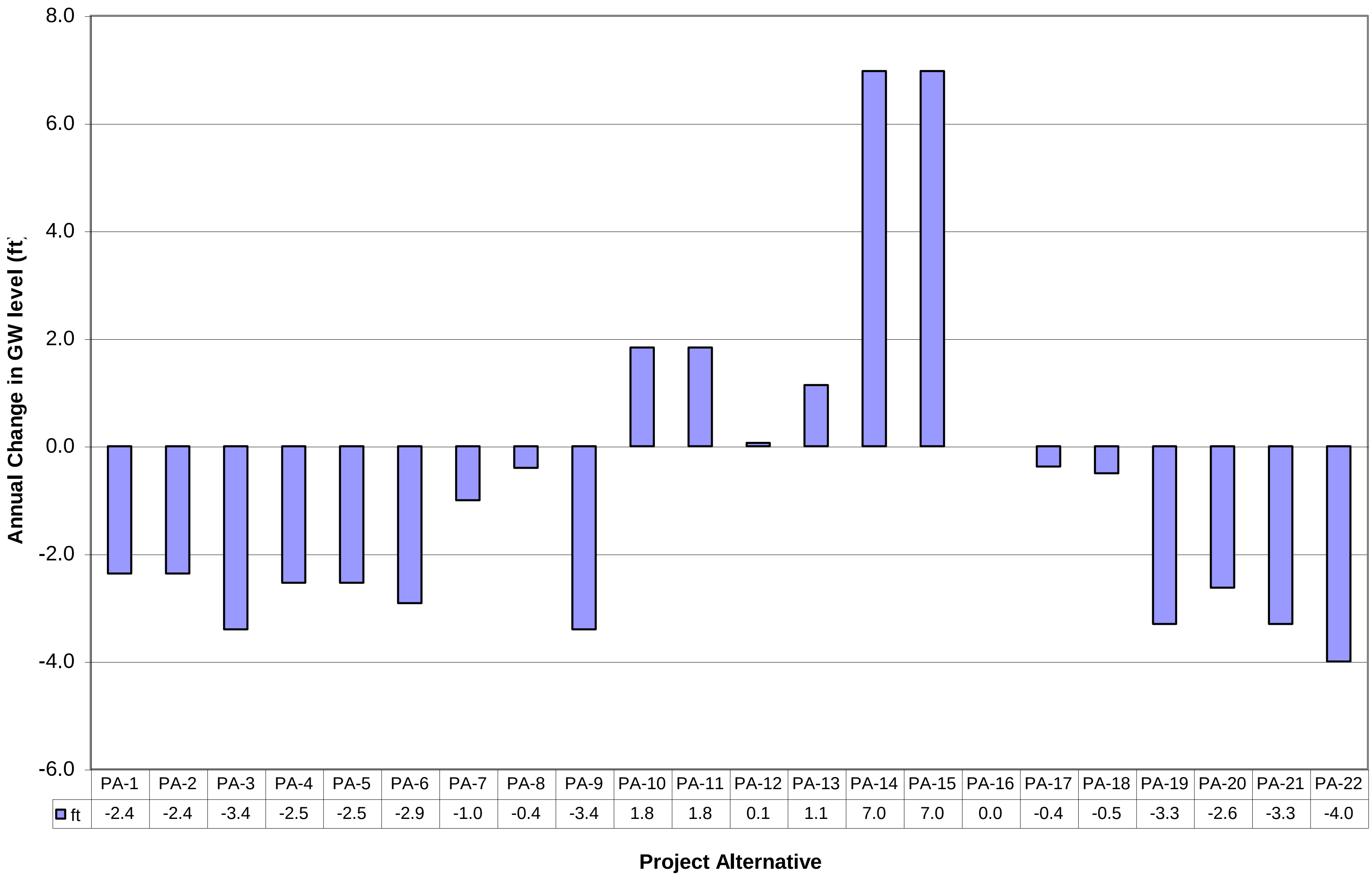

Figure 5.1 Changes in Groundwater Levels by Project Alternative

SUBJECTIVE ESTIMATES

Subjective estimates of the effect of several categories were made for all supply and facilities alternatives and are included in Table 5.3. Explanations of the rational for the designation under each category are briefly described here.

Pumping Water Level Changes

The potential to lower the groundwater level was considered negative while the potential to raise the groundwater level was considered positive.

Groundwater Quality Changes

The potential of each alternative to degrade or improve groundwater quality was assessed. The potential to degrade groundwater quality was considered negative. The potential to improve groundwater quality was considered positive.

Drainage Water Quality and Quantity changes

The potential to degrade drainage water quality or increase drainage water quantity was considered negative.

Changed Groundwater Yield

The potential to increase the groundwater yield was considered positive. Decreases to groundwater yield were considered negative.

Agricultural Production and, Local Job Loss

The alternatives were assessed to determine the potential to reduce the number of jobs available locally and the potential to impact the local farm production and economy thereby reducing the living and social standards within the area. The potential to reduce jobs or reduce farm production and the local economy were each considered negative. The potential to increase either were considered positive.

Cultural Environment, Community, and Cultural Resources

Alternatives that had the potential to reduce the cultural variety, or the established community were considered negative. Alternatives that enhanced the preservation or growth of cultural diversity were considered positive.

Land Use Planning

Alternatives that required variations from current land use or appeared incompatible with current and use were considered negative. Compatible alternatives were considered positive.

Biological Resources

Alternatives with the potential to decrease desirable wildlife populations, communities of desirable fauna assessed as being negative. Alternatives that had potential to increase these were considered positive.

Economic Benefits and Impacts

Alternatives that had the potential to decrease the activity of the economy through reduced productivity or land values were considered negative.

Implementability: Ease of, Requirements for, and Methods

Alternatives that required significant environmental mitigations to implement were considered negative.

Alternatives that could be implemented by conventional methods were considered positive.

Alternatives involving significant institutional obstacles were considered negative.

Utility, Public, and Transportation Service/Systems

Alternatives that impacted these by requiring an increased in service, or significant modification of existing facilities were considered negative.

Air Quality and Noise

Alternatives that had the potential to reduce air quality were considered negative.

Alternatives that had the potential to increase noise levels above ambient levels beyond the immediate vicinity of improvements or operations associated with alternative were considered negative.

Table 5.3 Subjective Evaluation

	Project Alternative	Pumping Water Level Changes	Groundwater Quality Changes	Drainage water quality and quantity	Changed Groundwater Yield	Agricultural Production	Local Job Loss	Cultural Environment and Community Change	Socioeconomic resources	Cultural resources	Land use/planning	Biological resources	Economic Benefits and Impacts	Implementability	Methods of implementation	Needs for Implementation	Utilities/service systems	Public services	Transportation/traffic	Air quality	Noise
		Assessments																			
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	+	+	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	+	+	+	NS	NS	NS	NS	NS
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-3	Use Exisiting Highline Canal. Serves area C	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-7	Northside canal extension. Serves area F.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	-	NS	NS	NS	NS	NS
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-14	Serves areas HDIB served by east side canal	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-15	Serves areas HDIB served by east side reservoir	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-16	Recharge Basins	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-17	EWD Improved Irrigation Efficiency	-	NS	NS	-	NS	NS	NS	NS	NS	NS	NS	NS	+	+	+	+	NS	NS	NS	NS
PA-18	Cropping Pattern Changes within EWD	NS	NS	NS	-	NS	NS	NS	NS	NS	NS	NS	+	+	+	+	+	NS	NS	NS	NS
PA-19	EWD Soil Stabilization and Water Conservation Practices	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-20	Constructed Meanders in Dredger Tailings	+	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-21	EWD Winter Water	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-22	No Action	-	-	NS	-	-	-	-	=	-	NS	NS	-	NS	NS	NS	NS	NS	NS	-	NS

These are designated +, -, or NS (NS meaning No Significant Distinction) and designated according to the criteria below.

Pumping Water Level Changes	Larger lifts are negative.
Groundwater Quality Changes	Potential to degrade the groundwater quality is negative.
Changed Groundwater Yield	Reduction in aquifers storage capability are negative.
Agricultural Production	Decreases in yield are negative.
Local Job Loss	Decreases in the number of jobs is negative.
Cultural Environment and Community Change	Large changes from existing conditions are negative.
Socioeconomic resources	Decreases in crop revenues and jobs are negative.
Cultural resources	Reductions in cultural diversity are negative.
Land use/planning	Changes in land use INconsistent with land use plans are negative
Biological resources	Reduction in diversity of species or population are negative
Economic Benefits and Impacts	Reductions in crop revenues and related economies are negative.
Implementability	Unmitigateable environmental or legal obstructions are negative.
Methods of implementation	Traditional methods are positive.
Needs for Implementation	Difficult conditions required for implementation are negative
Utilities/service systems	Significant changes to existing systems are negative.
Public services	Increases to public services are negative
Transportation/traffic	Increases in traffic or transportation services are negative.
Air quality	Deterioration fo air quality are negative.
Noise	Increases in noise in area occupied by persons are negative.

Chapter 6

Ranking of Alternatives

Introduction

This chapter ranks the alternatives. The alternatives are ranked according to their standing within several categories. Tables have been prepared listing alternatives in order of standing from most favorable to least favorable for these categories. Accompanying each table is an explanation of the criteria used to establish the ranking. The final section of this chapter summarizes the rankings

Direct Costs

The estimated costs for the application of the alternative are presented in Table 6.1 through Table 6.4. More detailed cost estimates for alternatives are included in Appendix B. The costs listed in Tables 6.1 through 6.4 are the total present value costs for the alternatives that include capital costs (design, construction, startup, and other initial costs) and operations and maintenance costs (including energy, repair and replacement costs). . All cost rankings are least cost highest to greatest cost lowest.

Table 6.1 Ranking of Project Alternatives by Capital Cost

	Project Alternatives	Capital Costs of Main Conveyance Facilities
PA-3	Use exisiting highline canal. Serves area C.	
PA-19	EWD Soil Stabilization and Water Conservation Practices.	$150,000
PA-21	EWD Winter Water.	$150,000
PA-7	Northside canal extension. Serves area F.	$290,000
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	$2,280,000
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	$2,400,000
PA-20	Constructed Meanders in Dredger Tailings.	$2,800,000
PA-16	Recharge Basins.	$3,738,000
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$3,800,000
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	$3,800,000
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$4,440,000
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	$8,300,000
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	$9,550,000
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$9,700,000
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	$11,100,000
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	$11,940,000
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$14,200,000
PA-14	Serves areas HDIB served by east side canal.	$16,540,000
PA-15	Serves areas HDIB served by east side reservoir.	$21,040,000
PA-17	EWD Improved Irrigation Efficiency.	$29,600,000
PA-18	Cropping Pattern Changes within EWD.	$298,300,000
PA-22	No Action.	

This table lists the alternatives in order of least cost to greatest cost for the cost to construct.

Table 6.2 Ranking of Project Alternatives by O M R & R Cost

	Project Alternatives	Annual Operations, Maintenance Repair, and Replacement
PA-3	Use exisiting highline canal. Serves area C.	
PA-17	EWD Improved Irrigation Efficiency.	
PA-18	Cropping Pattern Changes within EWD.	
PA-20	Constructed Meanders in Dredger Tailings.	
PA-19	EWD Soil Stabilization and Water Conservation Practices.	$750
PA-21	EWD Winter Water.	$750
PA-7	Northside canal extension. Serves area F.	$1,800
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	$3,000
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$5,700
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$5,700
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	$6,100
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	$6,300
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	$8,000
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	$19,000
PA-16	Recharge Basins.	$37,380
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$51,600
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	$55,500
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	$63,500
PA-14	Serves areas HDIB served by east side canal.	$74,600
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$84,100
PA-15	Serves areas HDIB served by east side reservoir.	$107,100
PA-22	No Action.	

This table lists the cost of operation and maintenance for a fifty year period in 2003 dollars.

Table 6.3 Ranking of Project Alternatives by Energy Costs

	Project Alternatives	Annual Energy Costs for Pumping
PA-3	Use exisiting highline canal. Serves area C.	
PA-7	Northside canal extension. Serves area F.	
PA-17	EWD Improved Irrigation Efficiency.	
PA-16	Recharge Basins.	
PA-18	Cropping Pattern Changes within EWD.	
PA-19	EWD Soil Stabilization and Water Conservation Practices.	
PA-20	Constructed Meanders in Dredger Tailings.	
PA-21	EWD Winter Water.	
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	$100,000
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	$122,000
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	$144,000
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$150,000
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$160,000
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	$250,000
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$570,000
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$570,000
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	$600,000
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	$730,000
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	$859,000
PA-14	Serves areas HDIB served by east side canal.	$1,429,000
PA-15	Serves areas HDIB served by east side reservoir.	$1,429,000
PA-22	No Action.	

This table lists costs for energy in 2003 dollars based upon an energy costs of $0.15 per kilowatt.

Table 6.4 Ranking of Project Alternatives by Total Costs

	Project Alternatives	Total Annual Cost for Capital payments, O&M, and Energy for main conveyance facilities
PA-3	Use exisiting highline canal. Serves area C.	
PA-19	EWD Soil Stabilization and Water Conservation Practices.	$20,750
PA-21	EWD Winter Water.	$20,750
PA-7	Northside canal extension. Serves area F.	$31,800
PA-20	Constructed Meanders in Dredger Tailings.	$250,000
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	$338,100
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	$350,300
PA-16	Recharge Basins.	$367,380
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	$443,000
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$495,700
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$555,700
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	$988,000
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$1,471,600
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	$1,589,000
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	$1,625,500
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$1,894,100
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	$1,972,500
PA-17	EWD Improved Irrigation Efficiency.	$2,590,000
PA-14	Serves areas HDIB served by east side canal.	$2,953,600
PA-15	Serves areas HDIB served by east side reservoir.	$3,376,100
PA-18	Cropping Pattern Changes within EWD.	$26,100,000
PA-22	No Action.	

This table lists the sum of capital, operating, and energy costs

Table 6.5 Ranking of Project Alternatives by Cost per Acre-ft of Water

	Project Alternatives	Cost per Acre-ft of Appropriated or In-lieu water	Cost per Acre-ft of water purchased at $50/Acre.ft
PA-19	EWD Soil Stabilization and Water Conservation Practices.	$4	n/a
PA-21	EWD Winter Water.	$4	n/a
PA-16	Recharge Basins.	$6	$56
PA-20	Constructed Meanders in Dredger Tailings.	$23	n/a
PA-3	Use exisiting highline canal. Serves area C.	$68	$118
PA-7	Northside canal extension. Serves area F.	$69	$119
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	$80	$130
PA-17	EWD Improved Irrigation Efficiency.	$89	n/a
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$100	$150
PA-14	Serves areas HDIB served by east side canal.	$102	$152
PA-15	Serves areas HDIB served by east side reservoir.	$106	$156
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	$109	$159
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	$109	$159
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$110	$160
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	$115	$165
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	$116	$166
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	$118	$168
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	$119	$169
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	$138	$188
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	$155	$205
PA-18	Cropping Pattern Changes within EWD.	$791	n/a
PA-22	No Action.		

This table lists the cost per acre-foot of water provided by the alternative. The quantity includes water delivered for irrigation, recharge, and in lieu water or conserved water.

Indirect Costs

Table 6.6 Changes in Crop Value

	Existing Crop		Alternate Crops Potential - Approximate Change in Crop Value1 (Dollars)												
	Area (Acres)	Value (per Acre)	Alfalfa	Pasture	Walnut	Almond	Misc. Mixed Deciduous	Peach/ Nectarine	Citrus	Truck, Nursery, & Berry	Vineyards	Corn	Other field	Grain	Dry Beans
Eastside ID															
Alfalfa	451	842.00		(318,000)	374,000	253,000	834,000	1,563,000	100,000	1,316,000	575,000	(97,000)	1,316,000	(231,000)	(109,000)
Pasture	3,904	137.00			5,984,000	4,938,000	9,970,000	16,274,000	3,619,000	14,135,000	7,729,000	1,917,000	14,135,000	749,000	1,807,000
Walnut	961	1670.00				(258,000)	982,000	2,534,000	(583,000)	2,007,000	430,000	(1,002,000)	2,007,000	(1,289,000)	(1,029,000)
Almond	21,884	1402.00					28,209,000	63,552,000	(7,397,000)	51,559,000	15,647,000	(16,938,000)	51,559,000	(23,482,000)	(17,551,000)
Misc. Mixed Deciduous	298	2691.00						482,000	(485,000)	318,000	(171,000)	(615,000)	318,000	(705,000)	(624,000)
Peach/Nectarine	696	4306.00							(2,258,000)	(382,000)	(1,524,000)	(2,561,000)	(382,000)	(2,769,000)	(2,581,000)
Citrus	49	1064.00									52,000	(22,000)	133,000	(36,000)	(23,000)
Truck, Nursery, & Berry	160	3758.00									(262,000)	(500,000)	0	(547,000)	(504,000)
Vineyards	7,454	2117.00										(11,099,000)	12,232,000	(13,327,000)	(11,307,000)
Corn	1,627	628.00											5,094,000	(487,000)	(46,000)
Other field	1,238	3758.00												(4,245,000)	(3,909,000)
Grain	3,971	329.00													1,076,000
Dry Beans	2,011	600.00													

This table presents the estimated change in crop values. Where crop changes will reduce crop values, the values are negative.

Table 6.7 Ranking of Project Alternatives by Delivered or Recharged Water

	Project Alternatives	Delviered or In Lieu Water, AF
PA-3	Use exisiting highline canal. Serves area C.	4,800
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	4,800
PA-19	EWD Soil Stabilization and Water Conservation Practices.	5,600
PA-21	EWD Winter Water.	5,600
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	8,700
PA-20	Constructed Meanders in Dredger Tailings.	11,000
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	11,700
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	11,700
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	13,100
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A.	13,100
PA-7	Northside canal extension. Serves area F.	24,000
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	28,800
PA-17	EWD Improved Irrigation Efficiency.	29,000
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	32,500
PA-18	Cropping Pattern Changes within EWD.	33,000
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B.	41,100
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	46,700
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	46,700
PA-16	Recharge Basins.	63,700
PA-14	Serves areas HDIB served by east side canal.	87,800
PA-15	Serves areas HDIB served by east side reservoir.	87,800
PA-22	No Action.	

This table presents the quantity of water that an alternative will provide. The quantity includes water delivered for irrigation, recharge, and in lieu water or conserved water.

Subjective Categories

Two tables were compiled here. The first lists the alternatives in order of those with the greater amount of "plus" marks from the subjective evaluation matrix. The second lists the alternatives in the order of those with the least amount of "minus" marks from the subjective evaluation matrix.

Table 6.8 Ranking of Project Alternatives by Positive Effects

	Project Alternative	Pumping Water Level Changes	Groundwater Quality Changes	Drainage water quality and quantity	Changed Groundwater Yield	Agricultural Production	Local Job Loss	Cultural Environment and Communi Change	Socioeconomic resources	Cultural resources	Land use/planning	Biological resources	Economic Benefits and Impacts	Implementability	Methods of implementation	Needs for Implementation	Utilities/service systems	Public services	Transportation/traffic	Air quality	Noise
PA-20	Constructed Meanders in Dredger Tailings	+	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	+	+	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	+	+	+	NS	NS	NS	NS	NS
PA-19	EWD Soil Stabilization and Water Conservation Practices	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-21	EWD Winter Water	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-18	Cropping Pattern Changes within EWD	NS	NS	NS	-	NS	NS	NS	NS	NS	NS	NS	+	+	+	+	+	NS	NS	NS	NS
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-7	Northside canal extension. Serves area F.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-14	Serves areas HDIB served by east side canal	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-15	Serves areas HDIB served by east side reservoir	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-16	Recharge Basins	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-17	EWD Improved Irrigation Efficiency	-	NS	NS	-	NS	NS	NS	NS	NS	NS	NS	NS	+	+	+	+	NS	NS	NS	NS
PA-3	Use Exisiting Highline Canal. Serves area C	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	-	NS	NS	NS	NS	NS
PA-22	No Action	-	-	NS	-	-	-	-	=	-	NS	NS	-	NS	NS	NS	NS	NS	NS	-	NS

These are designated +, -, or NS (NS meaning No Significant Distinction) and designated according to the criteria below.

Pumping Water Level Changes	Larger lifts are negative.
Groundwater Quality Changes	Potential to degrade the groundwater quality is negative.
Changed Groundwater Yield	Reduction in aquifers storage capability are negative.
Agricultural Production	Decreases in yield are negative.
Local Job Loss	Decreases in the number of jobs is negative.
Cultural Environment and Community Change	Large changes from existing conditions are negative.
Socioeconomic resources	Decreases in crop revenues and jobs are negative.
Cultural resources	Reductions in cultural diversity are negative.
Land use/planning	Changes in land use INconsistent with land use plans are negative
Biological resources	Reduction in diversity of species or population are negative
Economic Benefits and Impacts	Reductions in crop revenues and related economies are negative.
Implementability	Unmitigateable environmental or legal obstructions are negative.
Methods of implementation	Traditional methods are positive.
Needs for Implementation	Difficult conditions required for implementation are negative
Utilities/service systems	Significant changes to existing systems are negative.
Public services	Increases to public services are negative
Transportation/traffic	Increases in traffic or transportation services are negative.
Air quality	Deterioration fo air quality are negative.

Table 6.9 Ranking of Project Alternatives by Negative Effects

	Project Alternative	Pumping Water Level Changes	Groundwater Quality Changes	Drainage water quality and quantity	Changed Groundwater Yield	Agricultural Production	Local Job Loss	Cultural Environment and Community Change	Socioeconomic resources	Cultural resources	Land use/planning	Biological resources	Economic Benefits and Impacts	Implementability	Methods of implementation	Needs for Implementation	Utilities/service systems	Public services	Transportation/traffic	Air quality	Noise
		Assessments																			
PA-22	No Action	-	-	NS	-	-	-	-	-	-	NS	NS	-	NS	NS	NS	NS	NS	NS	-	NS
PA-11	South Central Canal Served by East Side Reservoir, Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	-	NS	NS	NS	NS	NS
PA-17	EWD Improved Irrigation Efficiency	-	NS	NS	-	NS	NS	NS	NS	NS	NS	NS	NS	+	+	+	+	NS	NS	NS	NS
PA-3	Use Exisiting Highline Canal. Serves area C	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-2	Turlock Main Canal Pump Station and Pipeline. Serves area A	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-4	East Avenue Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-5	Monte Vista Pump Station, Pipeline, and Canal from Highline Canal. Serves area D.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-6	Airport Pump Station and Pipeline from Branch Canal near Turlock Airport. Serves area E.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-7	Northside canal extension. Serves area F.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-8	Northside canal extension. Dry Creek Pump Station, East Satellite Reservoir and Canal, West Satellite Pump Station. Serves areas F and G.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-9	Turlock Lake South Pump Station, Pipeline, and Canal, Cattle Reservoir, West Satellite Facilities. Serves area G.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-10	South Central Canal Served by Eastside Canal Serves H & D with East Avenue Pump Station moved north and West Canal flowing east to west.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-12	North Central pump station and canal served by Eastside Canal. Serves area I.	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-13	North Central and West pump stations and canals served by Eastside canal. Serves areas I and B	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-14	Serves areas HDIB served by east side canal	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-15	Serves areas HDIB served by east side reservoir	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-16	Recharge Basins	+	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	-	+	+	NS	NS	NS	NS	NS
PA-18	Cropping Pattern Changes within EWD	NS	NS	NS	-	NS	NS	NS	NS	NS	NS	NS	+	+	+	+	+	NS	NS	NS	NS
PA-1	Tuolumne River Pump Station and Pipeline. Serves area A.	+	+	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	+	+	+	NS	NS	NS	NS	NS
PA-19	EWD Soil Stabilization and Water Conservation Practices	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-21	EWD Winter Water	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS
PA-20	Constructed Meanders in Dredger Tailings	+	NS	NS	+	NS	NS	NS	NS	NS	NS	+	NS	+	+	+	+	NS	NS	NS	NS

These are designated +, -, or NS (NS meaning No Significant Distinction) and designated according to the criteria below.

Pumping Water Level Changes	Larger lifts are negative.
Groundwater Quality Changes	Potential to degrade the groundwater quality is negative.
Changed Groundwater Yield	Reduction in aquifers storage capability are negative.
Agricultural Production	Decreases in yield are negative.
Local Job Loss	Decreases in the number of jobs is negative.
Cultural Environment and Community Change	Large changes from existing conditions are negative.
Socioeconomic resources	Decreases in crop revenues and jobs are negative.
Cultural resources	Reductions in cultural diversity are negative.
Land use/planning	Changes in land use INconsistent with land use plans are negative
Biological resources	Reduction in diversity of species or population are negative
Economic Benefits and Impacts	Reductions in crop revenues and related economies are negative.
Implementability	Unmitigateable environmental or legal obstructions are negative.
Methods of implementation	Traditional methods are positive.
Needs for Implementation	Difficult conditions required for implementation are negative
Utilities/service systems	Significant changes to existing systems are negative.
Public services	Increases to public services are negative
Transportation/traffic	Increases in traffic or transportation services are negative.
Air quality	Deterioration fo air quality are negative.
Noise	Increases in noise in area occupied by persons are negative.

Modifying Criteria

OTHER AGENCY ACCEPTANCE

This criterion makes a subjective estimate of the institutional and administrative issues and concerns other agencies may have regarding each alternative. This criterion was evaluated based upon the level of risk or perceived risk that other agencies may would encounter with an alternative. Those with the least risk to other agencies are considered more favorably.

COMMUNITY ACCEPTANCE

This criterion evaluates the level of public support or resistance an alternative receives or is expected to receive. Those with the greatest support are considered more favorably.

IMPLEMENTABILITY

This criteria estimates the ease of implementation and the time required to implement an alternative.

These modifying criteria were considered when drafting the conclusions and recommendations.

Chapter 7

Summary Recommendations

Summary and Conclusions

The report has been prepared to provide Eastside Water District's Board of Directors, a toolbox of alternatives that can be considered by the Board to improve the District's imbalance of water supply vs. demand. The alternatives of supply and conveyance have the potential to provide varying quantities of water, with varying costs and concerns. Several basic issues considered were:

1. A conclusion that the District's groundwater, safe yield, is inadequate to meet the existing and projected water demands. The shortfall is approximately 64,000 acre-feet annually.

2. If the District is going to eliminate the imbalance between demand and supply, the District must locate sources of water from outside the District.

3. That small projects, which contribute new water may be implemented regardless of the direct benefit to all in the District, so long as an indirect benefit goes to the whole District.

4. The District should now contact neighboring water agencies to inquire about their possible assistance in helping EWD to acquire water to balance the basin overdraft.

5. The District should continue to spearhead the movement to implement ground water conjunctive use and watershed management.

6. The effects of deferred action will be to continue the depletion of the quantity of groundwater. The continued depletion will cause an increase in the costs of energy to pump groundwater. However, this increase will not impact pumpers equally. Pumpers at the center of the cone of depression will see further reduction in pumping water levels, while people at the edge of the cone may see groundwater levels with less decline. Deferring action may cause no greater impact than described. However, in the worst case, the groundwater may deplete more rapidly than observed historically as the recharge pathways are drained and water levels fall below them. This condition could result in a relatively sudden depletion of the quantity and quality of groundwater. Also, continued overdraft may have an adverse impact on neighboring groundwater basins.

7. The timeline for implementation of any solutions should be driven by a conscious decision of the stakeholders to:

- Address the overdraft condition by acquiring water from neighboring water agencies and implementing large or small projects that contribute toward the solution.
- Address the condition through preparing contingency plans for implementation at such time that groundwater supplies become inadequate.
- Choose not to act at all.

Recommendations

The EWD groundwater basin has an average overdraft of approximately, 64,000 acre-feet/year. It is an objective, of the EWD Board of Directors, to mitigate this short-fall to the extent practical and economically feasible. To this end, there are two major issues, which need to be resolved in order:

1. Water Supply: The first issue is to identify and select the most feasible alternatives of supplemental water supply to balance the 64,000 acre-feet average annual basin overdraft.

2. Water Conveyance: After supplemental water supplies have been selected, it will be necessary to convey, store and use the water in a manner most cost efficient.

WATER SUPPLY ALTERNATIVES

The “Supplemental Water Supply Plan” (Report) identifies several alternatives, which might provide supplemental water to EWD. Some of the alternatives presented are more suitable and acceptable to the EWD Board of Directors while others are not. The more favorable alternatives are identified in order of priority as follows:

1. Acquire Water from TID: EWD best alternative is to try to acquire water, as it may be available, from TID for groundwater recharge and or as direct usage. A conjunctive use program would work very well with EWD due to their extensive usage of the groundwater basin. Water could be acquired on an intermittent basis as available for recharge, surface storage, or as direct usage in-lieu of groundwater pumping. This flexibility by EWD could ease any concerns by TID by their not having to provide water during lean water years.

2. Acquire Water from Merced ID: Water could be acquired on an as available and delivered through the Merced I.D. North Side Canal subject to capacity limitations and/or upgrade to the canal. Alternately, it may be possible to deliver water purchased from Merced I.D. by exchange to the TID system on the Tuolumne. Such exchanges can be very complicated and in some cases not possible.

3. Acquire Water from Modesto ID: This alternative would involve arrangement for capacity restricted delivery by TID and/or

construction of independent diversion facilities from the Tuolumne.

4. Reclamation/Reuse of Treated Municipal and Industrial Water: The city of Turlock and other cities have a problem in renewing their waste discharge permits in meeting new requirements established the Central Valley Regional Water Quality Control Boards. The Eastside Water District's AB 303 grant takes into consideration mutual neighboring concerns regarding reclaiming treated municipal wastewater reuse for irrigation purposes.

   Municipalities are facing new waste discharge requirements regarding NPDES permit renewals for effluent disposal. Reclamation and agricultural reuse with seasonal storage could contain run-off and eliminate the cities having to discharge into waterways. This option would reduce pending major increase treatment, capital and operational costs and may offer cities a less expensive way to dispose of their effluent water. This option has not been fully explored with the city of Turlock or other near-by cities, but it is worthy of further consideration due to the potential cost savings to the cities and irrigation water value to the growers.

5. Acquire Water from Other Water Agencies/Banking: EWD may consider acquiring water from other water districts agencies in central and northern California. To date there has been no long-term water transfers. However over the last 10 years there have been many annual transfers of water. The SWRCB is working on requirements for long-term transfers and have recently supported such a transfer from the Imperial Irrigation District to the City of San Diego. There is a vast water conveyance system in northern and central California, which may enable EWD to make water exchanges for their acquired water with TID or other water agencies for conveyance purposes. Water acquired from outside the area would have to be conveyed to EWD or an exchange made with a local district to enable EWD usage, depending on the source and location of any water acquired.

6. Other Alternatives: Other alternatives, listed below were investigated in the study, but are not recommended in deference to more favorable alternatives and/or feasibility:

   - Improved irrigation efficiency: This alternative was discounted due to the fact that a high percentage of irrigators within EWD use highly efficient state of the art irrigation technology and there is little room for large improvement. It is not considered practicable for EWD to address irrigation efficiencies outside its own boundaries.
   - Improved cropping patterns: This alternative is to pay growers to convert lands producing low value, high water consumptive use crops into higher value crops with lower consumptive use water requirements. The "low value" field crops identified are mainly comprised of alfalfa, pasture, corn and grain all of which are not grown for their individual value, but to support the local dairy

industry - a much higher value crop. Another complicating factor is that the dairy industry utilizes nutrient water, produced by the dairy, to fertilize these crops. Thus, the shift in cropping suggested by this alternative is extremely unlikely. Given these considerations this alternative is not recommended for further consideration.

- Storm Flows for Recharge Basins: This would conserve winter storm flows with-in EWD. Storm water would be diverted to various recharge basins with-in EWD. Storm flows may also be diverted to off-stream storage for detention and regulated releases.
- Storm Water Conservation Practices: There may be some water and soil conservation practices with-in EWD that conserve storm run-off water. The Soil Conservation Service has an inventory of possible alternatives to regulate run-off and provide soil conservation practices. However, the water conserved would be little in comparison to the need to balance the basin.

WATER CONVEYANCE ALTERNATIVES

This section defines the conveyance, storage, and delivery systems that could be developed for conveyance of the above water sources. Several different facilities are proposed. Which of these facilities will be developed depends upon which source of water is procured and which facilities produce the most water supply for the least cost. Appendix B in the report has rough cost estimates for each facility.

1. Turlock Main Canal: This is an existing canal owned and operated by Turlock Irrigation District. The canal transits the north side of EWD making it a potential facility to convey water to the District. However, use of this facility or any facility requires TID’s approval and that capacity exists or may be created by improvements for additional water. Water from this conveyance may be used by a direct distribution system to EWD as identified in the report and/or for groundwater recharge.

2. TID’s Highline Canal: This is an existing canal owned and operated by Turlock Irrigation District. The canal transits the west side of EWD making it a potential facility to convey water to the District. Water from this conveyance system may be used in-lieu with a direct distribution system to EWD and/or for groundwater recharge.

3. Groundwater Recharge Basins: Several sites are currently being explored which could be served by the above canal conveyance systems. This alternative would construct recharge basins within the area of the falling groundwater levels. The initial recharge rates demonstrated by the pilot project varied between 1.5 and 2.7 feet per day. These recharge rates have a tendency to fall-off rapidly and it is difficult to estimate what the annual recharge capacity of a given area might be. However, a reasonable average might be one half of the 1.5 feet per day. With a

recharge season of 200 days per year, the estimated average annual recharge achievable would be 150 acre-feet/acre annually. To achieve a complete balance of supply vs. demand for the 72,000 AF of annual overdraft would require approximately 480 acres of recharge facilities.

4. North Side Canal Extension: Area “F” (ref. report) would be served by this alternative of conveyance. The North Side Canal would be extended to meet and discharge into Dry Creek. Water would have to be acquired from Merced Irrigation District (MID) or TID. Dry Creek would then be used as a Conveyance system. Since only a canal would have to be constructed and no pumping would be required, this alternative appears to be the least expensive of constructed facilities. The North Side Canal and lateral are existing facilities owned by MID.

In summary, the conveyance facilities are dependent upon acquiring different sources of supply. The cost of facilities in the report, are rough estimates of facilities, capital and operational cost and are for comparison only. Further, the costs do not include costs associated with any changes to TID or Merced ID facilities that would be needed to accommodate the proposed water supply alternatives.

When supplemental water supplies are acquired, then it will be appropriate for specific designs and cost estimates made for conveyance of any particular source.